

Full Length Research Paper

Evaluation of bacterial profile and biodegradation potential of abattoir wastewater

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Abattoir wastewater treatments were monitored using physicochemical parameters, bacterial profile and biodegradation potential for 28 days at 7 days intervals. The stages of abattoir wastewater treatment were evaluated through determination of physicochemical parameters such as pH, conductivity, total dissolved solid, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, phosphate, nitrate and iron using standard procedures. Bacterial plate counts were determined using the pour plate method with nutrient agar. Characterization and identification of bacteria was done on the basis of cultural appearance of colony, morphology, differential and selective media. The results showed that *Escherichia* sp., *Pseudomonas* sp., *Enterobacter* sp., *Klebsiella* sp., *Staphylococcus* sp., *Salmonella* sp., *Streptococcus* sp. were common to both abattoir wastewater samples. *Serratia* sp. was identified only in Ikpoba Hill abattoir wastewater. The bacteria occurrence frequency revealed that *Escherichia* sp. was dominant ($P > 0.05$) in both abattoir samples while *Streptococcus* sp. was least abundant. Bacterial plate count revealed significant increase in both abattoir wastewater samples. BOD_5/COD ratio revealed that degradation was slow below normal limit of 0.6, and then significantly increased with time. Physicochemical parameters showed significant difference at $P > 0.05$ for both abattoirs. These results suggest that temporal variations of the effluent bacterial community may be useful to predict the wastewater treatment performance and settleability of activated sludge.

Key words: Bacteria profile, biodegradability, physicochemical parameters, bacterial community, abattoir wastewater.

INTRODUCTION

The environment is a very important and necessary component for the existence of both man and other biotic

organisms. The past two decades have witnessed a heightened concern over environmental degradation from

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pollution and depletion of natural resources. Organic and inorganic substances have been released into the environment as a result of domestic, agricultural and industrial activities (Mouchet, 1986; Lim et al., 2010). The release of wastewater especially from slaughterhouses into the environment has increased in recent time due to the continuous drive to increase meat production to meet the protein needs of the population. The meat processing industry produces large volumes of slaughterhouse wastewater (SWW) due to the slaughtering of animals and cleaning of the slaughterhouse facilities and meat processing plants (MPPs) (Padilla-Gasca et al., 2011; Bustillo-Lecompte and Mehrvar, 2015).

Abattoirs are generally known all over the world to pollute the environment either directly or indirectly from their various processes (Adelegan, 2002). Wastewaters are usually released from abattoirs directly into the ecosystems without adequate treatment process (Mittal, 2006; Arvanitoyannis and Ladas, 2008) thereby posing serious threats to surface water quality, general environmental safety and health.

In Nigeria, the abattoir industry is an important component of the livestock industry providing domestic meat supply to over 150 million people and employment opportunities for teeming population (Nafaranda et al., 2011). They are usually situated near aquatic environment where different untreated waste streams are discharged (Sangodoyin et al., 1992; Benka-coker et al., 1995; Adelegan 2002) and constitute public health concern to authorities. The impact of wastewater effluents on the quality of receiving water bodies are manifold and depend on volume of the discharge, chemical and microbiological concentration/composition of the effluents (Akporkor and Muchie, 2011). Slaughterhouse wastewaters (SWWs) contain high amounts of biodegradable organic matter, suspended and colloidal matter such as fats, proteins and cellulose (Nunez and Martinez, 1999; Caixeta et al., 2002). Biodegradable organic matter in receiving waters create high competition for oxygen within the ecosystem leading to high levels of biochemical oxygen demand (BOD) and a reduction in dissolved oxygen, which is detrimental to aquatic life. Nutrients (nitrogen and phosphorus) enrichment in receiving sensitive bodies of water can cause eutrophication by stimulating the growth of algae (called an algal bloom). Blooming and finally collapse of algae may lead to hypoxia/anoxia and hence mass mortality of benthic invertebrates and fish over large areas (Wu, 1999; Foroughi et al., 2010) due to aquatic dissolved oxygen depletion. These effects entail a negative impact on biodiversity, sensitive species may be eliminated, major changes in ecosystem and a number of serious human health hazards may occur.

The meat processing industries are under ever increasing scrutiny from environmental authorities to reduce its environmental impact (Pitt and Skerman, 1992). Adequate operation and efficient processes to

treat abattoir effluents are an important stage of meat production chain which requires special attention (Carlos-Hernandez et al., 2010). Therefore, SWWs require significant treatment for a safe and sustainable release to the environment (Johns, 1995). SWW treatment methods are similar to current technologies used in municipal wastewater and may include preliminary, primary, secondary, and even tertiary treatment. Thus, SWW management methods after preliminary treatment can be divided into five major subgroups: land application, physicochemical treatment, biological treatment, AOPs, and combined processes (Valta et al., 2015). Biological treatments are divided into anaerobic and aerobic systems as well as constructed wetlands (CWs). Aerobic systems are more common since they commonly operate at a higher rate than anaerobic systems; whereas, anaerobic systems require less complex equipment since no aeration system is required; nevertheless, both anaerobic and aerobic systems may be further subdivided into other processes, which have their own advantages and disadvantages (Bull et al., 1982; Tritt and Schuchardt, 1992; Johns, 1995; San Jose, 2004; Mittal, 2006; Bugallo et al., 2014; Vymazal, 2014).

Anaerobic digestion provides some exciting possibilities and solutions to handling human, animal, municipal and industrial wastes safely, controlling environmental pollution, and expanding food supplies. It is the preferred biological treatment that is applied in SWW treatment due to its effectiveness in treating high strength wastewater (Cao and Mehrvar, 2011). Anaerobic technology has been used to treat a variety of wastes including agricultural, food and municipal wastes (Li et al., 2011). Despite efforts to develop and implement anaerobic treatment systems for SWWs, problems persist at the operational and process level (Del Pozo et al., 2003; Mittal, 2006). These facilities are usually lacking in developing countries, unlike in developed countries where these facilities are adequately provided (Obgonnaya, 2008). Understanding the process of biodegradation requires an understanding of the microorganism profile that makes the process work. The objective of this study was to evaluate biodegradation processes and profile microorganisms necessary for anaerobic treatment of SWW.

MATERIALS AND METHODS

The sampling stations are both situated in the southern part of Edo state, Southern Nigeria. The area has two climatic regimes: the wet and the dry season with relatively high humidity all year round. Two of the most commonly used abattoirs in the metropolis (Eyan and Ikpoba Hill Abattoirs, Latitude 06°20'90.2"N; Longitude 005°38'82.8"E and Latitude 06°22'090"N; Longitude 005°42'093"N, respectively) were selected for the study (Figure 1).

Sample collection

Wastewater samples were collected according to the method of Adesemoye et al. (2006). Sterile 2.0 liters sample bottles were used

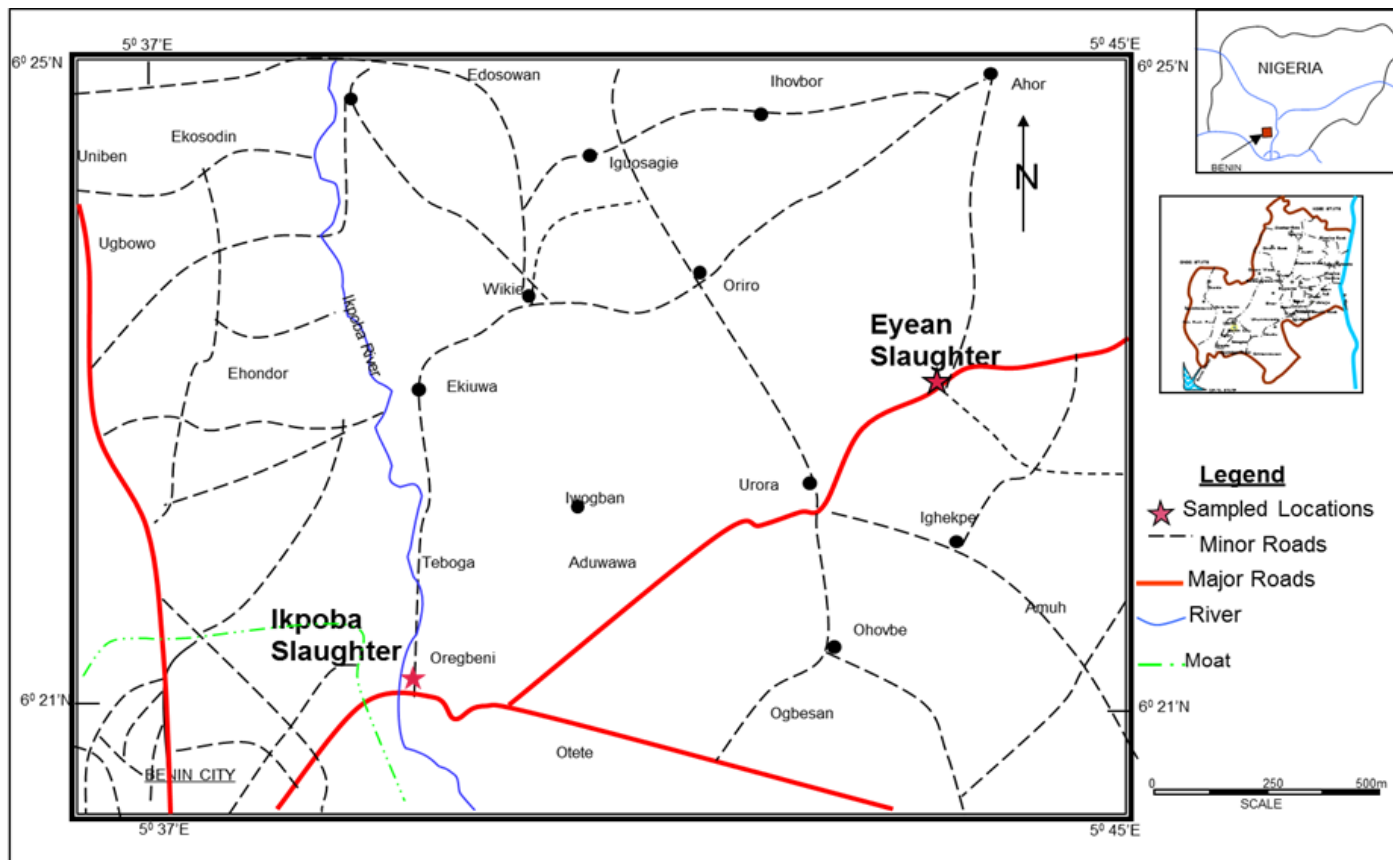


Figure 1. Map of study area in showing sampling locations.

to aseptically draw part of the slaughterhouse wastewater. 500 ml of the samples were collected at the two abattoirs as wastewater was running off the drainage system. Control samples were collected from water stored in buckets used for washing meat and utensils in the abattoirs. The samples were placed in a cooler containing ice blocks and were transported immediately to the laboratory within 4 to 6 h after collection for analysis.

Preparation of culture media

The media used for this study were; nutrient agar, MacConkey agar all of which were prepared according to manufacturer's instructions.

Microbiological analysis

From the dilutions of each sample, 0.1 ml aliquot was transferred aseptically into freshly prepared nutrient agar plates and spread evenly on the medium in duplicates. The inoculated plates were incubated at 37°C for 24 h after which, plates were examined for growth. Representative colonies of bacteria were picked from different plates after the incubation period. Pure cultures of bacteria were obtained by aseptically streaking representative colonies of different morphological types on to freshly prepared nutrient agar plates. The agar plates were further incubated at 37°C for 24 h. Discrete bacterial colonies, which developed on the plates, were used for subsequent characterization tests. Various tests were carried out on the bacterial isolates for possible identification.

One milliliter of broth culture of each isolate was used for all the tests. Bacterial isolates were identified in accordance with the schemes of the Bergey's Manual of Determinative Bacteriology (Holt et al., 1994).

Enumeration of total bacterial counts

To quantify bacterial abundance, abattoir wastewater samples were diluted serially in ten folds (10^{-5}) using sterilized distilled water. Determination of bacterial load in the abattoir wastewater samples were done in triplicates. Bacterial plate counts were carried out using the pour plate method with nutrient agar. This method was based on the serial dilution of water sample, which were then pipetted into each sterile Petri-dish. About 20 ml of molten nutrient and MacConkey agar was cooled to 45°C and poured into each Petri-dish containing 1 ml of the water sample. Plates were allowed to cool and then incubated in inverted position at 37°C. After 24 h of incubation the plates were counted by colony counter to obtain the total bacterial counts.

Characterization and identification

This was done on the basis of cultural appearance of colony, morphology, differential and selective media and by conventional biochemical tests (Cheesebrough, 2005). Gram staining and conventional biochemical test as urease, indole, citrate utilization, coagulase, oxidase and sugar fermentation tests were carried out

Table 1. Bacteria occurrence frequency for Abattoir effluent from Ikpoba.

Bacterial species (%)	Day 0	Day 7	Day 14	Day 21	Day 28
	$\bar{X} \pm SD$	$\bar{X} \pm SD$	$\bar{X} \pm SD$	$\bar{X} \pm SD$	$\bar{X} \pm SD$
<i>Pseudomonas</i> sp.	17.50±2.12	19.50±3.54	18.00±1.41	17.50±2.12	18.50±2.12
<i>Klebsiella</i> sp.	13.00±1.41	10.00±4.24	9.50±3.54	13.00±1.41	11.00±5.66
<i>Escherichia</i> sp.	29.00±1.41	26.00±5.66	25.00±4.24	29.00±1.41	24.00±2.83
<i>Staphylococcus</i> sp.	9.50±0.71	8.50±2.12	11.00±2.83	9.50±0.71	10.00±4.24
<i>Enterobacter</i> sp.	14.00±1.41	10.50±0.71	9.50±2.12	14.00±1.41	10.50±0.71
<i>Salmonella</i> sp.	8.50±0.71	9.00±0.00	10.50±2.12	8.50±0.71	9.00±0.00
<i>Serratia</i> sp.	5.00±0.00	10.0±4.24	8.00±7.07	5.00±0.00	11.00±2.83
<i>Streptococcus</i> sp.	3.50±0.71	6.50±6.36	8.00±0.00	3.50±0.71	6.00±2.83

Table 2. Bacteria occurrence frequency for abattoir effluent from Eyeam.

Bacterial species (%)	Day 0	Day 7	Day 14	Day 21	Day 28
	$\bar{X} \pm SD$	$\bar{X} \pm SD$	$\bar{X} \pm SD$	$\bar{X} \pm SD$	$\bar{X} \pm SD$
<i>Pseudomonas</i> sp.	18.00±1.41	19.50±0.71	18.50±2.12	18.00±1.41	18.00±1.41
<i>Klebsiella</i> sp.	11.00±1.41	13.50±2.12	12.50±3.54	13.50±2.12	11.00±1.41
<i>Escherichia</i> sp.	25.00±4.24	29.00±1.41	28.50±2.12	29.00±1.41	25.00±4.24
<i>Staphylococcus</i> sp.	11.00±2.83	8.00±1.41	10.00±4.24	11.00±2.83	11.00±2.83
<i>Enterobacter</i> sp.	11.00±0.00	19.00±0.00	10.50±0.71	15.00±5.66	11.00±0.00
<i>Salmonella</i> sp.	12.00±0.00	10.50±2.12	9.00±0.00	10.50±2.12	12.00±0.00
<i>Streptococcus</i> sp.	10.50±0.71	0.00±0.00	11.00±2.83	4.00±5.66	10.50±0.71

to determine differential and selective media.

Determination of physical and chemical characteristics

The physico-chemical properties determined were pH, conductivity, total dissolved solid, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, phosphate, nitrate and iron using the methods according to Ademoroti (1996) and APHA (1998).

Biodegradability tests

Biodegradability test of abattoir wastewater was performed in a series of four 2 L capacity plastic tanks with a working volume of 1.5 according to Mendes et al. (2006a). The experiment was conducted in the laboratory using anaerobic digesters at mesophilic temperature (36±1°C). A plastic tube connected the vial to a 2 L plastic with an inverted flask (Duran® flasks) containing an alkaline solution (0.5% w.v⁻¹ NaOH) to allowed methane production to be measured by the displacement of the liquid. In each digester, rumen fluid was used as inoculum. Each digester was purged for 5 min (300 mL/min) with inert gas (N₂) to create an anaerobic environment; the temperature was maintained at 35±1°C. The tests were carried out in duplicate for a minimum period of 28 days and gently stirred (100 rpm). Blank tests were made without substrate, maintaining the other conditions. Bottles were closed with butyl rubber stoppers (Rubber Bv, Netherlands) and sealed with aluminum screw caps (Fischer Scientific, Netherlands). The

headspace was flushed with N₂/CO₂ (80/20%v/v) and 0.8 ml of 0.125 M Na₂S was injected (performing a final working volume of 100 ml). The bottles were placed in a thermostatic room at 35±1°C without stirring. The tests ended when the cumulative methane production reached a steady state.

Data analysis

Basic statistical measurement of central tendency and dispersion to characterize the variations in day intervals in relation to the physicochemical and microbial conditions was carried out. Analysis of variance (ANOVA) was conducted to determine the number of colonies obtained for each protein formulation as well as the specific bacterium growing on different protein formulations were analysed by analysis of variance (ANOVA) (P<0.05). All analysis was performed using SPSS 16.0 windows applications software.

RESULTS AND DISCUSSION

Bacterial profile of abattoir wastewater

The results of the bacterial profile of abattoir wastewater samples are summarised in Tables 1 and 2. *Escherichia* sp., *Pseudomonas* sp., *Enterobacter* sp., *Klebsiella* sp., *Staphylococcus* sp., *Salmonella* sp., *Streptococcus* sp.

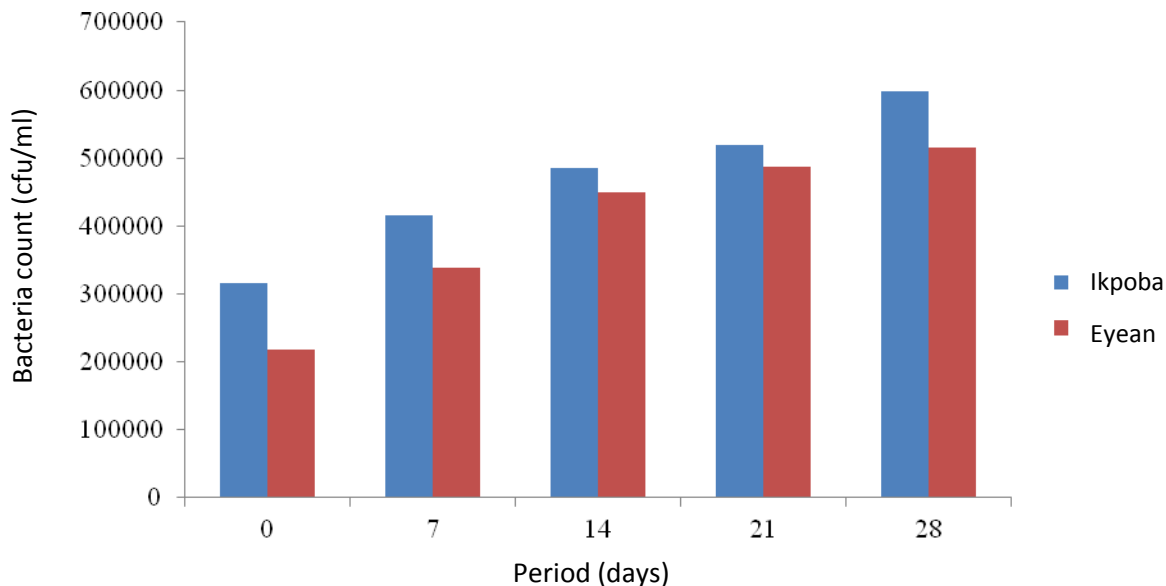


Figure 2. Variations in bacterial counts in Ikpoba hill and Eyan abattoir effluent.

were detected in all the wastewater samples except *Serratia* sp. which was identified only in Ikpoba hill abattoir wastewater samples. The bacteria occurrence frequency revealed that *Escherichia* sp. was dominant ($P > 0.05$) in both abattoir samples while *Streptococcus* sp. was least abundant. The order of dominance was *Escherichia* sp. > *Pseudomonas* sp. > *Enterobacter* sp. > *Klebsiella* sp. > *Staphylococcus* sp. > *Salmonella* sp. > *Serratia* sp. > *Streptococcus* sp. These abattoirs are situated along Ikpoba river where their effluents are constantly discharged. This observation certifies Ikpoba river as unsafe for domestic use (WHO, 1993) due to constant discharge of wastewater from abattoirs. The presence of pathogenic bacteria has been known to cause health hazards (Adeyemo et al., 2002; Akpan, 2004; Nafaranda et al., 2005).

Total bacterial populations were found to be higher in Ikpoba abattoir effluent than Eyan. Variations recorded in the bacterial counts at various day intervals for Ikpoba and Eyan abattoir effluents are represented in Figure 2. In both abattoir effluents, bacteria counts were found to be high. This result conforms the works of Nafaranda et al. (2011) on the elevation bacterial population in wastewaters from the slaughterhouses. Pathogenic species of bacteria identified from the colonies include *Escherichia* sp., *Staphylococcus* sp., *Enterobacter* sp., *Salmonella* sp. and *Streptococcus* sp. This is similar to Coker et al. (2001) who identified pathogenic species of bacteria were identified in abattoir wastewater at south western Nigeria.

The summary of physicochemical characteristics of the abattoir effluents collected from Ikpoba and Eyan analyzed for 28 days at 7 days intervals are

presented in Tables 3 and 4, respectively. The mean pH values increased gradually from 7.03 to 8.77 for Ikpoba hill abattoir wastewater and 6.88 to 8.17 for Eyan, abattoir wastewater respectively. The pH values obtained in this study were within the range of optimum pH levels for anaerobic digestion (Speece, 1996) and were within the World Health Organisation (WHO) tolerance limits of 6.0 to 9.0 for the discharge of wastewater into aquatic environment (Akan et al., 2010). The initial neutral pH that characterized the onset of this research contradicted the observation made by Adesemoye et al. (2006) which recorded an acidic pH in characterization of sampled abattoir effluent. The anaerobic degradation of organic compounds releases ammonia, which reacts with carbon dioxide produced during the anaerobic process, resulting in ammonium bicarbonate, which contributes to the increase in pH values. This phenomenon according to Padilla-Gasca et al. (2011), can be attributed to a high concentration of organic compounds present in the abattoir wastewater which is composed mainly of proteins (like blood).

One way analysis of variance showed a significant difference ($P < 0.05$) among the various pH taken at 7 days intervals for both Ikpoba hill and Eyan abattoir effluents. The mean electrical conductivity (EC) recorded for Ikpoba hill and Eyan abattoirs were in the range of 2749.49 to 23756.43 $\mu\text{S}/\text{cm}$ and 2047.13 to 14570.80 $\mu\text{S}/\text{cm}$ respectively. Conductivity varied irregularly within the study period and was above WHO standard permissible limit of 200 to 1200 mS/cm . This was expected as conductivity is related to the total dissolved solids in the wastewater. The rates of degradation of abattoirs effluent during the first two weeks were the

Table 3. Physicochemical characteristics of wastewater from Ikpoba hill abattoir.

Parameter	Day 0	Day 7	Day 14	Day 21	Day 28	NESREA permissible limit
	$\bar{X} \pm SD$	$\bar{X} \pm SD$	$\bar{X} \pm SD$	$\bar{X} \pm SD$	$\bar{X} \pm SD$	
pH	7.03±0.02 ^E	7.64±0.02 ^D	7.70±0.01 ^C	8.03±0.02 ^B	8.77±0.13 ^A	6-9
EC (µS/cm)	6702.93±14.24 ^D	22177.35±173.45 ^B	23756.43±150.51 ^A	19357.90±81.88 ^C	2749.49±7.76 ^E	N/A
TDS (mg/l)	3351±7.12 ^D	11088±86.73 ^B	11878±75.25 ^A	9678±40.94 ^C	1374±3.88 ^E	500
Phosphate (mg/l)	4.34±0.01 ^A	1.31±0.01 ^C	1.22±0.01 ^D	1.50±0.01 ^B	1.06±0.00 ^E	N/A
Nitrate (mg/l)	8.68±0.02 ^A	2.62±0.02 ^C	2.45±0.02 ^D	3.01±0.01 ^B	1.54±0.03 ^E	10
COD (mg/l)	522.83±1.11 ^E	1729.83±13.53 ^B	1853.00±11.74 ^A	1509.92±6.39 ^C	1446.46±0.14 ^D	250
DO (mg/l)	0.51±0.02 ^A	0.00±0.00 ^B	0.00±0.00 ^B	0.00±0.00 ^B	0.00±0.00 ^B	>0.5
BOD (mg/l)	234.23±0.50 ^E	509.16±1.44 ^B	676.44±2.86 ^C	774.97±6.06 ^B	830.14±5.26 ^A	50
Fe (mg/l)	57.65±0.12 ^D	190.73±1.49 ^B	204.31±1.29 ^A	166.48±0.70 ^C	23.65±0.07 ^E	N/A

Table 4. Physicochemical characteristics of wastewater from Eyean abattoir waste.

Parameter	Day 0	Day 7	Day 14	Day 21	Day 28	NESREA permissible limit
	$\bar{X} \pm SD$	$\bar{X} \pm SD$	$\bar{X} \pm SD$	$\bar{X} \pm SD$	$\bar{X} \pm SD$	
pH	6.88±0.02 ^D	7.68±0.02 ^C	8.16±0.01 ^B	8.36±0.01 ^A	8.17±0.01 ^B	6-9
EC (µS/cm)	2047.68±16.02 ^D	2841.13±39.78 ^C	2957.04±4.19 ^B	2906.55±2.06 ^B	14570.80±41.30 ^A	N/A
TDS (mg/l)	1023.84±8.01 ^D	1420.57±19.89 ^C	1478.52±2.09 ^B	1453.27±1.03 ^B	7285.40±20.65 ^A	500
Phosphate (mg/l)	14.21±0.11 ^A	10.24±0.14 ^B	9.84±0.01 ^C	10.01±0.01 ^C	2.00±0.01 ^D	N/A
Nitrate (mg/l)	28.43±0.22 ^A	20.49±0.29 ^B	19.69±0.03 ^C	6.27±0.00 ^D	1.25±0.00 ^E	10
COD (mg/l)	159.72±1.25 ^D	221.61±3.10 ^C	230.65±0.33 ^A	226.71±0.16 ^B	115.52±0.01 ^E	250
DO (mg/l)	0.97±0.03 ^A	0.00±0.00 ^B	0.00±0.00 ^B	0.00±0.00 ^B	0.00±0.00 ^B	>0.5
BOD (mg/l)	71.55±0.56 ^E	96.08±0.27 ^D	101.57±0.07 ^C	103.33±0.15 ^B	234.23±0.50 ^A	50
Fe (mg/l)	17.61±0.14 ^D	24.43±0.34 ^B	25.43±0.04 ^A	25.00±0.02 ^A	19.10±0.14 ^C	N/A

same for both locations. The effluent from Ikpoba Hill abattoir at onset had values greater than that of Eyean abattoir. These differences can be attributed to blood contents of the effluent.

Total Dissolved Solid (TDS) recorded for Ikpoba Hill and Eyean abattoirs ranged from 1374 to 11878 mg/l and 1023 to 7285 mg/l. TDS values obtained were generally higher than 1000 mg/l the upper limit set by WHO (WHO, 2011). The electrical conductivity and total dissolved solid exhibited similar trend in both abattoir effluents, this is as a result of the linear relationship that exist between the two parameters (Radojevic, 1999). Chemical Oxygen Demand (COD) is considered as the amount of oxygen consumed by the chemical breakdown of organic and inorganic matter.

The COD observed in this study showed that Ikpoba Hill abattoir effluent increased so abruptly when compared with Eyean abattoir effluent. About 48.2% reduction was observed in level of COD from Eyean abattoir effluent compared to Ikpoba abattoir effluent. The rate of reduction of COD of Eyean abattoir effluent confirms the effectiveness of degradation process to

reduce the pollutant load contained in the wastewater. Biochemical Oxygen Demand (BOD₅) recorded for the various abattoir effluents were found to be higher on the 28 days evidenced of high organic matter. The values recorded for the Ikpoba and Eyean abattoir effluent were 234 to 830 mg/l and 72 to 234 mg/l. High organic material presents in the abattoir wastewater is an indication of higher BOD₅ and COD. Higher COD and BOD concentrations recorded at Ikpoba abattoir effluent was due to high blood volume. This is in conformity with the finding of del Pozo et al. (2003). This fact had a great influence on the rest of the parameters and the nature of the wastewaters.

Some information on the wastewater biodegradability can be gained comparing different measures, example, BOD and COD where a high ratio of BOD to COD shows a relatively high biodegradability whereas a low ratio indicates that the wastewater is more slowly biodegraded (Vollertsen and Hvitved-Jacobsen, 2002). According to del Pozo et al. (2003) normal biodegradability of domestic wastewaters occurs at BOD₅/COD ratio of 0.6; though this study was based on biodegradation due to natural

attenuation of abattoir effluent. BOD₅/COD ratios observed in the first three weeks interval ranged between 0.29 to 0.51 and 0.43 to 0.46 for Ikpoba Hill and Eyea abattoir effluents. This low BOD₅/COD ratio, could be attributed to high blood volume in the abattoir waste according to del Pozo et al. (2003).

High degradation rate at the week four could possibly be as a result of the acclimatization of the microorganisms to the prevailing conditions. The dissolved oxygen (DO) in the various abattoir effluents were below undetectable concentrations before the end of the first 7 days interval. This observed change is due to anaerobic nature of the experimental setup and also as a result of increase in the microorganisms' activities which used up the available dissolved oxygen. The dissolved oxygen was on decreased from the onset of this experiment and went drastically to zero before the end of the first 7 days for both abattoir effluents from Ikpoba and Eyea. Phosphate and nitrate are among the prominent compounds in any abattoir effluent. The levels phosphate and nitrate compounds were higher in effluent from Eyea abattoir than that from Ikpoba Hill abattoir. This difference may be attributable to the high fecal contents of the effluents. Rodier (2009) reported that wastewater samples must have less than 50 mg/l of nitrates and 0.5 mg/l of phosphate before its discharge into aquatic environment. The results obtained in this study showed significant reduction of nitrate and phosphate concentration. High phosphate levels will result in the eutrophication of the river. Blood is also the major contributor to the nitrogen content while phosphorus originate from stomach contents in the effluent. High values of iron concentrations were also recorded for the effluents from Ikpoba Hill and Eyea abattoirs due to high blood volume observed in the effluents.

Conclusion

Slaughterhouses generate effluents of variable character which are heavily loaded with organic matter and microorganisms. The discharge of this wastewater into the aquatic environment without proper treatment impacts on the water quality. The physicochemical parameters of the abattoir wastewater in this study do not meet National Environmental Standards and Regulation Enforcement Agency (NESREA) permissible limit, and therefore not suitable for discharge into water bodies. It is therefore important to adopt appropriate abattoir wastewater treatment measures to prevent the contamination of the environment including surface water and ground water. Implementation of low cost, low technology management practices like separation of solids by screening, blood separation (protein recovery), primary settling, etc should be carried out to reduce the period of delayed degradation. This study inundates the fact that untreated

abattoir effluents generated at the Ikpoba Hill and Eyea abattoirs constitute serious environmental problem to the abattoir neighbourhood and health problem to people using the Ikpoba river for domestic purposes, hence there should be an enforcement of strict environmental management by regulatory authorities.

Conflict of Interests

The authors have not declared any conflict of interests.

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