Futo Journal Series (FUTOJNLS)
e-ISSN :2476-8456 p-ISSN : 2467-8325
Volume-2, Issue-1, pp- 186 - 194
www.futojnls.org

Research Paper July 2016

Assessment of Abattoir Wastes Management Strategy in Akure South West Nigeria

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Abstract

Abattoir produces large quantities of wastes (solid and liquid) that contain high organic pollutants. Most of these wastes are disposed indiscriminately into the environment thereby causing great damages to the ecosystems and poses great danger to healthy living. This work involves a comprehensive assessment of an existing wastewater management practice in Onyearugbulem abattoir market with the aim of developing the best management practices appropriate for such abattoir. Samples of wastewater generated from Onyearugbulem abattoir market were collected and the physico-chemical characteristics were analyzed in accordance with the Standard Methods for the Examination of Water and Wastewater. The results of the physico-chemical analysis obtained show that BOD_5 ranges from 750 - 1,895 mg/L, COD ranges from 1015 - 2400 mg/L, Dissolved Oxygen was found to be between 2 – 2.5 mg/L while Ammonia was between 53 to 96 mg/L, Phosphorus ranges from 18 – 24 mg/L and Alkalinity (as $CaCo_3$) was between 610 - 750 mg/L. The TDS obtained ranges from 560 – 925 mg/L and TSS was between 205 - 441 mg/L while TDS ranges from 332 – 815 mg/L. All these values above National Environmental Standards and Regulation Enforcement Agency (NESREA) limit. However, temperature which ranges from 24 – 32 ^oC and pH between 7.3 – 7.6 were within limit. Management of solid waste is by open dump and periodic evacuation to create spaces for further dumping.

Keywords *- Abattoir, physico-chemical, sustainable management, wastewater,*

1.0 Introduction

Abattoir which is also known as slaughter house is a place where animals are slaughtered for human consumption. Animals include cows, sheep, pigs and goats. The killing of animals for human consumption to meet the protein needs is inevitable in most nations of the world and dates back to antiquity. Wastes generated by abattoirs are potential environmental problems. Some of these problems are traceable to abattoir activities and waste management techniques. Waste generated by abattoirs include solid waste, made up of paunch content, bones, horns, and faecal components, slurry of suspended solids and fat (Sangodoyin & Akeredolu, 1992). The liquid wastes usually comprise of dissolved solid, blood, gut contents, urine and wash water (Bello & Oyedemi, 2009).

On an average, a slaughtered cow produces about 328.4 kg waste in form of dung, bone, blood and hoof (Sridhar, 1998). Robert (2005) also reported that 45 percent of live cow consists of non-meat

substances. Blood is one of the major dissolved pollutants in abattoir wastewater with its Chemical Oxygen Demand (COD) higher than any effluent from abattoir operations. (Olanrewaju & Adewumi, 2011) reported that liquid blood has a COD of about 400, 000 mg/L and congealed blood has a COD of about 900,000 mg/l. The blood is also high in nutrients, typically 2, 400 mg/L of nitrogen and 1, 500 m g/L of phosphorus.

Animal dung contains high organic matters that are valuable to crops. However, it contains salt, bacteria, viruses and other microorganisms that could impair water quality when washed into stream or river. It also has the potential to reduce the dissolved oxygen in water, thereby endangering aquatic animals. Akinro et al., (2009) carried out a physiochemical analysis on abattoir water from Araromi in Akure metropolis. The result indicates that the various samples were polluted biologically beyond permissible limits. Improper disposal of animal dung could lead to faecal oral transmission diseases in human being. Abattoir effluent reaching streams contributed significantly to the level of nitrogen, phosphorous and biochemical oxygen demand and other nutrients resulting in stream pollution. George (1995) attributed excessive nitrate problem in New Zealand ground waters to concentrated livestock and manure usage.

Most abattoirs in Nigeria are located within the residential areas for easy accessibility to meat consumers. Despite the close proximity to human residence, many abattoirs in the City center lack basic wastewater treatment facilities, thereby dispose their wastewater directly into the nearby streams and rivers. Sometimes, these streams and rivers serve as a source of water supply to the community downstream. Li (2009) reported that animal wastes can introduce enteric pathogens and excess nutrients into surface water and also contaminate groundwater. In view of this, groundwater within the vicinity of abattoir can be highly polluted. Analysis of samples hand dug well from within the vicinity of abattoirs were found to be highly polluted with abattoir effluents (Sangodoyin & Akeredolu, 1992; Sangodoyin & Agbawhe, 1992; Ogbonnaya, 2008; Nwanta et al., 2010; Adeoye et al., 2012; Magaji & Chup, 2012). This work is therefore aimed at carrying out a comprehensive assessment of the existing waste water management system in Onyearugbulem abattoir market and recommends the best management practices to be applied.

2.0 Material and Methods

2.1. Description of the Study Area

Akure is the capital of Ondo state in the Southwestern Nigeria (Figure 1). It is located between Latitude 7°12' N - 7^0 12' N and between Longitude 5° 15' E - 5° 17' E. Onyearugbulem abattoir market is located along Akure Owo express way. The city has a population of approximately 420, 000 inhabitants. The climate of Akure is subtropical with two main distinct seasons: rainy and dry season. The humidity of the air masses over the city varies from 60 % in January to 80 % in July (NIMET, 2003).

The Onyearugbulem abattoir was selected as the study area because of its location in the large expanse of built up area comprising of low, medium and high income earners. The abattoir is surrounded in the South with residential buildings and in the North by office complexes and west and east by private school and shops. The abattoir is about 50 meters off the road of Ilesa-Akure-Owo express way and cover a land mass of about 10, 000 m^2.

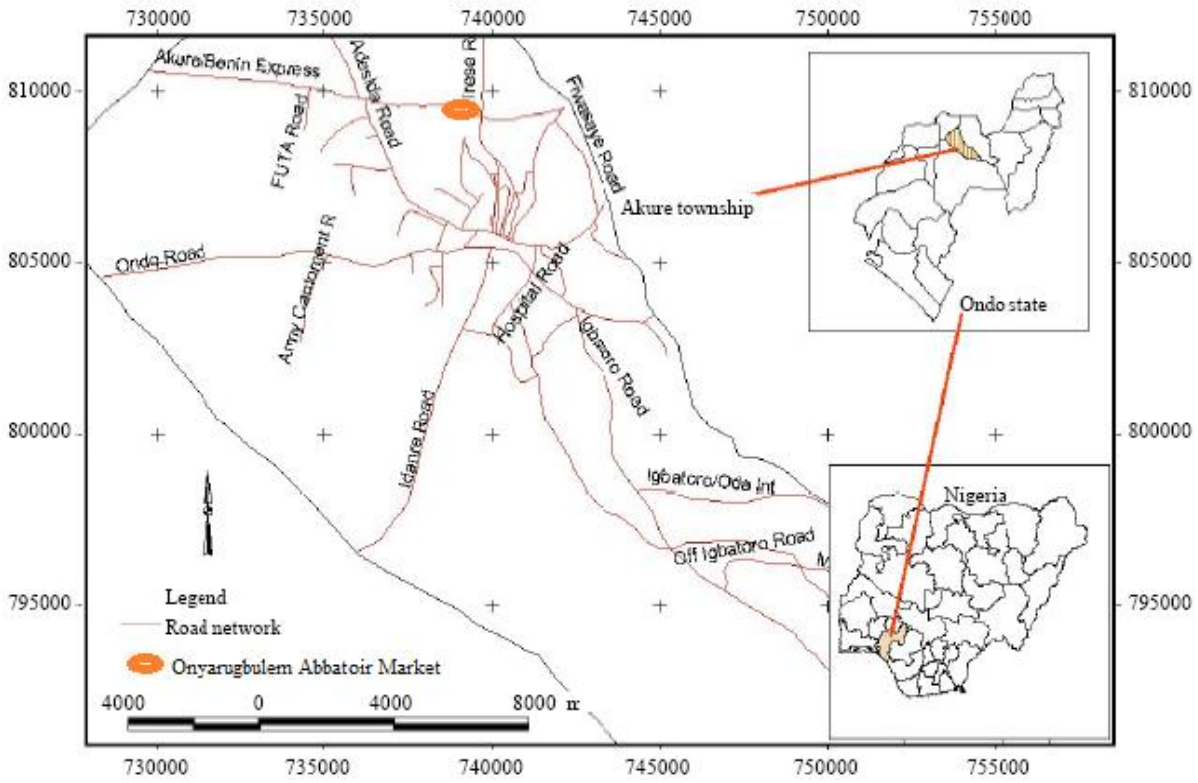

Figure 1: Location Map of Akure in Ondo State

2.2 Reconnaissance Survey

A reconnaissance survey was carried out at the Onyearugbulem abattoir market to ascertain the operational techniques and waste management procedure in the abattoir.

2.3 The Number of Animals Slaughtered

About 25- 40 cows are slaughtered daily in the abattoir depending on the day of the week and market forecast. Table 1 shows the number of cows slaughtered monthly between 2006 and 2011.

Table 1: Statistics of Monthly Cows Slaughtered between 2006 to 2011 (Obtained from Field Work).

Month	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
January	312	344	630	570	680	600
February	430	430	504	450	450	611
March	346	344	338	450	420	573
April	344	344	338	450	420	574
May	344	450	600	540	450	450
June	430	538	480	540	450	475
July	344	420	480	450	570	476
August	430	530	600	450	450	495
September	344	646	480	420	570	505
October	344	702	570	440	450	570
November	430	784	450	430	450	700
December	455	900	480	570	580	706
Total	**4440**	**6432**	**6159**	**5760**	**5940**	**6735**

2.4 Frequency of Inspection by Veterinary Officials

Veterinary Officer from the Ondo State Ministry of Health pay official visit to the abattoir daily to monitor the quality of meat being sold to public for consumption. Often, an approval is given before a cow is slaughtered.

2.5 Sample Collection and Analyses

Samples of wastewater for laboratory analysis were collected in sterilized plastic bottles. Sample bottle was rinse onsite three times with wastewater sample to be collected. During sample collection the materials used include: Hand protective gloves, plastic bottles, pH meter and thermometer.

Grab samples were collected early in the morning on each day of the week (except Sunday when abattoir is not in operation) between the hours of 7.00 am to 8.00 am when cows were normally slaughtered. Samples were collected at the centre of wastewater flow stream to obtain good representative.

All samples taken were analyzed immediately or within 72 hrs of collection. Samples were kept in refrigerator to maintain freshness of the samples in a reasonable state. Within the scope of this research work, the physical and chemical parameters examined were temperature, pH, total dissolved solid (TSD), total suspended solid (TSS), biochemical oxygen demand (BOD), COD, dissolved oxygen, ammonia - N, Phosphorus and Alkalinity. Laboratory analysis was carried out in accordance to the Standard Methods for Examination of Water and Wastewaters (APHA 1999).

2.6 Statistical Analysis

Data collected were subjected to statistical test of significance. Since the population standard deviation (σ_p) of the pollutant in the wastewater samples are unknown and the samples are of small size (n = 5), t-test was used to test for the significance of sample mean at 95 % confidence level. All statistical analyses were done by SPSS software for windows.

3.0. Results and Discussion

Summary of the result of quality test performed on five different day samples with mean and standard deviation is as shown in Table 2.

3.1 Physical Parameters

- **Temperature:** The temperature values obtained range from 24 to 29 ^{o}C with an average value of 26.30 ± 1 ^{o}C. This value is below the recommended value of 32 ^{o}C. Although this low Temperature may not adversely affect many living organism in the receiving water body because it does not deplete the dissolved oxygen; however, this low temperature may inhibit the activities of some species of bacteria that are useful in the decomposition of organic constitutes of wastewater.

- **Total Solid (TS), Total Suspended Solid (TSS) and Total Dissolved Solid (TDS):** The permissible limit of solids (TS, TSS and TDS) in wastewater to be disposed into environment is not specified in Environmental Standards and Regulations Enforcement Agency (NESREA) regulation but permissible limit for TSS and TDS is clearly stated in USEPA (2002) as 50 mg/L and 2, 000 mg/L respectively. The values obtained for TSS is exceptionally high (215 mg/L – 441 mg/L) with an average value of 326 ± 45 (552 % higher than the USEPA limit) while the TDS is low (332 mg/L – 815 mg/L) with an average of 510 ± 51 mg/L. This is due to the presence of highly rich organic matter in faecal component of cow paunch content discharged in abattoir wastewater.

Table 2: Results of Physicochemical Analysis

Parameters	Min	Max	Mean ± SE	t- value	Sig (2-tailed)	USEPA (2002)	NESREA (2011)
Water Usage Litres/day	2,000	3,500					
Average Number of Cow Slaughtered/day	20	40					
Quality Parameters							
Physical							
• Temperature ^{o}C	24	29	26.30 ± 1	25.642	.000	35	32
• Total Solid (TS) mg/L	560	925	790 ± 66	11.853	.000	NA	NA
• Total Suspended Solid (TSS) mg/L	215	441	326 ±45	7.218	.002	50.0	NA
• Total Dissolved Solid (TDS) mg/L	332	815	510 ±51	9.972	.001	2000.0	NA
Chemical							
• pH	7.3	7.6	7.5 ± 0.6	5.863	.004	6 - 9	6 - 9
• Biochemical Oxygen Demand (BOD_5) mg/L	750	1,895	1,249 ± 213	7.475	.002	100.0	30
• Chemical Oxygen Demand (COD) mg/L	1,015	2,400	1,800 ± 240	26.504	.000	NA	80
• Dissolved Oxygen (DO) mg/L	2.0	2.5	2.2 ± 0.09	9.930	.001	5.0	3.0
• Ammonia - N mg/L	53	96	78 ± 9	19.170	.000	50.0	NA
• Phosphorus mg/L	18	24	21 ± 1	27.256	.000	NA	1.0
• Alkalinity as $CaCO_3$ mg/L	610	750	700 ± 25	8.421	.003	400.0	NA

Note: (df = 4; n = 5) Probability > 0.05 = Not significant; probability < 0.05 = significant difference

3.2 Chemical Parameters

- **pH:** The pH value obtained ranges from 7.3 – 7.6. This value is slightly basic but it falls within the recommended value of 6 – 9. This pH is highly favourable to the use of conventional wastewater treatment processes that rely on the activities of bacteria in the decomposition of organic contents of wastewater.

- **Biochemical Oxygen Demand (BOD):** This is the most important wastewater quality parameter. It is the measure of the amount of oxygen required to completely oxidize the organic components of wastewater at a standard temperature of 20 ^{o}C in a 5-day time of incubation. The BOD_5 obtained is very high (1,015 mg/L – 2,400 mg/L) with an average of 1,249 ± 213 mg/L as compared to National Environmental Standard and Regulatory Agency (NESREA) recommended value of 30 mg/L. Disposing wastewater of this quality into receiving water body will cause high depletion of Dissolved Oxygen and result in offensive odour. This could also lead to the death of aquatic animals.

- **Chemical Oxygen Demand (COD):** This is an indirect measure of the amount of pollutants in wastewater that cannot be oxidized biologically. Similar to the values obtained for BOD_5, the COD is also very high. It ranges from 1,015 mg/L to 2,400 mg/L with an average value of 1,800 ± 240 mg/L while the recommended limit of 80 mg/L.

- **Dissolved Oxygen (DO):** All living organisms present in water depends on Dissolved Oxygen for survival. Depletion of DO can lead to the death of fish and other organisms present in water. The values obtained ranges from 2.0 mg/L to 2.5 mg/L as against the recommended minimum of 5.0 mg/L recommended by USEPA. This value could negatively impact the receiving water body by compromise the surviving chances of living organisms present.

- **Ammonium:** Un-ionized ammonia is toxic to fish and other aquatic animals. The amount of unionized ammonia is based on the pH of the wastewater, since ammonia is converted to the nontoxic ammonium ion with decreasing pH. The contribution of nitrogen in wastewaters can also increase the rate of eutrophication. The values obtained ranges from 53 mg/L to 96 mg/L with an average value of 78 ± 9 mg/L. This value is considerably higher than the USEPA recommended limit of 50.0 mg/L.

- **Phosphorous:** The common forms of phosphorous in wastewater are orthophosphate, polyphosphates and organically bound phosphates which are responsible for eutrophication in receiving water body. Eutrophication in lakes and reservoirs are excessive growth of algae, causing reduced water transparency, depletion of dissolved oxygen, release of foul odours, loss of finer fish species and dense growths of aquatic weeds in shallow bays. As recommended in NESREA regulations, the maximum permissible limit is 1.0 mg/L while the results obtained rages form 18 to 24 mg/L with an average value of 78 ± 9 mg/L.

The results obtained in this research is in conformity with the result of Mittal (2004) on abattoirs in Quebec, Canada with high pollutants concentration of TS (2,333 – 8,620 mg/L); TSS (736 – 2,099 mg/L) while average nitrogen and phosphorous are 6 and 2.3 mg/L. Abattoir effluents if not treated before disposal, could increase levels of nitrogen, phosphorous and total solids in receiving water body considerably. Excess nutrients cause the water body to become choked with organic substances and organisms. When organic matter exceeds the capacity of the microorganisms in water that break down and recycle the organic matter, it encourages rapid growth of algae which leads to eutrophication. Also improper disposal systems of wastes from abattoir could lead to transmission of pathogens to human and cause diseases.

The result of this research shows that all the physical and chemical parameters are far above the disposal standards recommended by USEPA (2002) and NESREA (2011) except temperature and pH that are within the acceptable limits. This is a clear indication that there is need to provide a good wastewater treatment facility in the abattoir.

4.0 Discussion

Most of the phosphorus and ammonia contaminants are generated from paunch wastes, which come from emptying of the animal stomachs and further processing of internal organs. Wastewater from these processes is often combined and referred to as the ‘green’ stream, and is primary treated separately from the ‘red’ stream. Paunch can be wet or dry dumped and combined with other wastes for composting.

The so called ‘red’ waste stream is generated mainly from water used to guarantee modern hygienic practice in the abattoir which becomes contaminated with blood and fats. Blood is the major source of nitrogen. The sustainable method of treatment is by the use of waste stabilization ponds (WSPs). WSPs which often referred to as biological ponds or lagoons, are holding basins used for secondary wastewater (sewage effluents) treatment where decomposition of organic matter is processed naturally, i.e. biologically. Based on the laboratory and field experiment, Babatola *et al.* (2016) proposed three trapezoidal shape anaerobic ponds (top width = 7 m; bottom width = 5 m; depth 3 m and length = 11 m, Volume = 594 m^3) with 25 days detention period for the treatment of the wastewater. They also recommended that the effluent

from anaerobic pond should be allowed to pass through a gentle slope with buffers to create a turbulent flow to increase dissolved oxygen.

For sustainable management of solid wastes generated in the abattoir, Table 3 contains activities and waste generated with strategies to minimize such wastes.

Table 3: Abattoir Activities, Waste Sources and Minimization Strategies

Area of Process	Activity	Type of Contaminants	Waste Minimisation Strategies
Cow pen	• Stock watering • Stock Feeding • Stock washing	• Cow dung • Hair	• Regular evacuation of cow dung for composting • Regular disinfectant of floor • Provide a roof to minimize odour
Slaughter house	• Killing slab wash • Carcase wash • Carcase splitting • Knife, axes and cutlass washing	• Blood • Tissue • Fat • Detergents • Disinfectants	• Collect blood into a blood pit • When collecting blood, do not use hose, instead use squeegee • Keep water pressure at minimal during washing of carcass • Remove all visible contaminants • Turn off tap when not in use
Paunch, gut and offal washing	• Paunch dump and rinse • Gut washing • Edible offal washing	• High BOD • High nutrient waste	• Collect all solids • Use dry dumping of paunch materials • Any liquid residue from paunch dumping should be treated with the effluent from the rendering unit

Although, the Ondo State Government has an environmental monitoring unit that is responsible for the enforcement of environmental laws, however, visit to most of the abattoirs in Akure shows that their impact are still minimal. It is recommended that more field officers are employed to ensure compliance and enforcement of NESREA regulations (NESREA, 2011) in all abattoirs.

5.0 Conclusion

Abattoir activities generate large quantities of waste that adversely affect ecosystem if not properly handled. All these wastes are polluted with biodegradable organic compounds, suspended solids and nutrients that are beneficially to farmers if properly handled. By recognizing this high pollution load and their importance as organic manure, the paper proposed possible solutions that can mitigate the problem in an environmentally sound manner by suggesting best available technology that can be implemented. The suggested technology is based on the abattoir wastes characteristics as identified by the study. This will help all abattoir management to take in place, a sustainable waste management practice suitable for Onyearugbulem market, Akure.

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