RESEARCH PAPER

Abattoir wastes generation, management and the environment: a case of Minna, North Central Nigeria

O Chukwu, PA Adeoye*, I Chidiebere

Department of Agricultural and Bioresources Engineering, Federal University of Technology, P.M.B.65, Minna, Nigeria

Abstract

An investigative survey approach was used to evaluate the abattoir waste generation and management in Minna, North Central Nigeria. This was investigated using questionnaire and personal communication. Water samples were taken from water sources in the abattoir and were assessed for physico-chemical analysis. From the survey, it was observed that a total of 289 and 382 cows and goats respectively are slaughtered daily in Minna abattoirs. This generates 3.92ton of blood, 2.9ton of intestinal content, 4.2ton of bone and 2.2ton tissues as abattoir waste daily. All the abattoirs visited use nearby streams and ponds as means of discharging these wastes slurry thereby giving rise to offensive odour, contribute to the organic and nutrients loads of the streams leading to eutrophication. The action was found to be unhygienic, uneconomical and dangerous to human health. There seems to be no sufficient measures or facilities to treat abattoir wastewater for environmental safety in Minna. High microbial load in the abattoir wastewater further confirmed the need to treat this wastewater rather than discharging it to the environment. All the water samples have their physico-chemical parameters tested higher than WHO limit except samples from boreholes. This also confirmed contamination from abattoir effluents.

*Corresponding Author: PA Adeoye ✉ pheterhardey@yahoo.com

Introduction

The continuous drive to increase meat production for the protein needs of the ever increasing world population has some pollution problems attached. Pollution arises from activities in meat production as a result of failure in adhering to Good Manufacturing Practices (GMP) and Good Hygiene Practices (GHP) (Akinro *et al.*, 2009). Consideration is hardly given to safety practices during animal transport to the abattoir, during slaughter and during dressing (Singh and Neelam, 2011). Abattoir waste just like any other waste can be detrimental to humans and the environment if definite precautions are not taken. In the Nigerian livestock industry, slaughter houses are littered with non-meat products and wastes that need to be recycled into useful by-products for further agricultural and other industrial uses (Osibanjo and Adie, 2007). This constitutes public health risks and nuisance in most slaughter houses spread across Nigerian markets, producing air, soil, and water pollution as well as infestation of flies and other disease vectors. For hygienic reasons abattoirs use large amount of water in processing operations; this produces large amount of wastewater. The major environmental problem associated with this abattoir wastewater is the large amount of suspended solids and liquid waste as well as odour generation (Gauri, 2006)

Effluent from slaughterhouses has also been known to contaminate both surface and groundwater because during abattoir processing, blood, fat, manure, urine and meat tissue are lost to the wastewater streams (Bello and Oyedemi, 2009). In Nigeria, many abattoirs dispose their effluents directly into streams and rivers without any form of treatment and the slaughtered meat is washed by the same water. Leaching into groundwater is a major part of the concern, especially due to the recalcitrant nature of some contaminants (Muhirwa *et al.*, 2010). The processes of adsorption and trapping by fine sandy materials, clays and organic matter can remove pathogenic organisms and some dissolved organic matter during passage of polluted water through the soil, thus reducing the microbial load. However, if there is too high departure of conditions from normalcy, beyond the carrying capacity of the natural process, diversity of autochthonous species could diminish while count of individual species that are able to survive may increase with possibility of grave consequences on groundwater (Osemwota, 2010). Adeyemo *et al.*, (2009) observed that facilities for waste recovery, treatment, and reuse are either inadequate or nonexistent in most Nigerian abattoirs. Thus, wastes are indiscriminately and improperly discharged and constitute environmental hazards. Leachates from their serial decomposition processes have the potential to pollute nearby surface water, with enteric pathogens and excess nutrients which may percolate into the underlying aquifers and contaminate hand-dug wells.

Blood constitutes the highest pollution load of all the components of abattoir effluents, followed by fat. Blood, one of the major dissolved pollutants in abattoir wastewater, has the highest COD of any effluent from abattoir operations. If the blood from a single cow carcass is allowed to discharge directly into a sewer line, the effluent load would be equivalent to the total sewage produced by 50 people on average day (Aniebo et al., 2009). The major characteristics of abattoir wastes are high organic strength, sufficient organic biological nutrients, adequate alkalinity, relatively high temperature (20 to 30°C) and free of toxic material. Abattoir wastewaters with the above characteristics are well suited to anaerobic treatment and the efficiency in reducing the BOD_5 ranged between 60 and 90% (Chukwu, 2008). The high concentration of nitrates in the abattoir wastewater also shows that the wastewater could be treated by biological processes. Due to the economic situation of the Nigeria, little interest has been shown to the effects of wastes from abattoirs to the environment. In developing cities like Minna where the awareness of the effects of abattoir is low, it

is very common to see people sinking shallow wells close to abattoirs. These shallow wells would draw contaminated water from the surrounding aquifer especially if the radius of influence of the well spans into the abattoir ground (Singh and Neelam, 2011)

From the viewpoint of environmental management, unreliable records made it difficult for proper assessment of waste load generated at each slaughter house; and thus, difficulty in planning for waste containment. Data would also not elicit government interest in addressing the problems at slaughter houses, if the proper records of huge amount of abattoir wastes generated and its yearly increase are not kept. For adequate management, it is important to know the quantity being generated daily, weekly and yearly, their characteristics and existing management facilities. It is also important to note that for one to understand the methods of handling and disposing waste there is need for a vivid knowledge of the basic characteristics of the waste in question and its quantity. The objectives of this study are therefore to assess the various types of wastes generated from abattoirs in Minna, Nigeria and to evaluate various methods of handling and disposing of the abattoir wastes and their environmental implications.

Materials and methods
Study site
Minna, the capital city of Niger State, Nigeria is located between latitude 9°, 36' 50"N and longitude 6°, 33' 25"E. It has a population of approximately 506,113. The average population density in Minna is about 3448 persons per km² (UNDP/NISEPA, 2009).The town experiences two distinct seasons, rainy season which spans between May and November and the dry season between December and April. The annual rainfall is about 1600mm with highest temperature hovering over 34°C.

The methodology adopted in this study is the investigative approach, this includes abattoir visitation, and distribution of questionnaires to the management and workers of the abattoirs spread across Minna. In the course of this investigation, nine abattoirs were visited with thirty-five questionnaires administered in each abattoir. The average number of cows and goats that are slaughtered daily weekly and monthly are assessed from the questions and the wastes generated are calculated based on Aniebo *et al.,* (2011) results, Table 1. Raw wastewater samples were taken from these abattoirs for physico-chemical analysis and samples were also taken from the adjoining streams receiving these effluents. Water samples were taken from shallow hand dug wells and bore holes located within these abattoirs vicinity and assessed for also for physico-chemical parameter. For water analysis, water samples were collected from these water sources in sterile 500mL container which was washed three times with the sample water prior collection. 30mL of the collected sample was filtered through a 0.45μm syringe filter and stored in a 20ml polypropylene container. It was stored under 4°C and taken for laboratory analysis within 6 hours of collection. The pH and conductivity of the water samples were measured in-situ (Multiline p4 Multimeter) and turbidity measured with Turbidimeter (TN-100 Eutech) instruments. The water samples were analyzed for chemical and bacteriological parameters using APHA (2005) methods. Total coliforms were analyzed using Membrane Filtration technique. For chemical analysis, the water samples were divided into two and their temperature were maintained at 4°C. The first portion was acidified to pH less than 2 with concentrated HNO_3 and left for 4 days to equilibrate before taking it for ICP analysis. The second portion (untreated) was used for IC (Ion Chromatography) analysis. Milliq water was used to prepare the laboratory blanks and was treated in the same way with the samples. Cations of low concentrations (≤ 0.01μg/L were analyzed with coupled plasma- mass spectrography (ICP-MS-Japan 7500). Major cations (≥ 0.1mg/L) were determined by coupled Plasma Optical Emission spectrography (ICP-

OES-5300, DV, USA). Anions were analyzed using IC Diomex CA, USA. Total Solids were analyzed using gravimetric method. The results of the analysis were then compared with World Health Organization (WHO, 2006).

Table 1. Waste generated per cow and goat in abattoirs.

	Cow	Goat
Blood/head (kg)	12.6	0.72
Intestinal content/head (kg)	8.0	1.25
Waste tissue/head (kg)	6.4	0.8
Bone/head (kg)	11.8	2.06

Source: Aniebo *et al.,* 2011

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Results and discussion

Table 1 gives the quantity of blood, intestinal content, waste tissue and bone that one cow and goat slaughtered can generate based on Aniebo, et al., (2011). This table was used to calculate the quantity of waste generated in Minna abattoirs which was presented in table 2.Monthly records of slaughtered animals in the abattoirs visited for the year 2010 is as presented in Fig. 1. From table 2, a total of 289 cows and 382 goats are slaughtered daily in Minna. When this is related to table 1, about 4ton of blood, 3ton of intestinal contents, 4.2 ton of bone and 2.2 ton of waste tissues are discharges daily In Minna from a total land area of 24.4hectares.These wastes are biological materials that can be composted, recycled and reused for farming activities. From figure 1, there is a sharp fluctuation in the number of animals slaughtered per day/month in Minna. The figure rises whenever there is a festival in the town because people tend to consume more animal protein during festive seasons. This may be attributed to high number of animals slaughtered in the month of December.

Abattoir waste management in Minna

There is no environmental friendly management system for abattoir wastes in Minna. Intestinal contents are washed into an open drain and are allowed to be washed into nearest water course, figure 2. Where the intestinal contents are not washed into open drain as in F-layout abattoir; they are just allowed to degrade openly and have formed heaps, figure 3. These heaps have become safe place for flies, worms and other scavenging animals. They create a nuisance to the abattoir workers, people living nearby and others that visit the abattoir to buy meat. Bone management system in F-layout abattoir is relatively better than management systems on other abattoirs visited. The bones are stacked up as raw materials for people that use them for production. This people come once in every week to pack them from the abattoir environment. In other abattoirs, these bones are not managed properly; they are just dumped in a place about 3 meters distance to the abattoirs, Fig. 4. This has also generated a lot of odour during degradation and makes life uncomfortable for people living around the area.
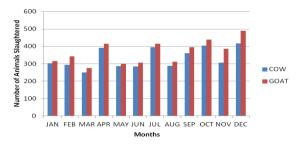

Fig. 1. Monthly number of animals slaughtered in Minna abattoirs for the year 2010.

Three of the abattoirs visited, Chanchaga, Paiko and Maikunkele adopted return to land method as way of managing their paunch contents. However, it was done in a hygienic manner because the abattoir workers are not trained on how the method can be safely used. After daily operations, small children, (majorly below age 10) are asked to pack them to an open place, dump them and use legs to spread them over the land to degrade. This has rendered the land uninviting for any farming operation, Fig. 5. The people involved in spreading also stand the risk of zoonosis because no form of covering is used either for their body, nose or mouth during spreading operation.

Another observed poor processing method being used for goat in all the abattoir visited is by using fire to remove goat hair. This process generates a lot of smoke and may contribute to global warming. The children set fire with used vehicle tyres to burn the hair off the goat skin. This can be replaced with hot bath management system which is cleaner, neater and pose no threat to the environment (Aniebo, et al., 2011).

Table 2. Total abattoir wastes generated in Minna.

Abattoir Name	Cow/day	Goat/day	Blood/day (kg)	Intestinal content/day (kg)	Bone/day (kg)	Waste tissue/day (kg)	Land area (ha)
F-layout	171	173	2,279.16	1669.9	2234.1	1232.8	5
Kpakungu	13	28	183.96	139.0	211.08	105.6	1.3
Maitunmbi	23	37	316.44	230.25	347.62	223.4	1.2
Chanchaga	14	30	198.00	149.5	227.0	113.6	1.1
Paiko	11	28	158.76	123.0	187.48	92.8	0.9
Maikunkele	16	24	211.88	158.0	238.24	121.6	1.2
Bosso	11	26	157.32	120.5	183.36	91.2	0.8
Kuta	21	22	280.44	195.5	293.12	152	1.4
Garatu	9	14	123.48	89.5	135.04	68.8	0.7
Total	289	382	3916.44	2875.5	4197.12	2201.82	24.4

Table 3. Physico- chemical analysis of water samples from the abattoirs.

Parameters	Raw effluent	Receiving streams				Hand dug wells				Bore Holes			WHO,2006
		F-lay	Kpa	Cha	Mai	F-lay	Pai	Mak	Gar	F-lay	Mai	Mak	
pH	7.53	6.9	7.4	7.2	7.8	6.8	6.9	8.1	6.9	6.8	7.1	7.8	6.5-8.5
Temperature (^{o}C)	24.12	23	25	27	24	26	24	24	23	23	26	22	
Turbidity (NTU)	630	221	246	302	291	0.8	0.8	0.7	1.8	0.06	0.09	0.03	0.1
Total solid (mg/L)	5748	1001	960	2071	3624	1026	1792	1089	2100	986	140	199	1000
Conductivity (μS/cm)	179.45	180.2	165	156	167	88	141	66	79	504	361	288	1200
COD (mg/L)	17,019	1004	1652	1541	3650	11	9.5	5.6	16.9	7.2	8.4	7.8	NG
Oil/grease	254	11	17	18	29	0.36	ND	ND	0.49	ND	ND	ND	NG
BOD_5 (mg/L)	10,836	961	1003	1211	2862	9	6.5	3.2	11.9	3.4	5.3	4.9	20
Nitrate (mg/L)	694	351	339	284	392	81	95	66	64	24	19	28	50
NH_3-N (mg/L)	589	186	249	114	206	64	71	65	49	11	15	9	50
Iron (mg/L)	36	12	19	23	13	11	18	12	6	0.8	0.6	1.2	0.3
Phosphorus (mg/L)	65.4	11.5	16.3	10.2	8.6	3.9	8.5	2.4	3.6	2.4	3.2	2.1	1.0
Sulphate (mg/L)	1009	680	640	730	380	560	325	189	692	160	119	205	450
Fluoride (mg/L)	25.0	14.9	11.8	17.2	16.8	4.8	11.2	18.6	0.62	1.4	2.9	3.6	2.0
Total coliform(cfu/100l)	19×10^5	6589	4828	6612	5186	54	38	61	24	11	0	0	0

F-lay: F-layout, Kpa: Kpakungu, Cha: Chanchaga, Mai: Maitumbi, Pai: Paiko, Mak: Maikunkele, Gar: Garatu, ND: Not Detected, NG: No Guideline.

From personal interview, all the abattoirs lacked the basic facilities needed in a standard abattoir except for F- Layout abattoir but the facilities provided have been destroyed by poor maintenance system. The abattoirs under investigation claimed they have been visited by sanitary inspectors from environmental agency at one time or the other. They also claimed that government made no provision abattoir waste treatment facilities or waste recycling system to enhance the safety of their discharges from the abattoirs.

Fig. 2. Intestinal content washed into open drains.

Fig. 3. A heap of intestinal contents.

There was also general acceptance by abattoir workers that there is no provision of direct waste evaluating personnel by the government indicating high neglect on the part of the government. Topography of various abattoirs visited allows gravity flow except Maitumbi abattoir which is located in a plain swampy area which makes the water stagnant in the area thereby causing a lot of odour. It was gathered from the interview that all

the workers in all the abattoirs use nearby bush as toilets except F- Layout abattoir which claimed to have a sanitary privy. It was established that eight of the abattoirs use shallow wells and boreholes for their water supply while one abattoir (Garatu) uses stream. There were problems encountered in some of the abattoirs visited because answers were restricted as the evaluation was misunderstood as a plot by the Government to assess their bad practice especially when the pictures were taken. All the abattoirs indicated that they discharge their wastes segregated and there was general acceptance that the nature of waste produced are in liquid, solid and slurry forms. From further investigation it was observed that most of the receiving streams are used for domestic and irrigation purpose by local farmers within the abattoir vicinity.

Water quality assessment in the abattoirs
The results of water quality assessments are as shown in table 3. All the parameter values are above the recommended limits by WHO.Turbidity in drinking-water is caused by particulate matter that may be present from water source as a consequence of inadequate filtration. These particulates can protect microorganisms from the effects of disinfection and can stimulate bacterial growth (Hunter *et al.*, 2009a). Turbidity is also an important parameter in process control and can indicate problems with treatment processes, particularly coagulation, sedimentation and filtration (Hunter *et al.*, 2009b). No health-based guideline value for turbidity has been proposed; however, it should be below 0.1 NTU for effective disinfection (Katsi *et al.*, 2007).

There is no evidence of any epidemiological reaction at high level of Total solids, but water becomes unpalatable and may lead to corrosion of containers (Kruawal *et al.*, 2005). Consequently, WHO (2006) set the highest permissible values of 1000mg/L. The palatability of water with a total solids level of less than 600 mg/L is generally considered to be good. From the

table, all the samples that have very low total solids are samples collected from boreholes at F-layout, Maitunmbi and Maikunkele. Other samples have their values higher than WHO (2006) recommended value.

Electrical conductivity is the ease to which a substance allows free flow of electricity through the ions in electrolytes example of water sample, (Mwendera, 2006). The WHO has set a maximum permissible level of the conductivity to be 1200 μS/cm. Any level above this can pose health risk of defective endocrine functions and also total brain damage with prolonged exposure (Hunter *et al.*, 2009b). All the water samples have their EC values less than the highest tolerable values. The maximum contaminant levels of the iron content based on WHO, (2006) is 0.3 mg/l. Despite not being a health concern high concentration of iron affect the quality of water, leading to bad taste and colouration of cooking utensils and food (Schaafer *et al.*, 2009)There is no noticeable taste at iron concentration below 0.3mg/l, although turbidity and colour may develop (Kruawal *et al.*, 2005). All the water samples have their iron content above recommended value. This high iron content may probably be attributed to influx of waste blood may be carried by runoff and deposited into the streams, shallow wells and boreholes.

Fig. 4. Bones dumped in open place.

Sulphate does not have a health-based guideline value; however the WHO recommends that a concentration higher than 450 mg/l is unhygienic due to problems to the gastro intestinal tract (Katsi *et al.*, 2007). About 50% of the water samples collected have their Sulphate values higher than the WHO limit. The three boreholes samples have their Sulphate values lower the limit. This may be attributed to their depth and the concrete slab on them which prevent abattoir effluents having access into them.

Fluoride (F $^-$) offers protection against dental decay at low concentrations but at higher levels above 2 mg/l causes serious problems such as dental and skeletal fluorosis (Kruawal *et al.*, 2005). All the samples except F-layout borehole have their fluorine content higher than values recommended by WHO. The high level of fluoride in shallow well can be corrected by introducing a concrete lining. Head wall can also be constructed on these wells to minimize surface runoff in to them.

Fig. 5. Unhygienic return to land method.

Nitrate is a nitrogenous compound that when it is in excess in our drinking water can cause reduction of oxygen capacity of blood, shortness of breath and blueness of skin. It has a WHO guideline value of 50 mg/l and if exceeded it is regarded as one of the causes of methaemoglobinaemia (Blue Baby Syndrome) in infants (Rossiter *et al.*, 2010) as well as a potential risk of stomach cancer in adults (Mwendera, 2006). High concentration of nitrate in both surface and shallow groundwater can probably due to poor sanitation and

latrine construction, fertilizer and other agrochemical use. From table 3, only three water samples, from boreholes have their nitrate values lower than WHO value. High nitrates concentrations in drinking waters point often towards contamination (Sworobuk *et al.*, 1987). Therefore, water sources with high nitrate values need to be checked for bacterial contamination.

The presence of total coliform provides evidence of recent faecal contamination and the detection should lead to further action. It is present in high number in human and animal faeces and rarely found in the absence of faecal pollution. Their presence can also reveal regrowth and possible biofilm function or contamination. They occur in both sewage and natural wastes and can also be excreted with human and animal faeces (Linda, 2005). WHO,(2006) recommends zero values for total coliform. However, none of the water samples taken are free from these bacteria.

Conclusions and recommendations

The study has provided data base for which waste from the various abattoirs can be estimated which would help engineers in taking the necessary procedure or precaution while trying to proffer solutions to the problems associated with abattoir. It should be noted that due to urbanization there would always be increase in population which would in turn increase consumption of meat, therefore, good information on the abattoir waste will go a long way to estimate possible problems and proffer suggestion on how to curb the menace created by abattoir wastes. The problems of waste generated in an abattoir can be better managed and corrected if proper assessment of the amount of waste generated are properly documented. This would help in accurate prediction of the best method to manage the waste generated.

In order to reduce the rate of pollution, it is recommended that the excrement must be discharged into soil at rates not exceeding the recommended rates given by the Federal Environmental Protection Agency (FEPA). This is to avoid salt and nitrate accumulation in the soil. There should be extensive use of compost and biogas produced from waste decomposition in the generation of electricity for the abattoir and the environment at large. This will help in the generation of revenue for the local government. Anti-odour chemicals should be used to suppress odour from animal waste and flies nuisance in the environment. Also wedge wire screen should be used to remove the suspended solid material from the effluents prior to discharge into streams. The use of aerobic digestion method should be practised since it takes lower retention time in reducing the BOD. Another method is the trickling filter aerobic method which can take smaller land size.

The physico-chemical parameters showed the negative impact of the abattoir effluent on the stream thus rendering the water of worthless value to humans. Furthermore, the abattoir urgently needs an effluent treatment facility to be installed to reduce the health hazard its effluent poses on the abattoir users and users of the streams receiving the effluent. Swift intervention by the government and other stakeholders by putting in place effluent treatment facilities to treat wastes from abattoirs in Minna as well as adoption of cleaner technologies will go a long way to curb the environmental health risks posed by these hazardous effluents from abattoirs.

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