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Assessment of Physicochemical Parameters and Heavy Metals in Sagamu Abattoir Waste Water Ogun State, Nigeria

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ABSTRACT: Abattoir wastewater is a great threat to environmental safety. This study was aimed at assessing the physiochemical constituents using standard methods and some heavy metals using Agilent Microwave Atomic Emission Spectrometer (MP-AES) 4200 model after sample digestion of wastewater from three (3) major abattoirs in Sagamu, Ogun State, Nigeria. The sample was digested using a mixture of nitric acid, hydrochloric acid and hydrogen peroxide. The digested samples were then analyzed for heavy metals. Data from the physicochemical characterization show that pH, TS, TDS, TSS and COD ranged from; (5.8 – 6.2), (11500 – 27733.33), (5500 – 9066.67), (6000 – 18666.67), and (1507.67 – 3671) respectively. The assessed heavy metals are in the range (mg/L): Zn (0.132-0.337), Cu (0.091 – 0.516), Mn (0.410 – 0.994), Fe (5.294 – 15.44), V (0.132 – 0.32), Cd (0.036 – 0.119), Ni (0.029 – 0.17), Pb (0.136 – 0.234), Cr (0.299 – 1.277), and Co (0.015 – 0.079). Zn, Cu and Fe are essential metals within tolerable limits except Mn that exceeded the limits of World Health Organization (0.04 mg/L) but below Federal Ministry of Environment (5 mg/L) while Ni, Pb and Chromium are above permissible limits in all samples. The pretreatment of the wastewater before discharging into environment is highly recommended and more research should be done on remediation to reduce the abattoir wastewater heavy metals concentration and the effect it is having on the ecosystem and the environment at large.

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The importance of slaughterhouses (popularly called abattoirs) to Nigeria's economy cannot be overstressed. The abattoir industry provides domestic meat supply to over 200 million people and employment opportunities for the Nigerian teeming population. They also serve as a major source of feedstock for animal husbandry. Also, the discharge wastes in some cases from abattoirs can be a valuable nutrients source for crops as fertilizers (Asibor *et al*., 2011). However, the activities of the slaughterhouses when not properly managed in an environmentally friendly manner have been found to lead to some major environmental challenges (Adelegan, 2002). Various products of livestock have been found to contain high loads of organic pollutants as well as heavy metals at a toxic level. These pollutants can accumulate in the animals' tissues and milk (if lactating) when they graze on contaminated plants and drink from polluted waters (Yahaya *et al*., 2009). In the natural environment, pollutants including heavy metals are present in various chemical forms and display varied effects in terms of chemical interactions, mobility, biological abundance, and; consequently, they have different potential toxicity. Some of these heavy metals can be persistent environmental contaminants since they cannot be

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decomposed easily (Osu *et al*., 2014). Similarly, the waste generated at abattoirs has also been said to pose a serious threat to the environment. The wastewaters are discharged directly into the ecosystems, and most times are not effectively treated and disposed of indiscriminately. These wastes have been reported to contain high organics and fats that are persistent in the environment (Adelegan, 2002). A study by Alani *et al.* (2014) had documented the impact of the effluents from the market on the physicochemical properties of the Ogun River with some of these major pollutants exceeding the World Health Organization (WHO) and Federal Ministry of Environment (FMEnv) limits in the water and sediments. Therefore, it has become imperative to constantly assess the environmental quality parameters to ascertain the conditions of these environmental media to maintain a balanced ecosystem and explore effective and sustainable management strategies for a healthy environment. Sagamu is a major city in Ogun State with a good number of Abattoirs. There have been reports that some butchers employ the use of unsanitary methods in the processing of the meat which include generally the indiscriminate disposal of wastes (blood, stomach contents, bones, and the burning of the fur into the immediate environment) (Adelegan, 2002). This will not only contaminate the soil but also the water quality of wells, boreholes within the abattoir vicinity, and any close by surface water. Incidentally, it is this same water that is used to wash the meat and the butchering materials, bath after the day's activity, drink, and other domestic activities within the slaughter area (Cadmus *et al*., 1999). One of the ways to determine threats to surface water quality is to assess the biochemical oxygen demand (BOD), chemical oxygen demand (COD), total solids (TS), pH, temperature, turbidity, and a lot of heavy metals, etc. (Ogbonna and Ideriah, 2014). In a typical Nigerian abattoir, the surrounding land is often marshy due to improper channeling of wastewater arising from the dressing of the slaughtered animals and washings at the lairage (Asibor *et al*., 2011). Therefore, there is the need to examine the water quality of such areas and ascertain their suitability for use in animal treatment and other purposes as being practiced in Nigeria. This study investigated some of the physicochemical parameters and heavy metals of effluents from Abattoirs around three areas namely Agbele, Akarigbo, and Majopa Sagamu in Ogun State, Nigeria.

MATERIALS AND METHODS

Study Location: The study was carried in Sagamu Town, Ogun State, Nigeria. It is located between Latitude of 6.832201 and Longitude of 3.631913. Three (3) sampling locations were chosen for investigation. They are Agbele abattoir (Latitude 6.8556039; Longitude 3.6266050), Akarigbo abattoir (Latitude 6.8285060; Longitude 3.6263851) and Majopa abattoir (Latitude 6.8485 and Longitude 3.6463). These Abattoirs have a large supply of livestock and as a result process large amount of meat (Figure 1).

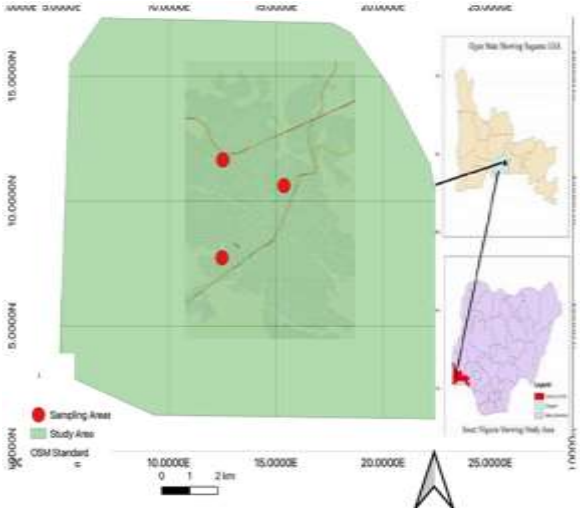

Fig 1: Map Showing Location of the Abattoirs at Shagamu Local Government Area, Ogun

Sampling Design: Forty-five (45) wastewater samples from the drainage were collected for this study with fifteen (15) samples each from the selected abattoirs and were homogenized. The samples were collected with the aid of a plastic scoop into two different plastic containers from each sampling location. The containers were previously cleaned by washing with a non-ionic detergent, rinsed with tap water, and finally rinsed with deionized water prior to usage. During sampling, the sample containers were rinsed with sample wastewater three times and then filled to the brim by grabbing some volume at different points within the drainage channel and was later mixed thoroughly to obtain a composite sample of that wastewater. At each sampling location, one of the containers was preserved with Nitric acid (HNO_3) for heavy metals analysis. This is done to reduce the pH below 2 to avoid precipitation or degradation of dissolved and suspended metallic elements. The other container was marked for physicochemical parameters and labeled accordingly. The samples were kept at about 4^oC in a cooler and transported to the laboratory. Some in-situ parameters such as colour, odour, pH, and Temperature were noted at the points of collection.

Sample Preparation and Analysis: The sample preparation and analysis of the physicochemical parameters were based on the American Public Health Association (APHA) series of Standard Methods of

Examination of Water and Effluent (APHA, 1998). All the reagents used were analytical grade and distilled water was used throughout for the preparation of the reagents. To check the analytical quality, reagent blank and duplicate determination were carried out where necessary.

Heavy Metals Analysis: The wastewater samples collected contain particulates and organic materials; it was therefore necessary to pre-treat the samples prior to analysis for trace metals. Wet digestion was employed using digestion mixture of nitric acid, hydrochloric acid and hydrogen peroxide. A 100 mL of the sample was measured into a beaker and 10 mL of digestion mixture (HNO_3, HCl, and H_2O_2; 3:3:1) was added slowly to the sample. The mixture was placed on a hot plate and evaporated down to about 20 mL. The mixture was cooled and 5 mL of concentrated HNO_3 was added and the mixture was covered with a watch glass then returned to the hot plate for more heating with the addition of few drops of HNO_3 until the solution appeared light coloured and clear. The walls of the beaker and the watch glass were washed down with distilled water and the sample filtere. The volumes of the samples were made up to 100mL with distilled water. (Radojevic and Bashkin, 1999).

A blank sample analysis was carried out and duplicate analysis was carried out. A multi-elements calibration standard of 1000 mg/L concentration from AccruStandard was used to prepare working standards at 0.2, 0.5, 1, 2 and 4 mg/L. The digested samples were then analyzed for heavy metals using Agilent Microwave Atomic Emission Spectrometer (MP-AES) 4200 model. The analytical cycle of the MP-AES consisted of 25 seconds sample uptake, 20 seconds to stabilize, then reading elements at preselected wavelengths and finally rinsing for 40 seconds with 5% HNO3.

Determination of pH and Temperature: The pH and temperature were measured with the aid of a handheld digital pH meter Hanna HI9024. The meter has the capacity to measure both pH and temperature simultaneously. It was calibrated with two buffer standard solutions (pH 4 buffer and pH 7 buffer). The buffer 4 solution was prepared by weighing a known amount of potassium hydrogen phthalate (KHP) and dissolved in a measured quantity of distilled water. While buffer 7 was prepared by weighing a known amount of potassium hydrogen phosphate (KH_2P0_4) and sodium hydrogen phosphate (NaH_2P0_4) dissolved in distilled water and transferred quantitatively into volumetric flask and made up to mark with distilled water. The pH and the temperature of the effluent samples were measured in situ. About 50mL effluent was measured into a beaker, the electrode was inserted into the beaker and the reading was taken and recorded.

Total Suspended Solids (TSS), Total Dissolved Solid (TDS) and Total Solids TS: TSS was determined by gravimetric method. The water sample of 100 mL each was filtered through a pre-weighed filter paper. The filter paper was then dried at 105^0C and re-weighed. The amount of suspended solids was determined from the increase in weight of the filter paper according to the following formula (Anon, 1992):

TSS (mg/L) = [(Final mass-Initial mass) g / volume of sample taken ml] X1000

TDS was done by the evaporation method. Evaporation dish was weighed and later 100 ml of the water sample introduced into the weighed dish and dried in an oven operated at 103°C for one hour to a constant weight. After drying, it was transferred to a desiccator and left to cool for one hour. The dish was finally weighed with its content. The difference in mass gives a measure of the total dissolved solids of the sample (Hach Water Analysis Hand book, 1997).

Turbidity: The water turbidity is the number of suspended substances and it is described by the water clarity. It was measure in nephelometry units (NTU) with the aid of Water Turbidity Meter.

Chemical oxygen demand (COD): Titrimetric method was employed in the determination of COD. A 10 mL of 0.125 M $K_2Cr_2O_7$ was added to 20 mL of the water sample using a pipette in a refluxing flask. Glass beads or anti -bumping chips were added. 30 mL of concentrated H_2SO_4 was added slowly and with gentle swirling. The flask was connected to the condenser and refluxed for 2 hours. After that, the flask was cooled and the condenser washed with distilled water into the flask and diluted to about 150 ml. The excess dichromate was titrated with 0.05 M ferrous ammonium sulphate (FAS) using 2 drops of ferroin as indicator. A blank mixture was prepared and treated using the same procedure (Ademoroti, 1996).

Alkalinity: The alkalinity was determined by titrating filtered waste water samples with sulphuric acid of known values of volume and concentrations. Based on stoichiometry of the reaction and number of moles of sulphuric acid needed to reach the end point using phenolphthalein indicator, the concentration of alkalinity in the waste water was calculated.

Chloride: The chloride present was determined using argentometry method. The amount of chloride present

in wastewater was determined by titrating the water sample with silver nitrate solution. The silver nitrate reacts with chloride ion according to1 mole of silver nitrate ($AgNO_3$) reacts with 1 mole of chloride. Silver chloride is precipitated quantitatively, before red silver chromate is formed. The end of titration is indicated by formation of red silver chromate from excess silver nitrate. The results are expressed in mg/L of chloride (Cl^- with a molecular weight of 35.453 g/mol)

RESULTS AND DISCUSSION

Physicochemical parameters of the effluent samples: The colour of all the wastewater samples from both Agbele (AGS) and Akarigbo (AKS) was generally dark brown while that of Majopa (MAS) was observed to be light yellow (Table 1). The colour and odour were objectionable; this is a clear indication of the effect of direct dumping of raw blood, fresh and decaying flesh as well as dung from the abattoir into the receiving river without any form of treatment. The samples' temperature ranges from 30.5 to 33.3°C which is in compliance with both the World Health Organization (WHO) and Federal Ministry of Table 1: Results of Physicochemical Parameters from Wastewater Samples (n=5). Environment (FMEnv) permissible limits of < 40C. The mean pH values of samples from AGS and AKS are 6.24±0.21 and 6.5±0.19 respectively which is well within the acceptable limits set by WHO and FMEnv. However, the samples from MAS showed an average pH value of 5.8±0.27 which is slightly lower than the acceptable lower limit of 6.0 by FMEnv (Table 2). One of the factors responsible for this could be the manner the waste generated is being handled at this location which differs from the first two sampling areas as clearly shown by the difference in colouration. The turbidity values measured from all the sampling areas are higher than the WHO guideline of 3 NTU for the discharge of wastewater into the river.

Table 1. Values of Physicochemical parameters

Parameters	**SAMPLING POINTS**								
/units	**AGS 1**	**AGS 2**	**AGS 3**	**AKS 1**	**AKS 2**	**AKS 3**	**MAS 1**	**MAS 2**	**MAS 3**
Appearance	Dark brown	Dark brown	Dark brown	Dark brown	Dark brown	Dark brown	Light yellow	Light yellow	Light yellow
pH	6.04	6.46	6.23	6.29	6.56	6.65	5.50	6.01	5.89
Temperature, ^oC	30.5	31.2	31.0	32.5	30.3	31.3	32.6	33.2	32.9
Turbidity, NTU	235	255	278	835	785	867	66	49	62
TS, mg/L	19000	17500	22400	29000	28500	25700	10500	13500	10500
TSS, mg/L	11500	14500	13000	19000	17500	19500	6000	4500	7500
TDS, mg/L	8500	3000	9400	10000	11000	6200	4500	9000	3000
COD, mg/L	1487	1672	1364	3396	3873	3687	3352	3678	3983
Alkalinity, mg/L	130	154	145	220	258	211	245	276	217
Chloride, mg/L	23.01	25.51	23.87	10.43	9.64	5.43	92.38	76.57	58.96

AGS= Agbele Sagamu wastewater sample. AKS= Akarigbo Sagamu wastewater sample. MAS= Majopa Sagamu wastewater sample,

Table 2: Mean Values of Physicochemical Parameters (n=45)

Parameters	**SAMPLING POINTS**			**WHO/USEPA**	**Maximum**
/units	**AGBELE (AGS)**	**AKARIGBO (AKS)**	**MAJOPA (MAS)**	**Limits (WHO 2004;2006)**	**Permissible Limits (FMEnv)(FEPA,1991)**
pH	6.24±0.21	6.5±0.19	5.8±0.27	6.5-9.5	6.0-9.0
Temperature, ^oC	30.9±0.36	31.37±1.1	32.9±0.3	<40	<40
Turbidity, NTU	256±21.52	829±41.33	59±8.89	3	N/A
TS, mg/L	19633.33±2510.64	27733.33±1778.58	11500±1732.05	2000	2000
TSS, mg/L	13000±1500	18666.67±1040.83	6000±1500	1000	30
TDS, mg/L	6966.67±3464.58	9066.67±2532.46	5500±3122.5	1000	N/A
COD, mg/L	1507.67±155.04	3652±240.42	3671±315.56	20	80
Alkalinity, mg/L	143±12.12	229.67±24.95	246±29.51	250	N/A
Chloride, mg/L	24.13±1.27	8.5±2.69	75.97±16.72	200	250

Table 3: Concentrations of Heavy Metals from Wastewater Samples (n=5)

METALS	**SAMPLING POINTS**								
(mg/L)	**AGS 1**	**AGS 2**	**AGS 3**	**AKS 1**	**AKS 2**	**AKS 3**	**MAS 1**	**MAS 2**	**MAS 3**
Zn	0.078	0.134	0.185	0.331	0.465	0.215	0.269	0.342	0.198
V	0.221	0.447	0.293	ND	0.184	0.211	0.412	0.196	ND
Cd	0.102	0.157	0.097	0.1	ND	0.008	0.057	ND	0.075
Fe	15.261	18.367	12.673	13.293	15.667	17.363	4.912	3.439	7.532
Ni	0.354	ND	0.157	0.043	0.072	0.067	0.056	0.032	ND
Cu	0.101	0.265	0.365	0.062	0.121	0.091	0.304	0.732	0.511
Co	0.051	0.103	0.082	0.047	0.089	ND	ND	0.035	0.011
Pb	0.345	0.122	ND	0.293	ND	0.174	0.246	ND	0.172
Cr	1.606	1.332	0.892	1.443	1.124	ND	ND	0.528	0.37
Mn	0.302	0.718	0.211	0.631	1.456	0.895	0.307	0.653	0.843

ND: Not detected

Table 4: Mean Values for Concentration of the Heavy Metals in the wastewater (n=45)

Parameters (mg/L)	SAMPLING POINTS			WHO/USEPA Limits (WHO 2004; 2006)	Maximum Permissible Limits (FMEnv)(FEPA, 1991)
	AGBELE (AGS)	AKARIGBO (AKS)	MAJOPA (MAS)		
Zn	0.132±0.054	0.337±0.125	0.27±0.072	1.0-3.0	3
V	0.32±0.115	0.132±0.115	0.203±0.206	0.5-2.0	<1.0
Cd	0.119±0.033	0.036±0.056	0.044±0.039	0.05	0.01
Fe	15.434±2.851	15.441±2.044	5.294±2.073	0.4	20
Ni	0.17±0.177	0.061±0.016	0.029±0.028	0.01-0.02	0.05
Cu	0.244±0.133	0.091±0.03	0.516±0.214	0.05	0.1
Co	0.079±0.026	0.045±0.045	0.015±0.018	1.0-3.0	0.5
Pb	0.156±0.175	0.234±0.084	0.139±0.126	0.4	0.05
Cr	1.277±0.36	0.856±0.758	0.299±0.271	0.05	<1.00
Mn	0.41±0.27	0.994±0.421	0.601±0.272	0.04	5

The respective mean values for turbidity of AGS, AKS, and MAS are 256±21.52 NTU, 829±41.33 NTU, and 59±8.89 NTU. All the samples showed higher values for total solids (TS), total dissolved solids (TDS), and total suspended solids (TSS) when compared to both WHO and FMEnv tolerance limits (Table 2). AGS, AKS and MAS have mean TS, TDS and TSS values of 19633.33±2510.64 mg/L, 27733.33±1778.58 mg/L, 11500±1732.05 mg/L; 6966.67±3464.58 mg/L, 9066.67±2532.46 mg/L, 5500±3122.5 mg/L; and 13000±1500 mg/L, 18666.67±1040.83 mg/L, 6000±1500 mg/L. The high values could be attributed to the fact that liquid wastes and solid wastes are not being segregated prior to disposal in the receiving river.

The Chemical Oxygen Demand (COD) ranged from 1364-3983 mg/L with mean values of 1507.67±155.04 mg/L, 3652±240.42 mg/L, and 3671±315.56 mg/L for AGS, AKS, and MAS respectively. These values are higher than the permissible limits of 20 mg/L and 80 mg/L set by WHO and FMEnv respectively. The high COD values are an indication of the degree of waste organic matter loading into the river. The values of chloride for AGS, AKS, and MAS are 24.13±1.27 mg/l, 8.5±2.69 mg/l, 75.97±16.72 mg/l. These values are lower than the WHO and FMEnv permissible limits. The World Health Organization (WHO, 2011) have highlighted the heavy metals of most immediate concern for water pollution to include Al, Cr, Mn, Fe, Co, Ni, Cu, Zn, Cd, and Pb. The presence of any of these metals may present a hazard if available at a concentration higher than the set threshold limit. However, it is important to note that some heavy metals, including Al, Cu, Cd, Fe, Pb, Mn and Ni are essential/beneficial if below the permissible limits. Nevertheless, some have also been found to be harmful even at trace level (Onianwa, 2001).

Tables 3 and 4 show the values for the concentration of heavy metals. The essential metals examined in this work were Zinc (Zn), Copper (Cu), Manganese (Mn) and Iron (Fe). Zn, Cu and Fe were within the permissible limits while Mn exceeded the set limits in water by WHO but below the maximum permissible limit set by FMEnv. The mean values of concentrations of Zn, Cu, Fe and Mn in AGS are 0.132±0.054 mg/L, 0.244±0.133 mg/L, 15.434±2.851 mg/L, and 0.41±0.27 mg/L respectively. In AKS, the average values of these metals in the same order are 0.337±0.125 mg/L, 0.091±0.03 mg/L, 15.441±2.044 mg/L and 0.994±0.421. Also, AGS have average concentrations of 0.27±0.072 mg/L, 0.516±0.214 mg/L, 5.294±2.073 mg/L and 0.601±0.272 mg/L respectively.

Vanadium (V) in AGS, AKS and MAS with the values of 0.32±0.115 mg/L, 0.132±0.115 mg/L and 0.203±0.206 mg/L respectively are all below the tolerance limits. Cadmium concentration at AGS with a value of 0.119±0.033 mg/L is higher than the limit, while AKS and MAS with respective values of 0.036±0.056 mg/L and 0.044±0.039 mg/L have slightly lower concentrations. Nickel (Ni), Lead (Pb) and Chromium (Cr) have higher values than the limits in all samples. This presents serious concerns because, these metals are generally toxic and can cause harms to the human system. Pb has been reported to cause inhibition of the synthesis of haemoglobin, hair loss and it is carcinogenic and damage to liver cells (Kpee and Edori, 2016). Also, when these metals occur in excess amounts, they can cause adverse effects on reproduction and fertilization in animals and initiate or promote carcinogenetic growths (Harmanescu *et al*., 2011).

Conclusion: It is very evident that the understudied abattoirs have poorly managed the wastes they generated in the course of their activities based on the results discussed. The resultant poor handling of these wastes has greatly impacted the environment. Again, the adverse impacts of untreated abattoir effluent from the Sagamu area of Ogun State on animals, plants, human beings, surface water of the Ogun River and other environmental media cannot be overemphasized.

Stakeholders including government need to work together to curtail this environmental malaise.

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