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Original Research Article

Evaluating Treatment Performance of a Small-Scale Vermifilter for Vermifiltration of Lafenwa Abattoir's Effluent, Lafenwa, Ogun State, Nigeria

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Abstract: Abattoir waste can be detrimental to the environment if improperly managed. In Nigeria, such wastes are dump in the open or nearby stream/river course, causing high oxygen demand, becoming heavy breeders of pathogens and micro-organism as well as increasing the risks of zoonotic disease outbreak threatening the quality of life and public health. This study explored the use of vermifiltration; a low-cost, odorless and sustainable wastewater treatment method that uses earthworms and microorganisms to break down abattoir waste effluent. A bio-reactor (presence of earthworms) and a control reactor system (absence of earthworms) each consisting of a collection tank, vermifiltration bed and a fabricated treated water collection tank used to treat the abattoir wastewater by varying the flow rate and concentration of the effluent that entered the vermifiltration system. This was across four levels and three replicates with Hydraulic Retention Time of 42,011.49 sec (116.69hrs) and Hydraulic Loading Rate of 8.7×10^{-6} m/s. Physico-chemical properties of discharge from bio-reactor recorded 11.010±1.755NTU for turbidity, 24.228±6.319mg/L for dissolved oxygen, 7.562±3.402mg/L for total suspended solid, 51.27±14.00mg/L for total dissolved solid, 6.3562±0.2584 for pH, 250.0±101.1CFU/mL for total coli count and 1296±200CFU/mL for total bacteria count respectively as against results from the control reactor which had mean values of 36.351±3.993NTU for turbidity, 14.277±2.241mg/L for dissolved oxygen, 19.569±1.996mg/L for total suspended solid, 137.21±37.40mg/L for total dissolved solid, 5.0958±0.5596 for pH, 2500.0±522.7CFU/mL for total coli count and 6413±1725CFU/mL for total bacteria count. The vermifiltration process was thus able to greatly reduce and filter out the pathogens found in the influent through the combined action of the earthworms and the filter layer of fine sand and gravel to a high degree. Thus, confirming that vermifiltration system could achieve good performance in the treatment of abattoir waste water.

Keywords: Vermifiltration, Bio-reactor, Pathogens, Effluent and Retention time.

1. INTRODUCTION

In livestock agricultural farming, meat production especially that of ruminant animals is one of the major drivers of greenhouse gas (GHG) emission (Whitton *et al.*, 2021), generating approximately 20 to 100 times more emission that plant-based produce (Clark and Tilman, 2017). Despite these warnings, there are still evidence of countries increasing their consumption rates especially in emerging economy countries as a way of boosting their Gross Domestic Product (GDP) (Whitton *et al.,* 2021). Thus, making it difficult in achieving zero emission in agriculture by the year 2030 is crucial.

According to notable researchers (Vanguardngr.com 2019), beef consumption is estimated at 360,000 tonnes per annum and was confirmed (Gambo 2020) in another study where beef consumption has been stressed as a preferred choice of animal protein hence the significance of Cattle rearing in the country. As the population increases (Michael and Odeyemi, 2017), so is the country's desire to meet the ever rising demand of meat consumption rises, but of what use is this cause, if its nobility is of little or no value when the environment is being destroyed in the process. (Nwanta *et al.*, 2008). On daily basis, animals are taken to the slaughter and carcasses processing area in the abbatoir, as a matter of fact, Lagos state alone being a major consumer of red meat, slaughters approximately 6000 cows daily (Sati *et al.*, 2023). This translates to tons of abbatoir effluents which consists of blood, intestinal contents, waste tissues and dungs that are being generated and mismanaged in the environment on daily basis (Aniebo *et al.,* 2009; Oruonye, 2015; Nwanta, 2008).

The typical study abbatoir (Lafenwa abbatoir inclusive) in Nigeria is often characterized as unhygienic, dilapidated, poorly drained and a major environmental risk. The sanitary condition is an eyesore with evisceration being done on the bare floor already stained with blood and faeces with little or no inspection and adequate sanitary enforcement from Local regulatory Authorities, thus giving room for contamination and pollution (Aiyedun*et al.*, 2020). Studies have shown that Lafenwa abbatoir waste (Fig. 1) are known to possess high oxygen demand because of the animal blood and paunch manure in them, which means if improperly handled, they are seriously detrimental to the environment they are disposed into, exerting high oxygen demand that will become heavy breeders of large population of micro-organisms as well as pathogens (Ezeoha and Ugwuishiwu, 2011) but unfortunately, most abbatoirs don't have treatment facilities to treat these effluents but instead choose to dispose their wastes into nearby watercourse deteriorating the water quality and gravely destabilizing the aquatic ecosystem. (Adewumi *et al.*, 2016).

Of all the waste treatment methods which includes; physical, biological and chemical, vermifiltration technique has shown to be of great choice due to its efficiency of waste treatment because it is eco-friendly, cost saving, requires lesser space and low energy (Rajneesh *et al.,* 2021). Thus, a great choice for developing nations like Nigeria to adopt. Results have shown that high strength wastewater from industries and animal farms have largely been treated to stable and satisfactory levels to be discharged into the environment as well as promoted into an integrated farming system. Despite the fact that wastewater or effluents containing intolerable concentration of salts or high intoxicants can increase mortality rate of earthworms, the vermifiltration method (Fig. 2) has proven over time to be very effective and less susceptible to cold weather because of the exothermic reactions it commonly entail (Tomar and Suthar, 2011; Arora and Kazmi, 2015).

The consideration of vermifilter to replace conventional bio filter created an innovative way of mass transfer and energy conversion through food chain extension. Records have shown that this method have the capacity of reducing Biological Oxygen Demand (BOD_5) by over 90%, Chemical Oxygen Demand (COD) by over 80%, Total Dissolved Solids (TDS) by over 90% and Total Suspended Solids (TSS) by over 90% by biological mechanism of 'adsorption' through body walls and 'ingestion' (Sinha *et al.*, 2008). Thus creating an odourless and cheaper medium of biodegradation, disinfection and detoxification of wastewater thus enhancing socio-economic values and ameliorating environmental problems. The aim of this study is to design and develop a portable small-scale vermifiltration technique and to administer the vermifilter treatment efficiency at the Lafenwa abbatoir effluent using the developed vermifilter.

2.1 Study Site Description

Lafenwa abbatoir, the study area lies approximately at latitude 7°09'39.0"N and longitude 3°20'54.0"E and has average elevation of 33m. Lafenwa is situated in Abeokuta North Local Government, which is the capital of Ogun State in South-Western Nigeria and its situated close to the river Ogun, a major source of potable water to the people of Ogun and Lagos state (Fig. 1).

The slaughter house at the abattoir is in different sections;

a) The butchering section: The section where the animals are slaughtered and rendered.
b) The rinsing section: The section where water is used to rinse and flush the blood and animal waste
c) The dung pit: The section in which intestinal contents are emptied with lots of cow dung.

The management of the abattoir is often together by an association of independent butchers and 100–200 cows are being butchered daily in which effluent from the slaughter house is discharged directly into The River Ogun and its environs without any form of treatment.

2.2 Conceptualization behind vermifiltration

The vermifiltration process was first conceived by the late Professor Jose Toha at the University of Chile in 1992, as a cost-effective and sustainable technology that produces no sludge (Wang *et al*, 2010). The Vermifilter (Fig. 2), which is also known as a bio filter for wastewater treatment works only in an aerobic condition in which effluents provides the growth of microorganism at the same time degrades it biochemically (Sigh *et al.*, 2020). Thus, the earthworm consumes the microbial biomass, digesting it and converting it into vermicompost (Fig. 2), rich in nutrients and minerals useful in plant production.

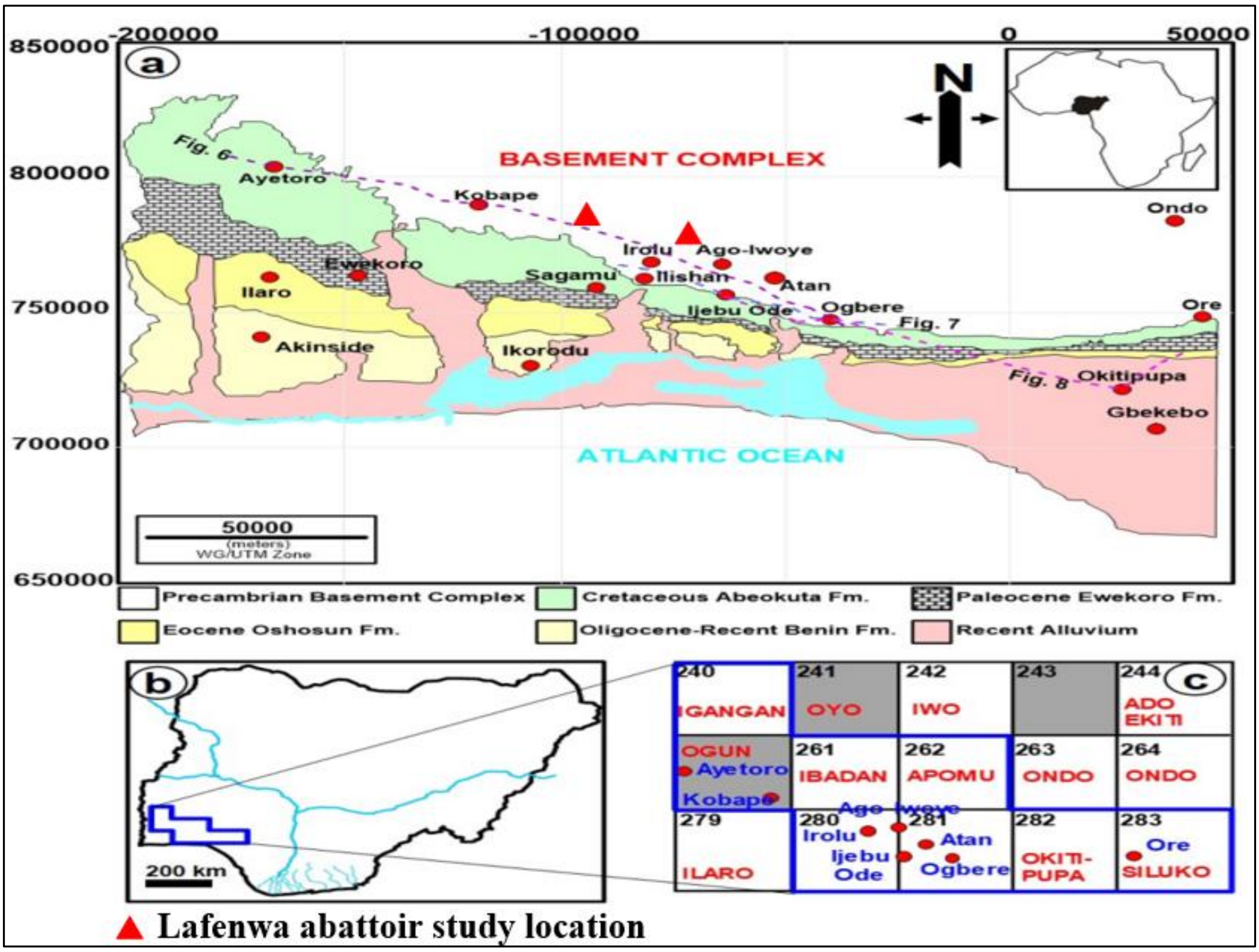

Fig. 1: Map showing location of Lafenwa abattoir study area and other notable abattoir, Ogun State

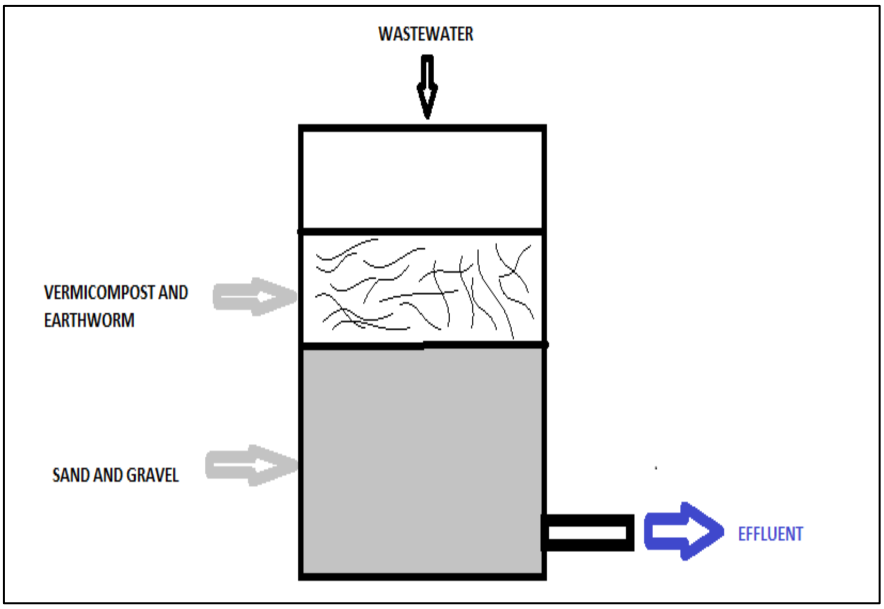

Fig. 2: A schematic representation of a vermifilter

There are three main variables that influences the quality of effluent produced from the vermifiltration process and they are; Hydraulic Retention Time (HRT) taken by the influent to flow through the vermifilter bed containing the earthworms, Hydraulic Loading Rate (HLR) and Time which is the adequate volume the vermifilter can effectively and efficiently treat (Sinha*et al.*, 2008). Both equations are given as follows;

a) **Time:** The time required for the influent to be in the Vermifilter and this is an important variable in determining the Hydraulic Retention Time (HRT). Time was varied at 2, 4, 6 and 8hr (7200, 14400, 21600 and 28800 seconds) respectively. It was done in order to determine the quality of result achieved from the vermifiltration process.

b) Hydraulic Retention Time

$$\mathrm{HRT} = (\rho * \mathrm{Vs})/\mathrm{Qww} \quad (1)$$

$$\rho = 1 - \left({}^{\mathrm{BD}}/_{\mathrm{PD}}\right) \mathrm{X}\ 100 \quad (2)$$

$$\mathrm{BD} = \frac{\text{Dry weight of the medium}}{\text{Volume of the medium}} \quad (3)$$

$$\mathrm{Vs} = h\pi r^2 \quad (4)$$

Where;

HRT is Hydraulic Retention Time (seconds), P is porosity of the entire medium, Vs is volume of the soil profile (Vermifilter bed), through which the influent flows and which have live earthworms, π is pi of a circle, r is the radius of the Vermifilter, h is the height of the Vermifilter which is usually in a cylindrical form, BD is Bulk Density of the medium, PD is Particle density of soil, Q_{ww} is the flow rate of the influent, V_{ww} is the volume of influent and t is the time taken to flow through the Vermifilter chamber (Sinha*et al.*, 2008).

c) Hydraulic Loading Rate

$$\mathrm{HLR} = \mathrm{Vww}/(\mathrm{A} \times \mathrm{t}) \quad (5)$$

Where;

HLR is Hydraulic Loading Rate (m/sec), V_{ww} is Volume of influent (cum), A is Area of soil profile exposed (square metre) and t is time taken by the effluent to flow through the soil profile (seconds) (Bhise and Anaokar,2015).

Earthworm burrowing action such as ingestion, grinding, digestion and excretion as well as reproduction helps increase in the surface area and bed porosity of the vermifilter processes which in turn increases the hydraulic conductivity of bedding media (Sigh *et al.*, 2020). Thus efficiently treating the wastewater. In the world at large, the commonest earthworm specie is the African Night Crawler (*Eudrilus euqinae*) and it has researched to be suitable for vermifiltration and they are famously found around swampy areas globally (Blakemore, 2015).

2.3 Characteristics of the small-scale vermifiltration bio-reactor

The bio-reactor setup was established behind Lafenwa Abbatoir slaughter house to accommodate ease of effluent transport from the slaughter house to the bio-reactor. The bio-reactor was designed and fabricated in three serially connected cylindrical compartments, (influent tank; 0.2m depth and 0.45m diameter, vermin bed; 0.45m depth and 0.45m diameter and effluent tank; 0.2m depth and 0.45m diameter respectively) all on a three-stepped wooden support frame. An L-shaped pipe of ½ inch (0.0127m) diameter was used to supply the effluent from the effluent tank to the vermin bed and to the collection tank.

A ½ inch (0.0127m) diameter control tap, used in controlling the discharge of the effluent was installed alongside each of the L-shaped pipe connecting the bottom of the effluent tank and the bottom of the vermi bed respectively. The L-shaped pipe from the effluent tank led to a shower head which faces the center of the top opening of the vermin bed. The shower head consisted of multiple tiny polypropylene holes, 0.1inch (0.00254m) in diameter that allowed provide uniform distribution of the effluent.

The vermi bed contained approximately 10kg of gravels of averaged diameter 0.066m and thickness 0.05m at the bottom which is preceded with10kg of fine sand had an average size 0.000175m and thickness of 0.1 m and on at the uppermost layer is the garden soil (sandy loam) of 0.24m thickness which accommodated the earthworms. The vermi bed had allowance for the treated effluent to be collected which in turn is discharged into the collection tank via the L-shaped pipe.

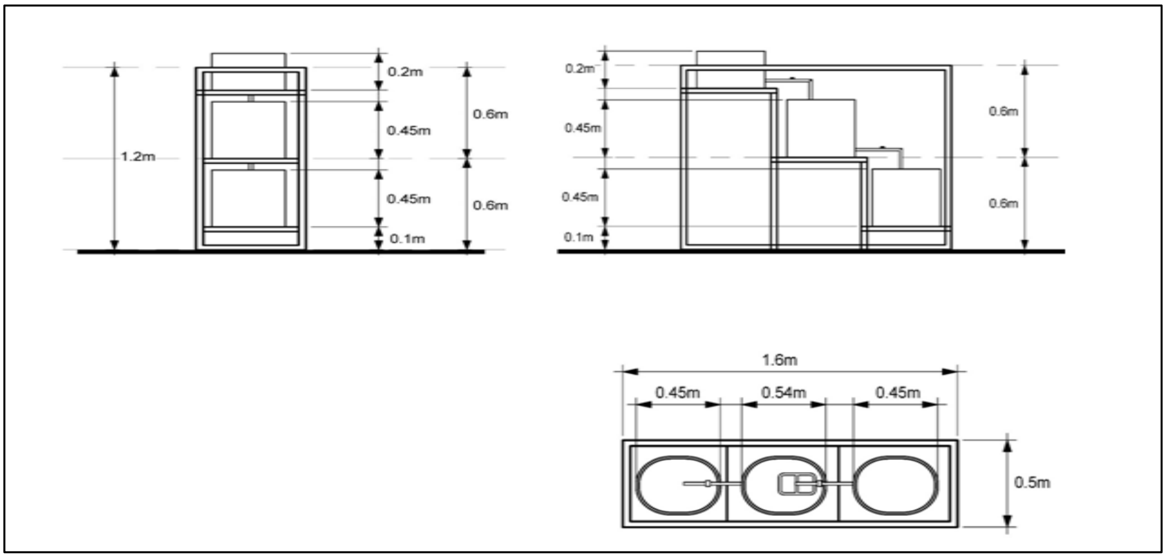

Fig. 3: First angle orthographic projection the small-scale bio-reactor

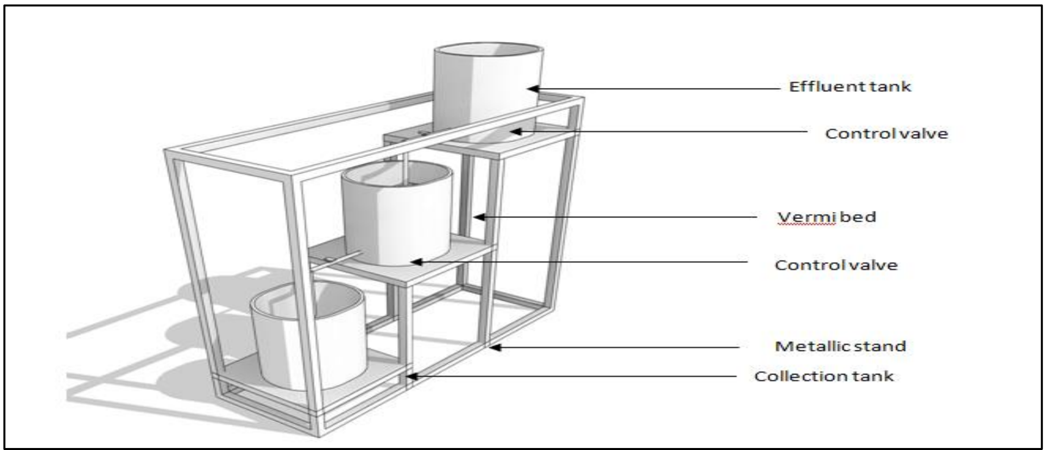

Fig. 4: Conceptual drawing of the bio-reactor

2.4 Earthworms

According to scholars (Hughes et al. 2009), earthworms (Fig. 5) are capable of simultaneously decomposing organic matter and ingesting heavy metals from both the influent and solids present in the wastewater. The earthworms function as a bio-filter (Figs. 3 and 4), whereby the influent is processed through the thick, viscid fluid discharged from their mouths. Once in the esophagus, calcium neutralizes the fluid before it is absorbed and decomposed by enzymes in the intestine. The resulting treated water is then released into the vermifilter bed as 'excreta' or vermicompost, which can be used as a beneficial soil additive for agriculture and horticulture. The African Night Crawler (*Eudriluseuginae*) which is suitable for vermifiltration was used. Stock of the earthworms was collected from Epe, a suburb and a fishing town of Lagos state. Physical identification of the earthworm species was done using a magnifying glass which was later proceeded by culturing of the stock earthworm using wet soil and cow dung.

Fig. 5: Images of African Night Crawler (*Eudriluseuginae)* used in the bio-reactor

2.5 Abattoir Effluent

Collection of the effluent sample was done in a 5L plastic container from the slaughter house in Lafenwa, Abeokuta North local government area of Ogun state. Upon arrival, it was thoroughly mixed with water at different ratios and supplied to the system in accordance with the determined HLR. The physical examination of the effluent showed high level of organic matter, microbial indicators, animal faeces, blood and animal fur.

2.6 Experimental Setup

4.4kilograms of earthworms was weighed and evenly placed on the soil in the vermi bed and given twenty one days (21days) to acclimatize with the new environment (Figs. 2-5). The abattoir effluent, $0.005m^3$ (5L) in volume, was measured and thoroughly mixed with water upon arrival. Samples of the effluent were taken for physico-chemical and biological test prior to the experiment. The mix ratio of effluent to water ratio were 1:0, 1:1 ,1:2 and 1:3 respectively before each experimental run. The time in which the influent is delayed in the vermin bed to enable the earthworms act on it was varied at four levels which are 2hours (7,200secs), 4hours (14,400secs), 6hours (21,600secs) and 8 hours (28,800secs) respectively. With consideration of the pipe diameter, the HLR was computed as; 34.9 X 10^{-6} m/s (7,200secs),17.45 x 10^{-6} m/s (14,400secs), 11.65 X 10^{-6} m/s (21,600secs) and 8.70 x 10^{-6} m/s (28,800secs) respectively. A control setup was established of which it formed a proper bases for result comparison.

The number of runs was determined using below equation;

$$R = M^{K} \qquad (6)$$

Where R is number of runs, M is the number of levels and k is number of factors (Montgomery, 2001). Each run had three replicates in order to reduce error, thus, a total of forty eight (48) experimental runs (3 replications, 4 levels and 4 runs) data collected were analysed using descriptive and inferential statistics with Minitab statistical software.

3. RESULTS AND DISCUSSION

3.1 Results from Bio and Control Reactors

The vermifiltration performance of the abattoirs effluent was investigated based on results observed from the experimental process monitoring for: turbidity reduction, Dissolved Oxygen (DO) levels, Total Suspended Solid (TSS) reduction, Total Dissolved Solid (TDS) reduction, pH levels, Total Coli and Bacteria count reductions (Table 1) which displayed the retention time of the influent in the vermin bed, along with the corresponding flow rates, hydraulic retention time (HRT) and hydraulic loading rate (HLR) as estimated using Equations 1-5.This was done for 8hrs, 6hrs, 4hrs and 2hrs respectively.

Table 1: Estimated Delay Time, Flow Rate, Hydraulic Retention Time (HRT) and Hydraulic Loading Rate (HLR) of the Bio -reactor

S/No	Time (hours)	Flow Rate x10^{-7} (m^3/s)	HRT (hours)	HLR x10^{-6}(m/s)
1	8	1.74	116.69	8.70
2	6	2.31	89.90	11.65
3	4	3.47	58.52	17.45
4	2	6.94	29.26	34.9

The average results (Tables 1-7) of a thorough analysis of the effluent treated by the bio-reactor and the control reactor was evaluated. The mean values of various parameters were calculated from the results obtained from both reactors. The bio-reactor had mean values of 11.010±1.755NTU, 24.228±6.319mg/L, 7.562±3.402mg/L, 51.27±14.00mg/L, 6.3562±0.2584, 250.0±101.1CFU/mL, and 1296±200CFU/mL for turbidity, dissolved oxygen, total suspended solid, total dissolved solid, pH, total coli count, and total bacteria count, respectively. On the other hand, the control reactor had mean values of 36.351±3.993NTU, 14.277±2.241mg/L, 19.569±1.996mg/L, 137.21±37.40mg/L, 5.0958±0.5596, 2500.0±522.7CFU/mL and 6413±1725CFU/mL for the same parameters of the experimental analyses.

It is necessary to take cognizance of the fact that soil, sand and gravel particles also contribute to filtration process by adsorption of impurities on their surfaces, hence the importance of setting up a control reactor that has no earthworm in it. The range for result of turbidity achieved in this study 8.79-13.92 NTU for the bio-reactor when compared favorably with 31.68-42.68 NTU from control reactor and 30.9-31.2 NTU from a previous study (Taiwo *et al*, 2014). Thus, attributing to the presence of earthworms in the bio-reactor. The Dissolved Oxygen (DO) values of 17.14-39.09 mg/L and 11.6-18.7mg/L for bio and control reactors respectively compared favorably to the values 5.5-6.0 mg/L for a similar results obtained (Taiwo *et al*, 2014) and 0.1-8.82mg/L (Ojekunle *et al*,2014). Thus also attributing to the veracious eating of organic waste in the influent by the earthworms (Sharma *et al*, 2005). The Total Suspended Solid (TSS) value of 3.59-16.69 mg/L and 17.20-24.56 mg/L for bio-reactor and control reactor respectively were better than the result of 79-95 mg/L from obtained previous result (Taiwo *et al*, 2014) and 690-7000 mg/L from another previous study (Ojekunle *et al*, 2014). This is because earthworms can significantly remove suspended solid in influent by 90% (Sinha*et al*, 2008). The range of values for Total Dissolved Solids (TDS) 32.69-87.67mg/L and 96-180 for bio-reactor and control reactor was within National Environmental Standards and Regulations Enforcement Agency (NESREA) standard of 500mg/L. The low values for bio-reactor was due to the capability of earthworms to remove solid fractions of wastewater during vermifiltration processes (Lakshmi*et al*,2014). According to another study (Damodhar *et al*, 2015), earthworms are capable of neutralizing the influent hence the improvement of the values of pH to 6.10-6.67 from bio-reactor which is better than values of 4.3-5.9 from control reactor. The value of 133.33-366.67CFU/mL is better than the value of 1933.3-3233.33CFU/mL from control reactor, the values of TBC 1033.33-1433.33CFU/mL for bio reactor compared favorably with the value of 4466.67-8233.3CFU/mL from control reactor and 2.5-4.7x10^2CFU/mL previously obtained (Taiwo *et al*, 2014) because adopted vermifiltration process was able to reduce the bacteria load in the wastewater to an extent it can be safely used for irrigation purposes (Musaida *et al*, 2013).

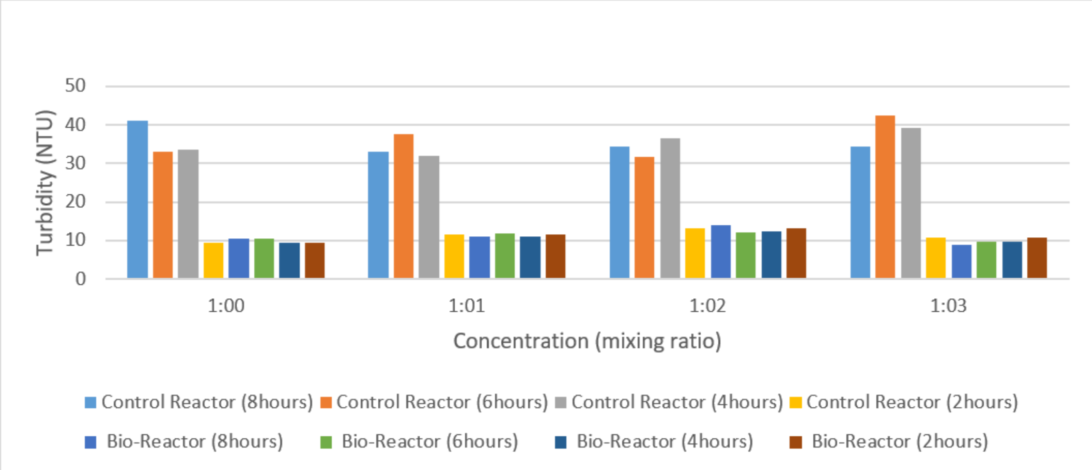

Fig. 6: Turbidity readings obtained in the Lafenwa Abattoir's Effluent

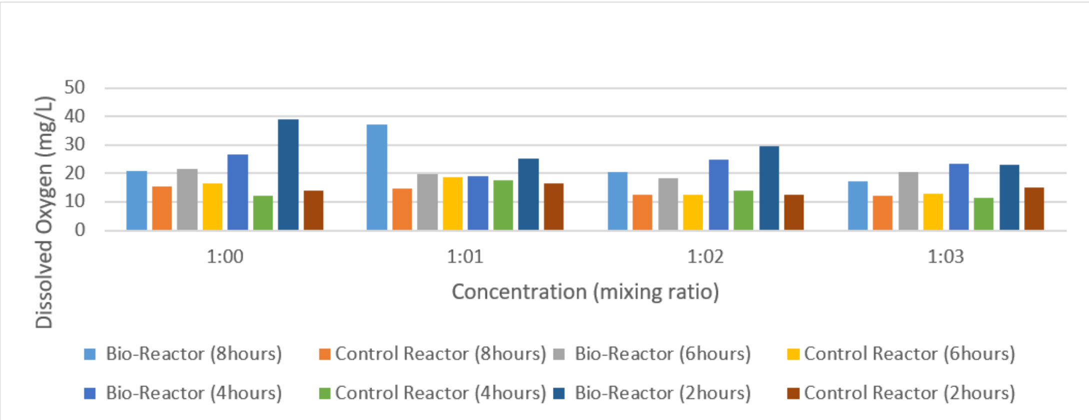

Fig. 7: Dissolved Oxygen readings obtained in the Lafenwa Abattoir's Effluent

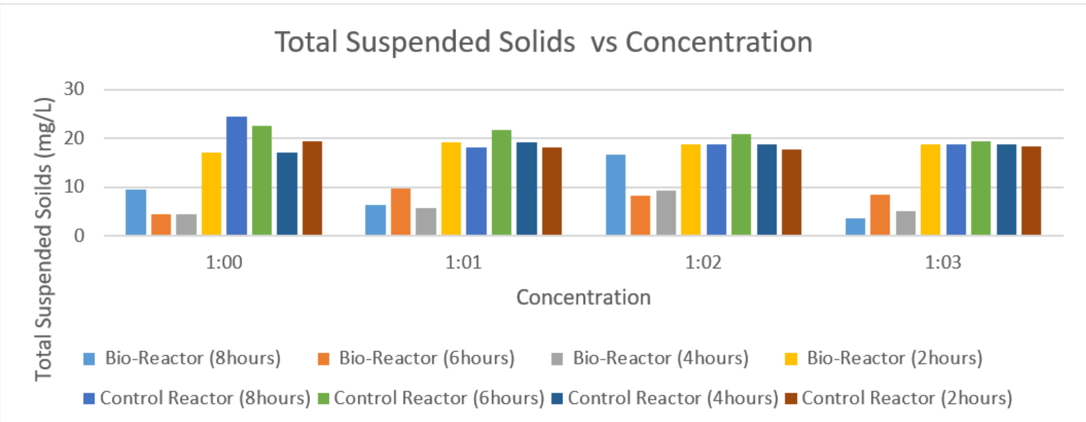

Fig. 8: Total Suspended Solids readings obtained in the Lafenwa Abattoir's Effluent

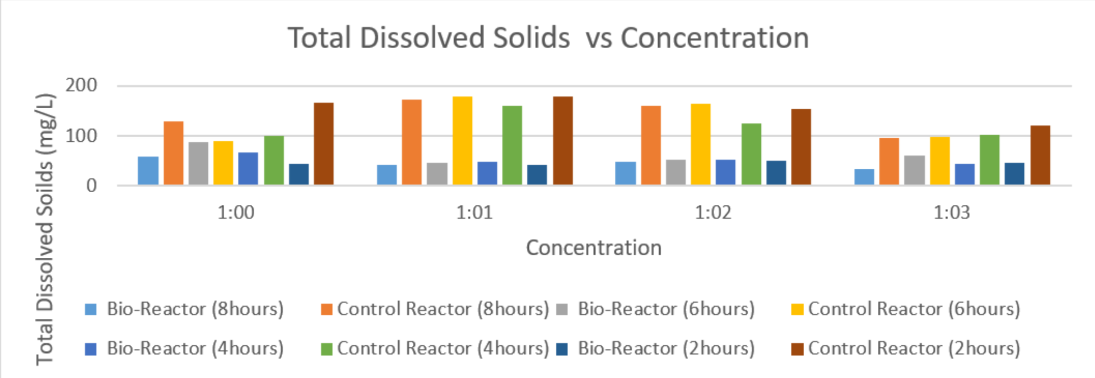

Fig. 9: Total Dissolved Solids readings obtained in the Lafenwa Abattoir's Effluent

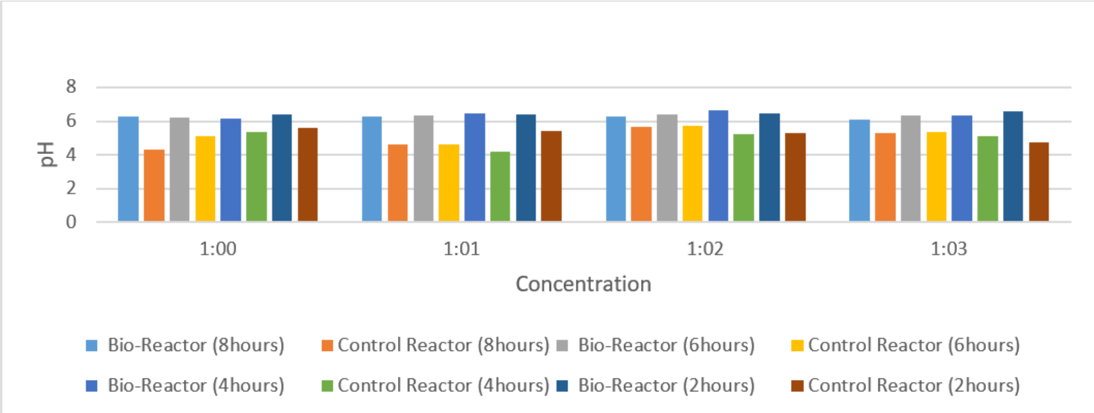

Fig. 10: pH readings obtained in the Lafenwa Abattoir's Effluent

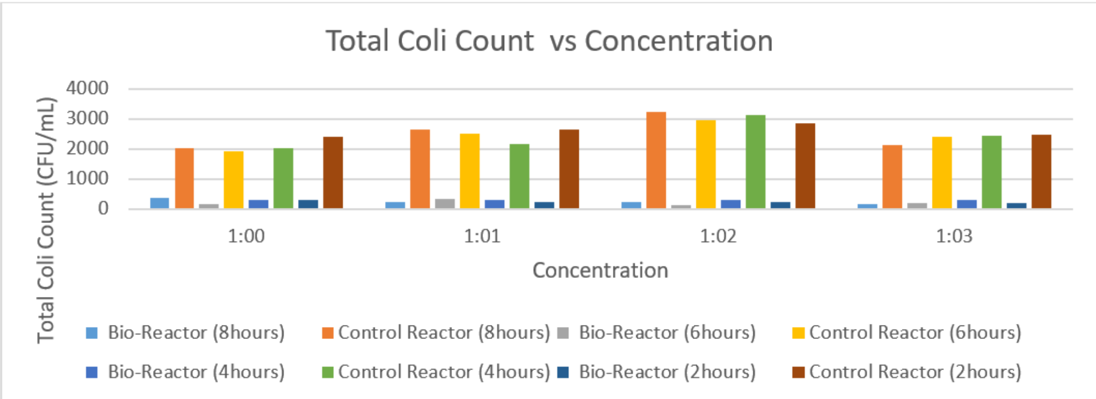

Fig. 11: Total Coli Count readings obtained in the Lafenwa Abattoir's Effluent

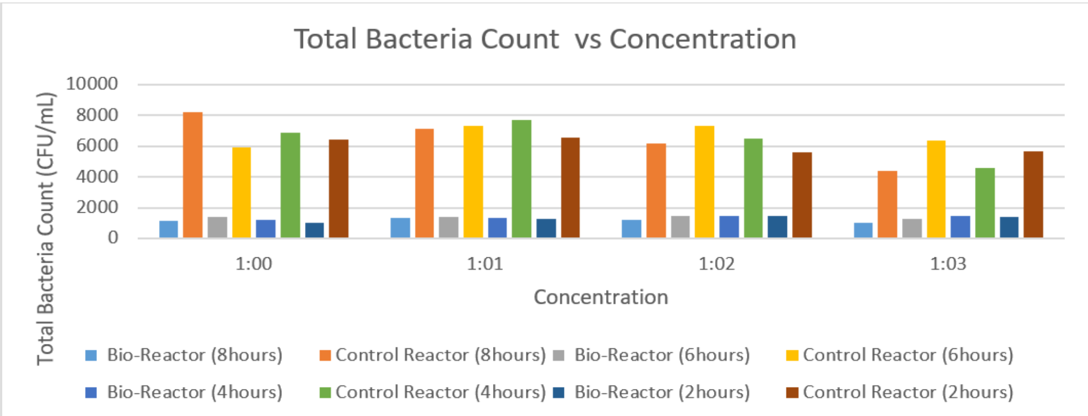

Fig. 12: Total Bacteria count readings obtained in the Lafenwa Abattoir's Effluent

3.2 Statistical Significance Levels between both Reactors

The statistical details of the p-values and F-values are presented in two-way displayed ANOVA table (Tables 2-13). As contained (Tables 2 and 3) in the tables, concentration significantly affected results of turbidity from both reactors but time had far less significant effect on bio-reactor values obtained as much as it did in the control reactor but the recorded (Tables 4 and 5) concentration and time have high significance on the values from both reactors, hence reflecting on their high coefficient of determination respectively. Concentration thus, had little significant effect on pH in the bi-reactor while time as well, had little significance in the control reactor as displayed (Tables 10 and 11) respectively. A rare case of both concentration and time having no effect on the values (Table 12) while the result of the Two-way ANOVA (Tables 13 to 15) had low coefficient of determination meaning no effect from either concentration or time.

Table 2: Two-way ANOVA of Turbidity from Bio-reactor versus Concentration, Time

Source	DF	SS	MS	F	P
Concentration	3	76.982	25.6608	15.72	0.000
Time	3	1.867	0.6223	0.38	0.767
Interaction	9	13.758	1.5287	0.94	0.508
Error	32	52.230	1.6322		
Total	**47**	**144.838**			
S= 1.278	R-Sq=63.94%	R-Sq(adj)=47.04%			

Table 3: Two-way ANOVA of Turbidity from Control Reactor versus Concentration, Time

Source	DF	SS	MS	F	P
Concentration	3	154.890	51.6299	14.33	0.000
Time	3	54.125	18.0416	5.01	0.006
Interaction	9	425.275	47.2527	13.12	0.000
Error	32	115.261	3.6019		
Total	**47**	**749.550**			
S= 1.898	R-Sq=84.62%	R-Sq(adj)=77.41%			

Table 4: Two-way ANOVA of DO from Bio-Reactor versus Concentration, Time

Source	DF	SS	MS	F	P
Concentration	3	242.60	80.866	33.89	0.000
Time	3	510.60	170.200	71.33	0.000
Interaction	9	1047.38	116.376	48.77	0.000
Error	32	76.36	2.386		
Total	**47**	**1876.94**			
S= 1.545	R-Sq=95.93%	R-Sq(adj)=94.02%			

Table 5: Two-way ANOVA of DO from Control versus Concentration, Time

Source	DF	SS	MS	F	P
Concentration	3	132.746	44.2485	64.17	0.000
Time	3	13.557	4.5191	6.55	0.001
Interaction	9	67.695	7.5217	10.91	0.000
Error	32	22.067	0.6896		
Total	**47**	**236.065**			
S= 0.8304	R-Sq=90.65%	R-Sq(adj)=86.27%			

Table 6: Two-way ANOVA of TSS from Bio-reactor versus Concentration, Time

Source	DF	SS	MS	F	P
Concentration	3	282.161	94.0535	320.53	0.000
Time	3	49.779	16.5931	56.55	0.000
Interaction	9	202.755	22.5283	76.78	0.000
Error	32	9.390	0.2934		
Total	**47**	**544.085**			
S= 0.5417	R-Sq=98.27%	R-Sq(adj)=97.47%			

Table 7: Two-way ANOVA of TSS from Control versus Concentration, Time

Source	DF	SS	MS	F	P
Concentration	3	33.504	11.1680	25.37	0.000
Time	3	60.685	20.2283	45.95	0.000
Interaction	9	78.951	8.7724	19.93	0.000
Error	32	14.087	0.4402		
Total	**47**	**187.227**			
S= 0.6635	R-Sq=92.48%	R-Sq(adj)=88.95%			

Table 8: Two-way ANOVA of TDS from Bio-Reactor versus Concentration, Time

Source	DF	SS	MS	F	P
Concentration	3	2886.40	962.132	14.86	0.000
Time	3	2166.40	722.132	11.15	0.000
Interaction	9	2082.69	231.410	3.57	0.004
Error	32	2072.00	64.750		
Total	**47**	**9207.48**			
S= 8.047	R-Sq=77.50%	R-Sq(adj)=66.95%			

Table 9: Two-way ANOVA of TDS Control Reactor versus Concentration, Time

Source	DF	SS	MS	F	P
Concentration	3	34436.4	11478.8	22.76	0.000
Time	3	7047.8	2349.3	4.66	0.008
Interaction	9	8124.4	902.7	1.79	0.109
Error	32	16139.3	504.4		
Total	**47**	**65747.9**			
S= 22.46	R-Sq=75.45%	R-Sq(adj)=63.95%			

Table 10: Two-way ANOVA of pH from Bio-reactor versus Concentration, Time

Source	DF	SS	MS	F	P
Concentration	3	0.22729	0.075764	1.18	0.333
Time	3	0.44729	0.149097	2.32	0.094
Interaction	9	0.41021	0.045579	0.71	0.695
Error	32	2.05333	0.064167		
Total	**47**	**3.13813**			
S= 0.2533	R-Sq=34.57%	R-Sq(adj)=3.90%			

Table 11: Two-way ANOVA of pH from Control reactor versus Concentration, Time

Source	DF	SS	MS	F	P
Concentration	3	3.5292	1.17639	8.44	0.000
Time	3	0.9042	0.30139	2.16	0.112
Interaction	9	5.8258	0.64731	4.64	0.001
Error	32	4.4600	0.13938		
Total	**47**	**14.7192**			
S= 0.3733	R-Sq=69.70%	R-Sq(adj)=55.50%			

Table 12: Two-way ANOVA of TCC from Bio-Reactor versus Concentration, Time

Source	DF	SS	MS	F	P
Concentration	3	41667	13888.9	1.59	0.212
Time	3	51667	17222.2	1.97	0.139
Interaction	9	106667	11851.9	1.35	0.249
Error	32	280000	8750.0		
Total	**47**	**480000**			
S= 93.54	R-Sq=41.67%	R-Sq(adj)=14.32%			

Table 13: Two-way ANOVA of TCC from Control Reactor versus Concentration, Time

Source	DF	SS	MS	F	P
Concentration	3	5791667	1930556	10.75	0.000
Time	3	175000	58333	0.32	0.807
Interaction	9	1126667	125185	0.70	0.706
Error	32	5746667	179583		
Total	**47**	**12840000**			
S= 423.8	R-Sq=55.24%	R-Sq(adj)=34.26%			

Table 14: Two-way ANOVA of TBC from Bio-Reactor versus Concentration, Time

Source	DF	SS	MS	F	P
Concentration	3	234167	78055.6	2.28	0.098
Time	3	230833	76944.4	2.25	0.101
Interaction	9	320833	35648.1	1.04	0.429
Error	32	1093333	34166.7		
Total	**47**	**1879167**			
S= 184.8	R-Sq=41.82%	R-Sq(adj)=14.55%			

Table 15: Two-way ANOVA of TBC from Control Reactor versus Concentration, Time

Source	DF	SS	MS	F	P
Concentration	3	26384167	8794722	3.12	0.040
Time	3	2869167	956389	0.34	0.797
Interaction	9	20365833	2262870	0.80	0.617
Error	32	90233333	2819792		
Total	**47**	**139852500**			
S= 1679	R-Sq=35.48%	R-Sq(adj)=5.24%			

4. CONCLUSIONS

The results of this study was successful as it showed that vermifiltration system could achieve good performance. The results were close to and some were better than the NESREA's permissible regulatory limits. The hydraulic Retention time of 42,011.49 sec and Hydraulic Loading Rate of 8.7×10^{-6} m/s were the best results from the various varied HRT and HLR and the further the delay of influent for earthworm to be in contact with it, the higher the purification efficiency to be obtained. In essence, the need to vary the time to various rates of HRT and HLR. Vermifiltration process was thus able to reduce pathogens found in the influent samples. Earthworms which served as a bio-filter ingested the pathogens (bacteria, fungus, protozoa and nematodes) found in both the wastewater as the pathogens served as food for the earthworms. They also secrete a celeomic fluid which has 'anti-bacterial' properties and arrest the formation of all microbes that is responsible for rotting. Some bacteria and fungi fostered by the worms also produced antibiotics which kill the pathogenic organisms in the influent invariably making the medium virtually sterile and odourless. This is highly recommended in other abattoir's effluent discharge to safeguard public health and preserve the environmental ethics for inhabitants and dwellers.

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