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Assessment of Municipal Sewage Effluent on the Growth Performance and Hematological Indices of the African Catfish (*Clarias gariepinus,* Burchell 1822) Juveniles

ADEWOLE Henry Adefisayo[1], AKINKUOLIE Samuel Olusayo[2], OLOLADE Promise Olabode[1], LAWAL Bola Morufat[3] and OLALEYE Victor Folorunso[1]

[1]Department of Zoology, Faculty of Science, Obafemi Awolowo University, Ile-Ife, Nigeria
[2]Institute of Ecology and Environmental Studies, Obafemi Awolowo University, Ile-Ife, Nigeria.
[3]Nigeria Institute of Oceanography and Marine Research, Victoria Island, Lagos, Nigeria
Corresponding author: email address: henryadewole@oauife.edu.ng Tel: +234(0)8037549914

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Abstract

The impact of municipal sewage effluent on the growth characteristics and hematological indices of an African catfish (*Clarias gariepinus*) was studied for 90 days with a view to determining potential toxicity of the risk of indiscriminate discharge of municipal sewage on the aquatic biota in a design of four exposure concentrations (0, 1.03, 2.06, 4.12 and 8.24%). The result of the study on the growth performance indices showed a predominant decrease in survival, mean weight gain (MWG), daily weight gain (DWG), and body weight gain (BWG) and a converse marginal decrease in other parameters with an increase in sewage concentration. However, hematological indices analyses showed a decrease ($p>0.05$) in red blood cell (RBC) count with the increased concentration of sewage effluent. Significantly higher ($p<0.05$) levels of white blood cell (WBC), Mean Corpuscular Haemoglobin Concentration (MCHC) and Platelet (PLT) were observed in exposed fish compared to the control group. The study concluded that an increase in sewage has an adverse effect on the growth and haematology of the fish.
Keywords: Sewage; Municipal; Discharge; Exposure; Toxicity; hematology

Introduction

Sewage, which is daily generated by man while meeting his various living requirements, has been defined as liquid waste products generated from domestic, commercial, industrial, and institutional sources (Katyal and Satake, 2001). It consists of dissolved or suspended pollutants that include wastes generated by humans such as faeces and urine and sullage. This domestic sewage is known to be a complex mixture of constituents of organic and inorganic matter and microorganisms together with water (Henry and Heinke, 1989; Carolyn, 2010; Ademoroti and Uwidia, 2011).

Apart from the serious environmental health problems that domestic sewage pollution could pose on those in contact, if discharged untreated, or not well treated (especially in many developing parts of the world), it can also affect the physico-chemical properties of receiving water bodies and aquatic life. There have been reports of several sewage-related pollutants posing toxicity risks to aquatic organisms (Diaz *et al.*, 2002; Ogunfowokan *et al.*, 2005; Garg 2006; Gomez-couso and Mendez-Hermida, 2006; Taiwo *et al.*, 2012). The authors reported reduction in fish abundance, mortality in fish and shell fish, impairment in reproductive development in amphibians and fish, and release of toxins that are deadly due to the presence of sewage related pollutants in aquatic environment. Therefore, bio-monitoring of aquatic pollution is quite fundamental (Aguayo *et al.*, 2004).

In toxicity studies, several researchers have used various fish species as a biosensor to several xeno-biotics compounds (Abrahamson *et al.*, 2007; Kerambrun *et al.*, 2011; Abdel-Moneim *et al.*, 2012; Al-Ghais, 2013; Maier *et al*., 2014; Vincze *et al*., 2014; 2015). Noteworthy is the African Catfish (*Clarias gariepinus*) which is one of the dominant fish found in rivers, dams, lakes, swamps, muddy waters, flood plains, and often culture (Cambray, 2003). The fish species have been widely used *in situ* as bioindicators of xenobiotic compounds in the aquatic environment (Sironka and Drastichova, 2004; Ramesh *et al.*, 2009; Nwani *et al.*, 2010; Sevcikova *et al.*, 2011; Fakolujo *et al.*, 2018; Akinbadewa *et al.*, 2020). This is due to their culturable attributes which include the fish's hardiness, bioaccumulation potential, and their wide tolerance to adverse environmental conditions.

Various biomarkers such as immune responses, histological alterations, changes in enzyme levels, gene expression alteration, etc., have been used in assessing the effect of various pollutants on organisms (Moore *et al.*, 2004; de la Torre *et al.*, 2007). However, analysis of blood samples, among other several biochemical analyses, has revealed several alterations or changes in the physiology of any organism (Bhatia *et al.*, 2004). This is simply because blood serves as a medium through which inter-and- intracellular substances are transported from various tissues and organs in the body. Several authors have used this means to expose the effect of environmental pollutants such as pesticides and heavy metals on fish (Bhatia *et al.*, 2004; Johal and Grewal, 2004).

Continual discharge of municipal sewage effluent into aquatic environments in developing countries especially Nigeria does not only damaging the quality of the environment by rendering water bodies unsuitable, it also threatens the health of aquatic biota. There is, therefore, a need to evaluate the effect of long-term discharge of sewage effluent on aquatic fauna especially on growth and heamatological indices of *Clarias gariepinus* a food fish in Nigeria, hence this study.

Materials and Methods

Sampling Area

Raw sewage samples were collected from the oxidation pond, Obafemi Awolowo University Ile – Ife, Osun State Nigeria, (Latitude 07^{o} 30. 450′ N and Longitude 004^{o} 30. 710′ E) (Figure 1).

Collection of test organism

One hundred and twenty (120) *Clarias gariepinus* juveniles (7.65 ± 0.02g) were sourced from a Bioresources Farm, Ile-Ife, Osun State, Nigeria. The fish were transported in an aerated chamber to the Fish Culture Laboratory, Department of Zoology, Obafemi Awolowo University where they were acclimatized for 14 days in twelve 40 L aquaria (90 x 45 x 45 cm) made of glass, filled to 30L mark with unchlorinated water each containing ten juveniles. To minimize waste production in the aquaria tanks, fish feeding was stopped a day to commence the experiment (Obiezue *et al.*, 2014).

Municipal sewage sample collection

The sewage discharge, used for the toxicity test, was obtained from the sewage treatment oxidation pond of the Obafemi Awolowo University Ile-Ife, Nigeria where municipal sewage pools. Sewage samples were collected in batches between late rain (September) and early dry season (December) from the discharge point where it runs into the nearby river. The sewage effluent was then kept in the refrigerator to prevent the continuation of microorganisms' activities before the experiment commences. All the sewage samples weekly collected for each month were poured together in a large container during the experiment to attain homogeneity and avoid variability in concentration.

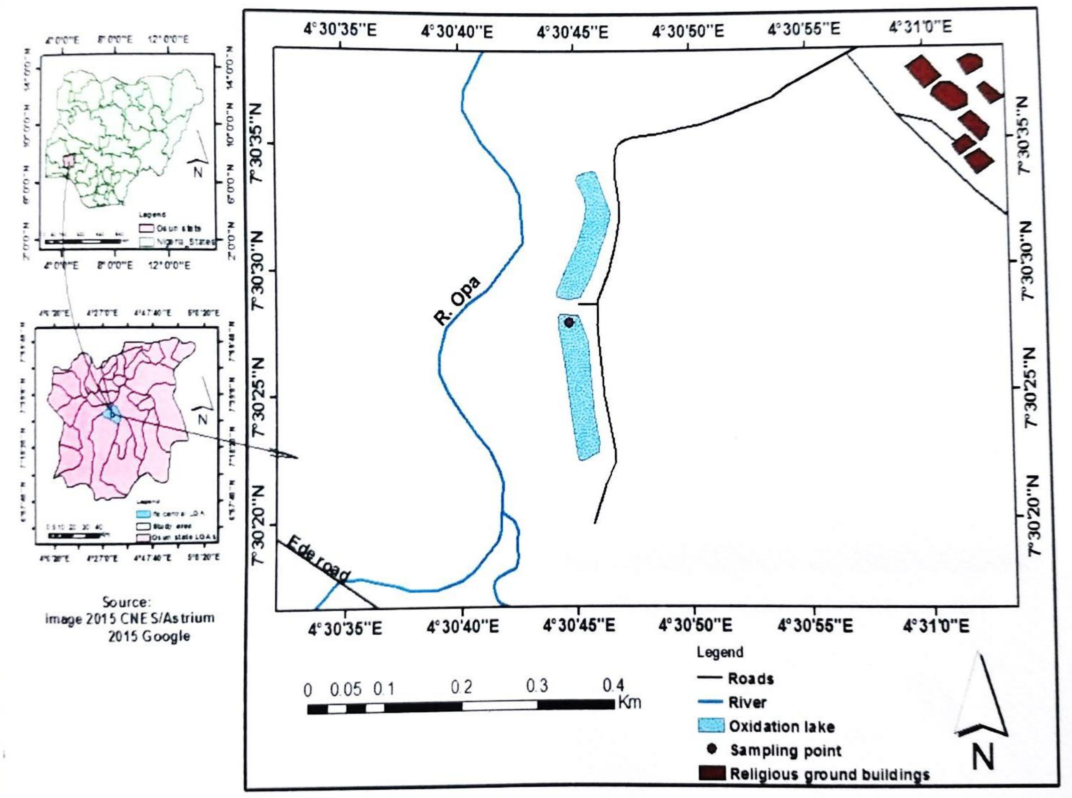

Fig. 1: Map showing the study area. (Inset: Map of Nigeria showing Osun State, Map of Osun State showing Ife Central Local Government Area and Map of oxidation pond and sampling point)

Physico-chemical analysis of the sewage sample and homogeneous media

The mixture of sewage effluent was analysed for physicochemical parameters before the commencement of the laboratory experiment. In the experimental setup, some of the physico-chemical parameters were measured *in situ* daily which include Temperature, pH, Conductivity, Salinity, Total dissolved solid using a Gowe® Multi-Function Water Quality Test Monitor as well as Dissolved Oxygen using Milwaukee D.O. meter. Other physico-chemical parameters such as biological oxygen demand, nitrate, total suspended solids, alkalinity, total solids, total acidity, phosphate, and chemical oxygen demand were determined once before every water turnover according to the method of APHA *et al*. (1992; 1995) and Golterman *et al*. (1978).

Acute toxicity test

The method of Rand (2008) was employed in range finding test for the definitive concentrations used in evaluating acute toxicity of the sewage effluent on the *Clarias gariepinus* juvenile. The pooled sewage effluent samples were properly mixed before been used at the different concentration of exposure in five labelled tank A to E. The different concentrations used A = 0 (ordinary water, serving as experimental control), B = 7.5L, C = 15L, D = 22.5L and E = 30L which were 0%, 25%, 50%, 75% and 100% of sewage sample respectively were prepared by the appropriate dilution with tap water. Ten fishes were exposed to each concentration for 96 hours during which the behavioural responses, percentage mortality at 96 hours, mortality after 96 hours, and LC_{50} (concentration at which half or 50% of the test organism died on exposure) of the fishes were evaluated. The 96-h LC_{50} of the fish was determined from the graph of percentage mortality against concentration (Figure 2).

Chronic toxicity test

The fish specimens were exposed to varying fractions concentration of the 96-hr LC_{50} value obtained from the acute toxicity test which were ½, ¼, $^{1}/_{8}$, $^{1}/_{16}$ and 0 of the 96-h LC_{50} value obtained which were 8.24L, 4.12L, 2.06L, 1.03L and 0L respectively and 50%, 25%, 12.5%, 6.25% and 0% respectively in concentration. The test solution was changed every 48 hours for 90 days.

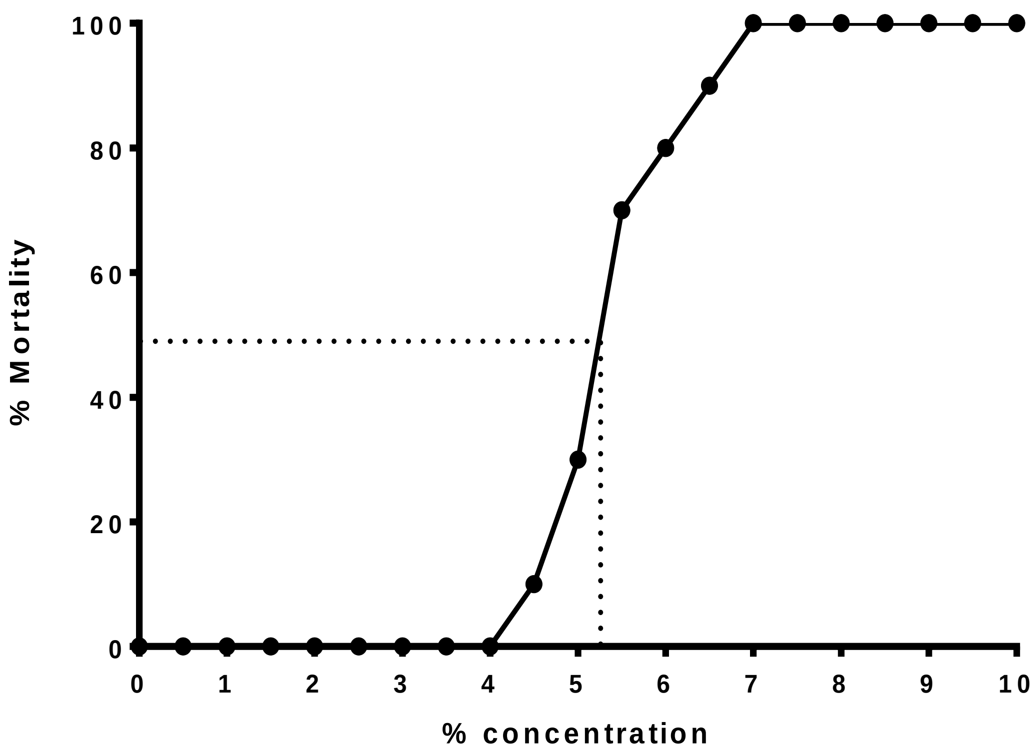

Fig 2: 96h LC_{50} value for *Clarias gariepinus* fingerlings exposed to different concentration of sewage effluent during the period of study

Evaluation of fish growth parameters

The experimental fish was weighed on a sensitive weighing balance (in grams). Fish in each experimental tank were fed 5% of their body weight twice daily, six days a week. Sampling done fortnightly for growth indices determinations were also used for ration allotment to allow for fish weight gain. According to Pitcher and Hart (1982) and Burel *et al.* (2000) as shown in Table 1, the fish growth performance, the quantity of the feed consumed, and the feed utilization indices were determined using the data generated.

Collection of blood and hematological analysis

2 ml of experimental fish blood sample obtained from the caudal vein using 5ml sterile plastic syringe fitted with 0.8 x 40 mm hypodermic needle into heparinized bottle coated with anticoagulant. After blood collection, the test fish was then separately placed in an aerated tank for necessary recovery. The fish hematological method as designed by Blaxhall (1973) was used in this study. Erythrocytes counted from the small squares of the improved Neubauer hemocytometer were used to estimate the Red blood cell (RBC) count (RBC $x10^6$ µl). The hematocrit (PCV, %) level of the fish blood sample was determined by collecting the blood sample through capillary action into heparinized capillary tubes in duplicate and centrifuging at 13000 rpm for 4 minutes in a centrifuging machine. Hemoglobin concentration (Hb, g/dl) evaluation was done using the photometrical cyanohemoglobin method following the standard formula by Svobodova (2001). The routine clinical method of Wintrobe (1978) was followed in evaluating the white blood cell (WBC) count of the test fish.

From the data generated for RBC, PCV and Hb, the Mean Corpuscular Haemoglobin (MCH), Mean Corpuscular Haemoglobin Concentration (MCHC), and Mean Corpuscular Volume (MCV) were calculated according to the established formula of Torts *et al.* (1988).

Statistical analysis

Data generated were presented as means and standard errors of the mean (±SEM). The statistical analysis was performed using Graph Pad Prism Graphical – Statistical Package Version 5. The differences in the mean values of the determined parameters across the treatments were determined by one-way ANOVA and comparisons of the means were done using the Bonferroni test. Mean values are considered to be significantly different at $p < 0.05$ level.

Results

The result of the physico-chemical parameters of the sewage effluent and the homogenous media is shown in Table 2. The analysed physicochemical parameters of the raw sewage effluent revealed that the conductivity, total solids and total dissolved solids level of the sample were higher compared to the other parameters such as BOD_5, salinity, nitrate, phosphate and dissolved oxygen analysed in the sewage sample.

Generally, among the physico-chemical parameters analysed in the homogenous media, temperature and pH were the only parameters with no significant difference ($p>0.05$) across the treatment, however highest temperature and pH values (27.09 ±0.04 ^{o}C and 7.13 ±0.04 respectively) were recorded in exposure treatment with 2.06 and 8.2% sewage concentration respectively (Table 2).

Apart from dissolved oxygen and biological oxygen demand levels of the culture media which significantly ($p<0.05$) decreased with increasing sewage concentration, all other determined parameters (with the exception of pH and temperature) increased ($p<0.05$) as the sewage concentration increases (Table 2).

Table 1: Growth Performance and Feed Utilization Indices

S/N	Parameter	Formula	Reference
	Growth parameter Indices		
1.	Specific Growth Rate (SGR)	$\frac{(\text{Log Wf} - \text{Log Wi}) X\ 100}{D}$	Brown (1957)
2.	Daily Weight Gain (DWG)	$\frac{\text{MWG}}{D}$	Pitcher and Hart (1982)
3.	Mean Weight Gain (MWG)	$W_f - W_i$	Pitcher and Hart (1982)
4.	Percentage Survival	$\frac{\text{Nf x 100}}{\text{Ni}}$	Deyab *et al.* (2009)
5.	Body Weight Gain (BWG)	$\frac{\text{MWGx 100}}{\text{Wi}}$	Davies and Ezenwa (2010)
	Feed Utilization Indices		
6.	Protein Efficiency Ratio (PER)	$\frac{\text{MWG}}{PI}$	Wilson (1989)
7.	Food Conversion Ratio (FCR)	$\frac{\text{TFI}}{MWG}$	Burel *et al.* (2000)
8.	Protein Intake (PI)	Diet Protein Content x DFI	Sveier *et al*. (2000)
9.	Total Feed Intake (TFI)	$\frac{\text{TWF}}{Nc}$	Abdel-Hakim *et al.* (2008)
10	Daily Feed Intake (DFI)	$\frac{\text{TFI}}{D}$	Abdel-Hakim *et al.* (2008)

Where; W_f = Final Fish Weight; W_i = Initial Fish Weight; D = Duration of Fish Rearing; N_f = final number of fish after the experiment, Ni = initial number of fish at the start of the experiment, TWF = Total Weight of feed fed; Nc = number of currently exposed fish, MWG =Mean Weight Gain, TFI = Total feed intake

The total suspended solid (73.67±14.47) and nitrate (0.31±0.09) levels of the homogenous media with 1.03% as compared with the control (62.67 ±12.81 and 0.27 ±0.04 respectively) were the only parameters that were not significantly different ($p>0.05$) among the exposed treatments.

Generally, conductivity levels were higher irrespective of the treatment compared to other determined physicochemical parameters. This was closely followed by total solids (Table 2).

Fish growth performance and feed utilization

Fish in the control tank had the least mortality rate (Table 3). The exposed groups had lower survival rate with increase in concentration through the 90 days exposure period (Table 3). Generally, as shown in Table 3, when compared to the fish exposed to varied sewage concentration, the fish in the control tank exhibited considerably ($p>0.05$) higher growth and feed utilization indices.

Except the feed conversion ratio which increases ($p<0.05$) with increasing sewage concentration, all other fish growth and feed utilization indices decreased ($p<0.05$) as sewage concentration increases. Among the exposed treatments, the treatments with highest sewage concentration had significantly ($p<0.05$) poor growth performance and feed utilization indices (Table 3).

Table 2: Physico-chemical properties of the Municipal Sewage and the Homogenous Media

Parameters	Raw Municipal Sewage	Sewage concentration					FEPA (1991) Limit	NESREA (2009) Limit	USEPA (2009) Limit
		0 %	1.03 %	2.06 %	4.1%	8.2%			
Temperature (°C)	27.00±0.21	26.95 ±0.02[a]	26.80 ±0.02[a]	27.09 ±0.04[a]	26.77 ±0.01[a]	26.93 ±0.01[a]	< 40	-	-
pH	7.24±0.07	6.88 ±0.05[a]	6.99 ±0.05[a]	7.05 ±0.03[a]	7.11 ±0.04[a]	7.13 ±0.04[a]	6.50-8.50	6.00-9.00	6.50-8.50
Conductivity (μS/cm)	626.83±67.75	164.72 ±4.07[a]	259.33 ±12.33[b]	345.50 ±20.17[c]	426.28 ±27.14[d]	512.67 ±35.38[e]	-	1000	-
Dissolved Oxygen (mg/l)	2.75±1.60	9.50 ±0.65[d]	2.99 ±0.16[c]	2.18 ±0.37[b]	1.74 ±0.50[ab]	1.38 ±0.08[a]	5.00	2 - 5	-
Chemical Oxygen Demand (mg/l)	35.40±2.11	3.27 ±0.26[a]	8.32 ±0.54[b]	12.11 ±0.39[c]	15.90 ±0.69[d]	25.36 ±0.47[e]	-	1000	-
Biological Oxygen Demand (mg/l)	0.07±0.01	6.10 ±0.15[d]	4.13 ±0.31[c]	4.56 ±0.11[c]	2.21 ±0.09[b]	1.07 ±0.01[a]	50.00	50	250
Salinity (psu)	0.56±0.02	0.08 ±0.02[d]	0.13 ±0.09[c]	0.21 ±0.04[c]	0.33 ±0.02[b]	0.38 ±0.02[a]	-	-	-
Alkalinity ($mgCaCO_3/l$)	209.67±22.20	21.18 ±2.84[a]	58.63 ±4.25[b]	97.75 ±7.20[c]	135.39 ±9.65[d]	168.30 ±11.42[e]	45	45	-
Acidity ($mgCaCO_3/l$)	89.00±14.26	12.80 ±1.87[a]	31.38 ±2.90[b]	47.86 ±4.56[c]	62.05 ±6.81[d]	74.86 ±7.21[d]	-	-	-
Total Dissolved Solids (mg/l)	407.00±35.10	87.33 ±3.94[a]	129.5 ±4.12[b]	159.33 ±6.53[c]	191.00 ±6.22[d]	224.33 ±8.69[e]	2000.00	500	500
Total Suspended Solids (mg/l)	200.17±29.42	62.67 ±12.81[a]	73.67 ±14.47[a]	125.00 ±24.95[b]	168.50 ±28.16[bc]	172.33 ±7.83[c]	30.00	50	-
Total Solids (mg/l)	607.17±36.32	157.39 ±4.94[a]	227.06 ±9.44[b]	314.28 ±17.24[c]	389.78 ±21.02[d]	468.00 ±28.72[e]	-	-	-
Nitrate (mg/l)	0.87±0.12	0.27 ±0.04[a]	0.31 ±0.09[a]	0.59 ±0.09[b]	0.66 ±0.05[b]	0.76 ±0.02[c]	20.00	10	10
Phosphate (mg/l)	4.99±0.11	0.04 ±0.01[a]	0.08 ±0.01[b]	0.95 ±0.08[c]	2.48 ±0.07[d]	3.69 ±0.10[e]	-	5	-

FEPA-Federal Environmental Protection Agency NESREA-National Environmental Standards and Regulations Enforcement Agency
USEPA-United States Environmental Protection Agency for maximum permissible limits for effluent from wastewater
**Mean values within the same row with the same superscript are not significantly different (p>0.05)*

Effects of municipal sewage on the haematological indices of Clarias gariepinus juveniles

In all the heamatological parameters determined after 90 days of exposure, only red blood cell count (RBC) levels of the exposed fish were insignificant ($p<0.05$) across the treatment (Table 4).
However, the white blood cell count (WBC) and mean corpuscular volume (MCV) increase ($p<0.05$) with increase in sewage concentration in the exposed fish (Table 4). The hemoglobin (Hb) level of the fish in highest sewage concentration (8.20%) was found to be lower ($p<0.05$) than the Hb level of the fish in other exposed groups and control which were not significantly different ($p>0.05$) from each other (Table 4). In addition, the fish in the control had highest heamatocrit level ($p>0.05$) compared to the exposed fish group up to 2.06% (Table 4).
The MCH and MCHC of the fish varied significantly (Table 4). Fish exposed to different sewage concentration had higher platelet count ($p<0.05$) compared to the control, however, the fish exposed to 2.06% sewage concentration had highest PLT count (Table 4).

Discussion

The pH of Sewage treatment during the exposure period ranged from 6.9 to 7.2 which was within safe limits of 6.0 to 8.5 as suggested by FEPA (2009), NESREA (2009), and USEPA (2009). The level of conductivity across the treatment tanks was also within the acceptable limits for aquatic organism (WHO, 1996; FEPA, 2009; NESREA, 2009; USEPA, 2009). While the recorded dissolved oxygen (DO) concentrations in all treatment tanks during the period of exposure were lower than permissible limits for aquatic life (FEPA, 2009; NESREA, 2009, USEPA, 2009).

The distress responses exhibited in the behaviour of the *C. gariepinus* during the toxicity test could be due to the effects of the chemical and biological constituents of the effluent which caused a quick depletion in oxygen concentration as *C. gariepinus* juveniles are known for high DO consumption. Higher levels of Biological Oxygen Demand (BOD) recorded in this study increase the rate of oxygen depletion due to the enormous quantity of organic matter that are biodegradable. This corresponds with the opinion of El-Sayed (2011) who reported that, DO rapidly depletes in sewage polluted water because of high BOD. However, this requires the critical necessity to assess the quantity of pollutants present in a given body of water. (El-Sayed, 2011). The result of low DO and high BOD in this study could explain the irregular swimming, frequent surfacing, and gasping for breath observed in the test organism's response to the environment which increased with exposure duration and concentration. The weakness and eventual comatose observed in the test fish over a long period of exposure with higher mortality in the high concentrations (75% and 100%) compared to (25% and 50%) could be linked to lower levels of oxygen and reduced amounts of chemical and biological constituents present. Consequently, abnormal behaviour and mortality of organism increase as concentration of pollutant and exposure duration increase. This corresponds with the submissions of Shobha *et al*. (2007) and Dahunsi *et al.* (2011) who opined that fish exposure to different concentrations of effluent can affect the feeding rate, color of the skin, pattern of swimming, and general behaviour of such fish.

High Total Solids (TS) and Alkalinity, was observed in the study throughout the duration of exposure. This is an indication that indiscriminate discharge of such effluent is potential source of toxicity to aquatic environment. The submissions of Adewoye *et al.* (2005) corroborate the observed effluent characteristics features as a result of organic loads in the wastewater. High Chemical Oxygen Demand (COD), may probably be due to high level of human faecal deposits and domestic wastes from the sewers, (Abdel-Satar, 2005; Abdo, 2010; Saad *et al.*, 2011) and an increase in water temperature

Table 3: Growth performance and Feed utilization of *C. gariepinus* exposed to varying concentration of sewage effluent.

Concentrations	Initial Weight	Final Weight	MWG (g)	DWG (g)	SGR (%)	DFI (g)	TFI (g)	FCR	PI	PER	Mortality %
0%	7.65 ±0.02[a]	76.79 ±3.82[d]	69.14 ±3.68[e]	0.77 ±0.05[c]	1.11 ±0.17[d]	0.08 ±0.01[c]	6.87 ±1.15[c]	0.09 ±0.01[a]	3.20 ±0.04[d]	21.61 ±2.56[b]	8
1.03%	7.65 ±0.02[a]	60.76 ±5.69[c]	53.11 ±4.85[d]	0.59 ±0.07[b]	0.99 ±0.04[c]	0.07 ±0.03[bc]	6.46 ±1.36[bc]	0.12 ±0.01[b]	2.80 ±0.16[c]	18.97 ±4.07[ab]	25
2.06%	7.65 ±0.02[a]	56.84 ±3.16[b]	49.19 ±1.38[c]	0.55 ±0.13[b]	0.97 ±0.06[bc]	0.07 ±0.02[bc]	6.06 ±1.13[bc]	0.12 ±0.02[b]	2.80 ±0.10[c]	17.57 ±3.22[a]	33
4.1%	7.65 ±0.02[a]	52.84 ±4.03[b]	45.27 ±2.05[b]	0.50 ±0.11[b]	0.93 ±0.03[b]	0.06 ±0.01[b]	5.87 ±0.58[b]	0.13 ±0.05[bc]	2.40 ±0.09[b]	18.86 ±5.01[ab]	42
8.2%	7.65 ±0.02[a]	35.38 ±6.33[a]	27.73 ±5.17[a]	0.31 ±0.03[a]	0.74 ±0.15[a]	0.04 ±0.01[a]	4.35 ±0.46[a]	0.16 ±0.02[c]	1.60 ±0.17[a]	17.33 ±3.08[a]	58

MWG – Mean Weight Gain; DWG – Daily Weight Gain; SGR – Specific Growth Rate; DFI – Daily Feed Intake; TFI – Total Feed Intake; FCR – Feed Conversion Ratio; PI – Protein Intake; PER – Protein Efficiency Ratio
**Mean values with the same superscript for same parameter are not significantly different (P<0.05)*

Table 4: Heamatological indices of *Clarias gariepinus* exposed to varying Municipal sewage concentrations for 90 days

Concentration (L)	Parameters							
	WBC (µl)	RBC (µl)	Hb (g/dl)	HCT (%)	MCV (fl)	MCH (pg)	MCHC (g/dl)	PLT (µl)
Control	14.54±0.90^{a}	3.03±0.39^{b}	10.04±0.21^{b}	35.22±0.23^{c}	105.82±3.82^{a}	39.84±1.89^{b}	32.84±0.83^{a}	25.46±0.28^{a}
1.03	31.42±1.78^{b}	3.20±0.27^{b}	11.52±0.74^{b}	33.69±1.40^{bc}	111.39±4.70^{b}	34.25±2.42^{a}	37.41±0.34^{c}	64.38±1.54^{c}
2.06	34.31±0.23^{c}	2.96±1.91^{b}	11.20±0.60^{b}	34.04±1.58^{c}	115.34±1.07^{b}	41.14±0.98^{b}	36.01±0.64^{c}	69.87±0.24^{d}
4.12	39.14±1.58^{d}	2.88±0.89^{b}	10.54±0.40^{b}	32.01±0.89^{b}	120.27±2.61^{c}	41.12±0.74^{b}	36.29±0.42^{c}	64.24±0.98^{c}
8.24	41.32±0.82^{e}	2.51±0.94^{b}	6.64±0.62^{a}	29.02±1.25^{a}	122.94±1.74^{c}	46.98±1.68^{c}	34.43±1.26^{b}	60.65±1.40^{b}

Table 4: Heamatological indices of *Clarias gariepinus* exposed to varying Municipal sewage concentrations for 90 days.
RBC = Red Blood Cell; HCT = Hematocrit; WBC = White Blood Cell; Hb = Haemoglobin,; PLT=Platelets; MCH = Mean Corpuscular Haemoglobin; MCV-Mean Cell Volume MCHC = Mean Corpuscular Haemoglobin Concentration.
**Mean values with the same superscript within the same column are not significantly different (P>0.05).*

during culture, which probably accelerated the rate of oxidation of organic matter (Abdo, 2004 and 2010).

Pollutants or presence of toxicants in culture media has been reported to affect the quantity of food consumed by fish (Ugwu *et al.,* 2006 and Eleyele *et al*., 2017). The introduction of the sewage effluent in the media tank could also be the reason for the decrease in the feed consumption (TFI) level in the exposed group which consequently led to a decrease in DWG, MWG and BWG of exposed fishes with increase in exposure period and concentration. However, fish under the control treatment apparently fed better than the exposed fish which was in support of Ugwu *et al.* (2006) and Eleyele *et al*. (2017) findings. The increase count of WBC with increase in sewage effluent concentration recorded in the exposed fishes may be due to the effect of the test fish fighting against the pollutants which resulted in the higher antibodies (WBC) production to enhance or promote the organism's good health status. This conforms to the report of Dahunsi and Oranusi (2013) that WBC count increase during acute and sub-lethal treatment probably because of lymphomyeloid tissue that is stimulated as a defense mechanism for toxicity tolerance in fish. The observed least level of hematocrit (HCT), Haemoglobin (Hb) and red blood cell (RBC) in exposed fish with highest sewage concentration compare to other treatments in this study could be as a result of the pollutant's influence on body fluid, which matches the trend seen in other fish species exposed to pollution as reported by Sancho *et al*. (2000), Seth and Saxena (2003), Adhikari *et al.* (2004), Gholami-Seyeskolaei *et al*. (2013) and Bacchetta *et al.* (2014). An increase in MCV, MCH and MCHC as seen in the fishes exposed to high sewage concentration compare to the control can be attributed to and explained as an anemic response to erythropoiesis and haemosynthesis suppression, as well as an increase in the rate at which erythrocyte is being destroyed in haematopoietic organs (Svoboda *et al.,* 2001; Gabriel and Ugbomeh, 2016). Platelets elevation in the exposed fish with increase in sewage effluent concentration suggests an interference of the pollutant with thrombocytopoiesis in the bone marrow as suggested by Gabriel and Ugbomeh (2016).

Conclusion

This study revealed that even at the lowest level of sewage concentration exposure, significant impacts which were detriment to fish growth, feed utilization and anomaly in blood parameters was observed which indicate the high levels of pollutants in the sewage. This study therefore concluded that improper discharge of sewage effluent into aquatic environment does not only inhibit fish growth nor cause anomaly in blood parameters with resultant negative eco-physiology of the fish *C. gariepinus*, it also alters the physicochemical properties of water and with continuous discharge overtime the aquatic environment will become unsafe for the aquatic organism.

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