Asian Journal of Fisheries and Aquatic Research

3(3): 1-12, 2019; Article no.AJFAR.48533

Impact of Pollution on Haematology and Histology of Juveniles of *Chrysichthys nigrodigitatus* in Ogbese River, Ondo State, Nigeria

Abidemi-Iromini, Atilola Olateju[1*]

[1]*The Federal University of Technology, Akure, Ondo State, Nigeria.*

Author's contribution

This work was carried out in assessment of environmental impact on some blood chemistry and tissues architectural status of economically important fish Chrysichthys nigrodigitatus in Ogbese River for optimum production and continual existence and the work has been put together and final manuscript proof read by Author.

Article Information

DOI: 10.9734/AJFAR/2019/v3i330036
Editor(s):
(1) Dr. Pinar Oguzhan Yildiz, Assistant Professor, Department of Food Engineering, The Faculty of Engineering, Ardahan University, Turkey.
Reviewers:
(1) Ali Türker Mugla, Sitki Kocman University, Turkey.
(2) Mahmoud Abdelhamid Dawood, Kafrelsheikh University, Egypt.
(3) Moses Mwajar Ngeiywa, University of Eldoret, Kenya.
Complete Peer review History: http://www.sdiarticle3.com/review-history/48533

Original Research Article

Received 25 April 2019
Accepted 01 July 2019
Published 10 July 2019

ABSTRACT

The silver catfish *Chrysichthys nigrodigitatus* is of economic importance in sub-sahara Africa. In Ogbese town, and its environs, it constitutes a means of income and food for fisherfolks and community members. Hence, this study was undertaken to assess health status of *Chrysichthys nigrodigitatus* using haematology and histological assessment of the fish specie due to the anthropogenic activities that takes place around the river body. A total 120 live juvenile fish samples of *C. nigrodigitatus* were collected around shallow habitats of Ogbese River by the assistance of fisherfolks using fish cage. Some water parameters measurements were taken: temperature, pH, DO, Turbidity and Conductivity. Morphometric measurement: Weight (g) and length (cm) of fish were taken. Haematology and histology of fish gills, liver and intestine were determined. Mean water temperature (27.70±0.18°C), pH (7.36±0.22), DO (6.98±0.15 mg/l), Turbidity (78.50±13.53 NTU) and Conductivity (148.35±27.98) of the river determined respectively. Mean body weight of fish was 148.15 ± 36.53 g, and mean length was 25.64 ± 2.86 cm. The gills,

**Corresponding author: Email: attytej@gmail.com;*

liver and intestines of the fish specie were examined to assess the architecture of the organs. Results of haematology studies of *C. nigrodigitatus* revealed high values in the parameters measured. Red Blood Cell was higher than the White Blood Cell with mean value of (225.63±10.45 103/mm3) while Eosinophils recorded lowest parameters with mean value of (1.75±0.52%). Results of histology of gills, liver and intestines showed that the gill filaments were eroded with deformation of the cartilage core and also hyperplasia of the secondary lamellae. The intestines showed atrophy in a mucosal layer, hemorrhage and dilation within blood vessels and within serosa of mucosa and for liver, picnotic nucleus were shattered, the hepatocytes were ruptured and there was increased kupffer cell count as a result of exposure to pollutants. The results indicated that pollution level of the environment have significant impact on health status of fish.

Keywords: Chrysichthys nigrodigitatus; Ogbese River; haematology; histology.

1. INTRODUCTION

Fish is one of the most important animal protein sources that are widely consumed by all races and classes of people [1]. It compares favorably with milk, meat, pork and poultry [2]. Fish and fishery products are highly nutritious and are excellent sources of other dietary essentials like vitamins and minerals. Fish fat contains a high proportion of polyunsaturated fatty acids which may help to decrease the incidence of atherosclerosis and heart related diseases [3]. Fish also provide an important complement to the predominantly carbohydrate-based diet of many people in Nigeria [3].

The silver catfish *Chrysichthys nigrodigitatus* (Lacepede, 1803) is a highly valued food-fish included among the dominant commercial catches exploited in Ogbese river, Ondo State, Nigeria. It is restricted to the bottom of deep water, omnivorous; consume bivalves, detritus, chironomids, crustaceans and vegetable matter [4]. This fish can be raised in both fresh and brackish water environments.

Fish health can be adversely affected by temperature changes, habitat deterioration and aquatic pollution [5]. Hematological parameters are considered an important indicator of fish health status, and provide valuable information to assess the fish welfare [6]. Hematology is also used as an indicator of physiological and pathological changes in fish (Chekrabarty and Banerjee 1988, Martins et al. 2008). It can be affected by several factors including gonad maturation [7], dissolved oxygen alterations [8], gender [9], spawning and water temperature [10], lotic or lentic environment [11], handling stress and transportation [12], fish inflammation [13], size, feeding and stocking density [14], microbial infection and parasitism [15,6,16].

Ogbese region comprises Ogbese community and some neighboring agrarian settlements that sustain it with agricultural produce. The location of Ogbese in the rain forest zone in South Western Nigeria gives it a natural tendency of wood, timber and food production in the region. The community serves as an economic life wire of Akure North Local Government Area of Ondo State that produces food crops in large quantities. Despite these economic potentials, the town still remains a remote rural settlement in the State.

Pollution of the rivers examined in this study is mainly through run-off activities from agricultural practices and commercial activities. Many studies have shown that very large quantities of heavy metals are found in run-off associated with the operation of motor vehicles, atmospheric fallout and road surface materials [17]. To the environmental scientists, the ultimate concern of trace metal contaminants in receiving water is their toxic impact on aquatic organisms including fish species [18]. Assessing pollutants in different components of the ecosystem is an important task in preventing risk to natural life and public health. Pollutants entering these receiving waters by way of run-off conveyance systems, indiscriminate dumping of wastes e.t.c, may adversely impact many of the desired uses. The Ogbese community has undergone great economic development in recent years. In fact, it is notably one of the fastest growing, economically important communities in Ondo State and handles a considerable number of micro- industries. The very popular market (Ogbese market) and the timber business coupled with unequalled agricultural practices have drawn people from several cultural backgrounds in the country to make the settlement inter-tribal. This increase in anthropogenic activities surrounding the area has lead to an increase in environmental degradation. These multiple sources make it especially difficult to identify and isolate the risks associated with this contaminated water. Influence of water quality parameters, as well as monitoring of *C. nigrodigitatus* fish health due to the water quality are limited in the environment, [19].

2. MATERIALS AND METHODS

2.1 Study Area

The study site was Ayede, Ogbese River along Akure-Benin expressway in Ondo State. The area lies between E6°SE8° and longitude N4°N6°E. The river has its source from Ayede-Ekiti in Ekiti state and flows through Ogbese in Ondo State to Edo State. The Ogbese community is about 10km east of Akure, the Ondo state capital.

2.2 Collection of Water Samples

Water samples were collected using water samplers at 10 cm depth at three points locations from the river body, and parameters were determined using multi- parameter machine for Dissolved oxygen, temperature, turbidity, conductivity, and pH.

2.3 Collection of Fish

120 live *Chrysichthys nigrodigitatus* fish samples were collected by the assistance of fisherfolks using fish cage at Ogbese River from May to August, 2018. They were then transported alive in buckets containing water to the Marine Biology Laboratory of the Department of Fisheries and Aquaculture Technology, The Federal University of Technology, Akure.

2.4 Length-weight Measurement

The weight in grams (g) of each specimen was taken using a digital weighing balance, which was wiped dry between samples. Standard length was measured in centimeters (cm) using a meter ruler.

Condition factor of the fish was assessed to know the state of health being of the fish.

$$K = \frac{100 \text{ X } W}{L^3}$$

K = Condition Factor
W = Body Weight of Fish in gram (g)
L = Standard Length of Fish in centimeters (cm)

2.5 Haematological Analysis

Blood samples were taken from the caudal vein of each fish using a syringe and transferred to 5ml of Ethylene Diamine Tetraacetic Acid (EDTA) bottles. After blood collection in the laboratory, the samples were maintained on ice and sent to the laboratory of Animal Production and Health Technology, Federal University of Technology, Akure for hematological analysis.

The haematological parametres analysed were; Erythrocyte Sedimentation Rate Count (ESR), Packed Cell Volume Count (PCV), Red Blood Cell Count (RBC), Haemoglobin Concentration (Hgb), White Blood Cell Count (WBC), Lymphocyte Count, Neutrophils Count, Monocytes Count, Basophils Count, Eusonophils Count. Mean Corpuscular Volume (MCV), Mean Corpuscular Haemoglobin (MCH) And Mean Corpuscular Haemoglobin Concentration (MCHC) were calculated according to [20].

The Haemoglobin was calculated as: Hb (g/100 ml) = Absorbance of test x Concentration of standard Absorbance of Total erythrocyte (RBC)

Red Blood Cell and White Blood Cell counts were calculated thus; = C x D x 4000

Where;

C = dilution factor (20)
D = number of cells counted

Hematocrit/ PCV = (Volume of packed red blood cell/ Volume of whole blood) X 100

White blood cell (WBC) = %WBC X total WBC + thrombocytes counts

The red cell indices – MCHC, MCH and MCV were derived thus;

Mean Cell Hemoglobin Concentration (MCHC) = (Hemoglobin (g/100 ml) / PCV (%)) X 100

Mean Corpuscular Haemoglobin (MCH) = (Hemoglobin (g/100 ml) / RBC (x10,000rbc/mm^3)) X 100

Mean Cell Volume (MCV) = (PCV/ RBC (x10,000 rbc/mm^3))X 100

2.6 Histological Analysis

The fish were dissected to collect gills, intestines and livers specimens to determine the health status of the fish. specimens were removed and rinsed in distilled water to remove blood stains. Histological Analysis was carried out according to Humason, [21]. The tissues were washed in 0.90% NaOH to remove the adherence of mucous and blood; and kept on blotting paper to drain the moisture. The samples were fixed in physiological saline solution for 24 hours. Tetra hydrofuron was used as dehydrating and clearing agent. Section of 6μ thickness were selected from respective specimens to observed histology changes by adding haematoxylin and Eosin counter stain. The results were expressed in photomicrograph.

2.7 Statistical Analysis

Data collected were analyzed using one-way ANOVA. Further tests were done using Duncan Multiple Range Test. And test of significance(s) was done at P >0.05.

3. RESULTS AND DISCUSSION

3.1 Physico-chemical Parameters of Water from River Ogbese

The physicochemical properties of water obtained from River Ogbese are presented in Table 1.

Table 1. Physico-chemical parameters of water from River Ogbese

Parameters	Range		EPA 2003 Standards and Limits
DO (mg/l^{-1})	5.80 – 7.99	6.98 ± 0.15	4.00 – 6.50
Turbidity (NTU)	67.00– 97.00	78.50 ± 13.53	50.00 (instantaneous); 25.00 (over 10 days); 10.00 (over a long time).
Temperature (°C)	26.44 – 30.64	27.70 ± 0.18	25°C – 30°C
Conductivity (μmhos/cm)	119.0– 178.0	148.35 ± 27.98	50 – 1500 (general range); 150 – 500 (good mixed fisheries)
Ph	6.81-8.12	7.36 ± 0.22	6.50 – 9.00

Table 2. Morphometric characteristic of *Chrysichthys nigrodigitatus* obtained from river ogbese

Length / Weight Relationship	Measurement
Length (cm)	25.64 **±** 2.09
Weight (g)	148.15 **±** 28.56
Condition Factor (K)	0.88
Intercept (a)	2.08
Slope (b)	2.29
Coefficient of determination (r^2)	0.64

Table 3. Haematological Profile of *Chrysichthys nigrodigitatus* from River Ogbese

Parameters	May	June	July	August
ESR	$3.50±0.71^a$	$4.00±0.78^a$	$3.75±0.42^a$	$4.00±0.00^a$
PCV (%)	$24.50±0.71^a$	$22.50±0.41^a$	$23.50±1.41^a$	$24.50±0.28^a$
RBC (μL)	$237.00±8.49^a$	$218.00±4.24^b$	$219.50±9.19^b$	$228.00±11.31^c$
WBC (μL)	$123.00±7.07^a$	$113.50±2.12^b$	$115.50±13.44^b$	$113.50±10.61^b$
Hb (gdL-1)	$8.15±0.21^a$	$7.80±0.42^a$	$8.00±0.28^a$	$8.50±0.21^a$
Lymphocytes	$59.00±1.41^a$	$50.00±0.00^a$	$55.00±1.41^a$	$59.50±2.12^a$
Neutrophils	$25.00±0.00^a$	$34.00±2.83^a$	$22.50±2.12^{ab}$	$23.00±4.24^{ab}$
Monocytes	$12.50±1.41^a$	$12.00±2.83^a$	$13.50±2.12^a$	$13.00±1.41^a$
Basophils	$2.00±0.71^a$	$2.50±0.91^a$	$2.00±0.41^a$	$2.50±0.71^a$
Eosinophils	$1.50±0.71^a$	$1.00±0.71^a$	$2.50±0.71^a$	$2.00±0.00^a$
MCHC (gdL-1)	$33.27±0.09^a$	$33.19±0.21^a$	$33.19±0.29^a$	$33.27±0.16^a$
MCH	$3.44±0.03^a$	$3.58±0.06^a$	$3.56±0.02^a$	$3.50±0.10^a$
MCV (pg)	$10.34±0.07^a$	$10.78±0.11^a$	$10.71±0.13^a$	$10.75±0.23^a$

Values on the same row with the same superscript alphabet are not significantly different. N = 30

Histology of the Gills

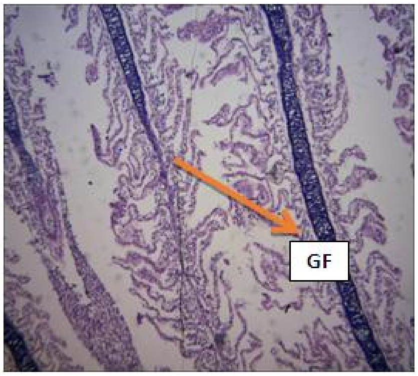

Plate 1. The gill filaments showed eroded cartilage
Magnification; x 100

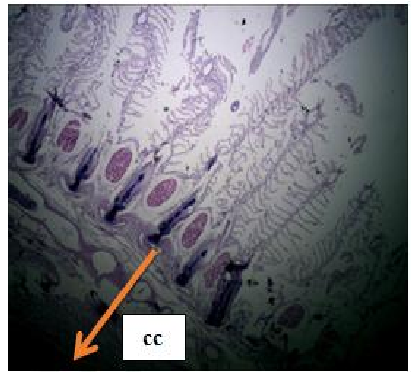

Plate 2. There is a deformation of the core
Magnification; x 100

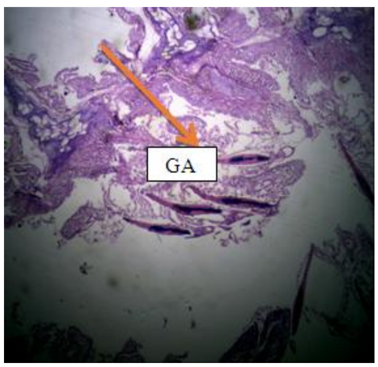

Plate 3. The gill arch and gill filaments are showing visible signs of lesions
Magnification; x400

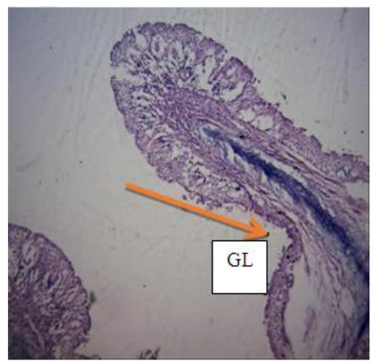

Plate 4. There is hyperplasia of the eroded secondary lamellae
Magnification; x 400

Histology of the Intestines

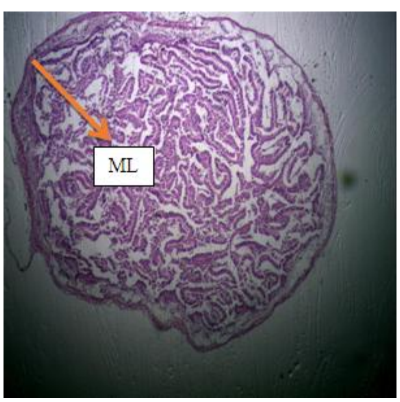

Plate 5. Shows atrophy in a mucosal layer
Magnification; x 100

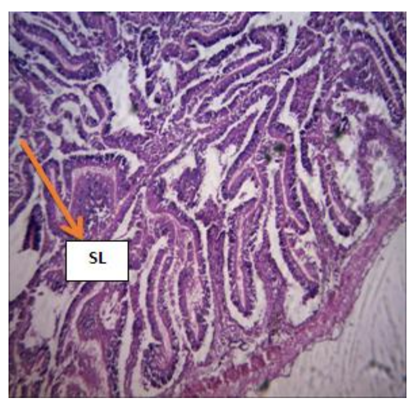

Plate 6. Intestine shows sign of haemorrhage
Magnification; x 100

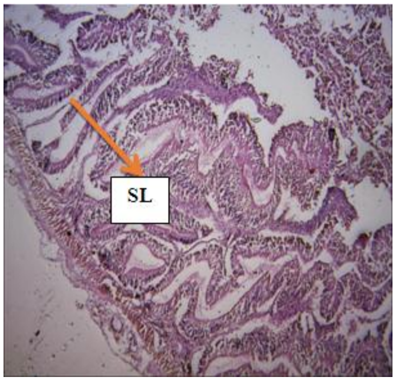

Plate 7. Shows hemorrhage and dilation within blood vessels and within serosa of mucosa
Magnification; x400

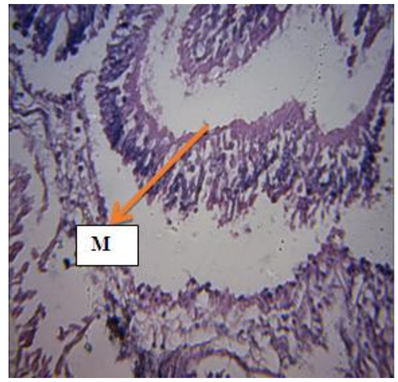

Plate 8. Shows severe degeneration and necrosis of mucosal membrane of intestine
Magnification; x400

Histology of the Livers

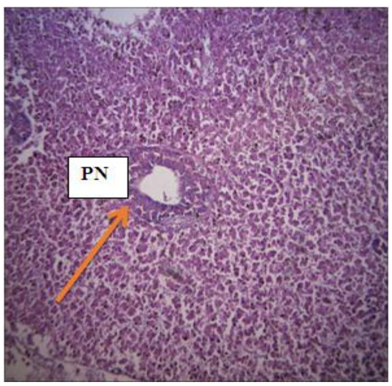

Plate 9. The picnotic nucleus are shattered
Magnification; x 100

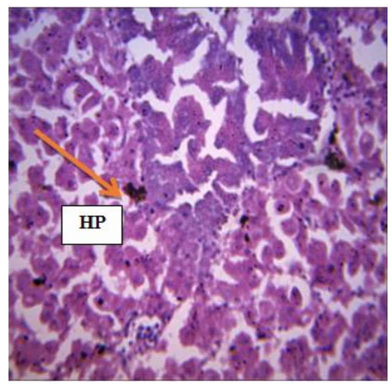

Plate 10. The hepatocytes are ruptured
Magnification; x 100

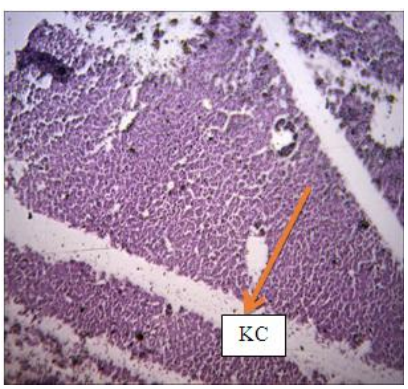

Plate 11. There is increased kupffer cells
Magnification; x400

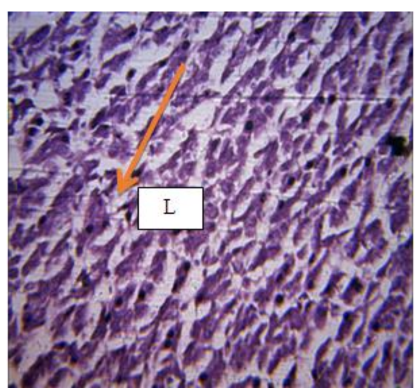

Plate 12. Visible lesions seen
Magnification; x400

GF= Gill Filaments, CC= Cartilage Core, GA= Gill Arch, GL= Gill Lamellae, ML= Mucosa Layer, SL= Serosa Layer, PN= Picnotic Nucleus, KC= Kupffer Cell, L = Lesion

Table 4. Range and mean haematological profile of *Chrysichthys nigrodigitatus* from river ogbese

Parameter	Range	Mean±SD	SR
ESR (mm)	3.00–4.00	3.81±0.35	4-10
PCV (%)	23.00-25.00	23.75±0.76	21-26
RBC ($10^3/mm^3$)	213.00–243.00	225.63±0.45	200-250
WBC ($10^3/mm^3$)	106.00-128.00	116.38±8.19	100-150
Hb (g/100ml)	7.60–8.30	8.11 ±0.27	5-10
Lymphocytes	58.00–61.00	55.88±1.19	64-80
Neutrophils (%)	20.00-26.00	26.13±2.33	25-30
Monocytes (%)	10.00–15.00	12.75±1.69	10-20
Basophils (%)	2.00–3.00	2.25±0.53	2-5
Eosinophils (%)	1.00–2.00	1.75±0.52	1-2
MCHC (gdL-1)	33.04–33.33	33.23±0.13	30-45
MCH (pg)	3.40–3.60	3.52±0.07	5-10
MCV (pg)	10.20–10. 90	10.65±0.22	10-15

Data are presented as Means ± S.D. ESR =Erythrocyte Sedimentation Rate, PCV =Packed Cell Volume, HB =Haemoglobin, RBC =Red Blood Cell, WBC =White Blood Cell, MCV =Mean Corpuscular Volume, MCHC =Mean Cell Haemoglobin Concentration, MCH =Mean Cell Haemoglobin. S.R = Standard Range (Eisler,1965)

3.2 Length, Weight, Condition Factor (K) and LWR of Chrysichthys Nigrodigitatus

Length (cm), Weight (g), Length / Weight Relationship and Condition factor (K) of *C. nigrodigitatus* obtained at River Ogbese are shown in (Table 2). The average body weight of *Chrysichthys nigrodigitatus* used was 148.15 ± 36.53 g which ranged from 106 g – 185 g, while the average body length was 25.64 ±2.86 cm ranging between 23 cm – 30 cm. The condition factor was 0.88. The "b" values of the fish were not equal to 3, hence growth in the individual species was allometric (i.e. b values were less/greater than 3) showing that the rate of increase in body length is not proportional to the rate of increase in body weight.

3.2.1 Haematological Parameters of *Chrysichthys nigrodigitatus*

Obtained from River Ogbese Tables 3 and 4 showed haematology characteristics of the *Chrysichthys nigrodigitatus.* The result showed high values in parameters measured, as compared to standard normal healthy fish haematology in unpolluted environment. Red Blood Cell was higher than the White Blood Cell count with mean value of (225.63±10.45). Eosinophils recorded the lowest count with mean value of (1.75 ±0.52).

3.2.2 Histology of *Chrysichthys nigrodigitatus*

Results of histology of gills, liver and intestines of *Chrysichthys nigrodigitatus* are given in the Plates 1 - 12 below. The gill filaments were eroded with deformation of the cartilage core and also hyperplasia of the secondary lamellae. The intestines showed atrophy in a mucosal layer, hemorrhage and dilation within blood vessels and within serosa of mucosa. Liver histology revealed shattered picnotic nucleus, ruptured hepatocytes and increased kupffer cells.

4. DISCUSSION

Results of physico-chemical parameters of water obtained in this study were within the tolerable range of fish as recommended by WHO [22,23] except for DO. The result was similar to the reports of Ansa (2004) on the benthic macrofauna of the Andoni flats in the Niger Delta Area of Nigeria, Chindah et al. [24] on effect of municipal waste discharge on the physico-chemical andphytoplankton in a brackish wetland in Bonny Estuary, and Ladipo et al. [25] on seasonal variations in physico-chemical properties of water in some selected locations of Lagos Lagoon who opined that waters with little change in physico-chemical parameters are generally more conducive to aquatic life. Most organisms including *C. nigrodigitatus* do not tolerate wide variations in physico-chemical parameters and if such conditions persist, death may occur. High oxygen demand experienced in this study is in line with Adebayo et al. [26] observation.

Ujjania et al. [27] opined that condition factor greater or equal to one is good, indicating a good level of feeding, and proper environmental condition. Mean K-values gotten from this study

(0.88) were less than one (1), hence revealing that the species fell slightly from being unhealthy. This support the report of Getso et al. [28] who worked on the Length-Weight Relationship and Condition factor of *C. gariepinus* and *O. niloticus* of Wudil River, Kano, Nigeria, and obtained condition factor less than one (1). Also feeding intensity, availability of food, fish-size, age, sex, season, stage of maturation, fullness of the gut, degree of muscular development and amount of reserved fat [29] also have influence on K factor of fish.

The observation of absolute Isometric growth (b = 3) in nature is occasional [30] and deviation from isometric growth is often observed in most aquatic organisms which changes shape as they grow [31]. The difference in the length-weight relationship also agrees with the report of Olurin and Aderibigbe [32] who stated that the differences may be due to sex and developmental stages of fish.

Mean heamotocrit value of *C. nigrodigitatus* was 23.75±0.76% which did not differ considerably from those found by Badawi and Said 1971 and Etim et al., [33]. The Red Blood Cell count had a mean value of 225.63 x $10^6 mm^3$ ± 10.45 x 10^6 mm^3. The Packed cell volume (PCV) had a mean value of 23.75±0.76%. Heamoglobin concentration had a mean value of 8.11±0.27g/dl. The mean haemoglobin value is low which may be due to the exposure of fish to pollutants resulting in inhibitory effect of those substances on the enzyme system responsible for the synthesis of haemoglobin according to Pamila et al., [34]. The low heamoglobin value obtain in blood assessed from *C. nigrodigitatus* from the water body may also be associated with less active fishes. Similar results were reported by Engel and Davis, (1964) and Rambhaskar and Rao, (1987). Eisler, [35] suggested that there was a correlation between haemoglobin concentration and the activity of the fish. The more active fishes tend to have higher haemoglobin values than the more sedentary ones. The high erythrocyte number was associated with fast movement, predaceous nature and high activities with streamlined body [36]. A fall in hematological parameters count, Hb% and PCV%, in the fishes, due to water pollution, has been reported along with acute anemia [37]. According to Singh et al. [38] the discharge of waste may cause serious problems as they impart odour and can be toxic to aquatic animals. The organic wastes present in Ogbese river seem to cause stress in the fish and as such seem to be responsible for the changes in the hematological parameters. The PCV or haematocrit is an important tool for determining the amount of plasma and corpuscles in the blood (measurement of packed erythrocytes) and is used to determine the oxygen carrying capacity of blood ([39]. Hematocrit or PCV in the present study is low compared to the works of Joshi et al. [10] and Banerjee and Banerjee [40] have suggested that pollutant exposure decreases the TEC count, Hb content and PCV value due to impaired intestinal absorption of iron.

There were variations in WBC quantity and leukocyte cell proportions (neutrophil, monocyte) in the fish specimens. The implication of this result is that the fish has been able to defend itself from invading pathogens both by cell and antibody-mediated responses [41]. Similar results were obtained by Sahan and Cengizler, [42] on carp caught from different regions of Seyhan River. Leukocytosis is directly proportional to severity of stress condition in maturing fish and is a result of direct stimulation of immunological defense due to the presence of pollutants in water bodies. This is in conformity with the report of Saravanan and Harikrishnan et al. [43] in freshwater fish, *Sarotherodon mossambicus*, when exposed to sublethal concentration of copper and endosulfan and by Nanda, [44] in respect of *Heteropneustes fossilis* during nickel intoxication. This may be attributed to alteration in blood parameters and direct effects of various pollutants. The lymphocytes are reported to be responsible for immune response [45], while neutrophils are reported to show the greatest sensitivity to change in the environment. Their characterization and identification revealed significance for assessing the changes in the physiological state of fishes.

Marked variations like hyperplasia, vacuolation, deformation of cartilage core, bubbling of gill filament, epithelial lifting, lamellar fusion; secondary lamellar damage, shorter secondary lamellae and erosion of secondary lamellae were noticed in the gill tissues of *C. nigrodigitatus* collected from river Ogbese. Similar results were obtained by several works: Fernandes and Mazon, [46,47,48] as they revealed alterations like aneurysm, mucous deposition, hypertrophy, fusion of secondary lamellae, ruptured epithelial layer, lifting of primary lamellae, lamellar swelling and necrosis. Through the gills, as the main site of xenobiotic transfer, the toxins are distributed through their bodies accumulating in tissues and organs and may have deleterious effects, [49].

The extent of liver damage observed in the present investigation indicates that chronic exposure always causes impairment to the architecture of the tissue. Since liver is involved in detoxification of pollutants [50], it is susceptible to a greater degree of disruption in its structural organization due to toxic stress. Some distinct changes like rupture of hepatocytes, melanomacrophages, increased Kupffer cell, increased pyknotic nucleus, vacuolation, ruptured nucleus, Blood congestion, cytoplasmatic vacuolation and nucleus disorganization were observed in the liver of fish; revealing environmental status impart on fish species. Macrophage aggregates have been suggested as potentially sensitive histological biomarkers and or immunological biomarker of contaminant exposure [51]. Histological changes observed in various studies in liver taken from the fishes exposed to pollutants include increased vacuoles in the cytoplasm, changes in nuclear shapes, focal area of necrosis (death of cells in a localized area), ischemia (blockage of capillary circulation), hepatocellular shrinkage, and regression of hepatocytic microvilli at the bile canaliculi, fatty degeneration and loss of glycogen. Marchand et al. [52] reported that histopathological changes of fish liver from polluted freshwater system shows structural alterations in hepatic plates or cords, multiple focal areas of cellular alterations leading to a loss of uniform hepatocyte structure, steatosis, cytoplasmic and nuclear alterations (hypertrophic and pyknotic nuclei) of hepatocyte, increase in the size of melanomacrophage centers (MMCs), and focal areas of necrosis. The results from this study also agrees with the result of microscopic examination of liver specimens from Lagos and Ologe Lagoon which were consistent with the findings of Olarinmoye et al. [53] in which liver of *C. nigrodigitatus* from Lagos lagoon showed several alterations including vacuolar hepatocellular degeneration and hepatic necrosis.

Histology of the Intestine in the study revealed visible sign of lesions. Although, uptake of metals occurs mainly through gills, it may also occur via intestinal epithelium. Histopathological alterations in the intestine of *C. nigrodigitatus* included severe degenerative and necrotic changes in the intestinal mucosa and sub mucosa, atrophy in the muscularis and sub mucosa and aggregations of inflammatory cells in the mucosa and sub mucosa with edema between them. These findings are in agreement with those of Hanna et al. [54,55,56,57], who opined that pollutants and contaminants affects gills by epithelial lifting, hyperplasia of epithelial cells and blood congestion within filaments and in liver tissue produced hemolysis between hepatocytes, cytoplasmic degeneration and necrosis. Whereas an aggregation of inflammatory cells, edema in an intestinal mucosal layer and hemorrhage between blood vessels were the main alterations observed in the intestine, the changes seemed to be more pronounced in the liver and gills rather than the intestine.

5. CONCLUSION

Human activities including industrialization and agricultural practices contributed immensely in no small measure to the degradation and pollution of aquatic environment which adversely has effects on the water bodies that is a necessity for life. Since water pollution has direct consequences on human well beings, an effective teaching strategy in the formal education sector is essential for aquatic health Regulation and monitoring, are effective ways of pollution management; therefore, policy makers and stakeholder have to attain agreement on strategies to be adopted in ensuring health aquatic environment. The need to enact legislation to regulate various types of pollution as well as to mitigate the adverse effects of pollution.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Abolude DS, Abdullahi SA. Proximate and mineral contents in component parts of *Clarias gariepinus* and *Synodontis schall* from Zaria, Nigeria. Nigerian Food Journal. 2005;23:1-8.
2. James O. The production and storage of dried fish. In: FAO Fisheries Report (ITALY). 1984;279.
3. Akande GR. Fish processing technology in Nigeria: Challenges and prospects. In: Aiyeloja AA, Ijeomah HM. (Eds.). Book of Reading in Forestry, Wildlife Management and Fisheries. Topbase Nigeria Ltd. New Oko Oba, Lagos. 2011;772-808.
4. Bankole NO, Yem IY, Olowosegun OM. Fish resources of Lake Kainji, Nigeria. In: Raji A, Okaeme N, Ibeun MO (Eds.). Forty

Years on Lake Kainji. Fisheries Research, NIFFR, New Bussa, Nigeria. 2011;20-42.

5. Skouras A, Broeg K, Dizer H, Von Western Hagen H, Hansen P, Stein Hagen D. The use of innate immune responses as biomarkers in a programme of integrated biological effects monitoring on flounder (*Platichthys flesus*) from the southern north-Sea. Helgol. Marine Resources. 2003;57:190–198.
6. Azevedo TMP, Martins MI, Bozzo FR, Moraes FR. Haematological and gill responses in parasitized tilapia from valley of Tijucas River, SC, Brazil. Sci Agric. 2006;63(2):115-120.
7. Ranzani-Paiva MJ, Godinho HM. *Estudos hematológicos* do curimbatá, *Prochilodus scrofa* Steindachner, 1881 (Osteichthyes, Cypriniformes, Prochilodontidae). Série vermelha. Bol Inst Pesca. 1985;12(2):25-35.
8. Ranzani-Paiva MJ, Silva-Souza AT, Pavanelli GT, Takemoto RM, Eiras AC. Haematological evaluation in commercial fish species from the floodplain of the upper Paraná River, Brazil. Acta Science. 2000;22:507-513.
9. Lusková V. Factors affecting haematological indices in free-living fish populations. Acta Vet Brno. 1998;67:249-255.
10. Joshi PK, Bose M, Harish D. Haematological changes in the blood of *Clarias batrachus* exposed to mercuric chloride. Journal of Ecotoxicology and Environmental Monitoring. 2002;12:119-122.
11. Val AL, Schwantes AR, Almeida-Val VMF, Schwantes MLB. Hemoglobin, hematology, intraerythrocytyc phosphates and whole blood bohr effect from lotic and lentic *Hypostomus regani* populations (São Paulo-Brazil). Composition of Biochemical Physiology. 1985;80B(4):737-741.
12. Gbore FA, Oginni O, Adewole AM, Aladetan JO. The effect of transportation and handling stress on hematology and plasma biochemistry in fingerlings of *Clarias gariepinus* and *Tilapia zillii*. World Journalof Agricultural Sciences. 2006;2(2):208-212.
13. Martins MI, Moraes FR, Fujimoto RY, Onaka EM, Bozzo FR, Moraes JRE. Carrageenin induced inflammation in *Piaractus mesopotamicus* (Osteichthyes: Characidae) cultured in Brazil. Bol Inst Pesca. 2006;32(1):31-39.
14. Rey Vázquez G, Guerrero GA. Characterization of blood cells and hematological parameters in *Cichlasoma dimerus* (Teleostei, Perciformes). Tissue and Cell. 2007;39:151-160.
15. Martins MI, Tavares-Dias M, Fujimoto RY, Onaka EM, Nomura DT. Haematological alterations of *Leporinus macrocephalus* (Osteichtyes: Anostomidae) naturally infected by *Goezia leporini* (Nematoda: Anisakidae) in fish pond. Arq Bras Medicine, Vetinary Zootechnique. 2004;56(5):640-646.
16. Jamalzadeh HR, Keyvan A, Ghomi MR, Gherardi F. Comparison of blood indices in healthy and fungal infected *Caspian salmon* (Salmo trutta caspius). African Journal Biotechnology. 2009;8(2):319-322.
17. Harper HH. Fate of heavy metals from runoff in storm water management systems. Ph.D. Dissertation, University of Central Florida, Orlando, Florida; 1985.
18. Sutherland RA, Tolosa CA. Multi-element analysis of road deposited sediment in an urban drainage basin, Honolulu, Hawaii. Environmental Pollution. 2000;110:483-495.
19. Ogunola OS, Onada OA, Falaye AE. Ecological risk evaluation of biological and geochemical trace metals in Okrika Estuary. International Journal of Environmental Research. 2017;11(2):149–173.
20. Houston AH. Blood and circulation. In: Schreck CB, Moyle PB (Eds), Methods in fish biology. Am Fish Soc, Bethesda, Maryland. 1990;273-334.
21. Humason GL. Animal tissue techniques. Los Alamos Scientific laboratories, San Francisco, W.H. Freeman. 1962;492.
22. World Health Organisation. Water quality surveys: A guide for the collection and interpretation of water quality data; Studies and Reports in Hydrology N 23, UNESCO/WHO; 2001.
23. World Health Organisation. Meeting the MDG drinking water and sanitation target: The urban and rural challenge of the decade. Guidelines for drinking water quality; Geneva; 2006. Available:http://www.who.int/water_sanitation_health/monitoring/jmpfi nal
24. Chindah AC. The effect of industrial activities on the periphyton community at theupper reaches of New Calabar River, Niger Delta, Nigeria. Water Resources. 1998;32(4):1137–1143.

25. Ladipo MK, Ajibola VO, Oniye SJ. Seasonal variations in physicochemical properties of water in some selected locations of the Lagos Lagoon. Science World Journal. 2011;6(4):5-11.
26. Adebayo OT, Fagbenro OA, Ajayi CB, Popoola OM. Normal haematological profile of *Parachanna obscura* as a diagnostic tool. Aquaculture International Journal of Zoological Research. 2007;3(4):193–199.
27. Ujjania NC, Kohli MPS, Sharma LL. Length-weight relationship and condition factors of Indian major carps (*C. catla*, *L. rohita* and *C. mrigala*) in Mahi Bajaj Sagar, India. Research Journal of Biology. 2012;2(1):30-36.
28. Getso BU, Abdullahi JM, Yola IA. Length-weight relationship and condition factor of *Clarias gariepinus* and *Oreochromis niloticus* of Wudil River, Kano, Nigeria. Journal of Tropical Agriculture, Food, Environment and Extension. 2017;16(1):1-4.
29. Gupta S, Banerjee S. Length-weight relationship of *Mystus tengara* (Ham.-Buch., 1822), a freshwater catfish of Indian sub-continent. International Journal of Aquatic Biology. 2015;3(2):114-118.
30. Bassey EA, Ricardo PK. Seasonality in growth of *Fundulopanchax gardneri* (Bolenger) in Mfangmfang pond in Uyo, Nigeria. The Zoologist. 2003;2:68-75.
31. Thomas J, Venus S, Kurup BM. Length-weight relationship of some deep-sea fishes inhabiting the continental slope beyond 250m depth along west coast of India. Naga. ICLARM Q. 2003;26:17-21.
32. Olurin KB, Aderibigbe OA. Length-weight relationship and condition factor of pond reared juvenile *Oreochromis niloticus*. World Journal of Zoology. 2006;1(2):82-85.
33. Etim NN, Williams ME, Akpabio U, Offiong EE. Haematological parameters and factors affecting their values. Scientific Education Centre N Am. 2013;2:37–47.
34. Pamila D, Subbaiyan PA, Ramaswamy M. Toxic effect of chromium, and cobalt on *Sartherodon mossambicus* (peters). Indian Journal of Environmental Health. 1991;3:218-224.
35. Eisler R. Erythrocyte count and haemoglobin content of nine species of marine teleosts. Chesapeake Sci. 1965;6:116–120.
36. Satheeshkumar P, Senthilkumar D, Ananthan G, Soundarapandian P, Khan AB. Measurement of hematological and biochemical studies on wild marine carnivorous fishes from Vellar estuary, Southeast coast of India Composition of Clinical Pathology. 2011;20:127-134.
37. Singh M. Haematological responses in a freshwater teleost *Channa punctatus* to experimental copper and chromium poisoning. Journal of Environmental Biology. 1995;16:339-341.
38. Singh KD, Srivastava B, Sahu A. Non-conventional absorbents for fresh water treatment containing phenolic compounds. Proceedings of the 22nd Annual Meeting American Society for Reproductive Immunology, June 6-9, 2002, Chicago, IL. 2002;73-74.
39. Larsson A, Haux C, Sjobeck ML. Fish physiology and metal pollution: Results and experiences from laboratory and field studies. Ecotoxicology and Environmental Safety. 1985;9:250-281.
40. Banerjee V, Banerjee M. Effect of heavy metal poisoning on peripheral hemogram in fish fossilis (Bloch) mercury, chromium and zinc chlorides (LC_{50}). Composition of Physiology and Ecology. 1998;13:128-134.
41. Kumar S, Lata S, Gopal K. Deltamethrin induced physiological changes in freshwater cat fish *Heteropneustes fossilis*. Bulletin of Environmental Contamination Toxicology. 1999;62:254-258.
42. Sahan A, Cengizler I. Determination of some haematological parameters in spotted barb (*Capoeta barroisi* Lortet, 1894) and roach (*Rutilus rutilus*, Linnaeus, 1758) living in Seyhan river (Adana city region)]. Turkish Journal of Veterinary and Animal Science. 2002;26:849-858.
43. Harikrishnan K, Sabu Thomas, Sanil George, Poul Murugan Satbjsh R, Sathish Mundayoor, Das MR. Pollution Research. 1999;18(3):261-269.
44. Nanda P. Haematological changes in the common Indian cat fish *Heteropneustes fossilis* under nickel stress. Journal of Ecobiology. 1997;9:243-246.
45. Cazenave J, Wunderlin DA, Hued AC, de los Angeles Bistoni M. Haematological parameters in a neotropical fish, *Corydoras paleatus*, (Jenyns, 1842) (Pisces, Callichthyidae), captured from pristine and polluted water. Hydrobiologia. 2005;537:25-33.
46. Fernandes MN, Mazon AF. Environmental pollution and fish gill morphology. In: Val

AL, Kapoor BG (Eds.). Fish adaptations. Enfield, Science Publishers. 2003;203-231.
47. Simonato JD, Guedes LB, Martinez BR. Biochemical, physiological and histological changes in the neotropical fish *Prochilodus lineatus* exposed to diesel oil. Ecotoxiciology and Environmental Safety. 2008;69:112-120.
48. Rajeshkumar S, Karunamurthy D, Halley G, Munuswamy N. An integrated use of histological and ultra-structural biomarkers in *Mugil cephalus* for assessing heavy metal pollution in east Berbice- Corentyne, Guyana. International Journal of Bioassays. 2015;4(11):4541-4554.
49. Vasanthi LA, Revathi P, Mini J, Natesan MN. Integrated use of histological and ultra structural biomarkers in *Mugil cephalus* for assessing heavy metal pollution in Ennore estuary, Chennai, Chemosphere. 2013;91:1156-1164.
50. Lagadic L, Amiard JC, Caquet T. Biomarkers and evaluation of the ecotoxicological impact of pollutants. In: Lagadic L, Caquet T, Amiard JC, Ramade F. Use of biomarkers for environmental quality assessment. Science Publishers, Enfield (NH) USA. 2000;475.
51. Schmitt CJ, Dethloff GM. Biomonitoring of environmental status and trends (BEST) program: Selected methods for monitoring chemical contaminants and their effects in aquatic ecosystems. Information and Technology Report USGS/BRD-2000-0005.Columbia, (MO):U.S; 2000.
52. Marchand MJ, Dyk JCV, Barnhoorn IEJ, Wagenaar GM. Histopathological changes in two potential indicator fish species from a hypereutrophic Freshwater ecosystem in South Africa: A baseline study; 2012.
53. Olarinmoye O, Taiwo V, Clarke E, Kumolu-Johnson C, Aderinola O, Adekunbi F. Hepatic pathologies in the brackish water catfish (*Chrysichthys nigrodigitatus*) from contaminated locations of the Lagos lagoon complex. Appl. Ecol. Environ. Res. 2009;7:277–286.
54. Hanna MI, Shaheed IB, Elias NS. A contribution on chromium and lead toxicity in cultured *Oreochromis niloticus*. Egyptian Journal of Aquatic Biology of Fish. 2005;9:177-209.
55. Bashir N. Bioaccumulation of heavy metals in organs of *Labeo rohita* and *Cyprinus carpio*. BS thesis, Department of Zoology, GC University, Faisalabad; 2010.
56. Yousafzai AM, Douglas P, Khan AR, Ahmad I, Siraj M. Comparison of heavy metals burden in two freshwater fishes, *Wallago attu* and *Labeo dyocheilus* with regard to their feeding habits in natural ecosystem. Pakistan Journal of Zoology. 2010;42:537-544.
57. Soufy H, Soliman M, El-Manakhly E, Gaafa A. Some biochemical and pathological investigations on mono sex Tilapia following chronic exposure to carbofuran pesticides. Global Veterinary. 2007;1:45-52.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle3.com/review-history/48533