



FRESHWATER

BIOLOGICAL ASSOCIATION OF NIGERIA
(FBN)



3rd

ANNUAL
CONFERENCE
2021

BOOK OF
PROCEEDINGS



THEME:

HARNESSING FRESHWATER RESOURCES
FOR SUSTAINABLE DEVELOPMENT IN A
CHANGING CLIMATE AND
ECONOMIC DIVERSIFICATION

 **Date:** 12th – 16th
September, 2021

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Main Campus, Nnamdi, Uyo, Akwa Ibom State, Nigeria.

**THE FRESHWATER BIOLOGICAL ASSOCIATION
OF NIGERIA (FBAN)**



3RD NATIONAL ANNUAL CONFERENCE

12TH – 16TH SEPTEMBER, 2021

THEME

**Harnessing Freshwater Resources
for Sustainable Development in a
Changing Climate and Economic
Diversification**

BOOK OF PROCEEDINGS

**UNIVERSITY OF UYO, AKWA-IBOM STATE,
NIGERIA**

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FRESHWATER BIOLOGICAL ASSOCIATION OF NIGERIA (FBAN)

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12TH - 16TH SEPTEMBER, 2021**

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INDUCTION OF MICROCYTIC-HYPOCHROMIC ANAEMIA IN *Clarias gariepinus* (BURCHELL, 1822) EXPOSED TO SUB-LETHAL CONCENTRATIONS OF 1, 1-DIMETHYL 4, 4-BIPYRIDILLIUM DICHLORIDE (PARAQUAT) UNDER LABPRATORY CONDITIONS

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ABSTRACT

Microcytic-hypochromic anaemia was induced in *Clarias gariepinus* (Burchell, 1822) at intervals of 1, 7 and 14 days. Experimental fish were exposed to test water separately diluted with sub-lethal concentrations of paraquat of 0, 0.06, 0.07, 0.09 and 0.12mg/L. 14 days' exposure to the sub-lethal concentrations of the toxicant resulted in microcytic-hypochromic anaemia in the exposed fish. Blood indices attributable to microcytic-hypochromic anaemia was observed with a significant ($p < 0.05$) decrease in haemoglobin, haematocrit, red blood cells, Mean corpuscular volume (MVC), Mean corpuscular haemoglobin (MCH), Mean corpuscular haemoglobin concentration (MCHC), white blood cells, lymphocytes, monocytes, Neutrophils and eosinophil compared with the fish in the control test.

Keywords: Toxicity, paraquat, *Clarias gariepinus*, microcytic-hypochromic and anaemia

INTRODUCTION

Determination of the toxic compounds in aquatic environments and their effects on aquatic organisms is a fundamental issue in ecotoxicological studies (Bagheri, 2007). One of the main causes of pollution of aquatic ecosystems is agricultural pesticide, which is used to deal with pests, weeds and agricultural diseases and they have adverse effects on the environment (Bahmani *et al.*, 2001). Within a few weeks of using these pesticides in agricultural activities, they entered to aquatic ecosystems through surface runoff and subsurface drainage (Abubakar *et al.*, 2019). Herbicides are generally used by farmers to control weeds, remove aquatic plants in rivers, lakes and water reservoirs, which generally have harmful effects on aquatic animals' health (Abubakar *et al.*, 2019). Fish is directly associated with the aquatic environment, hence, the incidence of physical and chemical changes in the aquatic environment quickly leads to measurable physiological changes in fish (Adhikari *et al.*, 2004). In recent years, the incidence of mortality due to pesticides, industrial effluents and sewage contamination has been reported in Iran (Agha *et al.*, 2012). One of the most important and reliable indicators for the health assessment and fish physiology is measurement of blood parameters which are influenced by the nutritional and environmental factors (Abubakar, 2016). Blood characteristics of fish are one of the most important evidences of their physiological processes and reflect the relationship between aquatic ecosystem characteristics and their health status (Osman and Kious, 2010). Having a normal range of fish blood parameters can be used as a bio-indicator (Abubakar, 2013). Changes in blood parameters in response to environmental conditions are response to environmental stress and can be considered as an important bio-indicator (Verma and Agarwal, 2007). Use of hematology parameters is expanding in aquaculture activities, particularly in toxicology researches, environmental monitoring and evaluation of aquatic animal health (Verma and Agarwal, 2007). There are few documented reports of effects of paraquat on the health status of fish. Paraquat (1,1-dimethyl-4, 4 Bipyridinium dichloride) is a non-selective contact herbicide. It acts in the presene of light which it absorbs at 260nm, to deslocate the green parts of all plants with which it comes in contact (Abubakar *et al.*, 2019). Paraquat is an herbicide that is used to destroy the weeds in tropical regions and it enters to aquatic ecosystems (Bahmani *et al.*, 2008). Paraquat is used in different parts of Iran with different climatic conditions and different agricultural activities, and the proposed amount of the herbicide is three liters per hectare for sugarcane plantations (Banasee *et al.*, 2008). The African catfish (*Clarias gariepinus*) is an ecologically important and commercially valued fish in Nigeria (Abubakar *et al.*, 2019). These mudfish are frequently and widely cultured in Nigeria waters including ponds (Abubakar *et al.*, 2019). There is paucity of information on toxicity of paraqua (1,1-dimethyl-4, 4 Bipyridinium dichloride) on catfish by the local fishermen. The aim of the present study was to determined microcytic-hypochromic anaemia in *Clarias gariepinus* under laboratory conditions.

BLOOD COLLECTION AND HEMATOLOGICAL TESTS
Blood sample was collected by caudal venous puncture using the method of Roberts (1966). A 25-gauge (0.5 mm) syringe. The syringe was inserted under the skin of the ventral midline of the caudal peduncle of the fish and then moved towards the vertebral column until the base of the column was reached. The needle was withdrawn

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a fraction of a millimeter and blood sample was obtained. Blood were collected at intervals of 1, 7 and 14 days from both the tested and control fishes. The blood was put into EDTA vials and taken to Central Research and diagnostic laboratory, Tipper garage, Tenke, Ilorin for hematological analysis. Hematological analysis was carried out using veterinary hematology analyzer model (PR-3125 Plus). The blood samples were put under the probe of the hematology analyzer to suction the blood into the machine. Four reagents were used for the analysis. The four reagents were put inside four bottles; one reagent per bottle each and were connected to the back of the machine. The four reagents were: Lysate reagent, Diluent reagent, Cleaner reagent and Waste reagent. The machine is automated, displays the results on its screen which were printed out.

STATISTICAL ANALYSIS

The median lethal concentration (LC₅₀) value was determined using the US EPA Software Probit analysis program, version 1.5. Data were analyzed with One-way analysis of variance (ANOVA) procedure using Statistical Product for Service Solution (SPSS version 16.0) for window. Statistical significance of differences between means was compared using Turkey (HSD) test.

RESULTS

Water quality parameters including temperature, pH and TDS were measured and recorded during the experimental period on a daily basis, which are shown in Table 1. The mean values of the water quality parameters of the different sub-lethal concentrations of Paraquat and control media to which the test fish (*Clarias gariepinus*) were exposed for 14 days are presented in Table 1. The values of parameters were found to be significantly different ($p < 0.05$).

Table 1: Physico-chemical parameters of test solutions on *Clarias gariepinus* (mean $\pm$ SD) for chronic(sub-lethal) test.

Concentration (mg/L ^a)	pH	Temperature (°C)	TDS (mg/L ^b)
0	8.05 $\pm$ 0.21 ^a	25.59 $\pm$ 0.82 ^a	176.34 $\pm$ 189 ^a
0.06	8.07 $\pm$ 0.18 ^a	25.60 $\pm$ 0.84 ^a	828.08 $\pm$ 179 ^a
0.07	8.06 $\pm$ 0.21 ^a	25.83 $\pm$ 0.82 ^a	828.31 $\pm$ 201 ^a
0.09	7.92 $\pm$ 0.40 ^a	25.91 $\pm$ 0.82 ^a	836.92 $\pm$ 193 ^a
0.12	7.92 $\pm$ 0.40 ^a	26.39 $\pm$ 0.71 ^a	853.31 $\pm$ 208 ^a

Values of parameters with the same superscript along the same column are not significantly different at ($p < 0.05$). Key: TDS (Total dissolved solids)

EFFECTS OF SUB-LETHAL CONCENTRATIONS OF PARAQUAT ON BLOOD PARAMETERS

The results of blood parameters of *C. gariepinus* exposed to sub-lethal concentration of paraquat are discussed below. The hematological responses and values obtained in the exposed and control groups at various sub-lethal concentrations are presented in Tables 2, 3, 4 and 5. The blood indices in each treatment varied significantly ($p < 0.05$) and were dose-dependent.

HEMATOLOGICAL PARAMETERS OF *Clarias gariepinus*

The results of hematological parameters on exposed *C. gariepinus* indicated a consistent reduction in the values of Hb, PCV, RBC, MCV, MCH, MCHC, WBC, Neutrophils, lymphocytes and monocytes respectively at ($p < 0.05$) on various days of exposure.

Table 2: Hematological parameters of *Clarias gariepinus* exposed to sub-lethal concentrations of paraquat (Mean $\pm$ SD) on Day 1.

Parameters	Control	Concentration (mg/L)			
		0.06	0.07	0.09	0.12
Hemoglobin (g/L)	8.99 $\pm$ 1.782 ^a	6.97 $\pm$ 2.970 ^a	6.96 $\pm$ 2.022 ^a	6.73 $\pm$ 1.411 ^a	6.17 $\pm$ 0.103 ^a
PCV (%)	18.93 $\pm$ 4.509 ^a	14.60 $\pm$ 4.383 ^a	14.03 $\pm$ 7.239 ^a	14.47 $\pm$ 6.149 ^a	8.23 $\pm$ 7.231 ^a
RBC ($\times 10^{12}$ L ⁻¹)	1.67 $\pm$ 0.727 ^a	1.64 $\pm$ 0.536 ^a	1.45 $\pm$ 0.639 ^a	1.17 $\pm$ 0.118 ^a	1.19 $\pm$ 0.732 ^a
MCV (fL)	144.43 $\pm$ 6.043 ^a	136.03 $\pm$ 4.578 ^a	127.96 $\pm$ 3.376 ^a	119.79 $\pm$ 2.636 ^a	108.83 $\pm$ 5.942 ^a
MCH (pg)	55.78 $\pm$ 5.747 ^a	49.60 $\pm$ 6.731 ^a	49.00 $\pm$ 3.857 ^a	47.40 $\pm$ 2.237 ^a	42.50 $\pm$ 2.180 ^a
MCHC (g/L)	55.82 $\pm$ 4.112 ^a	44.37 $\pm$ 6.161 ^a	45.00 $\pm$ 4.340 ^a	39.96 $\pm$ 1.759 ^a	38.33 $\pm$ 1.193 ^a
WBC ($\times 10^9$ L ⁻¹)	7993 $\pm$ 4.233 ^a	7665 $\pm$ 5.274 ^a	7053 $\pm$ 7.276 ^a	6063 $\pm$ 3.001 ^a	5673 $\pm$ 1.110 ^a
Neutrophils (%)	63.5 $\pm$ 2.699 ^a	61.1 $\pm$ 0.703 ^a	48.7 $\pm$ 3.899 ^a	40.9 $\pm$ 0.529 ^a	24.0 $\pm$ 0.250 ^a
Lymphocytes (%)	37.59 $\pm$ 2.263 ^a	34.13 $\pm$ 0.688 ^a	34.23 $\pm$ 6.739 ^a	33.70 $\pm$ 0.984 ^a	31.47 $\pm$ 1.702 ^a
Monocytes (%)	23.6 $\pm$ 0.914 ^a	12.5 $\pm$ 0.402 ^a	1.0 $\pm$ 0.850 ^a	0.97 $\pm$ 0.038 ^a	0.70 $\pm$ 0.103 ^a

Mean of parameters with the same superscript along the rows are not significantly different at ($p < 0.05$).

Hb-Hemoglobin; PCV-Packed cell volume; RBC-Red blood cell count; MCV-Mean Corpuscular Volume; MCH-Mean Corpuscular Hemoglobin; MCHC-Mean Corpuscular Hemoglobin Concentration; WBC-White blood cell count

Table 3: Haematological parameters of *Clarias gariepinus* exposed to Sub-lethal concentrations of paraquat (Mean $\pm$ SD) on Day 7

Parameters	Control	Concentration (mg/L)			
		0.06	0.07	0.09	0.12
Hb (g/dL)	5.90 $\pm$ 1.762 ^a	6.47 $\pm$ 2.650 ^a	6.20 $\pm$ 2.122 ^a	5.80 $\pm$ 1.41 ^a	4.47 $\pm$ 0.153 ^a
PCV (%)	18.03 $\pm$ 4.509 ^a	16.13 $\pm$ 4.030 ^a	15.57 $\pm$ 4.060 ^a	14.23 $\pm$ 3.027 ^a	11.13 $\pm$ 0.666 ^a
RBC ($\times 10^{12}/L$)	1.07 $\pm$ 0.727 ^a	1.44 $\pm$ 0.869 ^a	1.43 $\pm$ 0.280 ^a	1.34 $\pm$ 0.208 ^a	1.07 $\pm$ 0.128 ^a
MCV (fL)	144.43 $\pm$ 0.082 ^a	118.05 $\pm$ 5.518 ^a	114.06 $\pm$ 7.577 ^a	111.06 $\pm$ 5.047 ^a	103.07 $\pm$ 3.107 ^a
MCH (pg)	55.78 $\pm$ 5.740 ^a	55.37 $\pm$ 4.027 ^a	46.60 $\pm$ 2.722 ^a	46.17 $\pm$ 5.405 ^a	58.20 $\pm$ 5.024 ^a
MCHC (g/dL)	55.82 $\pm$ 4.112 ^a	42.73 $\pm$ 0.612 ^a	40.13 $\pm$ 4.531 ^a	40.03 $\pm$ 3.587 ^a	50.07 $\pm$ 7.705 ^a
WBC ($\times 10^3/L$)	7043 $\pm$ 8.235 ^a	6720 $\pm$ 7.056 ^a	5300 $\pm$ 1.428 ^a	4693 $\pm$ 3.672 ^a	3607 $\pm$ 7.705 ^a
Neutrophils (%)	65.0 $\pm$ 3.090 ^a	59.7 $\pm$ 1.550 ^a	48.7 $\pm$ 1.420 ^a	21.3 $\pm$ 2.048 ^a	78.7 $\pm$ 4.875 ^a
Lymphocytes (%)	97.5 $\pm$ 2.261 ^a	46.50 $\pm$ 2.188 ^a	46.23 $\pm$ 1.480 ^a	64.87 $\pm$ 4.654 ^a	1.27 $\pm$ 0.118 ^a
Monocytes (%)	1.25 $\pm$ 0.518 ^a	0.73 $\pm$ 0.681 ^a	0.63 $\pm$ 0.551 ^a	0.60 $\pm$ 0.529 ^a	1.27 $\pm$ 0.118 ^a

Mean of parameters with the same superscript along the rows are not significantly different at $p < 0.05$. Hb-Haemoglobin, PCV-Packed cell volume, RBC-Red Blood cell count, MCV-Mean Corpuscular Volume, MCH-Mean Corpuscular Haemoglobin, MCHC-Mean Corpuscular Haemoglobin Concentration, WBC-White Blood cell count.

Table 4: Haematological parameters of *Clarias gariepinus* 14 exposed to sub-lethal concentrations of paraquat (Mean $\pm$ SD) on Day 14

Parameters	Control	Concentration (mg/L)			
		0.06	0.07	0.09	0.12
Hb (g/dL)	6.94 $\pm$ 1.762 ^a	6.07 $\pm$ 2.108 ^a	5.97 $\pm$ 2.010 ^a	4.60 $\pm$ 1.300 ^a	2.38 $\pm$ 1.850 ^a
PCV (%)	18.03 $\pm$ 4.509 ^a	14.00 $\pm$ 4.357 ^a	13.06 $\pm$ 5.310 ^a	12.03 $\pm$ 7.543 ^a	11.07 $\pm$ 2.748 ^a
RBC ($\times 10^{12}/L$)	1.07 $\pm$ 0.727 ^a	1.14 $\pm$ 1.187 ^a	1.12 $\pm$ 1.120 ^a	0.97 $\pm$ 0.520 ^a	0.69 $\pm$ 0.147 ^a
MCV (fL)	144.43 $\pm$ 0.082 ^a	126.7 $\pm$ 1.268 ^a	123.8 $\pm$ 1.676 ^a	120.4 $\pm$ 3.934 ^a	119.03 $\pm$ 2.748 ^a
MCH (pg)	55.78 $\pm$ 5.740 ^a	49.02 $\pm$ 3.160 ^a	48.00 $\pm$ 4.423 ^a	44.30 $\pm$ 3.074 ^a	42.07 $\pm$ 5.077 ^a
MCHC (g/dL)	55.82 $\pm$ 4.112 ^a	38.20 $\pm$ 4.400 ^a	35.80 $\pm$ 3.487 ^a	35.23 $\pm$ 5.077 ^a	28.00 $\pm$ 6.245 ^a
WBC ($\times 10^3/L$)	7043 $\pm$ 8.235 ^a	5107 $\pm$ 5.630 ^a	3997 $\pm$ 0.023 ^a	3307 $\pm$ 3.014 ^a	2620 $\pm$ 1.410 ^a
Neutrophils (%)	65.0 $\pm$ 3.090 ^a	48.7 $\pm$ 2.580 ^a	23.7 $\pm$ 1.767 ^a	21.7 $\pm$ 1.531 ^a	19.0 $\pm$ 0.854 ^a
Lymphocytes (%)	97.5 $\pm$ 2.261 ^a	47.53 $\pm$ 1.051 ^a	47.10 $\pm$ 2.741 ^a	64.47 $\pm$ 2.700 ^a	91.17 $\pm$ 3.098 ^a
Monocytes (%)	1.25 $\pm$ 0.518 ^a	0.67 $\pm$ 0.353 ^a	0.57 $\pm$ 0.157 ^a	0.44 $\pm$ 0.103 ^a	0.27 $\pm$ 0.058 ^a

Mean of parameters with the same superscript along the rows are not significantly different at $p < 0.05$. Hb-Haemoglobin, PCV-Packed cell volume, RBC-Red Blood cell count, MCV-Mean Corpuscular Volume, MCH-Mean Corpuscular Haemoglobin, MCHC-Mean Corpuscular Haemoglobin Concentration, WBC-White Blood cell count.

Table 5: Summary of haematological parameters of *Clarias gariepinus* at the various days of exposure to sub-lethal concentrations of (Mean $\pm$ SD)

Parameters	Duration of exposure (Days)			
	Control	1	7	14
Hb (g/dL)	6.94 $\pm$ 1.762 ^a	6.51 $\pm$ 1.828 ^a	5.74 $\pm$ 1.644 ^a	4.67 $\pm$ 2.107 ^a
PCV (%)	18.03 $\pm$ 4.509 ^a	15.16 $\pm$ 7.255 ^a	14.20 $\pm$ 3.900 ^a	13.20 $\pm$ 4.571 ^a
RBC ($\times 10^{12}/L$)	1.07 $\pm$ 0.727 ^a	1.44 $\pm$ 0.0499 ^a	1.32 $\pm$ 0.310 ^a	0.94 $\pm$ 0.718 ^a
MCV (fL)	144.43 $\pm$ 0.082 ^a	122.87 $\pm$ 3.815 ^a	112.27 $\pm$ 5.090 ^a	122.48 $\pm$ 2.343 ^a
MCH (pg)	55.78 $\pm$ 5.740 ^a	47.13 $\pm$ 2.240 ^a	47.79 $\pm$ 4.014 ^a	45.84 $\pm$ 4.307 ^a
MCHC (g/dL)	55.82 $\pm$ 4.112 ^a	40.60 $\pm$ 4.534 ^a	40.27 $\pm$ 4.938 ^a	34.51 $\pm$ 5.174 ^a
WBC ($\times 10^3/L$)	7043 $\pm$ 8.235 ^a	6456 $\pm$ 4.201 ^a	5105 $\pm$ 4.714 ^a	3773 $\pm$ 4.172 ^a
Neutrophils (%)	65.0 $\pm$ 3.090 ^a	62.4 $\pm$ 1.340 ^a	55.2 $\pm$ 1.363 ^a	28.5 $\pm$ 1.635 ^a
Lymphocytes (%)	97.5 $\pm$ 2.261 ^a	93.56 $\pm$ 2.020 ^a	90.6 $\pm$ 4.352 ^a	95.07 $\pm$ 2.264 ^a
Monocytes (%)	1.25 $\pm$ 0.518 ^a	0.90 $\pm$ 0.353 ^a	0.59 $\pm$ 0.437 ^a	0.51 $\pm$ 0.264 ^a

Mean of parameters with the same superscript along the rows are not significantly different at $p < 0.05$. Hb-Haemoglobin, PCV-Packed cell volume, RBC-Red Blood cell count, MCV-Mean Corpuscular Volume, MCH-Mean Corpuscular Haemoglobin, MCHC-Mean Corpuscular Haemoglobin Concentration, WBC-White Blood cell count.

DISCUSSION

In this study, the monitored water parameters were not significantly different from the control sample after 14 days exposure period which means that Paraquat has no effect on the water parameters. This is in line with the study of Omoniyi et al. (2002) on the sub-lethal effects of tobacco leaf dust on the haematological parameters of *Clarias*.

gariepinus. The temperature (25.59°C-27°C) and pH (7.9-8.2) were within the range recommended for aquaculture practices. The water quality parameters studied were within the standard meant for aquaculture purposes. Researchers have reported pH of 6.5-9.0 to support fish life. Okomoda and Ataguba (2011) reported the pH of 6.5-8.3. Basically, in aquatic ecosystem, temperature is very essential for the survival of fishes through metabolism. As such, inability of fish to adapt to the environment could cause a change in their physiological response which could lead to mortality. The temperatures recorded in this study were within the ambient temperature of the area and values of surface water resources in Nigeria (Ben-Eledo *et al.*, 2017a). Hence, the fishes may not have died due to temperature. Dissolved solids contain inorganic and some organic compounds (Boyde, 2015). From the result of this study, temperature increases as the TDS increases in each treatment, this is in line with the findings of Raz (2019) who reported that in bodies of water-like rivers, higher levels of TDS changes the mineral content of the water which is important for the survival of aqua-biotas. Also, dissolved salts can dehydrate the skin of aquatic animals which can be fatal and also in line with the findings of Adewoye *et al.* (2005) who observed changes in characteristic features might have resulted from the organic loads in the water. The reductions observed in the hematological parameters (HB, PCV, RBC, MCV, MCH, MCHC, WBC, Neutrophils, Basinophils and lymphocytes) of *C. gariepinus* exposed to paraquat demonstrates the fact that pesticides cause a significant reduction in the haematological parameters of fish (Ada *et al.*, 2012). These reductions could also be the product of impaired erythropoiesis and rapid haemolysis of the RBC. Furthermore, the reduction in MCV in the present study reveals erythrocytic shrinkage leading to microcytic anaemia. This is in agreement with the work of Idi-Ogede and Samuel (2018) who also observed microcytic-hypochromic anaemia in *Oreochromis niloticus* exposed to sublethal toxicity of 2,3-dichlorovinyl dimethyl phosphate (sniper 1000EC). This reduction in MCV in the paraquat exposed fish could also arise due to osmoregulatory imbalances. Li *et al.*, (2011) reported that verapamil reduced the erythrocyte count, Hb and PCV in *O. mykiss*. Reduction in the values of these parameters was also reported in *Prochilodus lineatus* exposed to clomazone Pereira *et al.*, (2013) and in *Labeo rohita* exposed to fenvalerate (Prusty *et al.*, 2011). Reduction in the erythrocyte count was reported in *C. mrigala* exposed to ibuprofen (Saravanan *et al.*, 2012) and *C. albopinnatus* exposed to acetellic (Mgbenka *et al.*, 2005). The results from this study are also consistent with the results of Abubakar *et al.*, (2019) who reported Normocytic-Normochromic anaemia in *C. gariepinus* exposed to paraquat. It also agreed with the results in *Heteropneustes fossilis*, exposed to adrin and fenvalerate (Thakar and Bais, 2000), and in *Salmo gairdneri* and *Mystus vittatus* exposed to pesticides (John, 2007). Studies have shown that pesticides have cytotoxic effects in fish which impose severe oxidative stress on the fish (Mikula *et al.*, 2009; Nwani *et al.*, 2013). The anaemic exposure could be as a destruction of RBC (Abubakar, 2013). Generally, leucocytes modulate immunological functions in animals, including fish. The observed leucocytosis in the present study indicated abnormal immune protective response to paraquat intoxication. It also suggested that paraquat stimulated the immune system with a concomitant release of lymphocytes from the lymphomyeloid tissue as a defense response. It resulted in the leucocytosis and/or lymphocytosis, which altered body physiology. Leucocytosis was also reported in *C. carpio* exposed to lindane (Saravanan *et al.*, 2011), and in *O. niloticus* exposed to deltamethrin (El-Sayed *et al.*, 2007). While blood cells are the in smaller number compared with red blood cells and they have the defensive role in the body of organisms (Ezeri, 2001). Changes in the levels of white blood cells following exposure to paraquat may be due to disturbances in the process of hematopoiesis and subsequent reduction or non-specific immune weakening in fish (Kumar *et al.*, 2011). White blood cells include lymphocytes, neutrophils, eosinophils, monocytes and basophils, each of which plays a different role in the body of fish. Lymphocytes are seen in the blood circulation, lymphoid organs and other tissues, especially during inflammatory reactions. Lymphocytes are involved in the immune response of aquatic animals by antibody production (immunoglobulin). White blood cell differential count in this study showed that the percentages of lymphocytes in all the exposed concentrations after 14 days were measured less than the control group. Decrease in the percentage of lymphocytes exposed to pesticides was reported by different researchers. Nussey *et al.*, (2015) investigated the effects of sub-lethal concentrations of diazinon on grass carp (*Ctenopoma muriei*) and reported significant increase ($P < 0.05$) in percentage of neutrophils and significant reduction ($P > 0.05$) in the percent of WBC and monocytes compared with the control group in contrast to the results of this study. According to the results of this study, the blood indices including MCV, MCH and MCHC of *C. gariepinus* exposed to paraquat were lower than the control group ($P < 0.05$). Sarikaya and Yilmaz (2003) studied the toxicity effects of pesticide Lindane on blood indices (MCV, MCH and MCHC) of common carp, *Cyprinus carpio* with significant reduction ($P < 0.05$) in blood indices (MCV, MCH and MCHC) compared with the control group. Suteri (2003) reported reduction in hematological indices (MCV, MCH and MCHC) of *Cichlasoma diorxus* exposed to acute toxicity of Endosulfan. The reduction in size and quantity of hemoglobin of red blood cells is measured by the indices MCV, MCH, MCHC which can be a sign of anemia in fish (Feiz, 2010). The anemia may be as a result of stress due to bacterial infections (Silveira-Coffigny *et al.*, 2004) and exposure to agricultural pesticides (Mohammadian *et al.*, 2010). The presence of a large percentage of immature red blood cells in the bloodstream may be a reason for reduction of MCV and MCH. On the other side, reduction of MCHC in this study may be due to decreased in production of hemoglobin after exposure to the toxicant (Kazemi *et al.*, 2011).

CONCLUSION

This study revealed microcytic-hypochromic anemia in *C.garipepinus* exposed to sublethal concentrations of 1, 1-dimethyl- 1, 4, 4 Bipyridinium dichloride brought about as a result of abnormalities in MCV, MCH and MCHC. haematological parameters of the exposed *C.garipepinus* under laboratory conditions attributable to stress. Thus, it was concluded that Paraquat exposure has stressor effects on hematological parameters of the exposed fish species.

RECOMMENDATION

In line with the conclusion, it is recommended that:

- 1- The manufacturing industries should look into ways of reducing the potency of Paraquat to non-target organisms such as fish, and they should be compelled to state categorically the effect of Paraquat to non-target organisms.
- 2- Agricultural extension officers should enlighten farmers on the dangers of Paraquat to the environment and water body at large.
- 3- Attempt should be made to monitor the use of Paraquat by local fishermen.

REFERENCES

- Ahuhakar, M.I. (2013). Toxicity of 2,3-dichlorovinyl dimethyl phosphate (Sniper 1000EC) on *Clarias gariepinus* (Burchell 1822) and *Oreochromis niloticus* (Trewavas, 1983) under laboratory conditions. Unpublished Ph.D Thesis, Department of Aquaculture and Fisheries Management, Federal University of Agriculture, Abeokuta, Nigeria. 184pp.
- Ahuhakar, M.I (2016): *Fish Pathology in Perspective*: Published by Boga Press, Mokola-Ibadan, Oyo State, Nigeria. Pp. 178.
- Ahuhakar, M.I., Adeshina, I., Ayeleja, A.A., and Abdulraheem, I. (2019): Induction of Normocytic-Normochromic Anemia in *Clarias gariepinus* (Burchell, 1822) Exposed to Acute Toxicity of 1,1-Dimethyl 4,4-Bipyridinium (Paraquat) Under Laboratory Conditions. *FULafia Journal of Science and Technology*. Vol 5, No 2. Pp. 46-52.
- Ada, F.B., Ekpenyong, E., Bayim, B.P., (2012). Heavy metal concentration in some fish of *Chrysichthys nigrodigitatus*, *Clarias gariepinus* and *Oreochromis niloticus* in the great Kwa river, cross river state, Nigeria. *Global Adv. Res. J. Environ. Sci. Toxicol.* 1(7): 183-189.
- Adewoye S.O, Fawole O.O, Owolabi O.D, Omosho J.S. (2005). Toxicity of Cassava waste water effluent in African Catfish: *Clarias gariepinus*. *Ethiop. J. Sci.* 28(7):189-194.
- Adhikari, S., Sarkar, R., Chatterjee, A., Mahapatra, C.T. & Ayyappa, S. (2004) Effects of Cypermethrin and Carbosulfan on Certain Hematological Parameters and Prediction of Their Recovery in a Freshwater Teleost, *Labeonihita* (Hamilton). *Ecotoxicology and Environmental Safety*, 58, 220-226.
- Agha Mohammadi, M., Farniki, F. & Tokmehi, A. (2012) Study the Toxic Effects of Various Concentrations of the Herbicide Paraquat on Liver Tissue of Farmed Rainbow Trout.
- Bagheri, F. (2007). Study of Pesticide Residues (Diazinon, Azinphosmethyl) in the Rivers of Golestan Province (Gorganrud and Gharehsou). M. Sc Thesis, Tehran University of Medical Science, Tehran, Iran, 1-125.
- Bahmani, M., Kazemi, R. & Donskaya, P. (2001) A Comparative Study of Some Hematological Features in Young Reared Sturgeon. *Fish Physiology and Biochemistry*, 24, 135-140. <https://doi.org/10.1023/A:1011911019155>
- Bahmani, M., Kazemi, R., Yousefi, A., Hallajian, A. & Mojazi-Amiri, B. (2008). The final Project Report: Studying the Possibility of Artificial Reproduction of Farmed Stellate Sturgeon (Broodstock, Artificial Reproduction and Production of Fingerlings from Farmed Sturgeon Broodstocks). Iranian Fisheries Research Organization Press, 132 p.
- Damae, M., Mirvaghefi, R., Rafei, G. & Majazi-Amiri, B. (2008) Effect of Sub-Lethal Diazinon Concentrations on Blood Plasma Biochemistry. *International Journal of Environmental Research*, 2, 189-198.
- Ben-Elede VN, Kigigha LT, Izah SC, Elede BO (2017a). Water quality assessment of Epe creek in Yewa metropolitan Bayelsa.
- Beyer, L. A.; Beck, B. D.; Lewandowski, T. A. (2011-04-03). "Historical perspective on the use of animal bioassays to predict carcinogenicity: Evolution in design and recognition of utility". *Critical Reviews in Toxicology*. 41 (4): 321-338. doi:10.3109/10408444.2010.541222. ISSN 1040-8444 PMID 21438739 S2CID 2269228.
- Boech, Felix; Rusch, Lutz (2008). "The Contributions of Paul Ehrlich to Pharmacology: A Tribute on the Occasion of the Centenary of His Nobel Prize". *Pharmacology*. 82 (1): 171-179. doi:10.1159/000149383. ISSN 1621-7012 PMC 2790789 PMID 18679046.
- Boyd, C.E. (2015): *Water Quality: An Introduction*-Springer, Switzerland.

- El-Sayed, Y.S., Saad, T.T. & El-Bahr, S. M. A. (2007). Acute intoxication of deltamethrin in mono-sex Nile tilapia *Oreochromis niloticus* with special reference to the clinical, biochemical and haematological effects. *Environmental Toxicology and Pharmacology*, 24, 212-217.
- El-Shehly, A. A. & El-Kady, M.A.H. (2008). Effects of Glyphosate Herbicide on Serum Growth Hormone (GH) Level and Muscle Protein Content in Nile Tilapia (*Oreochromis niloticus* L.). *Research Journal of Fisheries and Hydrobiology*, 3, 84-88.
- Feiz, S. (2010). Effect of Herbicide Butachlor on Blood Parameters of Pikeperch. MSc Thesis, Islamic Azad University, Lahijan Branch, 110p.
- Idi-Ogede, A.M. and Samuel, O. (2018). Induction of microcytic-hypochromic anaemia in *Oreochromis niloticus* (Trewavas, 1983) exposed to sniper 1000EC under laboratory conditions. *International Journal of Biology Research* Vol. 3, Issue 1. Pp 300-305.
- John, P.J. (2007). Alterations of certain blood parameters of freshwater teleost *Myxus vitreus* after chronic exposure to Metasystox and Sevin. *Fish Physiol Biochem*, 33, 15-20.
- Kumar, N., Antony, P., Pal, A.K., Remya, S., Aklakur, M., Rana, R.S., Gupta, S., Raman, R.P. & Jadhav, S.B. (2011). Anti-Oxidative and Immuno-Hematological Status of Tilapia (*Oreochromis mossambicus*) during Acute Toxicity Test of Endo-sulfan. *Pesticide Biochemistry and Physiology*, 99, 45-52.
- Li, Z. H., Velisek, J., Grabic, R., Li, P., Kolarova, J., & Randak, T. (2011). Use of hematological and plasma biochemical parameters to assess the chronic effects of a fungicide propiconazole on a freshwater teleost. *Chemosphere*, 83, 572-578.
- Mgbemka RN, Mbah EN, Ezesno CI (2015). A Review of Small scale Farming in Nigeria: Need for Transformation. *Agricultural Engineering*.
- Mikula, P., Blahova, J., Kruzikova, K., Havelkova, M. & Nemethova, D. (2009). Effects of the herbicide LASSO MTX (alachlor 42% W/V) on biometric parameters and liver biomarkers in the common carp (*Cyprinus carpio*). *Pestic Biochemical Physiology*, 93, 13-17.
- Mohammadian, T., Kochanlian, P., Niku, S., Sheikholestani, M., Bita, S., Skandari, Gh. & Abhari Segorbad, H. (2010). Comparing the Effects of the GnRH Hormone Analogue Along with Anti-Dopamine Domperidone (Ova-Fact) by Linpe Method, with Common Carp Pituitary Extract (CPE) on Reproductive Indices of Banni (*Barrus sharpeyi*). *Iranian Veterinary Journal*, 2, 70-80.
- Musvy, G., Vanvuren, H.J. & Dupreez, H.H. (2015). Effect of Copper on the Differential White Blood Cell Counts of Mozambique Tilapia (*Oreochromis mossambicus*). *Comparative Biochemistry and Physiology*, 111, 381-388.
- Nwani, C.D., Nagpure, N.S., Kumar, R., Kushwaha, B. & Lakra, W.S. (2013). DNA damage and oxidative stress modulatory effects of glyphosate-based herbicide in freshwater fish, *Channa punctatus*. *Environmental Toxicology and Pharmacology*, 36, 539-547.
- Okanoda Victor A.U., Gabriel Atagua P.Y-2014/01/01 SP-82, EP-88, T1-Chemical and Biological Parameters of Portable Water in Kogi State Metropolis of Nigeria. Implications For Fish Pond Culture. Vol-12/0 - *Tropic Journal of Sciences ER* - Agedah, E.C., Ineyougha, E.R., Isah, S.C., & Oratoga.
- Omeriyi, I.T., Agbun, A.O. & Sodunke, S.A. (2002). Effect of lethal and sublethal concentrations of toxico (*Niporlona tobarcam*) leaf dust extract on weight and haematological changes in *Clarias gariepinus* (Burchell). *J Appl Sci Environ mgt*, 6(2): 37-41.
- Oxman, A.G.M. & Kious, W. (2010). Water Quality and Heavy Metal Monitoring in Water, Sediments, and Tissues of the African Catfish *Clarias gariepinus* (Burchell, 1822) from the River Nile, Egypt. *Journal of Environmental Protection*, 1, 389-400.
- Prusty, A. K., Kohli, M. P. S., Sahu, N. P., Pal, A. R., Saharan, N., Mohapatra, S., & Gupta, S. K. (2011). Effect of short term exposure of fenvalerate on biochemical and haematological responses in *Labeo rohita* (Hamilton), fingerlings. *Pesticides Biochemistry and Physiology*, 100, 124-129.
- Saravanan, M., Karthika, S., Malavizhi, A., and Ramesh, M. (2012). Ecotoxicological impacts of clofibrate acid and diclofenac in common carp (*Cyprinus carpio*) fingerlings: hematological, biochemical, immunoregulatory and enzymological responses. *Journal of Hazardous Materials*, 193, 188-194.
- Saribaya, R. & Yilmaz, M. (2003). Investigation of Acute Toxicity and the Effect of 2,4-D (2,4-Dichlorophenoxyacetic Acid) Herbicide on the Behavior of the Common Carp (*Cyprinus carpio* L., 1758, Pisces: Cyprinidae). *Chemosphere*, 52, 195-201.
- Sattar, M. (2003). *Ichthyology I, Anatomy and Physiology*. Naghah Mehr Press in Cooperation with University of Guilan, 659 p.

- Silveira-Coffigny, R., Prieto-Trujillo, A. & Ascencio-Valle, F. (2004). Effects of Different Stressors in Haematological Variables in Cultured *Oreochromis aureus* S. *Comparative Biochemistry and Physiology Part C: Toxicology and Pharmacology*, 139, 245-250.
- Thakur, P.B. Bais, V.S. 2000. Toxic effect of aldrin and fenvalerate on certain haematological parameters of a fresh water teleost, *Heteropneustes fossilis* (Bl.) pp 161-167.