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Effect of Zinc on Haematological Parameters of African Catfish (*Clarias gariepinus*)

Olurin K.B., Olojo E.A.A., Tijani O.B.

Department of Plant Science and Applied Zoology, Olabisi Onabanjo University, P.M.B. 2002, Ago-Iwoye, Ogun State, Nigeria.

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***Corresponding author:**

E-mail: emmanuelolojo@yahoo.co.uk

ABSTRACT

Zinc is one of the hazardous heavy metals which can cause serious health hazards in man when ingested in high quantities. Its natural occurrence in soil and water makes freshwater fish species to accumulate it in their flesh where it causes serious physiological disorders. This study monitors the effect of zinc toxicity on the haematology of the African catfish, *Clarias gariepinus* exposed to two concentrations (T_1 0.08mg/l and T_2 0.15mg/l) of Zinc sulphate ($ZnSO_4$) and monitored at 24 hour interval (24h, 48h, 72h, 96h and 120h). Parameters analyzed included packed cell volume (PCV), percentage haemoglobin (% Hb), red blood cell (RBC), white blood cell (WBC), erythrocyte sedimentation rate (ESR), mean cell volume (MCV fl), mean cell haemoglobin (MCH pg), percentage mean cell haemoglobin concentration (%MCHC), percentage lymphocytes (% Lym) and percentage neutrophil (% Neu)t. Results showed a decrease in values of PCV, %Hb and RBC while parameters such as WBC, ESR and %Lym increased as a result of the exposure. MCHC and Neut remained fairly constant throughout the experimental period. 100% mortality was recorded at 120h of exposure in concentration T_2. Results obtained from this study showed that zinc triggered haematological responses in *Clarias gariepinus.*

INTRODUCTION

The term "heavy metal" refers to any metallic element that has a relatively high density and toxic or poisonous even at low concentration [1]. Heavy metals include lead (Pb), copper (Cu), arsenic (As), cadmium (Cd), zinc (Zn), mercury (Hg), iron (Fe), and the platinum group elements. Heavy metals are essential for plants growth in trace or very minute quantities and toxic in relatively higher concentrations, biologically non-degradable but easily assimilated and bio-accumulated in the protoplasm of aquatic organisms [2].

Sources of heavy metals in aquatic environment may be categorized into natural anthropogenic activities, which result in gaseous emission and waste water discharges into air, water and land. When the substances in the emissions and effluent discharges in the environment are in very minute amount or in low concentrations are not toxic to plants and animals and have short residence time in the environment, they are described as contaminants [3].

When agricultural soils are polluted, their metals are taken up by plant and consequently accumulate in their tissues [4]. Animals that graze on such contaminated plants and drink from polluted waters, as well as marine lives that breed in heavy metal polluted waters also accumulate such metals in their tissues, and milk, if lactating [5,6,7,8]. Humans are in turn exposed to heavy metals by consuming contaminated plants and animals, and this has been known to result in various biochemical disorders.

Zinc toxicity

Heavy metals are emitted both in elemental and compound forms, (as well as organic and inorganic forms). Anthropogemic sources of emission are the various industrial point sources including former and present mining sites, foundries and smelters, combustion by-products and traffics [9]. Generally, metals are emitted during their mining and processing activities [1].

Lead is the most significant toxin of the heavy metals and the inorganic forms are absorbed through ingestion by food and water, and inhalation [10]. A notably serious effect of lead toxicity is its tetratogenic effects, lead poisoning also causes inhibition of the synthesis of haemoglobin; dysfunction in the kidneys, joints and reproductive systems, cardiovascular system and acute and chronic damage to the central nervous system (CNS) and peripheral nervous system (PNS) [11]. Other effects include damage to the gastrointestinal tract (GIT) and urinary tract resulting in bloody urine, neurological disorder and can cause severe and permanent brain damage. While inorganic forms of lead, typically affect the CNS, PNS, GIT and other

biosystems, organic forms predominantly affect the CNS [12,13,10,1] lead affects children by leading to the poor development of the grey matter of the brain, thereby resulting in poor intelligence quotient (IQ) [14]. Its absorption in the body is enhanced by Ca and Zn deficiencies. Acute and chronic effects of lead result in psychosis.

Zinc has been reported to cause the same signs of illness as does lead, and can easily be mistakenly diagnosed as lead poisoning [12]. Zinc is considered to be relatively non-toxic, especially if taken orally. However excess amount can cause system dysfunctions that result in impairment of growth and reproduction [13,15]. The clinical signs of zinc toxicosis have been reported as vomiting, diarrhoea, bloody urine, icterus (yellow mucus membrane), liver failure, kidney failure and anemia [16].

MATERIALS AND METHODS

African catfish, *Clarias gariepinus* were obtained from a local fish farm in Ago-Iwoye and transported in an oxygenated polythene bag; half filled with pond water. They were fed daily with a commercial feed and randomly distributed into different plastic bowls for two weeks before the commencement of the experiment. The body length of each species was taken, using a meter rule.

One hundred and eighty (180) fishes were divided into 12 plastics bowls (pH 7.7) before introducing the toxicant. The heavy metal used in the experiments was zinc sulphate ($ZnSO_4$). Fish were subjected to three treatments: $T_{1:}$ (0.08mg/l), T_{2} :(0.15mg/l) and control (0mg/l). Each treatment condition was replicated four times.

Fifteen fish were randomly distributed into each plastic bowl. Dead fish were discarded and replaced. Mortality was taken during the introduction of ($ZnSO_4$). In each plastic bowl, a fish was taken out every 24hours for blood analysis. The blood samples were collected with the use of 5ml plastic syringes and needle. The needle was inserted at the lower abdominal region of both the treated and control fish [17,18]. It was then pushed gently down to the bone marrow until blood started to enter the syringe. After detaching the needle from the syringe, the blood was put in an EDTA bottle containing anticoagulant, to prevent clotting of blood.

Mean cell haemoglobin concentration (MCHC)

MCHC= Hb/PCV)x 100%

This refers to the percentage haemoglobin in 1dl of packed RBC.

Calculation: Divide the Hb in g per dl by the PCV and express the result as a percentage e.g Hb content = 15g/dl blood

PCV= 0.48

Therefore MCHC = 15/0.48= 31.25%

Mean cell haemoglobin (mch)

= Hb/(RBC/10)

This expresses the average Hb content in picograms (pg) of a single RBC,

Calculation: Divide the Hb content in SI units by the RBC count in SI units and multiply by 10 e.g.

Hb= 14.5g/dl blood

RBC= 5.0 (x $10^{12/1}$)

Therefore, (MCV) = 14x 10/5.0 = 29 pg

Mean cell volume

(MCV)= PCV/(RBC/10).

This is the average volume of a single cell expressed in femolitre (fl)

Calculation: Divide the PCV by RBC and multiply by 1000 e.g.

PCV= 0.40

RBC= 5.0 (x 10^{12}/1/l)

Therefore, MCV= (0.4/5.0) x 1000= 80FL.

RESULTS

Variations in values of ten haematological parameters of catfish (*Clarias gariepinus*): PCV, % Hb, RBC, WBC, ESR, MCV (fl), MCH (pg), %MCHC, % Lym 8% Neut. exposed to two concentrations of $ZnSO_4$ at 24h, 48h, 72h, 96h and 120h are shown in Figures 1-10 respectively.

At 24 hours of exposure to $ZnSO_4$, differences in the values of PCV, Hb, RBC, WBC, ESR, MCH, Lym and Neut compared with the control values were not statistically significant at P>0.05 with the exception of MCV that was significant at P<0.05. MCHC shows no detection throughout the experimental period (Table No.3).

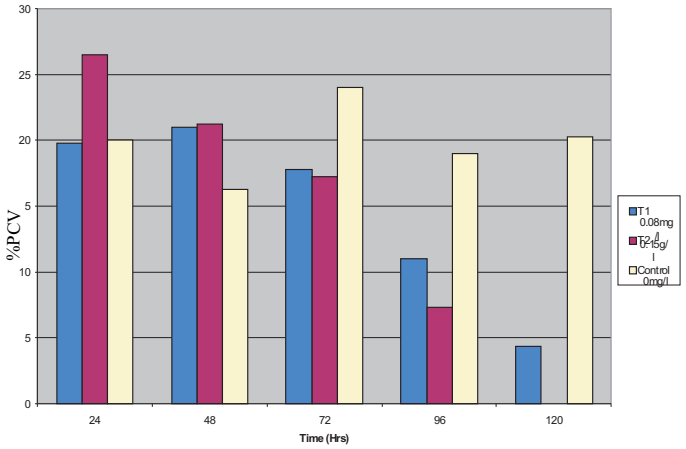

Fig. No. 1 : Changes in PCV of Clarias gariepinus exposed to $ZnSO_4$

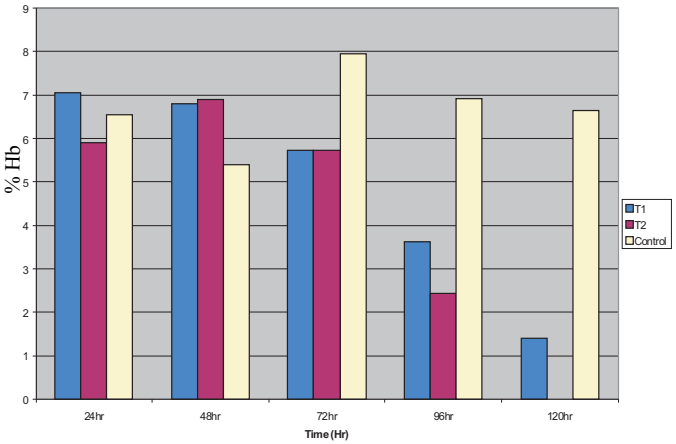

Fig.2 : `Variation in %Hb values of C. gariepinus exposed to $ZnSO_4$

Table No.1: Mean values ±SD of changes in haematological parameters (%PCV, %Hb, RBC, WBC, ESR, of *C. gariepinus* exposed to Zinc sulphate with concentration of (0.08mg/g in T_1) and 1 (0.15 in T_2).

		%PCV	%Hb	RBC (x 10^{12}/l)	WBC(x 10^{12}/l	ESR
CONTROL	X±SD	20.00+4.55	6.55±1.43	2.20±0.75	5.85±0.87	5.50±4.04
	Min-Max	14.00- 25.00	4.60-8.00	1.08-2.68	4.60-6.50	2.00-11.00
24hr	T_1X±SD	19.95+8.81	7.05+2.69	2.03±0.81	5.40±0.94	3.50±2.65
	Min-Max	1.00-30.00	3.60-10.00	1.04-2.96	4.20-6.40	1.00-7.00
	T_2X±SD	26.50±15.76	5.90±0.84	3.15±0.33	5.73±0.59	1.78±1.67
	Min- Max	5.00-7.00	5.00-7.00	2.80-3.56	4.90-6.20	0.10-4.00
48hr	X±SD	16.25±6.34	5.40±2.12	2.35±0.42	5.56±0.56	17.5±1.50
CONTROL	Min-Max	9.00-24.00	3.00-8.00	2.04-2.96	5.00-6.20	1.00-4.00
	T_1X±SD	21.00±8.04	6.80±2.24	3.09±0.46	8.03±1.51	5.25±3.30
	Min-Max	12.00-31.00	3.80-10.00	2.48-3.60	6.90-10.20	3.00-10.00
	T_2X±SD	21.25±6.34	6.90±2.22	1.83±0.53	9.25±0.97	10.50±2.65
	Min- Max	15.00-30.00	4.80-10.00	1.04-2.18	7.90-10.10	7.00-13.00
72hr	X±SD	24.00±3.37	7.95±1.11	3.09±0.61	11.20±2.56	8.75±4.81
CONTROL	Min-Max	19.00-26.00	6.30-8.60	2.18-3.48	9.20-14.40	5.00-15.00
	T_1X±SD	17.75±4.03	5.73±1.51	3.32±0.99	9.38±1.21	7.50±3.71
	Min-Max	13.00-22.00	4.00-7.30	2.14 - 4.22	8.10-10.60	4.00-12.00
	T_2X±SD	17.25±2.06	5.73±0.68	2.58±0.37	10.38±2.21	4.75±3.11
	Min- Max	15.00-19.00	5.00-6.30	2.08-2.96	7.90-13.20	2.00-9.00
96hr	X±SD	20.75±1.71	6.91±0.56	2.77+0.41	6.52+1.83	4.75±2.63
CONTROL	Min-Max	19.00-23.00	6.30 -7.60	2.20-3.18	4.80-9.10	1.00-7.00
	T_1X±SD	11.00±0.82	3.63±0.29	1.50±0.44	12.60±3.13	1.50±0.58
	Min-Max	10.00-12.00	3.30-4.00	1.04-2.02	9.20-16.60	1.00-2.00
	T_2X±SD	7.33±2.31	2.43±0.75	1.28±0.45	11.91±1.14	5.67±2.08
	Min- Max	6.00-10.00	2.00-7.60	1.00-1.80	10.60-12.80	4.00-8.00
120	X±SD	20.25±2.22	6.65±0.79	2.43±0.43	5.43±0.56	1.00±0.00
CONTROL	Min-Max	18.00-23.00	6.00-7.60	2.00-2.92	4.60-5.80	1.00-1.00
	T_1X±SD	4.33±1.15	1.40±0.35	1.13±0.13	11.27±1.70	7.33±1.15
	Min-Max	3.00-5.00	1.00-1.60	1.04-1.28	9.60-13.00	6.00-8.00
	T_2X±SD	-	-	-	-	-
	Min- Max	-	-	-	-	-

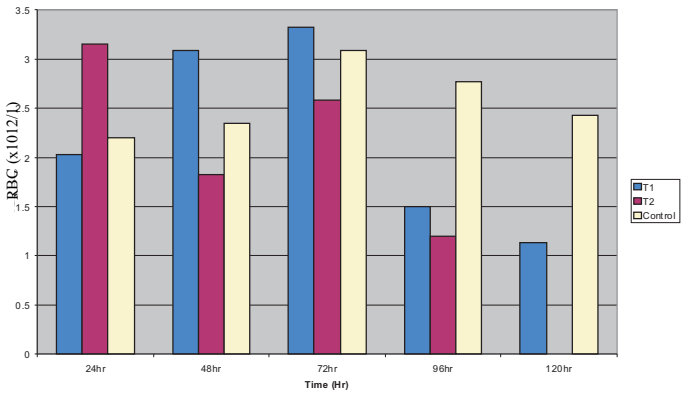

Fig.3 : `Variation in Red Blood Cell (RBC) of C. gariepinus under exposure to $ZnSO_4$

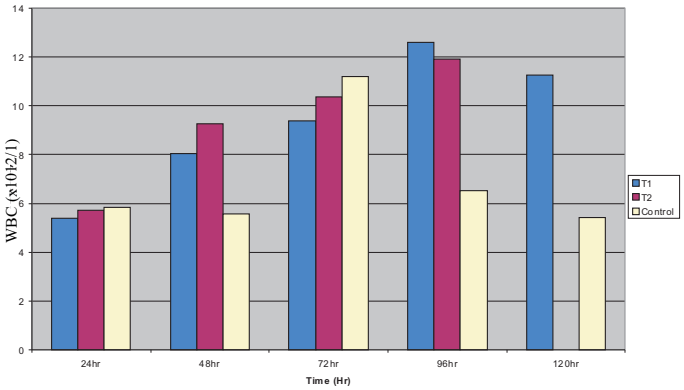

Fig.4 : Variation in the White Blood Cell (WBC) of C. gariepinus under exposure to $ZnSO_4$

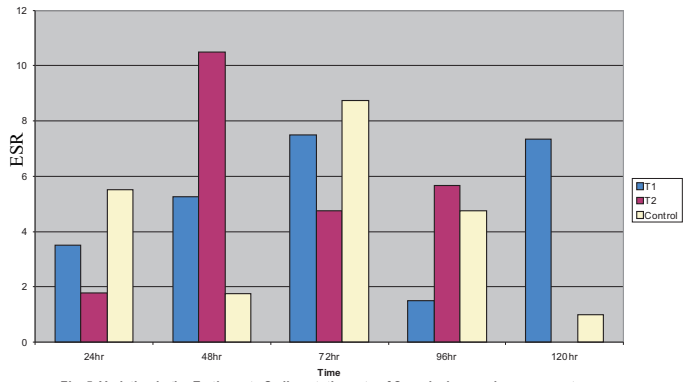

Fig.5 : Variation in the Erythrocryte Sedimentation Rate of C. gariepinus under exposure to $ZnSO_4$

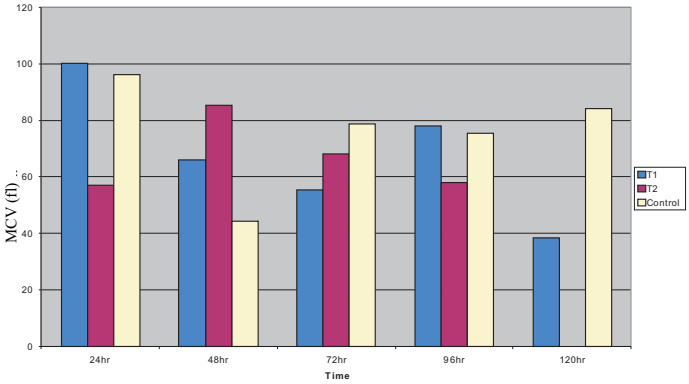

Fig.6 : Variation in the Mean Cell Volume (MCV) of C. gariepinus under exposure to $ZnSO_4$

Table No.2: Mean values ±SD of changes in haematological parameters (%MCV(fl), % MCH (pg),% MCHC,% LYM, % NEUT of *C. gariepinus* exposed to Zinc sulphate with concentration of 0.08mg/g in T_1) and 1 (0.15 in T_2).

		MCV(fl)	MCH(pg)	%MCHC	%Lym	%Neut
CONTROL	X±SD	96.25±23.16	31.75±7.80	3.00±0.00	61.75±5.56	38.25±5.56
	Min-Max	78.00-129.00	26.00-43.00	3.00-3.00	55.00-68.00	32.00-45.00
24hr	T_1X±SD	100.25±31.02	38.00±18.31	3.00±0.00	65.75±3.30	34.25±3.30
	Min-Max	59.00-134.00	19.00-63.00	3.00-3.00	62.00-70.00	30.00-38.00
	T_2X±SD	57.00±8.76	18.75±2.87	3.00±0.00	60.75±5.10	39.25±5.10
	Min- Max	51.00-70.00	17.00-23.00	3.00-3.00	54.00-65.00	35.00-46.00
48hr	X±SD	44.32±23.43	23.25±10.11	3.00±0.00	59.75±5.19	40.25±5.19
CONTROL	Min-Max	11.30-61.00	15.00-38.00	3.00-3.00	55.00-66.00	34.00-45.00
	T_1X±SD	66.00±16.31	21.50±5.69	3.00±0.00	66.50±5.51	33.50±5.51
	Min-Max	48.00-86.00	15.00-28.00	3.00-3.00	60.00-72.00	28.00-40.00
	T_2X±SD	85.34±60.08	38.75±8.46	3.00±0.00	60.50±7.05	39.50±7.05
	Min- Max	1.37-144.00	30.00-46.00	3.00-3.00	54.00-68.00	32.00-46.00
72hr	X±SD	78.75±5.56	26.00±2.00	3.00±0.00	60.50±4.20	39.50±4.20
CONTROL	Min-Max	75.00-87.00	25.00-29.00	3.00-3.00	55.00-65.00	35.00-45.00
	T_1X±SD	55.50±13.35	17.50±3.87	3.00±0.00	65.50±7.21	34.50±7.21
	Min-Max	45.00-75.00	14.00-23.00	3.00-3.00	56.00-72.00	28.00-44.00
	T_2X±SD	68.00±11.60	22.50±3.71	3.00±0.00	59.25±2.91	40.75±3.10
	Min- Max	51.00-77.00	17.00-25.00	3.00-3.00	55.00-62.00	38.00-45.00
96hr	X±SD	75.50±7.05	25.00±2.71	3.00±0.00	58.25±2.87	41.75±2.87
CONTROL	Min-Max	71.00-86.00	23.00-29.00	3.00-3.00	55.00-62.00	38.00-45.00
	T_1X±SD	78.00±21.37	26.00-7.07	3.00±0.00	63.75±5.21	36.25±5.21
	Min-Max	54.00-105.00	18.00-35.00	3.00-3.00	59.00-70.00	30.00-41.00
	T_2X±SD	58.00±2.00	19.00±1.00	3.00±0.00	67.67±2.52	32.33±2.52
	Min- Max	56.00-60.00	18.00-20.00	3.00-3.00	65.00-70.00	30.00-45.00
120	X±SD	84.25±5.60	27.50±1.91	3.00±0.00	60.50±4.20	39.50±4.20
CONTROL	Min-Max	79.00-90.00	26.00-30.00	3.00-3.00	55.00-65.00	35.00-45.00
	T_1X±SD	38.33±10.01	12.33±3.05	3.00±0.00	66.67±3.11	33.33±3.11
	Min-Max	28.00-48.00	9.00-15.00	3.00-3.00	64.00-70.00	30.00-36.00
	T_2X±SD	-	-	-	-	-
	Min- Max	-	-	-	-	-

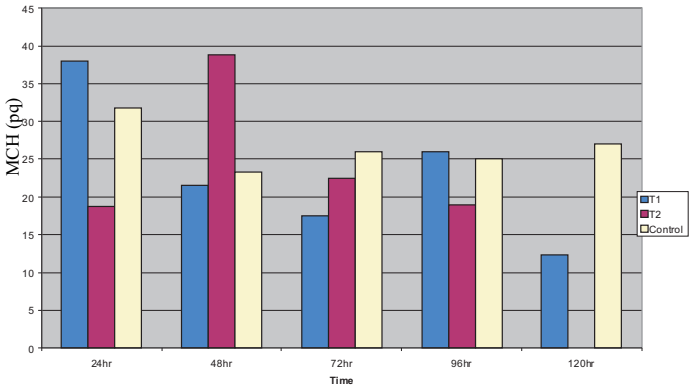

Fig.7 : Variation in the Mean corpuscular haemoglobin of C. gariepinus under exposure to $ZnSO_4$

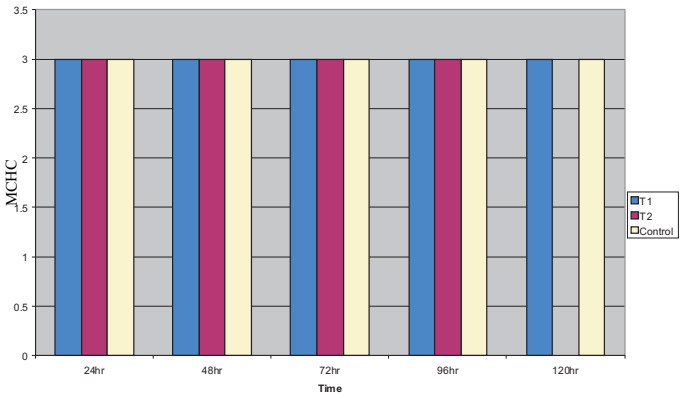

Fig.8 : Variation in the Mean corpuscular haemoglobin concentration of C. gariepinus under exposure to $ZnSO_4$

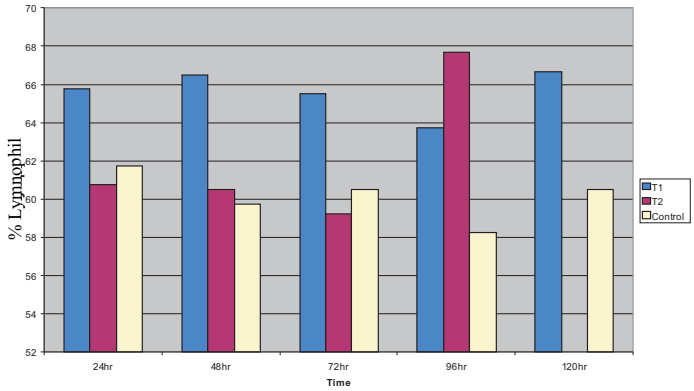

Fig.9 : Variation in %Lym of C. gariepinus under exposure to $ZnSO_4$

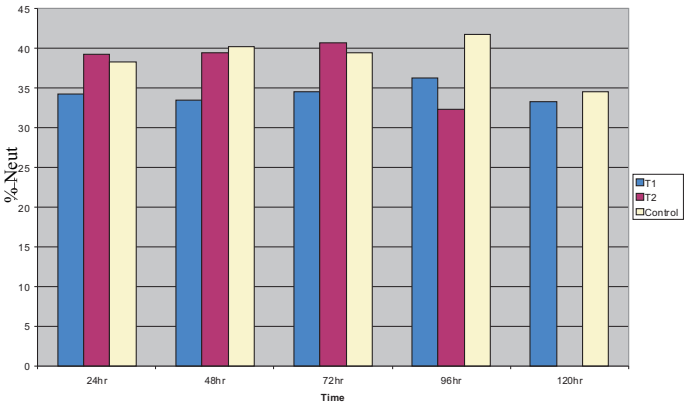

Fig.10 : Variation in %Neutrophil of C. gariepinus under exposure to $ZnSO_4$

Table No.3: The descriptives of the ten parameters

Parameters	Hours of exposure				
	24h	48h	72h	96h	120h
% PCV	.618	.542	.030*	.000*	.000*
% Hb	.682	.612	.034*	.000*	.000*
RBC(x$10^{12}/_l$)	.084	.013*	.361	.003*	.004*
WBC(x$10^{12}/_l$)	.731	.003*	.448	.012*	.001**
ESR	.255	.003*	.377	.046*	.000*
MCV(fl)	.048*	.361	.0.39	.192	.001**
MCH (pg)	.109	.031	.016*	.177	.000
% MCHC	--	--	--	--	--
% Lym	.330	.267	.240	.034*	.086
% Neut	.330	.267	.240	.034*	.086

* Values significant P<0.05
Values not significant P > 0.05
** Values highly significant P< 0.001
-- Shows no detection (MCHC throughout the hours of exposure).

Irrespective of the hour of exposure, $ZnSO_4$ had no significant impact on PCV, Hb, WBC, ESR, Lym and Neut while comparison between T_2 and T_1 showed that RBC and MCH were significantly different (TableNo. 4).

At 48h, comparison between the values of PCV, Hb, MCV, MCH, Lym and Neut in each treatment showed no significant difference (i.e. P>0.05) except RBC, WBC, ESR that showed significant difference at P<0.05 (Table No.3). Values of RBC showed a significant difference between treatments 1 and 2 (Table No.4).

At 72 hours, values of PCV, Hb, MCH, showed significant differences while RBC, WBC, ESR, MCV, Lym and Neut were not significant (Table No.3).

At 96 hours, PCV, Hb, RBC, WBC, ESR, Lym and Neut are significant while MCV, MCH shows no significant difference P>0.05 (Table No. 3).

At 120 hours, PCV, Hb, RBC and ESR were significant at (p<0.05). WBC and MCV were statistical significant at P<0.01. Lym and Neut did not show any significant i.e. (p>0.05) (Table No.3).

Total mortality was recorded in T_2 at 120 hours of exposure to $ZnSO_4$. Also, MCHC showed no detection throughout the hours of the experiment (24, 48, 72, 96 and 120 hours).

DISCUSSION

Comparing results with the control, the values of both treatments were higher than the control except for at 72 hours of exposure (control). Exposure of fishes to heavy metals zinc sulphate in water against time can cause reversible and irreversible changes in the homeostatic system of fish.

Table No.4: Comparisons for the 10 parameters throughout the hour of exposure.

Dependent Variable	(I) Treatment	(I) Treatment	24 Hours of Exposure		48 Hours of Exposure		72 Hours Of Exposure		96 Hours Of Exposure	
			Mean Diff. (I-J)	Std. Error	Mean Diff. (I-J)	Std. Error	Mean Diff.	Std. Error	Mean Diff.	Std. Error
PCV	omg zn/l	0.08mg zn/l	.2500	7.60026	-4.7500	4.91878	6.2500*	2.30338	9.7500*	1.15695
		0.15mg zn/l	-6.500	7.60026	-5.000	4.91878	6.7500*	2.30338	13.4167*	1.24965
	0.15mg zn/l	0.08mg zn/l	6.7500	7.60026	.2500	4.91878	.5000	2.30338	-3.6667*	1.24965
Hb	omg zn/l	0.08mg zn/l	-.5000	1.28970	-1.400	1.65395	2.2250*	.80984	3.2500*	.38093
		0.15mg zn/l	.6500	1.28970	-1.5000	1.653951	2.2250*	.80984	4.4417*	.41145
	0.15mg zn/l	0.08mg zn/l	-1.1500	1.28970	.1000	.65395	0.000	.80984	-1.1917*	.41145
RBC	omg zn/l	0.08mg zn/l	.1700	.46737	-.7400	.33449	-.2250	.49826	1.2750*	.30642
		0.15mg zn/l	-.9450	.46737	.5250	.33449	.5100	.49826	1.4850*	.33097
	0.15mg zn/l	0.08mg zn/l	1.1150*	.46737	-1.2650	.33449	-.7350	.49826	-.2100	.33097
WBC	omg zn/l	0.08mg zn/l	.4500	.57627	-2.4650*	.76408	1.8250	1.37790	-6.0750*	1.62007
		0.15mg zn/l	.1250	.57627	-3.6900*	.76408	.8250	1.37790	-5.3417*	1.74988
	0.15mg zn/l	0.08mg zn/l	.3250	.57627	1.2250	.76408	1.0000	1.37790	-.7333	1.74988
ESR	omg zn/l	0.08mg zn/l	2.0000	2.08710	-3.5000	1.83333	1.2500	2.77389	3.2500*	1.37878
		0.15mg zn/l	3.7250	2.08710	-8.7500*	1.83333	4.0000	2.77389	-.9161	1.48926
	0.15mg zn/l	0.08mg zn/l	-1.7250	2.08710	5.2500*	1.83333	-2.7500	2.77389	4.1667*	1.48926
MCV	omg zn/l	0.08mg zn/l	-4.0000	16.20271	21.6750	27.15733	-23.2500*	7.56362	2.5000	9.76921
		0.15mg zn/l	43.2500*	16.20271	-19.3425	27.15733	-12.5000	7.56362	20.0000	10.55195
	0.15mg zn/l	0.08mg zn/l	-43.2500*		19.3425	27.15733	12.5000	7.56362	-20.0000	10.55195
MCV	omg zn/l	0.08mg zn/l	-6.2500	8.21077	1.7500	5.86184	8.5000*	2.3333	-1.0000	3.29773
		0.15mg zn/l	13.0000	8.21077	-15.5000*	5.86184	3.5000	2.3333	-6.0000	3.56195
	0.15mg zn/l	0.08mg zn/l	-19.2500*	8.21077	17.2500*	5.86184	5.0000	2.3333	-7.0000	3.56195
LYM	omg zn/l	0.08mg zn/l	-4.0000	3.33542	-6.7500	4.22131	-5.000	3.61132	-5.5000	2.71761
		0.15mg zn/l	1.0000	3.33542	-.7500	4.22131	1.2500	3.61132	-9.4167*	2.93536
	0.15mg zn/l	0.08mg zn/l	-5.0000	3.33542	-6.0000	4.22131	-6.2500	3.61132	3.9167	2.93536
NEUT	omg zn/l	0.08mg zn/l	4.0000	3.33542	6.7500	4.22131	5.0000	3.61132	5.5000	2.71761
		0.15mg zn/l	-1.0000	3.33542	.7500	4.22131	-1.2500	3.61132	9.4167*	2.93536
	0.15mg zn/l	0.08mg zn/l	5.0000	3.33542	6.0000	4.22131	6.2500	3.61132	-3.9167	2.93536

The increase in haemotological parameters observed in control agreed with the findings of [19] that survival of fish can be correlated with increase in antibody production which helped in the survival and recovery lower haemoglobin level according to [20] might decrease in the ability of fish to enhance its activity in order to meet occasional demand.

A short-term exposure to low concentrations of heavy metal mostly induces an increase of these haematological indices. Exposed fish reaction causes an osmotic imbalance and changes in the regulatory system of ionic interchange which can diminish pH of blood and increase the volume of erythrocytes and subsequently, the percent of haematocrit.

In the white cell parameters, the trend in the lymphocytes count is mostly observed during the first hours of exposure reaction when fish tried to restore disturbed homeostasis, however, later a decrease of leucocytes count can be observed which shows the weakening of the immune system.

A decrease in the concentration of haemoglobin in blood, which is usually caused by the effects of toxic metals on gills, as well as decrease in oxygen also indicated anaemia or confirmed negative changes occurring in fish.

Although, zinc is a 'masculine' element that balances copper in the body, and essential for male reproductive activity [15], it also served as a co-factor for dehydrogenating enzymes and in carbonic anhydrase [21]. While zinc deficiency has been reported to cause anaemia and retardation of growth and development [12], this study showed that occurrence of zinc in high concentrations caused irreversible haematological perturbations some of which resulted in death of fish.

Lymphocytes being more numerous cells than the leucocytes, functioned in the production of antibodies and chemical substances serving as defence against infection. The primary consequence observed in changes in leucocytes count in stressed fish was suppression of the immune system and increased susceptibility to disease [22]. Values of lymphocytes varied along both time and concentration gradients. According to other authors, there was a decrease in the leucocytes concentration in the blood of carp under exposure to 0.25g/l of cadmium [23]. The significant interaction recorded between source of fish and health status seemed to suggest that the source of fish played an important role in the health status when adjudged by changes in WBC.

For MCV, a value higher than the normal range in an indication of macrocytosis and value smaller than the normal range in indicative of microcytosis.

A short term exposure of low concentration of heavy metal mostly induced an increase of these haematological indices. All that reflects the beginning of stress reaction in the fish caused by chemicals. Fish stress reaction caused an osmotic imbalance and

change in the regulatory system of ionic interchange, which can diminish pH of blood and increased the volume of erythrocytes and consequently the presence of haematocrit.

CONCLUSION

Zinc toxicity in sub-lethal concentrations is common in many freshwater habitats. This study showed the physiological imbalances that occurred in the haematological parameters of the African catfish. Hence, such variations in blood parameters of *Clarias gariepinus* can serve as an early warning of zinc contamination in the natural freshwater habitat where such fish lives.

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