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Research Article

Acute Toxicity, Haematology, Plasma Electrolyte Responses and Hepatosomatic Index in Mud Catfish, *Clarias gariepinus* (Burchell 1822) Exposed to Two Household Surfactants

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ABSTRACT

The acute toxicity and sub-lethal effects of the surfactants JIKB and MFLS on *Clarias gariepinus* were assessed in laboratory bioassays. Acute toxicity was evaluated over a 96-hour period, while sub-lethal effects on plasma electrolytes (potassium K+, sodium Na+, chloride Cl-), haematological parameters (white blood cells WBC, red blood cells RBC, haemoglobin HGB, and haematocrit HCT), and the hepatosomatic index were investigated over 21 days. Results indicated that MFLS (96h LC_{50} = 0.086 ml/L) was 3.28 times more toxic than JIKB (96h LC_{50} = 0.282 ml/L). Haematological analysis showed reductions in WBC, RBC, HCT, and HGB values. Plasma electrolyte levels in *C. gariepinus* exposed to JIKB and MFLS ranged from 146.7 mEq/L to 220.0 mEq/L for sodium, 5.13 mEq/L to 20.7 mEq/L for potassium, and 111.3 mEq/L to 217.3 mEq/L for chloride, with marked dose- and time-dependent increases. Hepatosomatic index values showed significant differences ($p < 0.05$) at days 7 and 21, but not at day 14 ($p > 0.05$). Control values for test organisms exposed to JIKB and MFLS at 7, 14, and 21 days were 3.51 ± 0.82, 2.41 ± 1.11, and 2.95 ± 0.22, respectively. Short-term exposure of *Clarias gariepinus* to low concentrations of JIKB and MFLS significantly disrupted physiological processes, as evidenced by altered haematological parameters, increased plasma electrolyte levels, and variations in hepatosomatic index. MFLS was significantly more toxic than JIKB. These findings highlight the potential environmental risks posed by these surfactants to aquatic life, underscoring the need for careful management and regulation.

Keywords: Acute toxicity, Electrolyte, Fish, Haematology, Hepatosomatic, Sub-lethal, Surfactant
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INTRODUCTION

Aquatic ecosystems are increasingly subjected to pollution from various anthropogenic sources, including household chemicals that enter water bodies through domestic waste. One such group of pollutants comprises surfactants, which are active agents found in many household cleaning products. Surfactants have been recognized (Lawal *et al.*, 2013) for their potential to cause significant environmental harm, particularly to aquatic organisms.

Fish have often been considered as the sentinel organism for health of aquatic environment and respond to myriad of substances produced by different kinds of anthropogenic activities in a manner similar to that of higher vertebrates (Beey, 2001; Barbieri, 2007). They can be used to screen chemicals that are potentially harmful to humans. The use of biological responses (biomarkers) in fish that are related to exposure or the effects of the contaminants has led to good results in environmental risk assessment.

The African catfish, *Clarias gariepinus* is a widely studied species in ecotoxicological research due to its economic importance and sensitivity to environmental changes. Previous studies have demonstrated that exposure to various pollutants, including pesticides and heavy metals; can affect the physiological and biochemical parameters of this species, such as haematology and plasma electrolytes (Adewoye et al., 2005; Gabriel et al., 2007). However, the specific impacts of household surfactants on *Clarias gariepinus* remain underexplored.

In assessing the toxic effects of chemicals on aquatic organism, understanding the acute toxicity of

pollutants is crucial for assessing their immediate risks to aquatic life. Acute toxicity tests measure the short-term effects of pollutants on organisms, providing critical data for environmental risk assessments (Rand, 1995). Haematological techniques has become more useful in toxicological research, environmental monitoring and assessment of fish health conditions as a result of the intimate relationship between fish and its aqueous environment (Musa and Omoregie, 1999). Blood parameters are considered patho-physiological indicators of the whole body and therefore are important in diagnosing the structural and functional status of fish exposed to toxicants (Jawad et al., 2004). Plasma electrolytes, including sodium, potassium, and chloride, play essential roles in maintaining osmotic balance and are crucial for various metabolic processes (Bury and Wood, 1999). Disturbances in these electrolytes can lead to severe physiological dysfunctions. Many studies have been carried out in the laboratory on the effects of toxicants on the haematology and electrolyte response of *C. gariepinus*, this include exposure to copper and lead (Annune and Ahuma, 1998), electrolyte response to permanganate (Kori-Siakpere, 2009), and exposure to aqueous leaves extracts of *Lepidagathis alopecuroides* (Gabriel et al., 2009).

The hepatosomatic index (HSI) is another valuable biomarker for assessing fish health. It represents the ratio of liver weight to body weight and can indicate the liver's response to toxic substances. An altered HSI often reflects hepatic damage or metabolic disruptions caused by pollutants (Fanta et al., 2003).

In spite of toxicity data available for surfactants, the research of their toxicity is still regarded limited (Liwarska-Bizukojc *et al.*, 2005) due to their extensive use in an emerging economy such as Nigeria. This study aims to evaluate the acute toxicity, haematological changes, plasma electrolyte responses, and hepatosomatic index in *Clarias gariepinus* following exposure to two common household surfactants (JIKB and MFLS). Understanding these impacts is crucial for assessing the ecological risks associated with surfactant pollution and for developing strategies to mitigate their adverse effects on aquatic life.

MATERIALS AND METHODS

Collection and Acclimatization of Test Organism

The Mud Catfish, *Clarias gariepinus* juveniles (12-15cm) used for this study were obtained from the Aquaculture Unit of the Department of Marine Sciences and transported in the evening to the Aquatic Toxicology and Ecophysiology Laboratory of the Department of Marine Sciences, University of Lagos. The juveniles were kept in rectangular glass tanks (113 × 54 × 13 cm) containing dechlorinated tap water. The fish were maintained for two (2) weeks. The dechlorinated tap water in the plastic tanks was renewed daily to prevent accumulation of waste metabolites and decaying food materials. Fish were fed twice daily on Coppens feed (2mm). Feeding was stopped 24 hours before they were introduced into the test concentrations. During the acclimatization period, mortality was less than 2%. Stocking and experimentation was carried out under ambient laboratory conditions.

Test Chemicals

The test chemicals Jik® (JIKB) and Morning Fresh® (MFLS) were purchased at Yem-Yem Supermarket, University of Lagos, Yaba, Lagos. Ingredient in MFLS includes Anionic surfactants, hydrotropes, salts, perfumes, colors and preservatives. JIKB is household bleach and is composed of sodium hypochlorite (3.85% m/v), water and fragrance.

Physico-Chemical Parameters of Test Media

Physico-chemical parameters (dissolved oxygen, pH, and temperature) of the test media were measured before and during the experimental period. The pH was measured using a pH meter and temperature was measured using a mercury-in-glass thermometer. The dissolved oxygen was determined using a Jenway DO meter (Model 9071).

Acute Toxicity Bioassays

A static renewal bioassay procedure was adopted for all the toxicity tests. Depending on the test concentration, a given volume (2 litres) of dechlorinated tap water was measured into bioassay glass tanks (32 × 15 × 18cm). Ten (10) active *C. gariepinus* juveniles were introduced into the test medium (2 litres) containing either JIKB or MFLS. Each concentration was replicated thrice, given a total of 30 fishes per treatment, including untreated media (control). The concentration of the test media were as follows:

JIKB: 0.30, 0.35, 0.40, 0.45, 0.50 ml/L.
MFLS: 0.06, 0.08, 0.10, 0.12, 0.14 ml/L.

Mortality was assessed every 24 hour over a 96 hour experimental period. Fish was assumed dead when there was no body or operculum movement, even

when probed with a glass rod. Dead fishes were removed and recorded to prevent contamination of the water.

Sub-Lethal Bioassay Procedure

Fishes were randomly distributed into plastic tanks (52 × 33 × 23 cm) with 20 litres of dechlorinated water at 15 fishes per tank. Exposures of fish to sub-lethal concentration of $1/10^{th}$, $1/20^{th}$, $1/50^{th}$ of 96hr LC_{50} values of the test compounds for duration of 21 days were as follows:
JIKB: 0.00, 0.00564, 0.0141, 0.0282 ml/L.
MFLS: 0.00, 0.0017, 0.0043, 0.0086 ml/L.

Haematological Analysis

At the end of each week (7 days), three (3) fishes were randomly selected from each tank, blood samples were obtained from the fishes by severance of the gill with syringe (2 ml) and collected into EDTA (Ethylene Diamine Tetra-acetic Acid) container (Mgbenka *et al.*, 2003). All blood samples were labelled and immediately taken to the laboratory for analysis. Haematological parameters analyzed for were white blood cells (WBC), red blood cells (RBC), haemoglobin (Hb), haematocrit (HCT), mean corpuscular volume (MCV), mean corpuscular haemoglobin **(**MCH), mean corpuscular haemoglobin concentration **(**MCHC), red cell distribution width (RDW)**,** platelets **(**PLT), mean platelate volume (MPV), platelet crit (PCT). All the haematological parameters were analyzed in the haematological laboratory of the University of Lagos Teaching Hospital (LUTH) by means of automated method using haematology automated analyzer (Mindray BC-3200).

Plasma Electrolyte Study

At the end of each week (7 days), three (3) fishes were randomly selected from each tank; blood samples were obtained from the fishes by severance of the gills with syringe (2ml) and collected into plain bottles. The bottle was then transported to Lagos University Teaching Hospital (LUTH) for analysis of plasma electrolytes; sodium, potassium, and chloride were all determined colorimetrically using commercial diagnostic kits, following the manufacturer's instruction; with the aid of a spectrophotometer.

Plasma sodium was measured by using an improved direct method of spectrophotometric measurement of sodium in plasma without deprotenization. The method is based on the fact that sodium is precipitated as triple salt, sodium magnesium uranyl acetate, with the excess uranium then being reacted with ferrocyanide producing a chromophore whose absorbance varies inversely as the concentration of sodium present in the sample. The measurement was done using a commercial kit.

Plasma potassium was measured using an improved direct method of spectrophotometric measurement of potassium in plasma without deprotenization. The amount of potassium was determined using sodium tetraphenylboron in a specifically prepared mixture to produce a colloidal suspension, whose turbidity is proportional to the potassium concentration in the sample. The measurement was done using a commercial kit.

Plasma chloride was measured using the thiocyanate colorimetric method which is based on the reaction in which chloride ions quantitatively displace thiocyanate ions react with ferric ions forming a red ferricthiocyanate complex, whose colour intensity is proportional to the concentration of chloride present in the sample. The measurement was done using a commercial kit.

Hepatosomatic Index (HSI)

At the end of each week, the HSI values were calculated from the ratio of total body weight and liver weight. After weighing, fishes were dissected to remove the liver from them for the determination of HSI. Moisture of the liver was removed using blotting paper and then weight of liver was recorded in grams. The hepatosomatic index of the fish was determined using the equation:

$$\text{HSI} = \frac{\text{Weight of the liver}}{\text{Weight of the body}} \text{ x } 100$$

In such a way weight of liver of every fish per week is recorded and the mean value of the liver of twenty-one fishes per week. The mean value of liver gives an idea about the condition of the liver of the fish and maturity of the fish. The health of fish is directly related to the condition of liver because it is the organ related with the digestion of food and storage of reserved food. So the good condition of the liver is the indication of the good health of fish.

Statistical Analysis

The dose-mortality response data from the 96-hour toxicity tests were subjected to probit analysis following Finney's methodology (1971). From this analysis, toxicity measurement indices were derived,

including LC_{50} (the median lethal concentration resulting in 50% mortality of the exposed organisms) and TF (toxicity factor for assessing the relative potency of the test chemicals based on their 96-hour LC_{50} values).

The differences in hematological profile, plasma electrolyte response, and hepatosomatic index of *C. gariepinus* subjected to varying concentrations of JIKB and MFLS over a 21-day period were assessed through graphical depiction, ANOVA, and Student-Newman-Keuls (SNK) test. Graphical representation was done using Microsoft Excel, while probit, ANOVA, and SNK analyses were analysed using SPSS 20.0 for Windows.

RESULTS

Physico-Chemical Parameters

The physico-chemical condition prevalent in the test solution and control in bioassays indicated that the dissolved oxygen content ranged between 2.4 to 4.8 mg/L and decreased with increasing concentration during the study. The hydrogen ion concentration (pH) ranged from 7.0 to 7.6 in treatments indicating a slightly alkaline reaction. The temperature ranged from 27.9 to 28.4 ^{o}C.

Acute Toxicity Test

The result of the acute toxicity test of JIKB and MFLS on *C. gariepinus* at 24, 48, 72, and 96hrs of exposure are shown in Table 1. The LC_{50} values of MFLS when tested against *C. gariepinus* was 0.175 ml/L, 0.132 ml/L, 0.106 ml/L, and 0.086 ml/L for 24h, 48h, 72h and 96h respectively.

The analysis of concentration-mortality data of JIKB when tested against *C. gariepinus* revealed that the derived toxicity indices (LC_{50}) was 0.454ml/L, 0.350 ml/L, and 0.282 ml/L for 48h, 72h and 96h respectively. No mortality was recorded in *C. gariepinus* exposed to the tested concentrations of JIKB in 24 hours. On the basis of computed Toxicity Factor (TF) using 96hLC_{50} MFLS was more toxic (TF = 3.28) on *C. gariepinus* than JIKB (Table 1).

Haematological Profile

White Blood Cell (WBC)

The lowest mean WBC (8.3±1.05 $\times 10^9$/L) was recorded in *C. gariepinus* exposed to 0.0282ml/L at day 7 while the highest mean WBC (65.6±1.76 $\times 10^9$/L) was recorded when exposed to Control (0.00 ml/L) on day 21 for JIKB (Table 2). For MFLS, the lowest mean WBC (10.0±1.32 $\times 10^9$/L) was recorded in *C. gariepinus* exposed to 0.0017ml/L on day 7 while the highest mean WBC (65.6±17.6 $\times 10^9$/L) was recorded in 0.0086ml/L on day 21 (Table 2). There was significant difference ($p<0.05$) in the WBC of test organisms exposed to different concentrations of JIKB at 7 and 14 days. The WBC in fish exposed to MFLS showed no significant difference ($p>0.05$) at day 7 and 21.

Red Blood Cell (RBC)

The mean RBC ranged 0.18±0.09 $\times 10^{12}$/L - 1.18±0.02 $\times 10^{12}$/L for JIKB. The values of RBC in the *C. gariepinus* increased with increasing days across treatments with JIKB (Table 3).
The lowest mean RBC (0.37±0.39 $\times 10^{12}$/L) was recorded in organism exposed to 0.0017ml/L on day 14 while the highest mean RBC (1.23±0.17 $\times 10^{12}$/L) in Control (0.00ml/L) on day 21 for MFLS (Table 3). There was no significant difference ($p>0.05$) in the RBC of test animal exposed to different concentrations of MFLS and JIKB at 7, 14 and 21 days.

Haemoglobin (Hb)

The mean HGB recorded in *C. gariepinus* exposed to JIKB ranged 1.20±0.75 g/dL - 6.20 ± 0.72 g/dL. The values of HGB in the *C. gariepinus* increased with increasing days across treatments with JIKB (Table 4). In *C. gariepinus* exposed to MFLS, mean HGB ranged 2.83±1.68 g/dL - 6.20±0.72 g/dL (Table 4). There was no significant difference ($p>0.05$) in the HGB of test organisms exposed to different concentrations of JIKB and MFLS at 7, 14 and 21 days (Table 4).

Haematocrit (HCT)

The lowest mean HCT (2.33±1.11 %) was recorded in *C. gariepinus* exposed to 0.00564ml/L of JIKB on day 14 while the highest mean HCT (16.7±2.82 %) was recorded in *C. gariepinus* exposed to Control (0.00ml/L) on day 21. In MFLS, the lowest mean HCT (6.10±5.52 %) was recorded in *C. gariepinus* exposed to 0.0017ml/L on day 14 while the highest mean HCT (16.7±2.82 %) was recorded in *C. gariepinus* exposed to Control (0.00ml/L) on day 21. The values of HCT in the *C. gariepinus* increased with increasing days of exposure across treatments with MFLS (Table 5). There was no significant difference ($p>0.05$) in the HCT of *C. gariepinus* exposed to different concentrations of JIKB and MFLS at 7, 14 and 21 days of exposure.

Table 1: Acute LC_{50} values for the toxicity of JIKB and MFLS against *Clarias gariepinus* at 24, 48, 72, and 96 hrs of exposure

Exposure time (Hrs)	LC_{50} (95%CL) %	Slope ± S.E	DF	Probit line equation	TF
		JIKB			
24	-	-	-	-	
48	0.454 (0.424-0.506)	7.59 ± 0.61	3	Y = (7.60 + 7.59x)	
72	0.350 (0.283-0.389)	4.60 ± 0.60	3	Y = (7.09 + 4.60x)	
96	0.282 (0.210-0.316)	6.57 ± 0.73	3	Y = (8.61+ 6.57x)	1.00
		MFLS			
24	0.175 (0.147-0.321)	6.001 ± 1.69	3	Y = (9.54 + 6.001x)	
48	0.132 (0.119-0.156)	5.89 ± 1.13	3	Y = (10.18 + 5.89x)	
72	0.106 (0.096-0.119)	5.07 ± 0.94	3	Y = (9.95 + 5.07x)	
96	0.086 (0.077-0.093)	6.16 ± 0.91	3	Y = (11.58 + 6.16x)	3.28

CL = Confidence limit LC=Lethal concentation DF= Degree of freedom TF= Toxicity factor = 96hLC_{50} value of MFLS /96hLC_{50} value of JIKB

Table 2: White blood cell (WBC) of *C. gariepinus* exposed to sub-lethal concemtrations of MFLS and JIKB

Concentration (ml/L)	White blood cell count ($\times 10^9$/L) during treatment (Days)		
	7	14	21
	MFLS		
0.0000	10.4 ± 1.03^a	52.2 ± 6.37^b	65.6 ± 17.6^a
0.0017	10.0 ± 1.32^a	20.4 ± 4.73^a	54.9 ± 0.47^a
0.0043	11.6 ± 0.75^a	56.2 ± 3.67^b	58.7 ± 4.01^a
0.0086	10.4 ± 0.95^a	60.5 ± 2.10^b	60.8 ± 0.25^a
	JIKB		
0.0000	10.43 ± 1.03^{ab}	52.2 ± 6.37^b	65.6 ± 1.76^a
0.0056	9.57 ± 1.00^{ab}	41.8 ± 4.37^b	59.1 ± 3.41^a
0.0141	11.20 ± 1.05^b	21.0 ± 4.44^a	61.1 ± 2.43^a
0.0282	8.30 ± 1.05^a	50.8 ± 5.38^b	60.7 ± 1.44^a

Mean with the same superscript letter in a column are not significantly different (p>0.05) when subjected to Student-Newman-keuls (SNK)

Table 3: Red blood cell (RBC) of *C. gariepinus* exposed to sub-lethal concentrations of MFLS and JIKB.

Concentration (ml/L)	Red blood cell count ($\times 10^{92}$/L) during treatment (Days)		
	7	14	**21**
	MFLS		
0.0000	0.57 ± 0.12^a	0.45 ± 0.48^a	1.23 ± 0.17^a
0.0017	0.57 ± 0.32^a	0.37 ± 0.39^a	1.14 ± 0.01^a
0.0043	0.76 ± 0.12^a	0.46 ± 0.07^a	0.89 ± 0.36^a
0.0086	0.52 ± 0.34^a	0.93 ± 0.44^a	1.17 ± 0.01^a
	JIKB		
0.0000	0.57 ± 0.12^a	0.45 ± 0.48^a	1.23 ± 0.17^a
0.0056	0.82 ± 0.301^a	0.18 ± 0.09^a	1.15 ± 0.05^a
0.0141	0.61 ± 0.17^a	0.49 ± 0.08^a	1.18 ± 0.02^a
0.0282	0.96 ± 0.10^a	0.46 ± 0.24^a	1.17 ± 0.01^a

Mean with the same superscript letter in a column are not significantly different (p>0.05) when subjected to Student-Newman-keuls (SNK)

Table 4: Haemoglobin of *C. gariepinus* exposed to sub-lethal concentrations of MFLS and JIKB.

Concentration (ml/L)	Haemoglobin level (g/dL) during treatment (Days)		
	7	14	21
	MFLS		
0.0000	3.60 ± 0.95[a]	3.60 ± 3.74[a]	6.20 ± 0.72[a]
0.0017	3.60 ± 1.67[a]	2.87 ± 1.44[a]	5.80 ± 0.00[a]
0.0043	3.80 ± 0.60[a]	3.60 ± 0.87[a]	4.80 ± 1.57[a]
0.0086	2.83 ± 1.68[a]	5.10 ± 2.18[a]	6.00 ± 0.00[a]
	JIKB		
0.0000	3.60 ± 0.95[a]	3.60 ± 3.74[a]	6.20 ± 0.72[a]
0.0056	3.70 ± 1.23[a]	1.20 ± 0.75[a]	5.90 ± 0.30[a]
0.0141	2.70 ± 0.44[a]	2.77 ± 0.58[a]	6.03 ± 0.15[a]
0.0282	4.83 ± 0.35[a]	3.13 ± 1.60[a]	6.00 ± 0.00[a]

Mean with the same superscript letter in a column are not significantly different (p>0.05) when subjected to Student-Newman-keuls (SNK)

Table 5: Haematocrit of *C. gariepinus* exposed to sub-lethal concentrations of MFLS and JIKB.

Concentration (ml/L)	Percentage (%) Haematocrit during treatment (Days)		
	7	**14**	**21**
	MFLS		
0.0000	7.70 ± 1.58[a]	5.60 ± 6.00[a]	16.7 ± 2.82[a]
0.0017	8.40 ± 4.69[a]	6.1 0 ± 5.52[a]	14.8 ± 0.62[a]
0.0043	10.8 ± 1.92[a]	7.07 ± 1.29[a]	11.6 ± 4.75[a]
0.0086	7.07 ± 5.12[a]	13.7 ± 7.18[a]	15.7 ± 0.12[a]
	JIKB		
0.0000	7.70 ± 1.59[a]	5.60 ± 6.00[a]	16.7 ± 2.82[a]
0.0056	9.43 ± 3.87[a]	2.33 ± 1.11[a]	14.9 ± 1.10[a]
0.0141	6.63 ± 0.95[a]	6.50 ± 1.25[a]	15.8 ± 0.47[a]
0.0282	14.4 ± 1.21[b]	5.77 ± 2.65[a]	15.6 ± 0.15[a]

Mean with the same superscript letter in a column are not significantly different (p>0.05) when subjected to Student-Newman-keuls (SNK)

Plasma Electrolyte Profile

Plasma Sodium (Na^+)

The maximum mean elevation of plasma sodium (220.0 mEq/l) was found in *C. gariepinus* exposed to JIKB at day 21 in the Control (0.00 ml/L) treatment while the lowest (151.0 mEq/l) was recorded in 0.0056 ml/L. The level of Sodium in *C. gariepinus* exposed to MFLS ranged 146.7 – 220.0 mEq/l (Table 6). Analysis of variance result showed that there was significant difference (p<0.05) in the mean levels of plasma sodium at different concentration of JIKB and MFLS at day 7 but there was no significant difference (p>0.05) in the mean plasma sodium of exposed *C. gariepinus* 14, and 21 days (Table 6)

Plasma Potassium (K^+)

There was a marked time-dependent increase in the levels of plasma potassium (Table 7). The lowest mean value of plasma pottasium (5.80 mEq/l) was recorded in *C. gariepinus* exposed to JIKB day 7 in the (0.0056 ml/L) treatment while the highest (21.8 mEq/l) was recorded in 0.0141 ml/L. The level of pottassium in *C. gariepinus* exposed to MFLS ranged 5.13 – 20.7 mEq/l (Table 7). Analysis of variance (ANOVA) showed significant difference (p<0.05) in the levels of plasma potassium in *C. gariepinus* exposed to different concentration of JIKB at day 7 and 21 (Table 7). Significant difference (p<0.05) was also recorded at day 7, 14 and 21 in MFLS exposed animals.

Plasma Chloride (Cl^-)

The lowest mean value of plasma chloride (114.0 mEq/l) was observed in *C. gariepinus* exposed to JIKB at day 7 in 0.0141 ml/L treatment while the highest 217.3 mEq/l was recorded in the Control (0.00 ml/L). The level of chloride in *C. gariepinus* exposed to MFLS ranged 111.3 – 217.3 mEq/l (Table 8). Analysis of variance showed that there was significant difference (p<0.05) in the mean levels of plasma chloride in *C. gariepinus* exposed to different concentrations of JIKB and MFLS at day 7 and 14 but

there was no significant difference (p>0.05) in the mean levels of plasma chloride at day 21.

Hepatosomatic Indices

The highest mean HSI value (5.21) was observed in *C. gariepinus* exposed to 0.00564ml/L of JIKB at day 7 and the lowest (1.60) at day 14 in 0.0141ml/L (Figure 1). The lowest mean HSI (1.92) in *C. gariepinus* exposed to MFLS was observed at day 14 at 0.0017ml/l and the highest mean HSI (6.78) value was observed in day 7 at 0.0017ml/L (Figure 2). Analysis of variance showed that there was significant difference (p<0.05) in the HSI of *C. gariepinus* exposed to different concentrations of JIKB and MFLS at day 7 and 21 but there was no significant difference (p>0.05) in the HSI at day 14.

DISCUSSION

The water quality variables in the experimental tanks were within the range acceptable for maximum performance of the fish in the test medium. There was concentration reduction in the values of dissolved oxygen in the exposed tanks, which was an indication that household surfactants affect the dissolved oxygen concentration during the experiment resulting in asphyxiation.

The acute toxicity study showed that the 96hLC_{50} values of JIKB and MFLS was 0.282 ml/L and 0.086 ml/L respectively when tested on the mud catfish, *Clarias gariepinus* while its toxicity was shown to increase with increasing concentration. The derived toxicity indices showed that MFLS was 3.28 times more toxic than JIKB. The highest concentration of the toxicants resulted in the highest mortality rate which is in agreement with the study of Chukwu (2001) and Ayoola (2008).

Changes in haematological parameters that were brought about by sub-lethal concentrations JIKB and MFLS indicated an anemic condition due to reduced synthesis of haemoglobin (Hb) and red blood cell (RBC) in most cases. Reduction of RBC has been reported to be due to development of hypoxic condition during the treatment which can lead to increase in destruction of RBC or decrease in rate of formation of RBC due to non-availability of Hb content in cellular medium (Chen *et al*., 2004). The decrease in haemoglobin concentration with increase in the concentration of the test chemicals is similar to those reported in *C. gariepinus* exposed to cassava effluents and tobacco (*Nicotiana tobaccum)* leaf extracts (Adeyemo, 2005; Omoniyi et al., 2002). Decrease in the Hb levels may impair oxygen supply to various tissues resulting in slow metabolic rate and low energy production (Atamanalp and Yanik, 2003).

The results of the white blood cells (WBC) revealed that there were fluctuations in the blood of the exposed fish when compared to the control group. Increase in WBCs count occurred as a pathological response since these WBCs play a great role during infestation by stimulating the haemopoietic tissues and the immune system through production of antibodies and chemical substances working as defense against infection (Lebelo et al., 2001; Hassen, 2002). WBC is important cells in the immune system, because of their main defensive function. The WBCs respond immediately to the change in medium due to xenobiotic transformation. During toxic exposure period of JIKB and MFLS, the WBC counts were enhanced. It indicated that fish can develop a defensive mechanism to overcome the toxic stress. The result suggested that the perturbations in these blood indices attributed to a defense reaction against toxicity of JIKB and MFLS may be due to the disturbances that occurred in metabolic activities of fish exposed below safe concentrations of toxicants. The toxicant caused haematological disturbance which could lead to impairment of the fish ability to combat diseases, reduce its chances for survival and potential for growth and reproduction. Adeyemo, (2005) and Gabriel et al. (2007) respectively recorded significant changes in the WBC of *C. gariepinus* exposed to cassava mill effluents and refined petroleum oil (kerosene). Similar changes were also recorded by Shakoori et al., (1996) in *Cyprinus idella* treated with fenvalerate, a pyrethroid pesticide.

There was no significant difference (p>0.05) in the mean values of haematocrit in the experimental fish with increase in concentration of the toxicant. Overall, the mean values of haematocrit in the exposed fish did not conform to any general pattern but fluctuated slightly with change in the exposure period. Haematocrit is an important instrument for determining the amount of plasma and corpuscles in the blood (measurement of packed erythrocytes) and used to determine the oxygen carrying capacity of blood (Larsson et al., 1985). Decrease in the haematocrit values recorded after exposure to JIKB and MFLS at day 21 are indicative of anaemia and haemodilution possibly due to gill damage or/and impaired osmoregulation (Larsson et al., 1985). It is evident from the haematological study that the sub-lethal concentration of JIKB and MFLS created a stress situation in the test organism resulting in decrease in the values of haemoglobin content,

Table 6: Plasma Sodium of *C. gariepinus* exposed to sub-lethal concentrations of MFLS and JIKB.

Concentration (ml/L)	Electrolyte response (mEq/l) during treatment (Days)		
	7	**14**	**21**
	MFLS		
0.0000	158.7 ± 3.06^{b}	161.0 ± 6.25^{a}	220.0 ± 30.0^{a}
0.0017	156.7 ± 2.08^{b}	155.3 ± 2.52^{a}	186.3 ± 7.09^{a}
0.0043	150.3 ± 1.53^{a}	162.0 ± 5.00^{a}	191.0 ± 10.4^{a}
0.0086	146.7 ± 4.73^{a}	158.3 ± 1.15^{a}	193.3 ± 12.6^{a}
	JIKB		
0.0000	158.7 ± 3.06^{b}	161.0 ± 6.25^{a}	220.0 ± 30.0^{a}
0.0056	151.0 ± 2.65^{a}	159.7 ± 2.52^{a}	194.7 ± 5.51^{a}
0.0141	158.3 ± 1.53^{b}	157.7 ± 2.52^{a}	208.3 ± 7.64^{a}
0.0282	157.3 ± 2.52^{b}	160.3 ± 1.53^{a}	191.7 ± 10.4^{a}

Mean with the same superscript letter in a column are not significantly different (p>0.05) when subjected to Student-Newman-keuls (SNK)

Table 7: Plasma Potasium of *C. gariepinus* exposed to sub-lethal concentrations of MFLS and JIKB.

Concentration (ml/L)	Electrolyte response (mEq/l) during treatment (Days)		
	7	**14**	**21**
	MFLS		
0.0000	9.20 ± 0.17^{c}	13.9 ± 0.90^{bc}	20.7 ± 0.96^{b}
0.0017	7.10 ± 0.36^{b}	10.0 ±0.20^{a}	20.0 ± 1.05^{ab}
0.0043	6.70 ± 0.20^{b}	14.6 ± 2.15^{c}	18.7 ± 0.76^{b}
0.0086	5.13 ± 0.59^{a}	11.8 ± 0.29^{ab}	18.2 ± 0.47^{b}
	JIKB		
0.0000	9.20 ± 0.17^{b}	13.9 ± 0.90^{a}	20.7 ± 0.96^{ab}
0.0056	5.80 ± 0.62^{a}	13.2 ± 3.07^{a}	19.4 ± 1.10^{a}
0.0141	6.50 ± 1.11^{a}	10.2 ± 0.97^{a}	21.8 ± 0.25^{b}
0.0282	9.23 ± 0.61^{b}	13.5 ± 1.12^{a}	20.1 ± 0.66^{ab}

Mean with the same superscript letter in a column are not significantly different (p>0.05) when subjected to Student-Newman-keuls (SNK)

Table 8: Plasma Chloride of *C. gariepinus* exposed to sub-lethal concentrations of MFLS and JIKB**.**

Concentration (ml/L)	Electrolyte response (mEq/l) during treatment (Days)		
	7	**14**	**21**
	MFLS		
0.0000	123.3 ± 2.89^{b}	151.0 ± 5.29^{b}	217.3 ± 32.7^{a}
0.0017	111.7 ± 3.79^{a}	127.7 ± 3.21^{a}	182.7 ± 15.8^{a}
0.0043	114.3 ± 4.04^{a}	129.3 ± 12.9^{a}	174.0 ± 4.58^{a}
0.0086	111.3 ± 5.86^{a}	114.7 ± 8.39^{a}	174.3 ± 8.14^{a}
	JIKB		
0.0000	123.3 ± 2.89^{b}	151.0 ± 5.29^{b}	217.3 ± 32.7^{a}
0.0056	112.3 ± 2.52^{a}	146.0 ± 25.4^{b}	180.3 ± 10.5^{a}
0.0141	117.7 ± 2.08^{ab}	114.0 ± 6.08^{a}	171.0 ± 22.6^{a}
0.0282	120.3 ± 6.11^{ab}	121.0 ± 3.46^{a}	184.3 ± 12.1^{a}

Mean with the same superscript letter in a column are not significantly different (p>0.05) when subjected to Student-Newman-keuls (SNK)

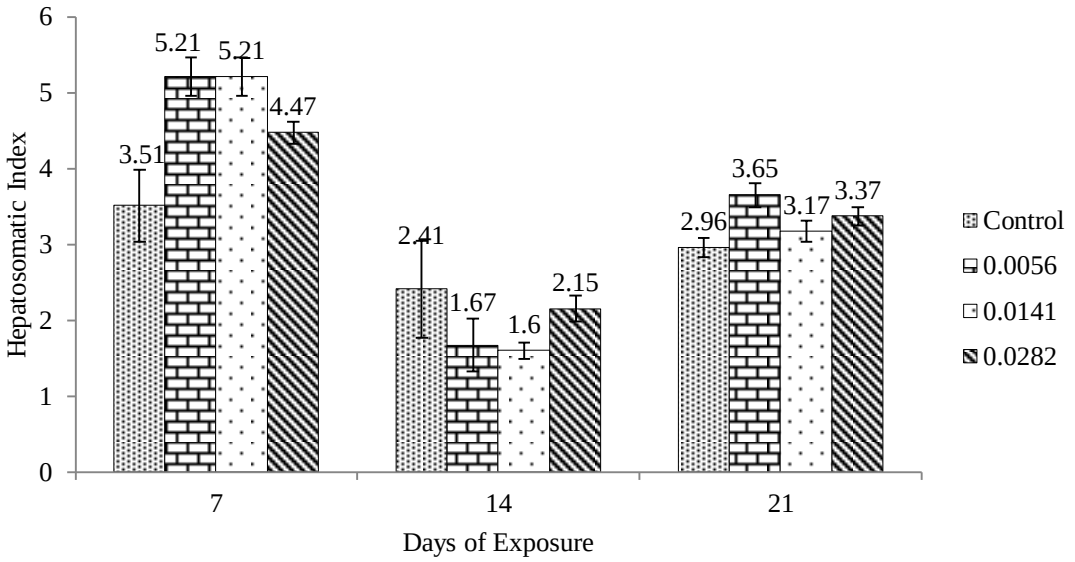

Figure 1: Mean values of Hepatosomatic index in *C. gariepinus* following exposure to different concentrations of JIKB over a period of 21 days.

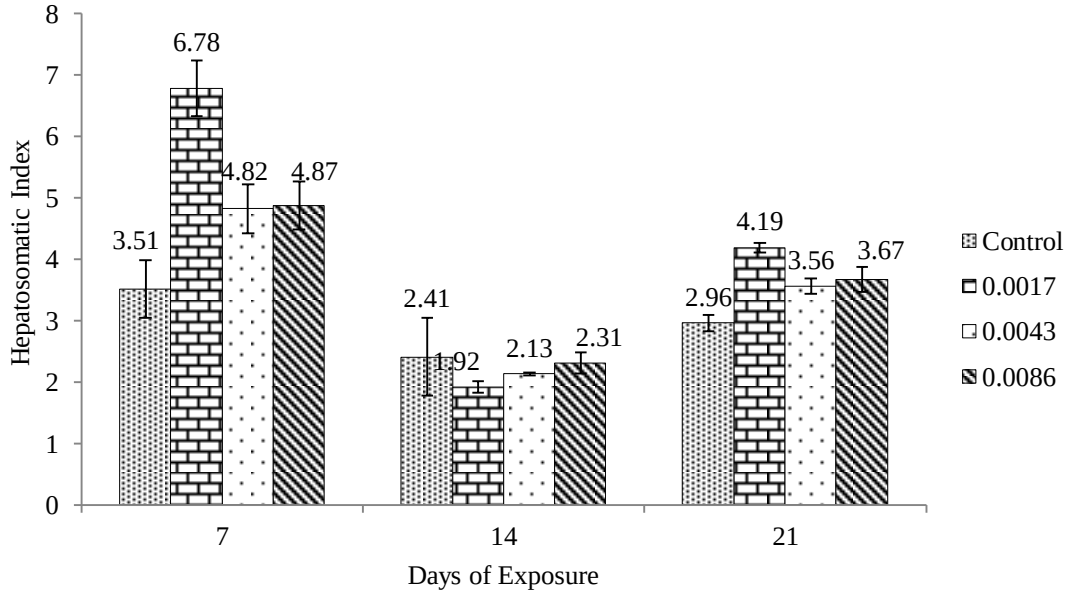

Figure 2: Mean values of Hepatosomatic index in *C. gariepinus* following exposure to different concentrations of Morning Fresh over a period of 21 days.

erythrocyte count and haematocrit of the *C. gariepinus* juvenile.

According to Mount and Zandi-Nejad (2020), electrolytes are essential for maintaining acid-base balance, controlling fluid distribution, preserving the osmotic pressure of bodily fluids, and promoting regular neuromuscular activity. All tissues depend on proper electrolyte balance to sustain functions like cellular metabolism, nerve impulse transmission, and muscular contraction (Gennari, 2016). The exposure of *C. gariepinus* to JIKB and MFLS showed reduction in the level of sodium (Na^+) levels in the exposed group when compared to the control group. Fish exposed to all treatment periods showed variations in their plasma potassium (K+) levels, which is unusual and can only be attributed to cell injury. When fish are exposed to environmental contaminants, electrolyte imbalances like this can signal considerable physiological stress

and possible harm to cellular integrity (Mount & Zandi-Nejad, 2020).

In the marine teleost *Lates calcarifer*, the enhancement of plasma sodium and chloride has been reported by Woo and Chui (1997). Plasma potassium concentration is proposed to be associated to nitrate uptake. The increase in plasma potassium in *C. gariepinus* exposed to JIKB and MFLS is reported, and the direct correlation for both ions leads to such an assumption.

There was reduction in the level of plasma chloride in the test organism with increasing concentration and exposure periods. Despite the decrease in chloride (Cl^-) level, other exchange mechanism may be a hyperactive response working jointly to chloride cells to maintain the physiological Cl^- levels. This process could result in the degeneration in these cells, in different water environments (Haygarth & Jarvis, 2002).

The general pattern of variation exhibited by Na^+, K^+ and Cl^- in the blood of the experimented fish shows that *C. gariepinus* adjusted effectively to the sub - lethal exposure to the various concentrations of JIKB and MFLS. This can also mean that the effect of JIKB on *C. gariepinus* was not as severe as that of MFLS at the concentrations used in the experiment. The consistent decrease in the mean levels of Na^+ with increased concentration of JIKB and MFLS may be as a result of the corresponding increase on muscular activity associated with the observed clinical symptoms of increased opercula rate, hyper-excitation, and uncontrolled movement (Ogamba et al., 2011).
The subsequent stabilization in the values of Na^+, K^+ and Cl^- even at the highest concentration of JIKB and MFLS could be a stress induced response as a result of the chronic exposure of *C. gariepinus*. This may have activated certain physiological and metabolic mechanisms that led to a rapid uptake of the electrolytes from the exposed water, food material, and the translocation of ions from other parts of the body of the test organism.

The Hepatosomatic index (HSI) is a useful biomarker to detect the hazardous effects of the environmental stressors (Pait & Nelson, 2003). In this study, there were fluctuations in the HSI values of *C. gariepinus* exposed to JIKB and MFLS. High values of HSI were found from day 7 to day 21, the mean value was significantly lower ($p<0.05$) in relation to other at day 14. At day 7, HSI increased suddenly and from day 14 on the tendency of the values was to rise with an exception for day 21 when a significant drop was recorded. Akerman et al. (2003) also found decrease in HSI values after 9 weeks in rainbow trout, *Oncorhynchus mykiss* injected with paraquat. On the contrary Figueiredo-Fernandes et al. (2006) found an increase of HSI in male and female tilapia, *O. niloticus*, exposed to paraquat. The slight increase in the HSI of the exposed fish indicated that the liver cells were affected possibly causing an increase in the rate of production of endoplasmic reticulum for the synthesis of protein in liver tissue (Anderson et al., 1988). The liver is responsible for enzymatic decontamination process, vitellogenin production and storage of glycogen as energy reserves. Therefore, in the presence of stressors, these qualities are altered resulting in deleterious effect on the fish (Jenkins, 2004).

This study suggests that in situ long-term exposure could be responsible for integrated biological effects, related to essential physiological functions, like metabolism and development or reproduction. The low HSI values found may be due to the accumulation in the liver for supplying energetic requirements during the time of scarce food items, sexual products elaboration and spawning activity.

The short-term exposure of *Clarias gariepinus* to household surfactants (JIKB and MFLS), even at very low concentrations, significantly disrupted the fish's physiological processes. These disruptions were evident in the altered haematological parameters and plasma electrolyte levels, indicating stress and potential damage to cellular integrity. Additionally, the hepatosomatic index study revealed that exposure to JIKB and MFLS led to notable metabolic and reproductive damage, highlighting the substantial impact of these surfactants on the overall health and viability of the fish. These findings underscore the ecological risks posed by household surfactants and emphasize the need for stringent regulations and improved management practices to protect aquatic life from such pollutants.

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REFERENCES

Adewoye, S. O., Fawole, O. O., Owolabi, O. D., & Omotosho, J. S. (2005). Toxicity of cassava wastewater effluents to African catfish: *Clarias gariepinus* (Burchell, 1822). *Ethiopian Journal of Science*, *28*(2), 189-194.

Adeyemo, O. K. (2005). Haematological and histopathological effects of cassava mill effluent in *Clarias gariepinus*. *African Journal of Biomedical Research*, *8*(3), 179-183

Åkerman, G., Amcoff, P., Tjärnlund, U., Fogelberg, K., Torrissen, O., & Balk, L. (2003). Paraquat and menadione exposure of rainbow trout (*Oncorhynchus mykiss*)—Studies of effects on the pentose-phosphate shunt and thiamine levels in liver and kidney. *Chemico-Biological Interactions*, *142*(3), 269-283. https://doi.org/10.1016/S0009-2797(02)00122-9

Andersson, T., Förlin, L., Härdig, J., & Larsson, Å. (1988). Physiological disturbances in fish living in coastal water polluted with bleached kraft pulp mill effluents. *Canadian Journal of Fisheries and Aquatic Sciences*, *45*(9), 1525-1536. https://doi.org/10.1139/f88-181

Annune, P. A., & Ahuma, F. T. (1998). Haematological changes in mudfish exposed to sublethal to concentrations of copper and lead. *Journal of Aquatic Sciences*, *13*, 33-36.

Atamanalp, M., & Yanik, T. (2003). Alterations in hematological parameters of rainbow trout (Oncorhynchus mykiss) exposed to mancozeb. *Turkish Journal of Veterinary and Animal Sciences*, *27*(5), 1213-1217.

Ayoola, S. O. (2008). Histopathological effects of glyphosate on juvenile African catfish (*Clarias gariepinus*). *American-Eurasian Journal of Agricultural and Environmental Sciences*, *4*(3), 362-367.

Barbieri, E. (2007). The use of active metabolism and swimming activity to evaluate the toxicity of Dodecil Benzen Sodium Sulfonate (LAS-C12) on the *Mugil platanus* (mullet) according to the temperature and salinity. *Water Environment Research*, *79*(8), 707-719. https://doi.org/10.2175/106143007x196697

Beey, A. (2001). What do sentinels stand for? *Environmental Pollution*, *112*(2), 285-298. https://doi.org/10.1016/S0269-7491(00)00038-5

Bury, N. R., & Wood, C. M. (1999). Mechanism of branchial apical silver uptake by rainbow trout is via the proton-coupled Na+ channel. *American Journal of Physiology-Regulatory, Integrative and Comparative Physiology*, *277*(5), R1385-R1391. https://doi.org/10.1152/ajpregu.1999.277.5.R1385

Chen, X., Yin, D., Hu, S., & Hou, Y. (2004). Immunotoxicity of pentachlorophenol on macrophage immunity and IgM secretion of the crucian carp (*Carassius auratus*). *Bulletin of Environmental Contamination & Toxicology*, *73*(1), 153-160. https://doi.org/10.1007/s00128-004-0407-z

Chukwu, L. O. (2001). Acute toxicity of treated industrial effluent to decapod crustacean, *Macrobranchium vollenhoevenii* (Herklots, 1857). *Journal of Science, Technology and Environment*, *1*(2), 21-33.

Fanta, E., Rios, F. S., Romão, S., Vianna, A. C. C., & Freiberger, S. (2003). Histopathology of the fish Corydoras paleatus contaminated with sublethal levels of organophosphorus in water and food. *Ecotoxicology and Environmental Safety*, *54*(2), 119-130. https://doi.org/10.1016/s0147-6513(02)00044-1

Figueiredo-Fernandes, A., Fontaínhas-Fernandes, A., Peixoto, F., Rocha, E., & Reis-Henriques, M. A. (2006). Effect of paraquat on oxidative stress enzymes in tilapia *Oreochromis niloticus* at two levels of temperature. *Pesticide Biochemistry and Physiology*, *85*(2), 97-103. https://doi.org/10.1016/j.pestbp.2005.11.001

Finney, D. J. (1971). *Probit analysis* (3rd ed.). Cambridge University Press

Gabriel, U. U., Ezeri, G. N. O., & Opabunmi, O. O. (2007). Haematological parameters of *Clarias gariepinus* exposed to crude oil. *Journal of Fisheries International*, *2*(1), 46-50.

Gabriel, U. U., Obomanu, F. G., & Edori, O. S. (2009). Haematology, plasma enzymes and organ indices of *Clarias gariepinus* after intramuscular injection with aqueous leaves extracts of *Lepidagathis alopecuroides*. *African Journal of Biochemistry Research*, *3*(9), 312-316

Gennari, F. J. (2016). Regulation of acid-base balance and disorders of metabolic alkalosis. *Journal of Nephrology*, *29*(4), 565-572.

Hassen, F. (2002). *Studies on diseases of fish caused by Henneguya infestation*, Ph.D Thesis, Faculty of Veterinary Medicine, Suez Canal University. Egypt. 112pp.

Haygarth, P. M., & Jarvis, S. C. (2002). *Agriculture, hydrology and water quality* (pp. xii+-502).

Jawad, L. A., Al-Mukhtar, M. A., & Ahmed, H. K. (2004). The relationship between haematocrit and some biological parameters of the Indian shad, Tenualosa ilisha (Family Clupeidae). *Animal Biodiversity and Conservation*, *27*(2), 47-52.

Jenkins, J. A. (2004). Fish bioindicators of ecosystem condition at the Calcasieu Estuary, Louisiana.

Kori-Siakpere, O. (2009). Electrolytes response to sublethal concentrations of potassium permanganate in the African catfish: *Clarias gariepinus* (Burchell, 1822). *International Journal of Integrative Biology*, *5*(1) 67-71.

Larsson, Å., Haux, C., & Sjöbeck, M. L. (1985). Fish physiology and metal pollution: results and experiences from laboratory and field studies. *Ecotoxicology and Environmental Safety*, *9*(3), 250-281. https://doi.org/10.1016/0147-6513(85)90045-4

Lawal, M. O., Samuel, O. B., Mogekwu, T. O., & Bolaji, D. A. (2013). Toxicity of two household liquid soaps on *Poecilia reticulata* Peters, 1859. *Brazilian Journal of Aquatic Science and Technology*, *17*(1), 35-41.

Lebelo, S. L., Saunders, D. K., & Crawford, T. G. (2001). Observations on blood viscosity in striped bass, *Morone saxatilis* (Walbaum) associated with fish hatchery conditions. *Transactions of the Kansas Academy of Science*, *104*(3), 183-194.

https://doi.org/10.1660/0022-8443(2001)104[0183:oobvis]2.0.co;2

Liwarska-Bizukojc, E., Miksch, K., Malachowska-Jutsz, A., & Kalka, J. (2005). Acute toxicity and genotoxicity of five selected anionic and nonionic surfactants. *Chemosphere, 58*(9), 1249-1253. https://doi.org/10.1016/j.chemosphere.2004.10.031

Mgbenka, B. O., Oluah, N. S., & Umeike, I. (2003). Effect of gammalin 20 (lindane) on differential white blood cell counts of the African catfish, Clarias albopunctatus. *Bulletin of Environmental Contamination & Toxicology*, *71*(2), 0248-0254. https://doi.org/10.1007/s00128-003-0157-3

Mount, D. B., & Zandi-Nejad, K. (2020). Disorders of fluid, electrolytes, and acid-base balance. In L. Goldman & A. I. Schafer (Eds.), *Goldman-Cecil Medicine* (26th ed., pp. 379-408). Elsevier.

Musa, S. O., & Omoregie, E. (1999). Haematological changes in *Clarias gariepinus* exposed to malachite green. *Journal of Aquatic Sciences, 14*, 37-42.

Ogamba, E. N., Inyang, I. R., & I. K. Azuma (2011). Effect of paraquat dichloride on some metabolic and enzyme parameters of *Clarias gariepinus*, *Current Research Journal of Biological Sciences*, *3*(3), 186-190.

Omoniyi, I., Agbon, A. O., & Sodunke, S. A. (2002). Effect of lethal and sub-lethal concentrations of Tobacco (Nicotiana tobaccum) leaf dust extract on weight and hematological changes in Clarias gariepinus (Burchell). *Journal of Applied Sciences and Environmental Management*, *6*(2), 37-41. https://doi.org/10.4314/jasem.v6i2.17174

Pait, A. S., & Nelson, J. O. (2003). Vitellogenesis in male *Fundulus heteroclitus* (killifish) induced by selected estrogenic compounds. *Aquatic Toxicology*, *64*(3), 331-342. https://doi.org/10.1016/S0166-445X(03)00060-2

Rand, G. M. (1995). Fundamentals of Aquatic Toxicology: Effects, Environmental Fate, and Risk Assessment. Taylor & Francis. https://doi.org/10.1201/9781003075363

Shakoori, A. R., Mughal, A. L., & Iqbal, M. J. (1996). Effects of sublethal doses of fenvalerate (a synthetic pyrethroid) administered continuously for four weeks on the blood, liver, and muscles of a freshwater fish, *Ctenopharyngodon idella*. *Bulletin of Environmental Contamination and Toxicology*, *57*, 487-494. https://doi.org/10.1007/s001289900216

Woo, N. Y. S., & Chiu, S. F. (1997). Metabolic and osmoregulatory responses of the sea bass *Lates calcarifer* to nitrite exposure. *Environmental Toxicology and Water Quality*, *12*(3), 257-264. https://doi.org/10.1002/(sici)1098-2256(1997)12:3%3c257::aid-tox9%3e3.0.co;2-7

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