original research article

TOXICOLOGICAL RESPONSES OF AFRICAN MUD CATFISH (*Clarias gariepinus*, Burchell, 1822) FINGERLINGS EXPOSED TO CULTURE WATER CONTAMINATEDWITH DIFFERENT CONCENTRATIONS OF CYPERMETHRIN

ABSTRACT

The toxicological effects of cypermethrin on *Clarias gariepinus* fingerlings and its contamination of culture water was studied. Ten fingerlings were stocked in each aquarium and was exposed to 5 different concentrations of cypermethrin and there was a control group. The fingerlings were exposed to 5, 10, 15, 20 and 30ppm of cypermethrin in triplicate. A total of 180 *C. gariepinus* fingerlings with a mean weight of 1.85 ± 0.29g were used throughout the study. The toxicant altered the physico-chemical parameters of culture water. The water temperature, pH, electrical conductivity and turbidity of the contaminated culture water increased with increase in the concentration of cypermethrin, while the DO decreased with increase in the toxicant concentration. Temperature, conductivity, pH and turbidity values were higher and the DO level was lower in the aquarium contaminated with the highest concentration of the toxicant compared to the control group. Statistically, the physico-chemical parameters varied significantly between the culture waters contaminated with different concentrations of cypermethrin across all exposure durations at $p<0.05$, except for temperature over 96 hours exposure period which was insignificant at $p>0.05$. The water temperature, pH and conductivity of the culture water were within the WHO acceptable limits except the dissolved oxygen (30ppm group over 72 and 96 hour exposure duration) and turbidity (5, 10, 15, 20 and 20ppm group) which were above the WHO permissible limit. The mortality data trend of fingerlings exposed to cypermethrin was concentration and duration dependent. The 96 hours LC_{50} value with 95% confidence limit of *C. gariepinus* fingerlings exposed to the toxicant was 9.332ppm ± 0.839, and was significant with a determination coefficient (r^2) of 0.88 at $P<0.05$. The low LC_{50} value for the fingerlings exposed to the pesticide indicated its high toxicity. In conclusion, contamination of culture water with cypermethrin led to the mortality of *C. gariepinus* fingerlings and the alteration of the physico-chemical parameters of the culture water. As a result, more similar research should be carried-out involving haemathological, reproductive, histological and other physiological alterations when fishes are exposed to cypermethrin so as to further reveal the toxic and harmful potentials of pesticides.

KEYWORDS: Toxicological, responses, concentrations, *Clarias gariepinus* and fingerlings

1. INTRODUCTION

Cypermethrin is globally used for the control of pest, in order to improve food productivity [1], but their use could create a risk of food contamination as well as affects non-target aquatic species like; invertebrates and vertebrates [2]. It is a synthetic pyrethroid, with a very high activity and stability [3]. Of all the pesticides available in the market, pyrethroids make about 25% of global pesticides sale [4]. The usefulness of the pesticide has always

marked its toxic effects on the aquatic environment [5]. Over 200 types of synthetic pesticides exist [6] and they all contain several heavy metals. These metals enter the water bodies, thereby affecting growth, physiology, reproduction and survival of fish [7].

Pesticides occupy a unique position among many chemicals which are encountered daily by man. Pesticides are deliberately added to the environment for pest control in homes and on farmlands. They are used in large quality by agro-farmers which in turn pollute our aquatic environment [8]. The toxicity of pyrethroids varies between biological species, due to the difference in elimination and metabolic degradation from the body [9]. Globally, Cypermethrin is used for the control of cotton, fruits and vegetables pest [9], copepod parasite infestation [10], aquatic and terrestrial ectoparasites [11] and for illegal fishing [9]. Agricultural run-off happens to be the main route of entry of cypermethrin into the aquatic eco-system, and this affects the non-target species [12]. Residues of these toxic chemicals found in water, sediment, fish and other aquatic biota, can pose a risk to organisms, predators and human being at high concentration (Lethal concentration), and are known to reduce the survival, growth, reproduction of fish and produce many visible effects on fish [13].

The rapid advancement of industrialization and green revolution has led to a number of environmental problems, with aquatic pollution being the most prominent. In Nigeria, effluents from industries, wastes from household activities and agricultural runoffs are directly discharged into streams, ponds and other aquatic bodies. These pollutants contain infectious pathogens, oil, hydrocarbon, radioactive substances, heavy metals, pesticides, herbicides and different corrosive substances such as acids and bases [14]. Yet these water sources are used for supplying water to the local masses and culturing of economically important and luscious fish species [14].

Water covers about 70% of the earth, and happens to be the most essential natural resources [15]. Despite this awareness of the essentiality of water, humans have ignored its importance by polluting it [16]. The advancement in industrialization has coincided with the problem of aquatic pollution. The use of mechanical and biological means of pest control has been abandoned for an easier and faster use of agricultural pesticides for control of pest, in order to generate massive crop yield, so as to meet-up with the ever growing human population [17, 18, 19]. The careless and indiscriminate use of these synthetic pesticides has led to the global pollution of water bodies [20, 21] leading to mortality of aquatic organisms and a general deterioration of the aquatic ecosystem [22, 23].

This study was aimed at evaluating the acute toxicity of cypermethrin on the survival of *C. gariepinus* fingerlings and the alterations in the water quality of the culture water.

2. MATERIALS AND METHODS

2.1 Test Chemical

Cypermethrin used for this study was purchased from Cross River State Ministry of Agriculture, Barracks Road, Calabar.

2.2 Collection and transportation of test fish

C gariepinus fingerlings were collected from the University of Calabar fish farm, Calabar, Cross River State using a scoop net in the early hours of the morning to avoid heat, high intensity and stress. The collected fingerlings were then transported to the Zoology and Environmental Biology laboratory using a plastic bucket containing a well aerated habitat water.

2.3 Acclimatization and maintenance of test fish

Once the fingerlings samples were taken to the laboratory, they were stored in a 30 x 30 x 80 cm tank containing a well aerated water and allowed to acclimate for 14 days in order to get used to the laboratory conditions. During the acclimation, the fingerlings were fed twice daily with coppens at 5% of their body weight. The water (borehole water) was changed every 48 hours to avoid contamination of water due to accumulated toxic waste metabolites and food particles. An aerator was also used in order to ensure adequate dissolved oxygen through-out the acclimatization period. Feeding of the fingerlings was stopped 48 hours to the commencement of the experiment.

2.4 Preparation of stock solution

The stock solution was prepared by dissolving 6mL of cypermethrin with 96.8% purity in 994 mL of water in a conical flask, which resulted in a 1000mL of the stock solution. The stock solution was then diluted serially to various concentrations.

2.5 Range finding test

A range finding test was carried-out using the test chemical, in order to determine the most appropriate range of concentration. A wide range of concentration was used for this purpose, including the concentration that killed all within 24 hours and another that did not kill the test organism within 96 hours. Through this, the most appropriate concentrations were selected for the experiment proper.

2.6 Test procedure

Eighteen aquaria measuring 60 X 30 X 30 cm^3 were used for the experiment. A total of 180 *C. gariepinus* fingerling weighing 1.85 ± 0.29g were used through-out the study,

which was carried-out in triplicates. Ten fingerlings of *C. gariepinus* fingerlings were introduced into each aquarium containing 1 litre of water. The fingerlings were then exposed to 5 different concentrations (5, 10, 15, 20 and 25ppm) of the toxicant and there was also a control group that were not exposed to any toxicant. The experiment was carried-out using a static non-renewal bioassay for 96hrs. The mortality and general behavior of fish was also observed after 24, 48, 72 and 96 hours of exposure. Fingerlings were considered dead when they cannot move any longer, even when touched with a glass rod. Dead fingerlings were removed immediately and then its mortality recorded.

2.7 Measurement of physico-chemical parameters

Water quality parameters of the culture water was monitored after 24, 48, 72 and 96 hours. The culture water for each fish group were tested in-situ for temperature (^{o}C), Conductivity (µs/cm), pH, dissolved oxygen (mg/L) and turbidity (N.T.U) once the toxicant was introduced. The water parameters were then monitored over the 96 hours period of the experiment, and compared to the control water parameters. This was done in order to find out the effect of cypermethrin on the water quality.

Temperature (^{o}C)

The surface water temperature was measured in-situ in culture water of each fingerlings group using mercury – in – glass thermometer in degrees Celsius (^{o}c). The thermometer was inserted at a depth of about 2cm from the surface water for about 3 minutes and the reading taken.

Hydrogen ion concentration (pH)

The pH of the water was measured in-situ using a model pH-1 pocket-sized pH meter. The meter glass probe was dipped into the culture water and readings taken.

Dissolved oxygen (DO) (mg/l)

The dissolved oxygen was measured in-situ using a dissolved oxygen meter, model DO-5509, calibrated in mg/L (milligrams per litre).

Turbidity (N.T.U)

The turbidity was measured in-situ using a turbidity meter. The meter was inserted 2cm from the water surface for about 2 minutes, and then the turbidity of the culture water read to the nearest N.T.U (Nephelometric turbidity unit).

Conductivity (µS/cm)

Conductivity was measured in-situ using a using Hannah Instrument (Bench meter 211 model). The meter was inserted 2cm from the water surface for about 2 minutes, and then the water conductivity value was taken to the nearest µS/cm.

2.8 Data analysis

The mortality data obtained were subjected to probit logarithm transformation. Regression analysis was also performed and the LC_{50} values was computed. The 95% confidence interval was also computed and the slope of the regression line tested using chi-square. Anova was also used to test for the significance of difference in water quality parameters between each concentration group at 0.05 level of significance and at their relevant degree of freedom. Also descriptive statistics (mean and standard deviation) was carried out on the physicochemical parameters of the contaminated culture water and the control group. Graph was plotted using Microsoft excel (MSE) version 2013. Probit analysis was carried-out using predictive analytical software (PASW) version 20.

3. RESULTS

3.1 Water quality of culture water

Water temperature (^{o}C)

The summary of the temperature alterations of the culture water contaminated with different concentrations of cypermethrin over a 96 hour exposure period is shown in Table 1. After 24 hours of exposure, the water temperature of the culture water had a mean and standard deviation of 29.000 ± 0.000, 29.250 ± 0.353, 28.965 ± 0.091, 28.025 ± 0.035, 29.025 ± 0.035 and 29.265 ± 0.332 ^{o}C when exposed to 0 (control), 5, 10, 15, 20 and 30 ppm of cypermethrin respectively. The lowest water temperature was observed in the culture water contaminated with 15ppm of cypermethrin (28.025 ± 0.035 ^{o}C), while the highest water temperature was observed in the culture water contaminated with 30ppm of cypermethrin (29.265 ± 0.332 ^{o}C) (Table 1).

After a 48 hours exposure duration, the water temperature of the culture water had a mean and standard deviation of 28.250 ± 0.353, 29.035 ± 0.049, 28.770 ± 1.032, 30.000 ± 0.000, 29.750 ± 0.353 and 30.650 ± 0.212 ^{o}C for the culture water contaminated with 0.00 (control), 5, 10, 15, 20 and 30 ppm of cypermethrin respectively. The lowest water temperature was observed in the culture water contaminated with 0.00ppm of cypermethrin (28.250 ± 0.353 ^{o}C), while the highest water temperature was observed in the culture water contaminated with 30ppm of cypermethrin (30.650 ± 0.212 ^{o}C) (Table 1).

After a 72 hours exposure duration, the water temperature of the culture water had a mean and standard deviation values of 28.500 ± 0.707, 28.950 ± 0.070, 28.755 ± 0.346, 30.300 ± 0.282, 30.025 ± 0.035 and 30.250 ± 0.353 ^{o}C for the culture water contaminated with 0.00 (control), 5, 10, 15, 20 and 30 ppm of cypermethrin respectively. The lowest water temperature was observed in the culture water contaminated with 0.00ppm of cypermethrin (28.500 ± 0.707 ^{o}C), while the highest water temperature was observed in the culture water contaminated with 20ppm of cypermethrin (0.025 ± 0.035^{o}C) (Table 1).

After a period of 96 hours, the water temperature of the culture water had a mean and standard deviation values of 28.500 ± 0.707, 29.150 ± 0.494, 28.750 ± 0.353, 25.250 ± 6.717, 29.755 ± 0.360 and 28.950 ± 0.070 ^{o}C for the culture water contaminated with 0.00 (control), 5, 10, 15, 20 and 30 ppm of cypermethrin respectively. The lowest water temperature was observed in the culture water contaminated with 15ppm of cypermethrin (25.250 ± 6.717 ^{o}C), while the highest water temperature was observed in the culture water contaminated with 20ppm of cypermethrin (29.755 ± 0.360 ^{o}C) (Table 1).

Table 1: The alterations in the temperature (^{o}C) of culture water contaminated with different concentrations of cypermethrin

	Temperature (^{o}C)						
Exposure Duration	0.00 ppm (control)	5ppm	10ppm	15ppm	20ppm	30ppm	WHO limit
24 Hours	29.000 ± 0.000^{a}	29.250 ± 0.353^{b}	28.965 ± 0.091^{c}	28.025 ± 0.035^{d}	29.025 ± 0.035^{e}	29.265 ± 0.332^{f}	
48 Hours	28.250 ± 0.353^{a}	29.035 ± 0.049^{b}	28.770 ± 1.032^{c}	30.000 ± 0.000^{d}	29.750 ± 0.353^{e}	30.650 ± 0.212^{f}	20 – 32^{o}C
72 Hours	28.500 ± 0.707^{a}	28.950 ± 0.070^{b}	28.775 ± 0.346^{c}	30.300 ± 0.282^{d}	30.025 ± 0.035^{e}	30.250 ± 0.353^{f}	
96 Hours	28.500 ± 0.707^{a}	29.000 ± 0.494^{a}	28.750 ± 0.353^{a}	25.250 ± 6.717^{a}	29.755 ± 0.360^{a}	28.950 ± 0.070^{a}	

Values are in mean ± Standard deviation

Values with different superscript are significantly different at P<0.05

The water temperature of the culture water varied across the different treatment group for through-out the observed duration. Statistically, the water temperature varied significantly between the culture water contaminated with 0.00, 5, 10, 15, 20 and 30ppm of cypermethrin over a 24, 48 and 72 hours period at p<0.05, while that of 96 hour duration did not vary significantly between the 0.00, 5, 10, 15, 20 and 30ppm cypermethrin contaminated group at

p>0.05. However, the water temperature of each culture water group through-out the duration observed were all within the WHO acceptable limits (Table 1).

Hydrogen ion concentration (pH)

The summary of the pH alterations of the culture water contaminated with different concentrations of cypermethrin over a 96 hour exposure period is shown in Table 2. After a period of 24 hours, the pH of the culture water had a mean and standard deviation values of 5.915 ± 0.021, 6.435 ± 0.544, 6.510 ± 0.014, 6.855 ± 0.077, 7.905 ± 0.007 and 8.005 ± 0.007 for the culture water contaminated with 0.00 (control), 5, 10, 15, 20 and 30 ppm of cypermethrin respectively. The lowest pH was observed in the culture water contaminated with 0.00ppm (control) of cypermethrin (5.915 ± 0.021), while the highest pH was observed in the culture water contaminated with 30ppm of cypermethrin (8.005 ± 0.007) (Table 2).

Table 2: The alterations in the pH (^{o}C) of culture water contaminated with different concentrations of cypermethrin

	pH values						
Exposure Duration	0.00 ppm (control)	5ppm	10ppm	15ppm	20ppm	30ppm	WHO limit
24 Hours	5.915 ± 0.021 [a]	6.435 ± 0.544 [b]	6.510 ± 0.014 [c]	6.855 ± 0.077 [d]	7.905 ± 0.007 [e]	8.005 ± 0.007 [f]	
48 Hours	5.915 ± 0.021 [a]	6.200 ± 0.565 [b]	6.250 ± 0.353 [c]	6.320 ± 0.014 [d]	7.250 ± 0.353 [e]	7.950 ± 0.070 [f]	6.5 – 8.5
72 Hours	5.700 ± 0.282 [a]	6.475 ± 0.063 [b]	6.950 ± 0.070 [c]	7.425 ± 0.530 [d]	7.900 ± 0.000 [e]	7.950 ± 0.070 [f]	
96 Hours	5.950 ± 0.070 [a]	6.950 ± 0.070 [b]	7.840 ± 0.014 [c]	7.875 ± 0.035 [d]	8.125 ± 0.035 [e]	8.955 ± 0.063 [f]	

Values are in mean ± Standard deviation

Values with different superscript are significantly different at P<0.05

After a 48 hours exposure duration, the pH of the culture water had a mean and standard deviation values of 5.915 ± 0.021, 6.200 ± 0.565, 6.250 ± 0.353, 6.320 ± 0.014, 7.250 ± 0.353 and 7.950 ± 0.070 for the culture water contaminated with 0.00 (control), 5, 10, 15, 20 and 30 ppm of cypermethrin respectively. The lowest pH was observed in the culture water contaminated with 0.00ppm (control) of cypermethrin (5.915 ± 0.021), while the highest water pH was observed in the culture water contaminated with 30ppm of cypermethrin (7.950 ± 0.070) (Table 2).

After a 72 hours exposure duration, the pH of the culture water had a mean and standard deviation values of 5.700 ± 0.282, 6.475 ± 0.063, 6.950 ± 0.070, 7.425 ± 0.530, 7.900 ± 0.000 and 7.950 ± 0.070 for the culture water contaminated with 0.00 (control), 5, 10, 15, 20 and 30 ppm of cypermethrin respectively. The lowest pH was observed in the culture

water contaminated with 0.00ppm (control) of cypermethrin (5.700 ± 0.282), while the highest water temperature was observed in the culture water contaminated with 30ppm of cypermethrin (7.950 ± 0.070) (Table 2).

After a period of 96 hours, the pH of the culture water had a mean and standard deviation values of 5.950 ± 0.070, 6.950 ± 0.070, 7.840 ± 0.014, 7.875 ± 0.035, 8.125 ± 0.035 and 8.955 ± 0.063 for the culture water contaminated with 0.00 (control), 5, 10, 15, 20 and 30 ppm of cypermethrin respectively. The lowest pH was observed in the culture water contaminated with 0.00ppm (control) of cypermethrin (5.950 ± 0.070), while the highest pH was observed in the culture water contaminated with 30ppm of cypermethrin (8.955 ± 0.063) (Table 2).

The pH of the culture water varied across the different treatment group, increasing with increase in the concentration of the toxicant through-out the observed duration. Statistically, the pH varied significantly between the culture water contaminated with 0.00, 5, 10, 15, 20 and 30ppm of cypermethrin over a 24, 48, 72 and 96 hours period at $p<0.05$. However, the pH of each culture water group through-out the duration observed were all within the WHO acceptable limits, except for the 30ppm group over 96 hours duration (Table 2).

Dissolved oxygen (DO) (mg/L)

The summary of the dissolved oxygen (DO) alterations of the culture water contaminated with different concentrations of cypermethrin over a 96 hour exposure period is shown in Table 3. After a period of 24 hours, the DO of the culture water had a mean and standard deviation values of 6.960 ± 0.042, 6.950 ± 0.000, 6.855 ± 0.035, 6.580 ± 0.148, 6.560 ± 0.070 and 6.460 ± 0.212 mg/L for the culture water contaminated with 0.00 (control), 5, 10, 15, 20 and 30 ppm of cypermethrin respectively. The lowest DO was observed in the culture water contaminated with 30ppm of cypermethrin (6.460 ± 0.212 mg/L), while the highest DO was observed in the culture water contaminated with 0.00ppm (control) of cypermethrin (6.960 ± 0.042 mg/L) (Table 3).

Table 3: The alterations in the dissolved oxygen (mg/l) of culture water contaminated with different concentrations of cypermethrin

	Dissolved Oxygen (mg/l)						
Exposure Duration	0.00 ppm (control)	5ppm	10ppm	15ppm	20ppm	30ppm	WHO limit
24 Hours	6.960 ± 0.042[a]	6.950 ± 0.000[b]	6.855 ± 0.035[c]	6.580 ± 0.148[d]	6.560 ± 0.070[e]	6.460 ± 0.212[f]	
48 Hours	6.960 ± 0.084[a]	6.875 ± 0.063[b]	6.775 ± 0.035[c]	6.505 ± 0.120[d]	6.465 ± 0.077[e]	6.020 ± 0.268[f]	>6
72 Hours	6.875 ± 0.035[a]	6.825 ± 0.035[b]	6.700 ± 0.028[c]	6.440 ± 0.056[d]	6.205 ± 0.007[e]	4.620 ± 0.862[f]	
96 Hours	6.555 ± 0.035[a]	6.435 ± 0.021[b]	6.375 ± 0.007[c]	6.365 ± 0.035[d]	6.355 ± 0.205[e]	4.415 ± 0.558[f]	

Values are in mean ± Standard deviation

Values with different superscript are significantly different at $P<0.05$

After a 48 hours duration, the DO of the culture water had a mean and standard deviation values of 6.960 ± 0.084, 6.875 ± 0.063, 6.775 ± 0.035, 6.505 ± 0.120, 6.465 ± 0.077 and 6.020 ± 0.268 mg/L for the culture water contaminated with 0.00 (control), 5, 10, 15, 20 and 30 ppm of cypermethrin respectively. The lowest DO was observed in the culture water contaminated with 30ppm of cypermethrin (6.020 ± 0.268 mg/L), while the highest DO was observed in the culture water contaminated with 0.00ppm (control) of cypermethrin (6.960 ± 0.084 mg/L) (Table 3).

After a 72 hours duration, the DO of the culture water had a mean and standard deviation values of 6.875 ± 0.035, 6.825 ± 0.035, 6.700 ± 0.028, 6.400 ± 0.056, 6.205 ± 0.007 and 4.620 ± 0.862 mg/L for the culture water contaminated with 0.00 (control), 5, 10, 15, 20 and 30 ppm of cypermethrin respectively. The lowest DO was observed in the culture water contaminated with 30ppm of cypermethrin (4.620 ± 0.862 mg/L), while the highest pH was observed in the culture water contaminated with 0.00ppm of cypermethrin (6.875 ± 0.035 mg/L) (Table 3).

After a period of 96 hours, the DO of the culture water had a mean and standard deviation values of 6.555 ± 0.035, 6.435 ± 0.021, 6.375 ± 0.007, 6.365 ± 0.035, 6.355 ± 0.205 and 4.415 ± 0.558 mg/L for the culture water contaminated with 0.00 (control), 5, 10, 15, 20 and 30 ppm of cypermethrin respectively. The lowest DO was observed in the culture water contaminated with 30ppm of cypermethrin (4.415 ± 0.558 mg/L), while the highest DO was observed in the culture water contaminated with 0.00ppm (control) of cypermethrin (6.555 ± 0.035 mg/L) (Table 3).

The DO of the culture water varied across the different treatment group, decreasing with increase in the concentration of the toxicant through-out the observed duration. Statistically, the DO varied significantly between the culture water contaminated with 0.00, 5, 10, 15, 20 and 30ppm of cypermethrin over a 24, 48, 72 and 96 hours period at $p<0.05$. However, the DO of each culture water group through-out the duration observed were all within the WHO acceptable limits, except for the 30ppm group over 72 and 96 hours observed duration (Table 3).

Water conductivity (µs/cm)

The summary of the water conductivity alterations of the culture water contaminated with different concentrations of cypermethrin over a 96 hour exposure period is shown in Table 4. After a period of 24 hours, the conductivity of the culture water had a mean and standard deviation values of 165.000 ± 0.000, 165.500 ± 0.707, 166.500 ± 0.707, 168.000 ± 1.414, 168.500 ± 0.707 and 170.500 ± 0.707 µs/cm for the culture water contaminated with 0.00 (control), 5, 10, 15, 20

Table 4: The alterations in the conductivity (µs/cm) of culture water contaminated with different concentrations of cypermethrin

	Conductivity (µs/cm)						
Exposure Duration	0.00 ppm (control)	5ppm	10ppm	15ppm	20ppm	30ppm	WHO limit
24 Hours	165.000 ± 0.00[a]	165.500 ± 0.71[b]	166.500 ± 0.71[c]	168.000 ± 1.41[d]	168.500 ± 0.71[e]	170.500 ± 0.71[f]	
48 Hours	165.000 ± 0.00[a]	167.000 ± 0.41[b]	168.000 ± 0.00[c]	168.500 ± 0.71[d]	172.500 ± 3.53[e]	177.00 ± 2.828[f]	250 µs/cm
72 Hours	165.500 ± 0.70[a]	166.000 ± 0.00[b]	171.500 ± 0.71[c]	176.500 ± 0.71[d]	178.500 ± 2.12[e]	180.500 ± 0.71[f]	
96 Hours	165.000 ± 0.00[a]	170.500 ± 0.71[b]	171.500 ± 0.71[c]	185.500 ± 0.71[d]	189.000 ± 1.41[e]	189.500 ± 0.71[f]	

Values are in mean ± Standard deviation

Values with different superscript are significantly different at $P<0.05$

and 30 ppm of cypermethrin respectively. The lowest conductivity was observed in the culture water contaminated with 0.00ppm (control) of cypermethrin (165.000 ± 0.000 µs/cm), while the highest DO was observed in the culture water contaminated with 30ppm of cypermethrin (170.500 ± 0.707 µs/cm) (Table 4).

After a 48 hours exposure duration, the conductivity of the culture water had a mean and standard deviation values of 165.000 ± 0.000, 167.000 ± 1.414, 168.000 ± 0.000, 168.500

± 0.707, 172.500 ± 3.535 and 177.000 ± 2.828 µs/cm for the culture water contaminated with 0.00(control), 5, 10, 15, 20 and 30 ppm of cypermethrin respectively. The lowest conductivity was observed in the culture water contaminated with 0.00ppm (control) of cypermethrin (165.000 ± 0.000 µs/cm), while the highest conductivity was observed in the culture water contaminated with 30ppm of cypermethrin (177.000 ± 2.828 µs/cm) (Table 4).

After a 72 hours exposure duration, the conductivity of the culture water had a mean and standard deviation values of 165.500 ± 0.707, 166.000 ± 0.000, 171.500 ± 0.707, 176.500 ± 0.707, 178.500 ± 2.120 and 180.500 ± 0.707 µs/cm for the culture water contaminated with 0.00 (control), 5, 10, 15, 20 and 30 ppm of cypermethrin respectively. The lowest conductivity was observed in the culture water contaminated with 0.00ppm (control) of cypermethrin (165.500 ± 0.707 µs/cm), while the highest conductivity was observed in the culture water contaminated with 30ppm of cypermethrin (180.500 ± 0.707 µs/cm) (Table 4).

After a period of 96 hours, the conductivity of the culture water had a mean and standard deviation values of 165.000 ± 0.000, 170.500 ± 0.707, 171.500 ± 0.707, 185.500 ± 0.707, 189.000 ± 1.414 and 189.500 ± 0.707 µs/cm for the culture water contaminated with 0.00 (control), 5, 10, 15, 20 and 30 ppm of cypermethrin respectively. The lowest conductivity was observed in the culture water contaminated with 0.00ppm (control) of cypermethrin (165.000 ± 0.000 µs/cm), while the highest conductivity was observed in the culture water contaminated with 30ppm of cypermethrin (189.500 ± 0.707 µs/cm) (Table 4).

The conductivity of the culture water varied across the different treatment group, increasing with increase in the concentration of the toxicant through-out the observed duration. Statistically, the conductivity varied significantly between the culture water contaminated with 0.00, 5, 10, 15, 20 and 30ppm of cypermethrin over a 24, 48, 72 and 96 hours period at $p<0.05$. However, the conductivity of each culture water group were all within the WHO acceptable limits (Table 4).

Turbidity (N.T.U)

The summary of the turbidity alterations of the culture water contaminated with different concentrations of cypermethrin over a 96 hour exposure period is shown in Table 5. After a period of 24 hours, the turbidity of the culture water had a mean and standard deviation values of 3.600 ± 0.000, 9.850 ± 0.212, 19.100 ± 0.141, 19.650 ± 0.212, 39.900 ± 0.141 and 40.650 ± 0.212 Nephelometric turbidity unit (N.T.U) for the culture water contaminated with 0.00 (control), 5, 10, 15, 20 and 30 ppm of cypermethrin respectively. The lowest turbidity was observed in the culture water contaminated with 0.00ppm (control) of

cypermethrin (3.600 ± 0.000 N.T.U), while the highest conductivity was observed in the culture water contaminated with 30ppm of cypermethrin (0.650 ± 0.212 N.T.U) (Table 5).

After a 48 hours exposure duration, the turbidity of the culture water had a mean and standard deviation values of 3.600 ± 0.000, 10.800 ± 0.141, 19.850 ± 0.070, 19.950 ± 0.707, 40.505 ± 0.007 and 41.750 ± 0.353 N.T.U for the culture water contaminated with 0.00(control), 5, 10, 15, 20 and 30 ppm of cypermethrin respectively. The lowest conductivity was observed in the culture water contaminated with 0.00ppm (control) of cypermethrin (3.600 ± 0.000 N.T.U), while the highest turbidity was observed in the culture water contaminated with 30ppm of cypermethrin (41.750 ± 0.353 N.T.U) (Table 5).

Table 5: The alterations in the Turbidity (N.T.U) of culture water contaminated with different concentrations of cypermethrin

	Turbidity (N.T.U)						
Exposure Duration	0.00 ppm (control)	5ppm	10ppm	15ppm	20ppm	30ppm	WHO limit
24 Hours	3.600 ± 0.000[a]	9.850 ± 0.212[b]	19.100 ± 0.141[c]	19.650 ± 0.212[d]	39.900 ± 0.141[e]	40.650 ± 0.212[f]	
48 Hours	3.600 ± 0.000[a]	10.800 ± 0.141[b]	19.850 ± 0.070[c]	19.950 ± 0.070[d]	40.505 ± 0.007[e]	41.750 ± 0.353[f]	5
72 Hours	3.650 ± 0.070[a]	12.750 ± 0.070[b]	19.850 ± 0.070[c]	19.900 ± 0.707[d]	41.750 ± 0.353[e]	42.250 ± 0.353[f]	
96 Hours	3.700 ± 0.494[a]	16.260 ± 0.339[b]	26.500 ± 0.282[c]	27.010 ± 0.014[d]	47.475 ± 0.601[e]	47.545 ± 0.643[f]	

Values are in mean ± Standard deviation

Values with different superscript are significantly different at $P<0.05$

After a 72 hours exposure duration, the turbidity of the culture water had a mean and standard deviation values of 3.650 ± 0.070, 12.750 ± 0.070, 19.850 ± 0.070, 19.950 ± 0.707, 41.750 ± 0.353 and 42.250 ± 0.353 N.T.U for the culture water contaminated with 0.00 (control), 5, 10, 15, 20 and 30 ppm of cypermethrin respectively. The lowest turbidity was observed in the culture water contaminated with 0.00ppm (control) of cypermethrin (3.650 ± 0.070 N.T.U), while the highest turbidity was observed in the culture water contaminated with 30ppm of cypermethrin (42.250 ± 0.353 N.T.U) (Table 5).

After a period of 96 hours, the turbidity of the culture water had a mean and standard deviation values of 3.700 ± 0.494, 16.260 ± 0.339, 26.500 ± 0.282, 27.010 ± 0.014, 47.475 ± 0.601 and 47.545 ± 0.643 N.T.U for the culture water contaminated with 0.00 (control), 5, 10, 15, 20 and 30 ppm of cypermethrin respectively. The lowest turbidity was observed in the

culture water contaminated with 0.00ppm (control) of cypermethrin (3.700 ± 0.494 N.T.U), while the highest turbidity was observed in the culture water contaminated with 30ppm of cypermethrin (47.545 ± 0.643 N.T.U) (Table 5).

The turbidity of the culture water varied across the different treatment group, increasing with increase in the concentration of the toxicant through-out the observed duration. Statistically, the turbidity varied significantly between the culture water contaminated with 0.00, 5, 10, 15, 20 and 30ppm of cypermethrin over a 24, 48, 72 and 96 hours period at $p<0.05$. However, the turbidity of each culture water group were all above the WHO acceptable limits except for the control group (Table 5).

3.2 Mortality and survival profile of *Clarias gariepinus* fingerlings

The summary of the survival and mortality profile of *Clarias gariepinus* fingerlings exposed to different concentrations of cypermethrin is shown in Table 6. The *C. gariepinus* fingerlings exposed to 0.00ppm (control) concentration of cypermethrin had 10 survivors (100% survival). No fingerlings mortality was recorded in the control group (0% mortality). The 5ppm concentration of the toxicant recorded 8 survivors (80% survivor) and a mortality of 2 (20% mortality). The 10ppm toxicant concentration recorded 6 survivors (60% survivor), with a mortality of 4 (40% mortality). The 15ppm concentration of cypermethrin recorded 4 survivors (40% fingerlings), while mortality of 6 was recorded (60% fingerlings mortality). The 20ppm concentration of the toxicant recorded 3 survivor (30% fingerlings survivor) and a mortality of 7 (70% fingerlings mortality). No fingerlings survived in the 30ppm cypermethrin treatment group (0% survival), but all the fingerlings died after 96 hours of exposure (100% mortality) (Table 6).

Table 6: A 96 Hrs survival and mortality profile of *Clarias gariepinus* fingerlings exposed to different concentrations of cypermethrin

Cypermethrin Concentration (ppm)	Survival	% Survival	Mortality	% Mortality
0 (control)	10	100	0	0
5	8	80	2	20
10	6	60	4	40
15	4	40	6	60
20	3	30	7	70
30	0	0	10	100

3.3 A 96 hours probit transformation

The summary of the probit transformation mortality data for *C. gariepinus* exposed to different concentration of cypermethrin is shown in Table 7. The mortality data trend of fingerlings exposed to cypermethrin were concentration dependent (Table 6). The fingerlings of *C. gariepinus*

Table 7: A 96 Hrs Probit Transformation of mortality data of *Clarias gariepinus* fingerlings exposed to different concentrations of cypermethrin

Conc (ppm)	Log Conc (x)	N	R	P	M_R	Y	R_P	*P*
0 (control)	0.00	10	0	0.00	0	0.00	0.00	0.00
5	0.699	10	2	0.20	20	1.428	0.572	0.143
10	1.000	10	4	0.40	40	4.417	-0.417	0.442
15	1.176	10	6	0.60	60	6.525	-0.525	0.653
20	1.301	10	7	0.70	70	7.807	-0.807	0.781
30	1.447	10	10	1.00	100	9.055	0.945	0.905

n = Number of fish fingerling tested at each concentration, r = Number of fish fingerling responding, p = Response rate, r/n, M_R = Mortality rate, Y = Expected probit from visual regression line, R_P = Residual probit, *P* = Probability

showed signs of stress, erratic behaviour and gasping for air when exposed to different concentrations of cypermethrin, due to respiratory impairment.

The regression equation for the probit transformation of *Clarias gariepinus* fingerlings exposed to different concentration of cypermethrin was y = 63.454X – 11.45 (Table 8) and was significant at $P<0.05$, yielding a determination coefficient (r^2) of 0.88 (Table 8), a chi-square

Table 8: Results of regression analysis of 96 Hrs Log Concentration–probit relationship of *Clarias gariepinus* fingerlings exposed to different concentrations of cypermethrin

Conc. (Log Unit)	Response rate, p	Equation	Co-efficient of determination, r^2	Significant level, α
0.00	0.00			
0.699	0.20			
1.000	0.40	Y = 63.454X – 11.451	0.88	0.05 (Sig)
1.176	0.60			
1.301	0.70			
1.477	1.00			

Table 9: Chi-square Tests of *Clarias gariepinus* fingerlings exposed to different concentrations of cypermethrin

	Chi square	df[a]	Sig.
PROBIT Pearson Goodness-of-FitTest	1.884	3	0.88[a]

Table 10: LC_{50} with 95% confidence limits of *Clarias gariepinus* fingerlings exposed to concentrations of cypermethrin

LC_{50} with ± 95%CL	Confidence limits	
	Lower	Upper
9.332ppm ± 0.839	12.76	14.44

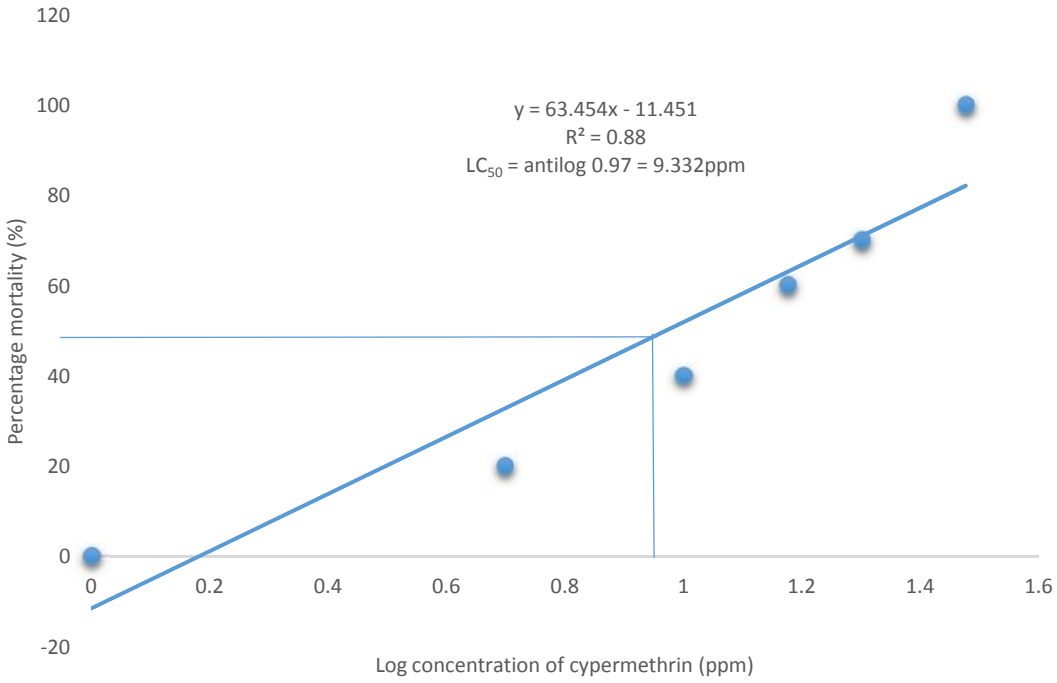

Fig 1: Probit transformation graph of *Clarias gariepinus* fingerlings exposed to different concentrations of cypermethrin

value of 1.884 (Table 9), and a 96 hours LC_{50} with 95% confidence limit of 9.332ppm ± 0.839 (Figure 1) (Table 10) and a lower and upper limit values of 12.76 and 14.44 respectively (Table 10).

4.DISCUSSION

Cypermethrin are deliberately added to the environment in large quality by agro-farmers to control pest, and this in turn pollute our aquatic environment [8]. The presence of environmental stress such as low dissolved oxygen, high temperature and high ammonia reduces the ability of organisms to maintain its internal environment (i.e. metabolism, catabolism) [24]. Fish growth depends on water quality to boost its production and physicochemical parameters are known to affect the biotic components of an aquatic environment in various ways. Cypermethrin is a globally used for the control of pest, in order to improve food productivity [1], but their use creates risk of food contamination as well as affects the non-target aquatic species like fish [2]. It is a synthetic pyrethroid, with a very high activity and stability [3]. The response of fish to variety of metal and organic pollutants are transient and are dependent on species, enzymes and single or mixed contaminants [25]. Water pollution affects organisms and plants that lives in these water bodies and in almost all cases, the effect is damaging not only to the individual specie and populations, but also to the natural biological communities [26]. When pesticides are applied on farmlands, only 1% gets to the target organism, as most of these chemicals remain in the environment, and as such the pollution of the environment on the long run is inevitable [27].

The present study revealed variations and alterations in the physico-chemical parameters of contaminated with different concentrations of cypermethrin. The water temperature, pH, electrical conductivity and turbidity of the contaminated culture water increased with increase in the concentration of the toxicant, this corroborated with the report of [28] who also reported an increase in water quality with increase in toxicant concentration. On the other way round, dissolved oxygen (DO) decreased with increase in the toxicant concentration, this corroborated with the reports of [29] who also observed a decrease in the DO values of culture water when contaminated with cypermethrin. The decrease in the DO and increase in pH, turbidity could be due to the increase in the microbial activities and bio-chemical oxygen demand as a result of the introduction of the toxicant. Also, the increase in the conductivity of culture water with increased toxicant concentration could be due to the increased chemical ions associated with the chemical. In general, temperature, conductivity, pH values were higher and the DO level was lower in the aquarium contaminated with the highest concentration of the toxicant (30ppm cypermethrin concentration) than in the control aquarium. Statistically, the physico-chemical parameters varied significantly across the culture water group contaminated with different concentrations of toxicant over all durations of contamination at $p<0.05$, except for water temperature over 96 hours exposure period

which was insignificant at $p>0.05$ and this was contrary to the report of [30] who reported insignificant alterations in all physico-chemical parameters but dissolved oxygen.

The range of the water temperature, dissolved oxygen, pH, turbidity and DO of culture water observed in the culture water contaminated with cypermethrin in the present study were not within the same range reported by [28, 29]. The pH and conductivity range of the present study was lower, but temperature and DO range were higher than that reported by [28, 29]. The variation between the findings could be due to the difference in the toxicants, concentration of the toxicants and differences in chemical components of the test toxicant. The water temperature, pH and conductivity of the culture water were within the WHO acceptable limits except the dissolved oxygen (30ppm group over 72 and 96 hour duration) and turbidity (control group) which were above the WHO permissible limit, and as a result, the toxicant made the water contaminated and unconducive for the fingerlings thereby causing mortality. Even as most of the water parameters were within the WHO acceptable standard after 96 hours of contamination with the toxicant, there is a high tendency of a chronic contamination of the water over a long period of time, leading to its pollution. Apart from the alteration of the water and fingerlings mortality, the fish (biological organisms) could accumulate the toxicants from the toxicant into their tissues, which are consumed by humans, leading to a lot of health challenges.

The toxicity of cypermethrin on *Clarias gariepinus* fingerlings observed for the present study was concentration and duration dependent, with mortality increasing with increase in the concentration of the toxicant as well as exposure duration and this corroborated with the findings of [30, 31, 32]. The fingerlings of *C. gariepinus* exposed to different concentrations of the cypermethrin showed abnormal behaviours changes and appearence like; repeated darting movement within an hour of introduction, darkening in the eye and skin, spiral swimming, death, erratic swimming and loss of balance due to impaired metabolism and nervous disorder (respiratory impairment), and this was similar to the findings of [33, 34, 35, 31, 32, 36, 37, 38, 39, 31], who all reported similar changes in behaviour of fingerlings when exposed to chemicals. The respiratory distress of test fingerlings exposed to the cypermethrin may be due to decrease in the dissolved oxygen contents in the culture water [40].

As observed in the present study, no mortality was observed in the control group, but mortality was recorded for the 5ppm group upwards and similar result was observed by [41]. The 96 hours LC_{50} with 95% confidence limit for *C. gariepinus* exposed to different

concentrations of cypermethrin was 9.332ppm, indicating its high toxicity. The 96 hours LC_{50} value observed for cypermethrin on *C. gariepinus* in the present study was higher than those reported by [31] (1.80ppm) who evaluated the toxicological and histopathological changes of *C. gariepinus* exposed to cypermethrin, [42] (0.04ppm) who carried-out a histological study on the intestine and liver tissues of *Oreochromis mossambucus* exposed to cypermethrin and [41] (0.60ppm) who studied the acute toxicity of mercury to *C. gariepinus*. These discrepancies in the 96 hours LC_{50} value of the different study could be due to the difference in components of the toxicant, difference in toxicant, toxicity of the chemicals, fish species and age of fingerlings used. The difference could also be due to the fact that the response of fish to variety of metal and organic pollutants are transient and are dependent on species, enzymes and single or mixed contaminants [25]. Also, the difference in the toxicity of cypermethrin in the present study compared to that observed in the aforementioned findings could be due to difference in biological species, difference in elimination and metabolic degradation from the body [9]. The relatively low LC_{50} value observed for the present study denotes that cypermethrin are highly toxic to *Clarias gariepinus* fingerlings causing the mortality of the fingerlings, bio-accumulation in the fish tissues, resulting in high risk to public health for the consumers of such contaminated aquatic resources.

5. CONCLUSION

In conclusion, the cypermethrin caused significant alterations in the physicochemical parameters of water, compared to the control aquarium water, increasing in some cases (temperature, pH, turbidity and conductivity), and reducing in some cases (DO). Also, the toxicant raised some water parameters to undesired levels, leading to the bio-accumulation of toxicants in the fingerlings. The toxicological effects of the toxicant was concentration and duration dependent**.** The cypermethrin was highly toxic to the fingerlings, causing mortality in the process, as a result, more research of this kind should be carried-out involving haemathological, reproductive, histological and other physiological alterations due to exposure of *C. gariepinus* to cypermethrin, so as to further reveal the toxic and harmful potentials of pesticides.

ETHICAL CONSIDERATION

The authors ensured that all ethical and other basic principles underlying behavior and advancing welfare for the use of animals in research, including handling, relevant laws and regulations were considered before proceeding with the research. Permission was also received from the relevant bodies for the use of fish for this experiment.

REFERENCES

1) Usmani KA and Knowles CO. Toxicity of pyrethroids and effect of synergists to: larval and adult *Helicoverpa Zea*, *Spodoptera frugiperda*, and *Agrotis ipsilon* (Lepidoptera Noctuidae). Journal of Economic Entomology. 2001; 94:868–873.

2) Das, BK and Mukherjee SC. Toxicity of cypermethrin in *Labeo rohita* fingerlings. Journal of aquatic toxicology. 2003; 1:12-19.

3) Khan BA, Farid A, Khan N, Rasul K, Perveen K. Survey of pesticide use on fruits and vegetables in district Peshawar. Sarhad Journal Agriculture. 2006; 22: 497–501.

4) Zhang WJ, Jiang FB, Ou JF. Global pesticide consumption and pollution: with China as a focus. International Journal of Academic Ecology and Environmental Science. 2011; 1: 125–144.

5) Olaruntuyi O, Mulero O and Odunkale B. Histopathology of *O. niloticus* exposed to Actellic 25 EC. Journal of Aquatic Science. 1992; 6:13-17.

6) Latif A, Ali M, Sayyed AH, Iqbal F, Usman K, Rauf M, Kaoser R. Effect of Copper Sulphate and Lead Nitrate, Administered Alone or in Combination, on the Histology of Liver and Kidney of *Labeo rohita*. Pakistan Journal Zoology. 2013; 45:913–920.

7) Hayat S, Javed M, Razzaq S. Growth performance of metal stressed major carps viz. *Catla catla, Labeo rohita* and *Cirrhina mrigala* reared under semi- intensive culture system. Pakistan Veterinary Journal. 2007; 27:8–12.

8) Wick A and Dave G. Acute Toxicity of Leachates of Tire Wear Materials to Daphnia magna-Variability and Toxic Components. Chemosphere. 2006; 64: 1777-1784.

9) Aydin R, Koprucu K, Dorucu M, Koprucu SS, Pala M. (2005). Acute toxicity of synthetic pyrethroid cypermethrin on the common carp (*Cyprinus carpio L.*) embryos and larvae. Aquaculture International. 2005; 13: 451–458.

10) Athanassopoulou F, Ragias V, Tavla J, Christofilloyannis P, Liberis N. Preliminary trials on the efficacy of ivermectin against *Lernathropus kroyeri* (Crustacean) in cultured sea bass *D. labrax* L. Aquatic Resources. 2001; 32:77.

11) Treasurer JW and Wadsworth SL. Interspecific comparison of experimental and natural routes of *Lepeophtheirus salmonis* and *Caligus elongatus* challenge and consequences for distribution of Chalimus on Salmonids and therapeutant screening. Aquatic Resources. 2004; 35:773–783.

12) Arjmandi A, Tavakol M, Shayeghi M. Determination of organophosphorus insecticide residues in the rice paddies. International Journal Environmental Science and Technology. 2010; 7: 175–182.

13) Rahman MZ, Hossain Z, Mellah MF and Ahmed GU. Effect of diazinon 60EC on *Anabustes tudineus*, *Channa punctatus* and *Barbades gomonotus*, Naga. The ICLARM Quarterly. 2002; 25:8-11.

14) Vethaak AD, Van der Burg B and Brouwer AD. Netherlands Research Platform on Endocrine- disrupting compounds (NEDIC). In: Endocrine-disrupting compounds: wildlife and human health risks. Proceedings of a day symposium. The Hague, the Netherlands. 2002: 144-146.

15) Terry LA. Water Pollution. Environmental Law Practice. 1996; 4(1):19-29.

16) Prusty AK, Meena DK, Mohapatra S, Panikkar P, Das P, Gupta V, Behera BK. Synthetic pyrethroids (Type II) and freshwater fish culture: Perils and mitigations. International Aquatic Resources. 2005; 7:163–191.

17) Akhtar MS, Pal AK, Sahu NP, Alexander C, Meena DK. Dietary pyridoxine enhances thermal tolerance of *Labeo rohita* (Hamilton) fingerlings reared under endosulfan stress. Journal of Thermal Biology. 2009; 36:84–88.

18) Chandola M, Rathore M, Kumar B. Indigenous pest management practices prevalent along the hill farmers of Uttarakhand. Indian Journal of Traditional Knowledge. 2011; 10(2):311–315.

19) Gupta SK, Pal AK, Sahu NP, Saharan N, Mandal SC, Chandraprakash AMS, Prusty AK. Dietary microbial levan ameliorates stress and augments immunity in *Cyprinus carpio* fry (Linnaeus, 1758) exposed to sub- lethal toxicity of fipronil. Aquaculture Resources. 2012: 11–20.

20) Gilliom RJ, Barbash JE, Crawford GG, Hamilton PA, Martin JD, Nakagaki N, Nowell LH, Scott JC, Stackelberg PE, Thelin GP, Wolock DM. The Quality of our nation's waters: Pesticides in the nation's streams and ground water, US Geological Survey. 2007: 150.

21) Ngidlo RT. Impacts of pesticides and fertilizers on soil, tail water and groundwater in three vegetable producing areas in the Cordillera Region, Northern Philippines. Ambient Journal of Experimental Agriculture. 2013; 3(4):780–793.

22) Kumari P. Fish: Protein Rich Diet for Tribal People. Chaturbhuj Sahu, Sarup and Sons, New Delhi (edited by Aspects of Tribal Studies) 2005: 121.

23) Gupta SK, Pal AK, Sahu NP, Jha AK, Akhtar MS, Mandal SC, Das P, Prusty AK. Supplementation of microbial levan in the diet of *Cyprinus carpio* fry (Linnaeus, 1758) exposed to sublethal toxicity of fipronil: effect on growth and metabolic responses. Fish Physiology and Biochemistry. 2013: 31-38.

24) Ezra AG and Nwankwo DI. Composition of phytoplankton algae in Glib' reservoir, Bauchi, Nigeria. Journal of Aquatic Sciences. 2001; 16 (2): 115- 118.

25) Pavlović SZ, Mitić SSB, Radovanović TB, Perendija BR, Despotović SG, Gavrić JP and Saicić ZS. Seasonal variations of the activity of antioxidants defense enzymes in the Red mullet (*Mullus barbatus*) from Adriatic Sea. Mar. Drugs. 2010; 8(3): 413-428.

26) Agrawal A, Pandey RS and Sharma B. Water pollution with special reference to Pesticide Contamination in India. J. Water Resources and Protection. 2010; 2: 432-448.

27) Lawson EO, Ndimele PE, Jimoh AA and Whenu OO. Acute toxicity of lindane (gamma hexachloro-cyclohexane) to African catfish (*Clarias gaeriepinus* Burchell 1822). International Journal of Animal and Veterinary Advan. 2011; 3: 63-68.

28) Amabye TG and Semere T. Bioassay of Lindane (Gamalin 20) to *Hetrobrancus bidorsalis* Juveniles. Journal of Analytical and Bioanalytical Techniques, (2016; 7 (4): 332 – 340.

29) Mukadam M and Kulkarni A. Acute Toxicity of Cypermethrin, a Synthetic Pyrethroid to Estuarine Clam *Katelysia opima* (Gmelin) and Its Effect on Oxygen Consumption. Journal of Agricultural Chemistry and Environment. 2014; 3: 139-143.

30) Adeboyejo OA, Fagbenro OA, Adeparusi EO and Clarke EO. Acute Toxicity of Industrial Effluents from Agbara Environs of Ologe Lagoon on Early Life stages of African Catfish *Clarias gariepinus.* American Journal of Research Communication. 2013; 1 (3): 50-60.

31) Andem AB, Ibor OR, Joseph AP, Eyo VO, Edet AA. Toxicological evaluation and histopathological changes of synthetic pyrethroid pesticide (Cypermethrin) exposed to African Clariid mud Cat fish (*Clarias gariepinus*) fingerlings. International Journal of Toxicological and Pharmacological research. 2016; 8(5): 360 – 367.

32) Ivon EA, Andem BB, Oju I, Joseph AP and Ndome CB. Toxicological and Histopathological responses of African Clariid mud catfish, *Clarias gariepinus* (Buchell, 1822) fingerlings exposed to different detergents (Zip and Omo). Annual Research and Review in Biology. 2017; 13 (1): 1 – 9.

33) Sambasivam S, Karpagam G, Chandran R and Khan SA. Toxicity of leaf extract of yellow oleander, *Thevetia nerifolia* on Tilapia. Journal of Environmental Biology. 2003; 24: 201-204.

34) Oti EE. Acute toxicity of water extracts of bark of the *Thevetia peruviana* to the African freshwater catfish ―Heteroclarias‖ hybrid fingerling. J. Fish.Tech. 2003a; 2: 124-130.

35) Oti EE. Acute toxicity of water extracts of bark of neem plant *Azardirachta indica* (Cod) to the African river pike (*Hepsetus odoe)* (Sarcodaceae) (Bloch). In: Fisheries Society of Nigeria Conference Proceeding (Eds.: A. A. Eyo and J.O. Ayanda). 2003b: 34.

36) Avoaja DA and Oti EE. Effect of sub lethal concentration of some pesticides on the growth and survival of the African Fresh water catfish –Hetero Clarias. Journal of Biotechnology. 1997; 8 (1): 40 – 45.

37) Rao JV and Murty AS. Toxicity and Metabolism of sulfan in three freshwater Catfishes. Environmental Pollution. 2002; 27: 223 -231.

38) Rao, J. V. Rani, C. H., Kavithia, P., Rao, R. N. and Madhavendra, S. S. (2003). Toxicity of chlorpyrifos to the fish *Oreochromis mossambicus*. *Bulletin of Environmental contamination and Toxicology*, 70 (5): 985 – 992.

39) Wani AA, Sikdar-Bar M and Khan HA. Acute toxicity of copper sulphate to African catfish, (*Clarias gariepinus*). Gerf Bulletin of Biosciences. 2013; 4(1):14-18.

40) Dede EB and Kaglo HD. Aqua-toxicological effects of water soluble fractions (WSF) of diesel fuel on *O. niloticus* fingerlings. Journal of Applied Science and Environmental Management. 2001; 5 (1): 93-96.

41) Guedenon P, Edorh AP, Hounkpatin ASY, Alimba CG, Ogunkanmi A, Nwokejiegbe EG and Boko M. Acute Toxicity of Mercury (HgCl2) to African Catfish, *Clarias gariepinus*. Research Journal of Chemical Sciences. 2012; 2(3): 41-45.

42) Karthigayani T, Denis M, Remy ARA, Shettu N. Histological study of the intestine and liver tissues in the fish *Oreochromis mossambicus* exposed to cypermethrin. Journal of Modern Biotechnology. 2014; 3(4):48–54.