



Research Article

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The Impact of Dichlorvos -Pesticide on African Catfish *Clarias Gariepinus*



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Abstract

The toxicity of dichlorvos (18 -20 mg/L) on *Clarias gariepinus* juveniles (mean weight 41.6±1.2(g) and mean length 18.5±2.5 (cm) was investigated in the present study using static bioassays over a period of 96 hours. The determined 96 hours LC₅₀ of the exposed fishes was 17.21mg/L with lower and upper confidence limits of 15.78–18.19mg/L respectively. When the fishes were exposed there was strong evidence of stress responses characterised by hyperactive swimming with subsequent erratic with jerky movements before death which increases with time and concentration of exposure. The quality of water investigated in this study showed no change in dissolved oxygen, pH and temperature. The hepatosomatic indices (HSI) and condition factors (K) which are stress indices due to environmental pollutants decreased within 15 days of exposure and increase in concentration of dichlorvos indicating that it has detrimental effect on the liver of exposed fish with time.

Introduction

The useful state of water for humans and animals that is appropriate has become a rife concern [1]. There is a rapid decline in the quality of water from natural water resources arising from the demand of industrialisation which employ application of synthetic fertilisers and use of various insecticides and pesticides. Chemicals of agricultural or industrial origins have been reported to be source of contaminations to aquatic ecosystems by runoff and ground leaching through the area [2]. Dichlorvos (2,2- dichlorvinyl dimethyl phosphate) an agricultural insecticide is used to control household pests in public health and protecting crops and stored products. It is reported to be effective against mushroom flies, aphids, spiders, mites, caterpillars, whiteflies in greenhouse, outdoor fruits and vegetable crops [3]. It has contact and stomach insecticidal effect on food and non-food crop pests [4] and anticholinesterase action associated with the nervous systems of insects [3,5] stated that the volatility of dichlorvos will favour the vaporisation of a significant proportion of applied substance into the external atmosphere which is expected to dissipate rapidly through dilution, degradation and precipitation, reducing the atmospheric (concentrations well below levels. However, aquatic lives run a risk of toxicity if rain falls within 4 hours of application. Increased use of pesticides results in the excess inflow of toxic chemicals, mainly into the aquatic ecosystem [6,7]. This work aims at investigating the effects of dichlorvos on the wellbeing of aquatic organisms particularly on African catfish *C. gariepinus*. It belongs to the Claridae family and it is geographically located in Africa, the middle east, Brazil and Indonesia. They make fresh water, lakes, rivers and swamps and human made oxidative ponds

and urban sewage system their habitats. The adult catfish can be 1-1.5m in length and weigh up to 60kg with flat body head, broad terminal mouth with four pairs of barbells and large accessory breathing organs made up of modified gill arches [8].

Materials and Methods

Source of experimental fish

One hundred juveniles of *C. gariepinus* were obtained from Rojenny tourist game village, Idemili LGA. Anambra state, Nigeria in 300 litre capacity plastic containers and transported to Heildin fisheries laboratory unit in Enugu state, Nigeria. The mean body weight and the length of the species were 41.6±1.2 (g) and 18.5±2.5 (cm) respectively.

Acclimatisation

The fish were acclimatised to laboratory conditions for 14 days and fed with top fish feed with crude protein of 38% on daily basis. The container was cleaned, and the water changed every morning. Less than 2% mortality was observed during the acclimatisation.

Range finding test

The preliminary tests to determine the range of concentrations used in this experiment were performed by exposing 10 juvenile catfish to 25 litres of dechlorinated tap water containing 18,20 and 22µl of dichlorvos respectively for 96 hours until suitable concentration that produced 100% mortality was obtained. The fish were not fed for 24 hours before and during the exposure time.

Experimental procedures

10 juvenile catfish were exposed to different concentrations of 18, 20 and 22µl dichlorvos in 10 litres of dechlorinated water from volume to volume (v/v) stock solution (10ml of concentrated dichlorvos in 1 litre of dechlorinated water) in triplicates. The mortality rate, behavioural characteristics of the catfish and the physicochemical properties of water such as pH, temperature, and dissolve oxygen were analysed every 24 hours for 96hour period [9]. The 96 hours lethal concentration (LC50) of dichlorvos was determined following the probity analysis method [10]. Dead fishes were removed from the experiment pond every morning to avoid contamination at every 24 hours interval for 96 hours. Based on the 96 hours LC50 value, the hepatosomatic indices (HSI) and condition factor (CF) of the Catfishes exposed to two sub-lethal concentrations of dichlorvos (21 and 43 mg/L) for 15 days were then determined according to White and Flecher

(1985). A set of 10 fish were also maintained in dechlorinated tap water (0.00mg/l) as the control. The experiment was set in triplicates.

Statistics

Using the SPSS statistical package (version 17), the standard error mean (SEM) and Duncan’s multiple range test were used to determine the significance at 10% probability test. The significance between data were analysed with the one-way analysis of variance (ANOVA).

Result

At the highest concentration of 22mg/L dichlorvos, 87 percent mortality of juvenile catfish was recorded within the 24 to 96 hours exposure. The least percentage mortality was observed in the lowest concentration of 18mg/L. No death was recorded in the control during the period of exposure (Table1).

Table 1: Percent Mortality of juvenile African Catfish *C. gariepinus* exposed to different concentrations of dichlorvos for 24, 48, 72 and 96 hours.

Concentration mg/L	Number of fishes exposed to pesticide	Mortality with time (hours).				Total rate	% of survival	% of mortality
		24	48	72	96			
Control	30	0 ^{a1}	0a1	0 ^{a1}	0 ^{a1}	0 ^{a1}	100 ^{a1}	0 ^{a1}
18	30	0 ^{a1}	1a1	3 ^{a1}	4 ^{a1}	8 ^{b2}	73.3 ^{a1}	26.7 ^{a1}
20	30	0 ^{a1}	6b2	9 ^{b2}	5 ^{b2}	20 ^{b2}	33.3 ^{b2}	66.7 ^{b2}
22	30	2 ^{a1}	10 ^{b2}	6b2	8 ^{b2}	26 ^{b2}	13.3 ^{b2}	86.7 ^{b2}

Table 2: Behavioural characteristics of juvenile African Catfish *C. gariepinus* exposed to different concentrations of dichlorvos for 24, 48, 72 and 96 hours.

Concentration mg/L	Air gulping	Hyper Activity	Erratic swimming	Equilibrium status	Skin discolouration
24hrs					
Control	-	-	-	-	-
18	+	+	++	++	-
20	+	+	++	++	-
22	+	+	++	++	-
48hrs					
Control	-	-	-	-	-
18	-	-	-	-	-
20	+	+	++	++	+
22	+	+	++	++	+
72hrs					
Control	-	-	-	-	-
18	+	++	++	+	+
20	+	+++	++	+	++
22	++	+++	++	+	+++
96hrs					
Control	-	-	-	-	-
18	+	++	+++	++	++
20	++	++	+++	++	++
22	+++	++	+++	++	++

The following keys represent; - None, + Mild, ++ Moderate, +++ Strong

The percent mortality increased with increasing concentration. The behavioural responses of the juvenile catfish exposed to 18,

20 and 22mg/L dichlorvos for 24,48,72 and 96 hours respectively showed faster swimming, opercula activity, surfacing and gulping

of air in almost all concentrations at exposure time compared to the control. However, at higher concentrations of 20 and 22mg/L, within 40 minutes of exposure the fish appeared to be hyperactive and swimming became erratic with jerky movements while at 18mg/L, the fish showed normal behaviour for the first 48hours then stopped swimming and remained static in response to the changes in the surrounding environment. There was mean pH 7.1, temperature 27 °C and dissolve oxygen 5.1 for water quality in various treatments with dichlorvos. The lethal concentration of dichlorvos that will kill 10-90% (LC₁₀₋₉₀) of the experimental

organism at 24, 48, 72 and 96hours was significantly different (P<0.05). At the exposure period, the median LC₅₀ ranges from 17.21 (15.78-18.19) to 17.98 (16.27-19.35). The hepatosomatic indices (HSI) with 95% confidence limits showed a significant difference across the sub-lethal concentrations for day 1 and 15. The condition factor (CF) of *C.gariepinus* exposed to sub-lethal concentrations of dichlorvos was significantly different throughout the exposure duration compared to control (Table 1-6) (Figure 1).

Table 3: Mean water parameters of juvenile African Catfish *C. gariepinus* exposed to different concentrations of dichlorvos.

Concentration mg/L	pH	Temperature (°C)	Dissolved oxygen Mg/L
Control	7.1±0.0 ^{a1}	28±0.0 ^{a1}	5.1±0.0 ^{a1}
18	7.1±0.0 ^{a1}	27±0.0 ^{a1}	5.1±0.0 ^{a1}
20	7.1±0.0 ^{a1}	27±0.0 ^{a1}	5.1±0.0 ^{a1}
22	7.1±0.0 ^{a1}	27±0.0 ^{a1}	5.0±0.0 ^{a1}
Standard	6.7 – 8.5	26-28	5-10

Table 4: Lethal Concentrations (LC) of Dichlorvos on juvenile African Catfish *C. gariepinus* exposed for 24, 48, 72 and 96 hours.

Lethal concentration	Hours			
	24	48	72	96
LC ₁₀	15.73(14.03-16.89) ^{a1}	16.12(14.05-17.50) ^{a1}	15.73(14.03-16.89) ^{a1}	15.73(14.03-16.89) ^{a1}
LC ₂₀	16.31(14.71-17.40) ^{a1}	16.84(14.90-18.12) ^{a1}	16.31(14.71-17.40) ^{a1}	16.31(14.71-17.40) ^{a1}
LC ₃₀	16.68(15.5-17.73) ^{a1}	17.31(15.47-18.5) ^{b2}	16.68(15.15-17.73) ^{a1}	16.68(15.15-17.73) ^{a1}
LC ₄₀	16.97(15.50-17.98) ^{a1}	17.68(15.90-18.54) ^{b2}	16.97(15.50-17.98) ^{a1}	16.97(15.50-17.98) ^{a1}
LC ₅₀	17.21(15.78-18.19) ^{b2}	17.98(16.27-19.35) ^{b2}	17.21(15.78-18.19) ^{b2}	17.21(15.78-18.19) ^{b2}
LC ₆₀	17.24(16.03-18.37) ^{b2}	18.24(16.59-19.12) ^{b2}	17.41(16.03-18.37) ^{b2}	17.42(16.03-18.19) ^{b2}
LC ₇₀	17.60(16.25-18.53) ^{b2}	18.48(16.87-19.35) ^{b2}	17.60(16.25-18.53) ^{b2}	17.60(16.25-18.53) ^{b2}
LC ₈₀	17.77(16.44-18.68) ^{b2}	18.69(17.12-19.74) ^{b2}	17.77(16.44-18.68) ^{b2}	17.77(16.44-18.68) ^{b2}
LC ₉₀	17.92(16.62-18.81) ^{b2}	18.88(17.36-19.91) ^{b2}	17.92(16.62-18.81) ^{b2}	17.92(16.62-18.61) ^{b2}

Values outside the brackets are Lethal Concentrations (LC). First value within the bracket is the lower confidence and the second value is the upper confidence respectively. Value with different numeric superscripts differ significantly (P<0.05) between different concentrations within the same exposure duration.

Table 5: Hepatosomatic indices (HSI) of juvenile African Catfish *C.gariepinus* exposed to sublethal concentrations of Dichlorvos for 1, 5, 10 and 15 days.

Exposure days	Control	Concentration mg/L	
		21	43
1	1.03±0.42 ^{b2}	1.69±0.59 ^{b2}	1.22±0.12 ^{b2}
5	0.77±0.36 ^{b2}	0.76±0.35 ^{b2}	0.88±0.27 ^{b2}
10	0.92±1.62 ^{b2}	0.71±0.88 ^{b2}	0.50±0.66 ^{b2}
15	0.75±0.10 ^{b2}	0.88±0.10 ^{b2}	0.60±0.40 ^{b2}

Values with different alphabetic (lower case) superscripts differ significantly (P < 0.05) between exposure periods within the same concentration. The values with different numeric superscripts differ significantly (P<0.05) between different concentrations within the same exposure duration.

Table 6: Condition factor (CF) of juvenile African Catfish *C. gariepinus* exposed to sublethal concentrations of Dichlorvos for 1, 5, 10 and 15 days.

Exposure (days)	Control	Concentration (mg/L)	
		21	43
1	1.74±0.57 ^{b2}	2.47±0.57 ^{b2}	2.81±0.48 ^{b2}

5	1.71±0.00 ^{a1}	3.59±3.76 ^{b2}	1.64±0.46 ^{b2}
10	5.53±0.53 ^{b2}	2.36±2.56 ^{b2}	2.29±1.34 ^{b2}
15	6.51±0.99 ^{b2}	1.23±0.01 ^{a1}	1.17±0.17 ^{b2}

Values with different alphabetic (lowercase) superscripts differ significantly (P<0.05) between exposure periods within the same concentration. Value with different numeric superscripts differ significantly (P<0.05) between different concentrations within the same exposure duration

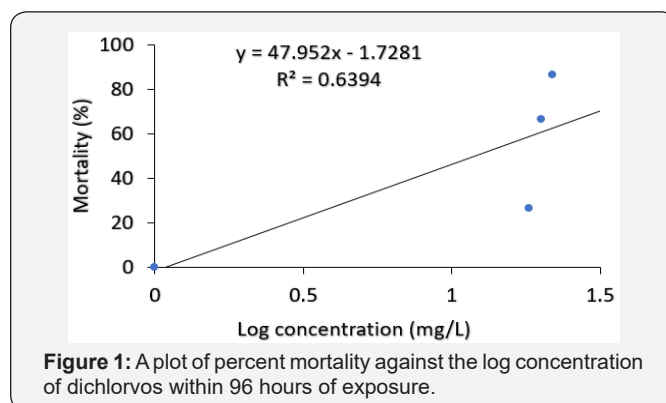


Figure 1: A plot of percent mortality against the log concentration of dichlorvos within 96 hours of exposure.

Discussion

The present study is to demonstrate the toxic effects of dichlorvos in the juveniles of the freshwater fish *Clarias gariepinus*. In this study, the survival rate of *C. gariepinus* decreased as the concentration of dichlorvos increased. At 96hour exposure to dichlorvos, the mortality percent for control, 18, 20 and 22mg/L test samples were 0, 27, 67 and 87 respectively. This finding agrees with earlier reports by Asuquo et al. Oti, Adakole [11-13]. Toxicity of dichlorvos to organisms has however been shown to be dependent on concentrations, sex, developmental stages and exposure periods [14].

Behaviour provides a unique perspective linking the physiology and ecology of an organism and its environment and allows the organism to adjust to external and internal stimuli to best meet the challenge of surviving in a changing environment [15]. The results showed that dichlorvos affected the behavioural characteristics of *C. gariepinus*. The control specimens were not hyperactive and showed normal swimming patterns, skin colour, equilibrium status and fin movements throughout the exposure period. However, with increasing dichlorvos concentrations and exposure duration, hyperactivity, air gulping, erratic swimming and equilibrium instability increased. Besch [16] reported that there are contact (high excitability in a moment), exertion (fast swimming, leaping and attempts to jump out of the toxicant), equilibrium instability and death phases characterising behavioural responses of fish to toxicants. Prolonged exposure to dichlorvos imposed tiredness and stress on the fish suggesting that there is insufficient intake of oxygen accompanied with detrimental effect on energy production, body building mechanism and ultimately nervous breakdown of fish. Heath, Kormakik & Cameron, Kumar & Krishna Moorthy [17-19] reported deleterious limitations in the use of energy synthesising macromolecules in fish subjected to environmental stress. The quality of water for dichlorvos did not show any significant change in the mean value of pH, temperature and dissolved oxygen compared to the control. The values fall within the normal range of water quality for aquaculture [20]. In this research the 96 hours exposure has 17.21mg/L LC_{50} values with lower and upper confidence limits of 15.78 and 18.19 respectively. Ofojekwu et. al. [21] reported LC_{50} value of 15.85g/L for fingerlings of *Tilapia zilli* exposed to urea fertiliser. Toxicity of pesticides to organisms is affected by the strains of species, size, age, sex, temperature, water quality and formulation of the test chemicals [22]. Fishes are more susceptible to the environmental variations and respond more to pollutants than mammals. The fish liver has been shown as a model for studying the relationship between environmental factors with the hepatic structures and the functions [23]. Hepatosomatic Index (HSI) and Condition Factor (CF) gives an indication of the overall health condition of fish and have been widely used as stress indicator due to environmental pollutants [24]. In the present study, there was a significant reduction in HSI and CF on day 15 following exposure to 21 and 43mg/L compared to day 1 respectively. Jordan et. al. [25] reported decreased CF in fish exposed to various toxicants.

The HSI values are generally elevated in vertebrates experiencing induction of hepatic microsomal P-450 for detoxification of the pollutants while decline in the HSI and CF may suggest a general detrimental effect of dichlorvos pesticide on the liver of fish [26].

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