Faculty of Natural and Applied Sciences Journal of Applied Chemical Science Research
Print ISSN: 3027-0359
www.fnasjournals.com
Volume 3; Issue 1; March 2026; Page No. 32-38.
DOI: https://doi.org/10.63561/jacsr.v3i1.1231

Haematological Effects of Subacute Dichlorvos Toxicity in Clarias gariepinus

***[1]Agbeyi, E.V., & [1]Oghenerhoro, S.P.**
[1]Department of Environmental Management and Toxicology, Dennis Osadebay University, Asaba Delta State

***Corresponding author email**: agbeyierhomarhua@yahoo.com

Abstract
The use of agrochemical in agricultural practices both in peasant and commercial aimed at boosting food production has led to the use of organophosphate and organochlorine herbicides that are environmental and biodiversity unfriendly. This work examined the subacute toxicity of dichlorovos on haematological parameters of Claria gariepinus . Sixty (60) post juvenile C. gariepinus weighing between 100-500g and 10.2-20.3cm in length were randomly divided in tens into 30 liters of distilled water in 50 liters experimental tank arranged into group A, B, C, D and E. Group A served as the experimental control. The fish were exposed to 0.00mg/l (control), 0.2mg/l, 0.4mg/l, 0.8mg/l and 1.6mg/l of dichlorvos respectively, for 28 days. At the end of 28 days, blood samples were taken using a 2ml syringe into EDTA bottles for analysis. Result showed that there was a significant $p<0.05$ increase in mortality of C.gariepinus as the concentration of dichlorovos increases. The haematological parameters indicated an increase $p<0.05$ in MCHC, MCV, MCH PLATELET, L and M compared with the control. HB, RBC, WBC, N, E and PCV showed a decrease compared with control. This increase and decrease in haematological indices indicate haematological stress on the blood of the fish. This revealed that dichlorovos pesticide even at low concentration has haematological effect on C.gariepinus and other aquatic organisms.

Keywords: Dichlorovos, Haematological, Subacute, Claria Garienpinus, Practices

Introduction

In Nigeria, agrochemicals especially chlorinated hydrocarbons and the organophosphate are routinely employed as part of the integrated farming practice to protect crops from insects, weeds and diseases of animals (Oladunjoye et. al., 2022). In line with this, toxicity test became imperative (APHA 2007) to estimate potential hazard as part of risk assessment protocol in agriculture especially fish farming. Normally, toxicity test are carried out for the purpose of predicting what biological organisms would be perturbed by the toxicant they are exposed to or explicitly quantify the effects of a toxicant on the health of an organism (Omoniyi et. al., 2002; Omeregie et. al., 2009).

The rearing of *Clarias gariepinus* started in the early 70s in Central and Western African countries. It received wide acceptance when it was realized to be a very suitable species for aquaculture and of high economic value. It has since been the most widely cultured fish in Nigeria and in the rest of Africa continent. (Adedeji et.al. 2019). It matures quickly and has a wider range of tolerance to climatic conditions. The African Catfish (*Clarias gariepinus*) is widely distributed in African freshwater and Middle East and it is an economical fish species in aquaculture in the tropical and subtropical countries and has become the most farmed fish in Nigeria (Abubakar and Adeshina, 2019). FAO 2016 confirms that as much as 5% of African populations, 35 million people depend wholly or partly on catfish for their livelihood. Different species of catfish are African air-breathing catfish (*Heterobranchus longifilis*) **(**Oribhabor and Ikeogu, 2016), Philippine catfish (*Clarias batrachus*) (Brian, *et.al*, 2015), and African mud catfish (*Clarias gariepinus*) (Omoniyi et al., 2013, Ashade et al., 2011).

Dichlorovos also known as DDVP (Dimethyl 2 2- dichlorovinyl phosphate) or sniper is an imported chemical, marketed and used by farmers in Nigeria (Fawole et. al. 2007). It is composed of chlorine and phosphorus elements as active ingredients. Dichlorovos insecticide is a highly effective insecticide used for the control of a wide range of insects, in stored agricultural produce, warehouse disinfestation and field application on a wide range of crops. In Nigeria, DDVP is used for the protection of crops and animals (Omoniyi et al., 2013).

The aquatic environment receives toxic substances that are used to control weeds and pests. Most of these toxic chemicals end up in water bodies through agricultural, domestic, and industrial activities (Ololade & Oginni, 2010; Fırat et al., 2011). Due to the resilience nature of African catfish, they are known to survive in harsh environmental conditions (Ibrahim et al., 2023; Basharat et al., 2023). Previous studies have sought to estimate the potential hazards of these chemicals as a form of risk assessment through toxicity testing (Omoniyi et al., 2013; Tak, et.al. 2014). Some of these studies have assessed the toxicity of DDVP on various life stages of C. garienpinus including (Ajise et.al., 2023) who studied the Survival Rate of C. garienpinus (post juveniles) in a Pesticide Polluted Environment with DDVP (Sniper). This study is essential to further define and for the additional to knowledge based on the dose/concentration of DDVP to fishes and other aquatic organisms.

Materials and Methods

Study location

This study was conducted in the animal farm house in the Biological Science Department, Environmental Management and Toxicology Unit, Dennis Osadebay University Asaba Delta Nigeria. Dennis Osadebay University is located in Delta State, Nigeria with a geographical location coordinate of 6015’10’’N
and 60 42’12’’E. The study area was carefully chosen to reflect the real-world conditions in which *Clarias gariepinus* or anther aquatic organisms may encounter pesticide pollution.

Experimental Fish

Sixty post Juvenile *Claria garienpinus* weighing between 102-450g and measuring 10.4-21.3cm in length were purchased from a registered fish farm at Ugbolu community in Asaba, Delta State and were transported to the farm house of the Biological Department. The fish were acclimatized (Naa & Agokei 2010) for 7 days before the commencement of the experiment. During acclimation, the fish were fed with commercial fish feed at 5% of their body weight daily. Unconsumed feeds were taken out by changing the water. They were maintained under a natural photoperiod (12 hours light and 12 hours dark) and water qualities were monitored and maintained within optimal ranges for *Clarias garienpinus* survival (Akinrotimi *et al*., 2012).

Pesticide Preparation and Exposure

Sniper, DDVP (Dimethyl 2, 2- dichlorovinyl phosphate), was obtained in its pure form from a certified chemical supplier at Ogbogologo market, Asaba Delta State. Stock solutions were prepared by withdrawing 2mls of undiluted DDVP and then diluting with dechlorinated water of 1L of volume to achieve the desired concentrations. Treatment concentrations of 0.2mg/l, 0.4mg/l, 0.8mg/l and 1.6mg/l were measured from the stock and exposed to the fish in experimental tanks according to the treatment groups. The control tanks contain only experimental fish and dechlorinated water. This method was adapted from (Omitoyin *et al*., 2006).

Experimental Design

The experiment was conducted in a completely randomized design with five treatments, each containing different concentration of pesticide and a control group (no pesticide). 10 fishes were subjected to each 30 liters of distilled water in 50 liter experimental tanks. The fishes were then exposed to group A- 0.00mg/l (control), group B- 0.2mg/l, group C- 0.4mg/l, group D- 0.8mg/l and group E- 1.6mg/l of DDVP dosage respectively. The exposure period lasted for 28 days, as performed by (Muiruri *et al.*, 2013). In the exposure period, fish behaviors were observed and recorded.

Water Quality Monitoring

Water quality was maintained within recommended ranges for *Clarias garienpinus* to minimize any confounding effects due to poor environmental conditions. The water in the experimental tanks was replaced two days intervals to maintain consistent pesticide concentrations, and any uneaten feed or waste was siphoned out.

Fish Observations and Data Collection

During the 28-days exposure period, the fish were keenly observed regularly for signs of toxicity. Abnormalities in the following activities were observed; swimming patterns, respiratory distress, lethargy and loss of equilibrium and were recorded. Mortality was recorded at 48-hour intervals sometimes 96 hours interval, and dead fish were immediately removed from the tanks to avoid further contamination. The percentage of surviving fish in each treatment group was calculated at the end of the exposure period to determine the dose-respond of the experimental set-up.

Full Blood Count (FBC) Analysis

After 28 days of the experiment, surviving fish from each treatment group were taken for Full Blood Count (FBC) analysis to check for haematological abnormalities as a result of DDVP exposure to the fish. 2ml syringe each for each treatment was used to collect blood sample into EDTA bottles. This was to ascertain detection of any changes in the blood components such as packed cell volume (PCV), hemoglobin (HB), red blood cells (RBC), mean corpuscular hemoglobin concentration (MCHC), mean corpuscular hemoglobin (MCH), mean corpuscular volume (MCV), white blood cells (WBC), neutrophils (N), lymphocytes (L), eosinophils (E), and monocytes (M) and platelets (PLT). The extent of blood damage was done based on a semi-quantitative grading system, which provided insights into the sub-lethal effects of pesticide exposure on the fish wellbeing.

Statistical Analysis

All data collected were subjected to computer based excel statistical package using One-way analysis of variance (ANOVA) to determine significant differences among the treatment groups. A significance level of $p<0.05$ was used to assess statistical significance.

Results

Behavioural Changes Of The Fishes

The behavioral changes in the post juvenile were monitored in the different concentrations for 4 weeks on *C. garienpinus* post juveniles on exposure to different concentrations of (Dichlorvos) sniper insecticide.

Control group A (0.0mg/l)

There was normal swimming of the fish and they responded well to feeding.

Group B (0.2mg/l)

Normal swimming was observed in the 1st and 2nd weeks. But in 3rd and 4th weeks post juveniles of the *Claria garienpinus* became agitated, restless by erratic in move and gulping for air. They fairly respond to feeding and they assumed vertical position before death, with a 70 % survival at the end of 28 days experimental period.

Group C (0.4mg/l)

Pesticide toxication started after 24hours with erratic movement, gulping for air, colliding with each other and by 2 weeks post juveniles exhibited caudal bending. The fish feeding response was fair and there was 20% survival at the end of the experiment.

Group D (0.8mg/l)

The fish were trying to jump out of the test medium immediately they were exposed to 0.8mg/l dosage. Sudden erratic movement, loss of equilibrium, opercula movement decreased as exposure time increased and gulping for air are the activities observed. Besides, the juveniles became sluggish and remained at the button of the toxicants. Post juveniles became dark in colour, caudal bending and excessive mucus secretion from gills after death were observed. At the end of 28days, 20% of the fish survived although in a critical state.

Group E (1.6mg/l)

There was incessant jumping, loss of equilibrium, swimming to the surface for air, vertical positioning, quick and fast swimming. Movement of fish became weaker as exposure time increased and death occurred. Excessive mucus secretion was also observed. Poor response to feeding started in the late first week through to the end of the experiment. A very dark colouration of the fish was also observed vividly. 10% of the fish survived.

The results of the 28 days sub-acute toxicity test of the post juvenile of *Clarias gariepinus* exposed to various concentrations of Dichlorvos insecticide was presented in Table 1.

Table 1 shows the mortality of post juvenile at each week of the experimental period. In control group A (0.0 mg/l), no mortality was recorded in week1 to week4 with 0 % mortality and 100% survival. In group B (0.2 mg/l) there was zero mortality in week 1 and a death in week 2 to week 4 each with 30% mortality and 70% survival. In group C (0.4 mg/l) there was a death of fish in week 1 and 2 each and 3 death in week 3 and 4 each with 80% mortality and 20% survival. In group D (0.8 mg/l), 2 fishes died in week one, 3 died in week 2 and 3 each and no death was recorded in week 4 with 80% mortality and 20% survival. In group E (1.6 mg/l), 2 fishes died in week 1 and week 2 each; 3 fishes died in week 3 and 2 fishes died in week 4 with 90% mortality and 10 % survival.

Table 1. Mortality of *C.gariepinus* post juveniles exposed to sub-acute concentrations of Dichlorvos for 28 days i.e approximately 4 weeks

Conc.ml/l	No. of fish/treatment	Period of exposure weekly				% mortality	%survival
		Wk1	Wk2	Wk3	Wk4		
Group A, control 0.0	10	0	0	0	0	0	100
Group B 0.2	10	0	1	1	1	30	70
Group C 0.4	10	1	1	3	3	80	20
Group D 0.8	10	2	3	3	0	80	20
Group E 1.6	10	2	2	3	2	90	10

Mean presentation of the duplicate of the treatment of the weekly mortality of the fish, percentage mortality, and percentage survival on each concentration/dose.

Table 2: Statistical result of haematological parameters of post juveniles of *Clarias garienpinus* at the end of the 28 days exposure to Dichlorvos (sniper) insecticide.

GROUPS	PCV (%)	HB (g/dl)	RBC ($x10^{12}/^{1}$)	WBC ($\times10^{9}/^{1}$)	PLT ($\times10^{9}/^{1}$)	MCHC (g/l)
GROUP A CONTROL	21.5 ±0.5	7.15±0.15	3.55 ±0.05	6.8 ± 0.3	176 ±1.0	32.8 ±1.3
GROUP B	17.2±0.86	5.86 ± 0.36	3.18 ±0.09	7.38 ±0.52	193 ±5.08	33.66±0.36
GROUP C	23± 1.30	7.64 ±0.42	3.88 ±0.22	9.8 ± 1.04	196.4 ±10.36	33.9 ±0.26
GROUP D	21±2.08	7 ±0.68	3.63 ±0.32	9.2.66±0.24	199 ± 16.25	32.76 ±0.17
GROUP E	19 ±1.29	6.3 ±0.41	3.15 ±0.06	9.85 ± 1.21	184.25 ±3.81	32.9 ±0.40

Mean ± standard error of haematological parameters at the end of the 28 days treatment

Table 3: Statistical result of haematological parameters of post juveniles of *Clarias garienpinus* at the end of the 28 days exposure to Dichlorvos (sniper) insecticide.

TREATMENT GROUPS	MCH (pg)	MCV (fl)	N (%)	L (%)	E (%)	M (%)
GROUP A CONTROL	19.8±0.3	67.1 ±1.4	34.0 ±3.0	59.0 ±1.00	3.0 ± 1.00	4.0±1.10
GROUP B	20.2 ±0.77	68.8 ±1.27	33.6 ±2.35	59.2 ±3.35	2.6 ± 0.50	4.6 ± 0.67
GROUP C	21.5 ±0.51	65.1 ±0,59	23.8 ± 3.30	68 ± 3.22	2.6 ± 0.244	5.6 ± 0.40
GROUP D	19.46 ±0. 67	70.03±0.6	26.3±2.33	66.33± 3.17	2.66± 0.88	4.66± 0.88
GROUP E	21.75± 0.62	65.025 ±0.7	34 ±1.58	60 ± 2.19	2 ± 0.40	4 ± 0.70

Mean ± standard error of haematological parameters at the end of the 28 days treatment
N= neutrophils, E= eosinophils, L= lymphocytes, M= monocytes

Haematological indices analyzed across the five groups (Group A to Group E) include packed cell volume (PCV), haemoglobin (HB), red blood cells (RBC), white blood cells (WBC), platelets (PLT), mean corpuscular haemoglobin concentration (MCHC), mean corpuscular haemoglobin (MCH), mean corpuscular volume (MCV), and the white blood cell differential counts for neutrophils (N), lymphocytes (L), eosinophils (E), and monocytes (M).

Discussion

This study tends to evaluate the effects Dichlorvos insecticide has on the environment using *Claria garienpinus* as the biotic organism for the bioassay. This pesticide is a widely used chemical in agriculture both commercial and peasant farming systems. The use of the pesticide in commercial farming usage is to boost agricultural production while in peasant farming usage (the locals) is to reduce the physical removal of pests including weeds.

The sublethal toxicity test of this research rooted on the fact that Dichlorvos application in the field may be diluted due to agricultural run-off into nearby aquatic water body. This may lead to the bioaccumulation of the toxicant and later lead to mortality of the aquatic life in such water body, as clearly examined in this research work showed that all the fish in the control medium survived while mortalities were observed in all treatments. This bioaccumulation resulting in increased concentration of the toxicant in water posed dose-response relationship. This has also been reported by (Zhang et al., 2010 and Umar et al., 2010; Fafioye et.al., 2004) on the dose response of zebra fish on Dichlorvos based on concentration of the pesticide.

The formation of mucus in the gills observed on the death fish is a testimony of a respiratory deprivation of oxygen from the fish. Mucus is a slimy and viscous gelatinous substance that has the adhesive feature to attach to surfaces like the gills of the fish thereby obstruction proper exchange of gases between the gills and the external environment. This work goes concurrent with the work of (Omoniyi et al., 2002) that reported that accumulation of mucus on gills reduces respiratory activity because of the inability of the gill surface to actively carry out gaseous exchange, thus the recorded mortalities.

The experiment duels on 28 days subacute toxicity bioassay of Dichlovos on *C. garienpinus*. This is to register and evaluate the toxicological potential of Dichlorvos, record the LD_{50} of sniper at certain concentration and examine the haematological effects of the concentrations on *C. garienpinus* post juvenile as a test model used for aquatic toxicity test. The evaluation strategy to examine the potency of Dichlorvos has also be reported by (Abubakar *et.al*. 2019) when they examined the Histopathological effects of Dichlorvos (sniper 1000EC) on the gills, livers and kidney of *C. garienpinus*.

In the behavioural change of the fish were gulping for air, erratic swimming, vertical standing, sluggish movement and death. All these behavioural changes have physiological stress as the physiological implication on the fish. The implication is that the fishes were struggling for survival in a strange environment. this early observation of the effect of the fish due to the exposure to Dichlorvos or other toxicamts supported the behavior reported by (Agbeyi et.al. 2025; Sylvester et.al.2020; Ojutiku et.al. 2014; Fafioye et al., 2004). The decrease observed in PCV. RBC and HB in some concentrations is an indication of lack oxygen, which could result to anemic condition leading to the frequent gulping of air by the fishes, although this decrease is not statistically significant (P>0.05) . This finding goes well with the findings of (Sylvester *et.al*. 2020), when they exposed *Clarias gariepinus to* sublethal doses of Dichlorvos, leading to a slight decrease in PCV, RBC and HB.

It is generally known that white blood cell (WBC) is responsible for the fighting against xenobiotics. Thus, for the protection of the organisms from the clinical effects of Dichlorvos (xenobiotic), there was an increase in white blood cells of C. *gariepinus* in order to terminate the toxic effect of the pollutant compared with the control. The findings of this work are in line with (Sylvester *et.al*. 2020; Gunde &Yerli 2012) findings where increase in Dichlorvos comcentration lead to an increase in white blood cell. Neutrophils (N) and Eosinophils (E) which are the components of the white blood cell experience a fluctuation result as the doses increase in a decrease pattern. This fluctuation outcome as a result of Dichlorvos pesticide on Neutrophils (N) and Eosinophils (E) of the blood of *C.garienpinus* was also reported by (Sylvester *et.al*. 2020; Ozoemena,2025), when they evaluated sublethal dose of Dichlorvos on Blood Cells and Enzymes of *Clarias anquillaris.* This may lead to clinical condition called neutropenia and eosinopenia which will result in weak immunity.

The other components of the white blood cell such as Lymphocytes (L) and Monocytes (M) experience a significant increase as the concentration of the Dichlorvos increases. This is a call to due by the physiological system to fight against Dichlovos as a foreign body in the blood. This research support the analysis done by (Raimi *et.al. 2025*) on their work on the exposure of African Catfish (*Clarias gariepinus*) to DDVP (Dichlorvos) insecticide to determine haematological aberration.

The MCHC, MCH and MCV are relative stable when compared with the control. There is no statistical difference ($p>0.05$) of the results when compared with the control. This results is in accordance with the findings of (Ezike, 2017; Akintomi et.al., 2023) when they exposed C. garienpinus to Dichlorvos on an acute toxicity test. This parallel outcome could be as a result of the close similar doses or concentration the *C.garienpinus* was exposed to.The increase in platelet has great significance compared with the control. This could be as a result of the production of thrombosis to prevent excessive haemorhage as a result of internal injury in the fish. This credibility was claimed due to the function of platelet in the prevention of excessive bleeding.

Conclusion

The abnormalities in behaviours, mortalities and the haematoxicological effects of dichlorvos on *Clarias gariepinus* even on subacute concentration under laboratory conditions, suggest that the use of Dichlorvos by farmers and as domestic insecticide be curtailed or restricted so as to preserve the lives of non-target organisms, especially the fishes in the water bodies. Used or unused cans of sniper should not be disposed discarded into aquatic environment.'

References

Abubakar, M. I., Adeshina, I., Abdulraheem, I., & Abdulsalami, S. (2019). Histopathology of the gills, livers and kidney of *Clarias gariepinus* (Burchell, 1822) exposed to sniper 1000EC under laboratory conditions. *Acta Biologica*, *26*, 19–30.

Naa, B., & Agokei, E. O. (2010). Effects of acclimation on haematological parameters of *Tilapia guineensis* (Bleeker, 1862). *Science World Journal*, *5*(4), 1–4.

Ajise, B. B., Oginni, O., Abubakar, M. I., Adeshina, I., Abdulraheem, I., & Abdulsalami, S. (2019). Histopathology of the gills, livers and kidney of *Clarias gariepinus* (Burchell, 1822) exposed to sniper 1000EC under laboratory conditions. *Acta Biologica, 26*, 19–30.

Adedeji, O. B., Adeyemo, O. K., & Agbede, S. A. (2019). Effects of diazinon on blood parameters in the African catfish. *African Journal of Biotechnology*, *8*(16), 3940–3946.

Agbeyi, E. V., Odia, M., & Festus, O. O. (2025). Aquatic toxicity bioassay of cassava mill effluent using tadpoles (*Sclerophrys regularis*). *FUDMA Journal of Sciences*, *9*(8), 210–213.

Ajise, B. E., Oginni, O., Sadiq, S. K., Akinola, O. A., & Okuneye, O. J. (2023). Acute toxicity of dichlorvos to *Clarias gariepinus* juveniles. *African Journal of Health, Safety and Environment*, *4*(1), 72–80.

Akinrotimi, O., Abu, O., Agokei, E., & Uedeme-Naa, B. (2012). Effects of direct transfer to fresh water on the haematological parameters of *Tilapia guineensis* Bleeker, 1862. *Animal Research International*, *7*(2), 1199–1205.

Akinrotimi, O. A., Uedeme, S. S., Akinola, O., & Okuneye, O. (2023). Acute toxicity of dichlorvos to *Clarias gariepinus* juveniles. *African Journal of Health, Safety and Environment*, *4*(1), 72–80.

American Public Health Association, American Water Works Association, & Water Pollution Control Federation. (2007). *Standard methods for the examination of water and wastewater* (16th ed.). Washington, DC.

Ashade, O. O., Ashiru, A. W., & Obiri, C. M. (2011). The comparative study of the toxic effects of 2-3 diclorovinyl dimethyl phosphate (DDVP) and chlorpyrifos on the behaviour and haematology of African *Clarias gariepinus*. *International Journal of Science and Society*, *1*(1), 38–47.

Basharat, H., Ali, M. R., Ahmed, A., Kausar, R., & Akhter, S. (2023). Effects of feeding levels on production characteristics of pond-raised African catfish in pond culture system of Pakistan. *Sarhad Journal of Agriculture*, *39*(1), 166–173.

Brian, S. S., Francis, P., Vesagas, C., Marc, T., Tan, C., Joycelyn, C. J., & Jonas, Q. (2015). Status assessment of *Clarias* species in the Philippines: Insights from DNA barcodes. *The IUCN Red List of Threatened Species*, *27*(2), 21–40.

Ezike, C. O. (2017). Acute toxicity and haematology of *Clarias gariepinus* (Burchell, 1822) exposed to 2,2-dichlorovinyl dimethyl phosphate (dichlorvos). *International Journal of Fisheries and Aquatic Studies*, *5*(5), 100–105.

Fafioye, O. O., Adebisi, S. O., & Fagade, A. A. (2004). Toxicity of *Parkia biglobosa* and *Raphia vinifera* extracts on *Clarias gariepinus* post juveniles. *African Journal of Biotechnology, 3*(11), 137–142.

Fawole, O. O., Ogundiran, M. A., Ayandiran, T. A., & Olagunju, O. F. (2007). Proximate and mineral composition in some selected freshwater fishes in Nigeria. *Journal of Food Safety, 9*, 52–55.

Firat, O., Cogun, H. Y., Yüzereroglu, T. A., Gök, G., Firat, O., Kargin, F., & Kötemen, Y. (2011). A comparative study on the effects of a pesticide (cypermethrin) and two metals (copper, lead) to serum biochemistry of Nile tilapia, *Oreochromis niloticus*. *Fish Physiology and Biochemistry, 37*(3), 657–666.

Gunde, G. E., & Yerli, S. V. (2012). The comparative study on the acute toxicity of dichlorvos on guppy (*Cyprinus carpio* L., 1758). *Journal of Biology and Chemistry, 40*(2), 165–170.

Ibrahim, A. A., Yahaya, Z. S., & Hashim, Z. H. (2023). Relationship between pH, water temperature, dissolved oxygen and parasitic infestation of freshwater fishes in Temengor, Bersia and Chenderoh reservoirs, Perak, Malaysia. *Biological and Environmental Sciences Journal for the Tropics, 20*(1), 105–114.

Muiruri, J. M., Nyambaka, H. N., & Nawiri, M. P. (2013). Heavy metals in water and tilapia fish from Athi-Galana-Sabaki tributaries, Kenya. *International Food Research Journal, 20*(2), 891–896.

Oladunjoye, R. Y., Bankole, S. T., Fafioye, O. O., Salisu, T. F., Asiru, R. A., Olalekan, O. B., & Solola, T. D. (2022). Histo-morphological alteration of lethal and sub-lethal effect of glyphosate-based herbicide on catfish hybrid (*Heteroclarias* sp.). *Nigerian Journal of Animal Production, 49*(1), 177–193.

Ololade, I. A., & Oginni, O. (2010). Toxic stress and hematological effects of nickel on African catfish, *Clarias gariepinus*, fingerlings. *Journal of Environmental Chemistry and Ecotoxicology, 2*, 14–19.

Ojutiku, R. O., Avbarefe, E. P., Kolo, R. J., & Asuwaju, F. P. (2014). Toxicity of *Parkia biglobosa* pod extract on *Clarias gariepinus* juveniles. *Global Journal of Fisheries and Aquaculture, 2*(1), 133–138.

Omitoyin, B. O. (2006). Haematological changes in the blood of *Clarias gariepinus* juvenile fed poultry litter. *Livestock Research for Rural Development, 18*, 1–6.

Omoniyi, I. T., Adeogun, K. L., & Obasa, S. O. (2013). Lethal effects of 2,2-dichlorovinyl dimethyl phosphate (DDVP) on fingerling and juvenile *Clarias gariepinus* (Burchell, 1822). *Croatian Journal of Fisheries, 71*, 19–24.

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 haematological changes in *Clarias gariepinus* (Burchell). *Journal of Applied Sciences and Environmental Management, 6*, 37–41.

Omoregie, E., Malachy, N. O., Ajino, I., Romanus, I., & Kazimievz, W. (2009). Effect of single superphosphate fertilizer on survival and respiratory dynamics of *Oreochromis niloticus*. *Acta Ichthyologica et Piscatoria, 39*(2), 103–110.

Oribhabor, B. J., & Ikeogu, G. C. (2016). Acute toxicity of the pesticides, dichlorvos and lindane against the African air-breathing catfish, *Heterobranchus longifilis* Valenciennes, 1840 (*Siluriformes: Clariidae*). *10*(3), 272–278.

Ozoemena, C. C. (2025). Toxicological effects of chronic inhalation exposure of 2-2 dichlorovinyl dimethyl phosphate on haematological indices of New Zealand white rabbits. *International Journal of Research and Reports in Hematology, 8*(1), 31–42.

Raimi, C. O., Balogun, A. T., & Ajibare, A. O. (2025). Haematological indices of African catfish (*Clarias gariepinus*) juvenile exposed to DDVP (dichlorvos) insecticide. *Journal of Agriculture, Aquaculture, and Animal Science, 2*(1), 229–235.

Sylvester, C. I., Iniobong, R. I., & Ifiemi, J. F. (2020). Evaluation of sublethal dichlorvos poisoning on blood cells and enzymes of *Clarias anquillaris*. *International Journal of Research Studies in Biosciences, 8*(1), 7–13.

Tak, A. M., Bhat, F. A., Jan, U., & Shah, G. H. (2014). Sublethal haematological effects of dichlorvos on the freshwater fish, *Cyprinus carpio* var. *communis*. *International Journal of Recent Scientific Research, 5*(7), 1334–1337.

Umar, M., Stephen, S. H., Abdullahi, M., & Garba, M. (2010). Dichlorvos concentrations in locally formulated pesticide (ota-piapia) utilized in Northeastern Nigeria. *Scientific Research and Essay, 5*(1), 49–54.

Zhang, Z. Y., Yu, X. Y., Wang, D. L., Yan, H. J., & Liu, X. J. (2010). Acute toxicity to zebrafish of two organophosphates and four pyrethroids and their binary mixtures. *Pest Management Science, 66*, 84–89.