Acute Toxicity of Pyrethroids on *Oreochromis niloticus* juveniles

Mustapha Alhaji Saleh[1], Rabiu Sabo[2], Mustapha Abdulkarim[3], Sani Abba Nasidi[4] and Saeed Musa Saeed[5]

Department of Science Laboratory Technology, Mai Idriss Alooma Polytechnic, Geidam, Yobe state, Nigeria, PMB 1020

Department of Mechanical Engineering, Mai Idris Alooma Polytechnic, Geidam, Yobe state, Nigeria, PMB 1020

Corresponding author: mustaphasaleh06@gmail.com

Abstract

A study was carried out to evaluate the toxicity of two pyrethroid insecticides on *O.niloticus* juveniles. Cyperforce and kilsect were used in the study. Acute toxicity was determined using the (OECD, 1992) 96hr static method of toxicity testing. Concentrations used are 0.5, 1.0, 1.5, 2.0 and 2.5µg/L. The experiments were repeated 3 times for each concentration with a blank serving as a control. Bioassay results (96hr) showed that both the two pyrethroids are toxic. Data obtained was evaluated using probit analysis method and the LC_{50} at ($p<0.05$) was 1.63 and 0.58 µg/L for cyperforce and kilsect respectively. It can be concluded that the pyrethroid insecticides used (cyperforce and kilsect) were toxic to *O.niloticus* juveniles though there is a significant difference between the toxicity of the two with kilsect showing more toxicity.

Keywords: *Toxicity, Pyrethroids, Oreochromis. niloticus ,juveniles*

Introduction

The use of synthetic insecticides in agriculture is the most widespread method for pest control in agricultural farms. Although benefits associated with insecticides use are most frequently identified as a reduction in losses due to pests. These insecticides are commonly introduced into aquatic systems via runoff from sprayed fields, during rainstorm events and to a lesser extent through spray drift (EPA, 2012).

Contamination of surface waters has been well documented worldwide and constitutes a major issue at local, regional, national, and global levels (Cerejeira *et al*., 2003; Spalding *et al*., 2003). Environmental pollution caused by pesticides, especially in aquatic ecosystems has become a serious problem. Contamination of water by pesticides, either directly or indirectly, can lead to fish kills, reduced fish productivity, or elevated concentrations of undesirable chemicals in edible fish tissue which can affect the health of humans consuming these fish. Fish consumption accounts for about 35% of animal protein consumption in Nigeria. The fish is low in saturated fat, calories, carbohydrates and sodium, and is a good protein source. It also contains the micronutrients phosphorus, niacin, selenium, vitaminB_{12} and potassium. Fish also serve as a natural, biological control for most aquatic plant problems. It also consumes floating aquatic plants, such as duckweed watermeal (*Lemna* sp.), most undesirable submerged plants, and most forms of algae. The fish can help purify the water by consuming vegetation and detritus, greatly reducing purification costs. These fish are consumed by humans and other vertebrates (Cross, 2000).

Agricultural insecticides when applied in the soil may end up in adjacent water bodies when there is surface run off, spray drift or via uncontrolled disposal. These insecticides may pose some detrimental effects on non-target organisms like fishes which is a good source of protein. This study will explore whether these insecticides are toxic and at what concentration they become toxic. The aim of the study was to evaluate the toxicity of two pyrethroid insecticides on Nile tilapia (*Oreochromis niloticus*).

Materials and Methods

The procedure was adopted from OECD guideline for testing of chemicals which was adopted by the Council on 17th July 1992.

Collection and Maintenance of test species

The test fish, Nile Tilapia (length 10.0±2.0cm; weight 20±5gram) were obtained from Kanye Dam located at N 11º57'38.0 and E 008º08'22.6 at Kabo L.G.A of Kano State. The fish was collected early in the morning to prevent direct heat from sunlight that might change the temperature of the water. The fishes were placed in 25 liters Jerrican with the handle removed for air circulation and easy removal of the test specie and were brought to the lab. They were transferred into a 35 liters capacity container to give them a large area for swimming and were held in the laboratory for at least 2 days for acclimatization before they are used for testing. The specimens were held in water collected from the site where the fish was collected. The fishes were not fed 24 hours before the test is started.

Collection of test chemicals

Two insecticides belonging to pyrethroid class were selected with different active ingredients. They are Kilsect and Cyperforce which were purchased from the retail marketers of pesticides section of Sabon Gari market. The insecticides selected are most recommended by the farmers.

Preparation of test concentrations

The concentrations of the test solutions used are (0.5, 1.0, 1.5, 2.0 and 2.5µg/L).

Bioassay (96hr static method of toxicity test)

Five concentrations in a geometric series were made. 3 replications for each concentration were made. The designated concentration of the test concentration was taken with a syringe and it is then added to the 35 liters capacity plastic tanks containing 25 liters of water and a glass stirrer used to stir the whole water to ensure maximum distribution of the chemical throughout the container. Each container was labelled with the added concentration. The fishes were then added to plastic tanks. One blank containing no chemical was added in addition to the test series to serve as a control. A wire guaze was the used to cover the tank so as to prevent jumping by the fishes and ensure air circulation.

Conditions of exposure

Duration: Preferably 96 hours.

Loading: A number of four fish in each plastic tank to prevent overcrowding that may tempers with the oxygen concentration and the temperature of the water.

Feeding: None

Disturbance: Disturbances that may change the behavior of the fish should was avoided.

Data collection

The fishes were inspected after the addition of the test substance after 30 minutes, 1, 2, 3, 4, 5 and after 24, 48, 72 and 96 hours. Fishes are considered dead if there is no operculum movement. Records are kept of visible abnormalities (e.g. loss of equilibrium, swimming behavior, respiratory function, morphological damage, pigmentation, etc.).

Statistical Analysis

Probit analysis was used to determine the LC_{50} using Biostat 2009 v.5.8 statistical software and student's t-test was used to compare the mortality between the two pyrethroids.

Results

Toxicity test (96hr)

Results of the bioassay of the two pyrethroid insecticides are presented in table 3.0 and 3.1. Total (100%) mortality was recorded only at concentration of 2.0 and 2.5µg/L for kilsect whereas for cyperforce even the highest concentration does not elicit mortality and survival was observed at all concentrations. Kilsect was more toxic to the fish than cyperforce because survival was observed even at highest concentration. The LC_{50} determined from the probit analysis was 1.63µg/.L for cyperforce and 0.58µg/L for kilsect indicating clearly that kilsect is more toxic than cyperforce.

Table 1.0. Mortality profile of a pyrethroid insecticide (cyperforce) on *Oreochromis niloticus* juveniles

Conc. µg/L	Replication	Initial No.	Final No.	% Mortality
0.5	3	4	4	0
1.0	3	4	3	25
1.5	3	4	2	50
++-2.0	3	4	1	75
2.5	3	4	1	75
Control	3	4	4	0

LC50=1.63 µg/L

Table.2.0 Mortality profile of a pyrethroid insecticide (kilsect) on *Oreochromis niloticus* juveniles

Conc. µg/L	Replication	Initial No.	Final No.	% Mortality
0.5	3	4	2	50
1.0	3	4	1	75
1.5	3	4	1	75
2.0	3	4	0	100
2.5	3	4	0	100
Control	3	4	4	0

LC50=0.58 µg/L

Discussion

Mortality and behavioural changes are often manifested when fishes are exposed to a toxic substance. According to Finney's Probit Analysis Method the 96-hr LC_{50} value of cyperforce in tilapia juveniless (*Oreochromis niloticus*) was found to be 1.63µg/L in my work. This shows that cyperforce is toxic to fish. Alpha-cypermethrin is an active pyrethroid, which intensively controls a wide range of pests in agriculture and animal breeding. Alpha-cypermethrin is highly toxic to aquatic invertebrates. Although spray drift may result in toxic effects on aquatic invertebrates, the rapid loss of alpha-cypermethrin from the water gives potential for recovery. The 96-hr LC_{50} values range between 0.7 and 350 µg/L (Bradbury and Coats, 1989). Alpha-cypermethrin is practically non-toxic to birds but is highly toxic to fish and aquatic invertebrates. In general, the hypersensitivity of fish to pyrethroid intoxication is partly due to species' specific differences in pyrethroid metabolism, but principally to the increased sensitivity of the piscine nervous system to these pesticides. It is also highly toxic to bees and causes no mutagenic effects. Bradbury and Coats (1989) have reviewed the toxicology of pyrethroids in

mammals, birds, fish, amphibia and invertebrates (terrestrial and aquatic) and cited 96-hr LC_{50} cypermethrin toxicity as 2.2 µg/L for *Tilapia nilotica*, 0.9-1.1 µg/L for carp (*Cyprinus carpio*), 1.2 µg/L for brown trout (*Salmo trutta*), 0.5 µg/L for rainbow trout (*Salmo gairdneri*), and 0.4 µg/L for *Scardinius erythropthalmus*.

Behavioural changes due to cyperforce exposure in my work is similar to those reported by Polat *et al*., (2002) for beta-cypermethrin. As can be seen from the results, early life-stages are more sensitive than adult fish. Edwards *et al*., (1986) reported acute cypermethrin toxicity in rainbow trout such as gill flailing, hyperactivity, loss of buoyancy and inability to remain upright. My result is in agreement with these. The changes in behavioural response started 6 hours after dosing depending on the concentration of the toxicant. The fish started to display intense activity 2 hours after dosing for kilsect. They left themselves to water currents and make sudden movements at a concentration of 1.0µg/L. The fish gave response when tapped on the aquaria walls at a toxicant concentration of 1.5µg/L and gave no such response at higher concentration. This is because of the neuro toxic effects of the pyrethroid. These results obtained for cyperforce are in agreement with the results of other workers. Smith and Stratton (1986) report the toxic effects (LC_{50}) of *cis*-cypermethrin on various fish species as follows: 2.0µg/L (96-hr) for Atlantic salmon adults (*Salmo salar*) and 6.0µg/L (96-h) for rainbow trout adults (*Salmo gairdneri*). Smith and Strappon (1986) report the toxic effects as 9.0µg/L (24-h) and 8.0µg/L (48-h) for mosquito fish adults (*Gambusia affinis*) and 10.0 µg/L (24-h) and 6.0µg/L (48-h) for desert pupfish (*Cyprinodon macularius*). In this research, the 96hr value is 1.63µg/L which is lower than theirs as their readings are taken after 24 and 48hrs. It shows that the LC_{50} value decreases with increase in number of hours of exposure. Examining cypermethrin toxicity to other aquatic organisms, the work of Clark *et al*., (1987) reported the cypermethrin 96-hr LC_{50} for grass shrimp (*Palaemonetes pugio*) as 0.016µg/L.

The 96hr LC_{50} value of kilsect was 0.58µg/L which shows that kilsect is more toxic than cyperforce by comparing the LC_{50} values of the two. Lambda-cyhalothrin which is the active ingredient of kilsect is highly toxic to a number of fish and shellfish. The reported LC_{50} (96 hr) is 210 ng/L for bluegill sunfish, 240 ng/L for rainbow trout, 360 ng/L for *Daphnia magna*, 4.9 ng/L for mysid shrimp, and 0.8 ng/L for sheepshead minnow. Because lambda-cyhalothrin is commonly applied to rice fields to control insects, potential water and sediment contamination may lead to toxicity in aquatic organisms such as mosquito fish, shrimps, crabs, and clams. Lambda-cyhalothrin showed high toxicity to shrimp (*Macrobrachium nippoensis* de Haan) and Zebrafish (*Brachydanio rerio* H.B). The 96-hr LC_{50} was 20–70 ng/L for shrimp and 0.98–7.55 µg/L for Zebrafish.

Statistical analysis using student's t-test reveals 5.07 for the calculated value and 2.306 for table value indicating a significant difference between the effect of cyperforce and kilsect on *Oreochromis niloticus* juveniles.

Conclusion

Based on the findings from the research, it can be concluded that cyperforce and kilsect is toxic to *Oreochromis niloticus* juveniles though there is a difference between the LC_{50} of the two in which kilsect shows more toxicity than cyperforce at the same concentration. Also statistical difference exists between the effects of the two pyrethroids to *Oreochromis niloticus* juveniles. Government, research institute and other stakeholders should try and explore other effective methods of pest control that are environmental friendly.

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