Alterations in the Levels of Ions in Muscle and Liver of African Catfish, *Clarias gariepinus* Exposed to Paraquat Dichloride

E.N. Ogamba, I.R. Inyang and S.S. AlforGod
Department of Biological Sciences, Niger Delta University, Wilberforce Island, PMB 071, Bayelsa State, Nigeria

Abstract: The electrolyte levels (Sodium and Potassium) were determined in the liver and muscle of African catfish, *Clarias gariepinus* exposed to various sub-lethal concentrations of paraquat dichloride (0.01, 0.02, 0.03, 0.04 and 0.05 mg/L). Sodium (Na⁺) decreased significantly (p<0.05) from the control as the concentration of paraquat increased, with the exception of the first experimental group (with lowest concentration of paraquat), where the liver Na⁺ level was significantly (p<0.05) higher than the control, while the muscle Na⁺ level did not vary significantly (p>0.05) from the control. Thus, the variation of Na⁺ tended to depend on the concentration of paraquat. On the other hand, potassium (K⁺) did not show any distinct pattern, with significantly (p<0.05) higher values at the various concentrations of paraquat than the control. However, there was no significant (p>0.05) difference between the K⁺ levels in both the liver and muscle of the control and those of the fifth experimental group, with the highest concentration of paraquat treatment. This pattern of variation exhibited by Na⁺ and K⁺ suggested that the fish adjusted effectively to stress within the limits of toxicant exposure used in this study.

Key words: *Clarias gariepinus*, electrolytes, liver, muscle, paraquat dichloride

INTRODUCTION

Pesticides are a group of toxic compounds used by humans that have a profound effect on aquatic life and water quality (Luskova et al., 2002). Pesticide are beneficial chemicals that can protect against forest and farm crop losses and can aid more efficient food production. They are used to prevent or stop the spread of destructive and nuisance organisms. However, the benefits of pesticides are not derived without consequences. The disadvantages of pesticides include their toxicity to humans, animals, useful plants and their persistence in the environment. Pesticides are diverse and so have been grouped according to the type of organisms they impact most, such as herbicides, insecticides, fungicides, and so on. However, the focus of this research is on herbicides.

Herbicides are organophosphate chemicals widely applied to agricultural crops, forest lands, gardens and lawns. They are often directly applied to lakes and ponds to control nuisance growth of algae, submerged water plants, floating water plants and emergent water plants. The capacity of a herbicide to harm an organism depend on the toxicity of the herbicide, exposure time, dosage or concentration, persistence on the environment and temperature (Adeyemo et al., 2003).

Paraquat dichloride is characteristically non-selective, very fast in action, becomes biologically inactive when it comes in contact with soil and rain-fast within minutes of application. Paraquat is slightly to moderately toxic to many species of aquatic origin including rainbow trout (Sam, 1987; Pimentel and Edwards, 1982). At high levels, paraquat inhibits the photosynthesis of some algae in stream water (Kenneth, 1990).

African catfish (*Clarias gariepinus*) are found in inland waters throughout much of the old world, and is one of the most widely spread catfish genera in the world (Kori-siakpere et al., 2007). They are recognized by their long tapering body, dorsal and anal fins, flat bony head and a broad terminal mouth with four pairs of barbells. *Clarias* also have large accessory breathing organ composed of modified gill arches, and a high adaptive ability (Adeyemo et al., 2003).

Several researchers have reported alterations in the metabolite and electrolyte activities of some aquatic organisms exposed to various pesticides such as the effects of Cypermethrin on Rainbow trout (Mohammed, 2002; Velisek et al., 2006), Quinalphos on *Labeo rohita* (Das and Mukherjee, 2000); Diazinon on *Carp* (*Cyprinus carpio*) (Luskova et al., 2002).

This research aims to investigate the toxicity of paraquat dichloride on African catfish (*Clarias gariepinus*) electrolytes.

MATERIALS AND METHODS

Experimental Procedure: Thirty-eight juvenile African catfish (*Clarias gariepinus*) (mean weight; 149.21±1.44...
A trial test was carried out using various concentrations of paraquat prepared by pipetting 0.01, 0.02, 0.03, 0.04 and 0.05 mL of the original concentration of paraquat and making it to 30 L with borehole water in the test aquaria; to make 0.05, 0.10, 0.20, 0.30 and 0.40 mg/l solutions (Grinshaw, 1978). Three fishes were exposed to each concentration of paraquat. As in the acclimation period, the water was changed daily and the aquaria washed with a piece of foam. After washing, the test solution was renewed immediately and fish were fed. This was done in order to determine the range of concentrations for the definitive test.

Sublethal concentrations of the definitive test were same as those of the trial test. Eighteen fishes were introduced individually into each of the aquaria containing the various concentrations of the toxicant for a period of 96 h. Every other procedure was as in the trial test. The physicochemical parameters of the aquaria water were measured using the standard methods as described in APHA (1998). The following values were obtained: Temperature 26°C, alkalinity 12.22-19.09 mg/L, pH 6.20-6.37, conductivity 99.50-136 µS/cm, Turbidity 0.18-0.55 NTU and Dissolved Oxygen 5.35-7.21 mg/L.

At the end of the experiment, fish were killed and dissected for the collection of muscle and liver samples. Then 0.05 g of each of the organs were macerated with pestle and mortar. The samples were then digested, extracted and analyzed for sodium (Na+) and potassium (K+) in line with the methods outlined by Logawamy et al. (2006) and APHA (1998).

The data were subjected to analyses of variance (ANOVA). Where difference exist, Duncan Multiple Range Test (DMRT) were used to test for pair-wise significant difference (p<0.05) between treatments (wahua, 1999).

RESULTS AND DISCUSSION

Generally, there were significant (p<0.05) fluctuations in the mean levels of sodium (Na+) and potassium (K+) in both the liver and muscle tissues of Clarias gariepinus at the different treatment levels of paraquat dichloride.

In the liver, Na+ increased significantly (p<0.05) at 0.01 mL/ paraquat exposure from the control value and decreased steadily with increased paraquat concentration before stabilizing at the lowest mean values at 0.04 mL and 0.05 mL of paraquat treatment. Also, K+, fluctuated significantly (p<0.05) above the control value at the various concentrations of paraquat exposure before decreasing again to the K+ value of the control at the highest level of toxicant treatment (Table 1).

The fluctuations in the mean values of Na+ in the muscle of the experimental fishes were minimal. Some of the values recorded were comparable to the value of the control experiment with no significant (p<0.05) relationship displayed between the sodium values and the concentrations of paraquat in experimental groups 1 and 2. However, there were significant (p<0.05) variations between the Na+ values of the remaining experimental groups and the control. Similarly, the mean values of K+ in the muscle of the fish showed minimal variations with significantly(p<0.05) higher mean value observed in the group exposed to 0.0 mL/L of paraquat, while the lowest value was recorded in the group treated with 0.04 mL/L of the toxicant (Table 2).

The general pattern of variation exhibited by Na+ and K+ in both the liver and muscle of the experimental fish suggests that Clarias gariepinus adjusted effectively to the chronic exposure to the various concentrations of paraquat dichloride. It might also mean that the toxicity of paraquat was not too severe on Clarias gariepinus at the concentrations used in the experiment. The consistent decrease in the mean levels of Na+ with increased concentration of paraquat may be as a result of the corresponding increase on muscular activity associated with the observed clinical symptoms of increased opercula rate, hyper-excitation and uncontrolled movement. Similarly, Logawamy et al. (2006) reported significant decreases in the sodium and potassium levels in the liver of fish exposed to paraquat dichloride. Also,
Sharp et al. (1972) reported significant decrease of plasma electrolytes of experimental animals, and that rats dying from paraquat toxicity showed the highest amount of paraquat in organs such as kidney, liver and muscles.

The subsequent stabilization in the values of Na⁺ and K⁺ even at the highest concentration of paraquat could be a stress-induced response occasioned by the chronic exposure of the Clarias spp., which may have activated certain physiological and metabolic mechanisms that could have led to a rapid uptake of the electrolytes from the water, food material, the translocation of ions from other parts of the body of the organism to the liver and muscle tissues and a possible reduction of ion efflux. Similar opinion was also expressed by Kori-Siakpere et al. (2007) when they studied the metabolic parameters of Clarias gariepinus exposed to paraquat. Since the electrolytes are responsible for the proper functioning of all types of tissues, the presence of the active ions of alkali metal Series (Na⁺ and K⁺) are essential for the activities of many enzymes. Some of the most interesting adaptive adjustments that fish of all kinds make in their particular environments concern the maintenance of proper water and salt balance in their tissues. Changes in osmoregulation of fish exposed to toxicants can be elucidated by measuring the liver and muscle sodium (Na⁺) and potassium (K⁺) levels and the total osmolarity. A disturbed ionic regulation can affect the homeostasis of the fish. The regulation of electrolyte concentration of fish is accomplished by some special organs such as liver, kidney, skin/muscle (Sam, 1987).

Critical loss of body electrolyte reduces the ionic concentration and thus leads to the loss of water, which in turn leads to decline of fish homeostasis. It is important therefore, for fish to be able to maintain water and ion balance and thereby survive in a changing environment. Survival through acute challenges, according to Kori-Siakpere et al. (2007), lies upon the ability of fish to reduce ion-efflux while restoring sufficient uptake to maintain body ion level.

CONCLUSION

In conclusion, the fluctuations in the liver and muscle electrolytes of the experimental fishes were minimal. This may be due to the health status of the fish and their capacity to withstand stress, the physicochemical parameters of the bath water, low toxicity of paraquat to Clarias gariepinus, and possibly, other variables that may not have been considered in this study. This agrees with the report by Sam (1987) that the toxicity of paraquat on the African catfish is low because the toxicant is not a cumulative compound. Sub-lethal concentrations of paraquat dichloride used in this study did not induce lethal effect on Clarias gariepinus.

ACKNOWLEDGMENT

We are grateful to Mr. Ollor Ollor of the Department of Medical Laboratory Sciences, Rivers State University of Science and Technology, Port Harcourt for assisting with the analyses.

REFERENCES


