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Variations of Some Electrolytes in the Plasma of Black Jaw Tilapia (*Sarotherodon melanotheron*) Exposed to Some Pesticides in the Laboratory

Ogubunka SO* **and Ike-Obasi JC**

African Regional Aquaculture Center, Nigerian Institute for Oceanography and Marine Research, Nigeria

Abstract

Variations in some electrolytes namely Sodium (Na^+), Potassium (K^+), Chloride (Cl^-) and Calcium (Ca^{2+}) in the plasma of *Sarotherodon melanotheron exposed* to paraquat dichloride (PARAQ), 2,2-dichlorovinyl phosphate (DDVP) and dimethoate (DMC) at the concentrations of 0.00 control, 0.50, 1.00, 1.50, 2.00 and 2.50 mg/L were carried out to determine the extent of osmotic injury in fish exposed to these chemicals. A total of seventy five adult sizes of *Sarotherodon melanotheron* were used for the study. Results from the study indicated that the values of Na^+ and K^+ ions significantly increased ($P<0.05$) in the exposed fish when compared to the control values, while significant reduction ($P<0.05$) of Ca^{2+} was equally observed in the treated fish and no significant difference ($P >0.05$) in the values of Cl^- between the control and exposed fish. Comparatively, these variations were more prominent in the fish exposed to paraquat dichloride.

Keywords: Contaminants; Tilapia; Electrolytes; Plasma; Aquatic environment

Introduction

Pollution of aquatic environments through the use of pesticides results in acute and chronic contamination of fish and other organisms. Though pesticides are often misunderstood to refer only to insecticides, the term pesticide also applies to herbicides, fungicides, acaricides and other substances used to control pest. The pesticides impair some important organs in the system of the fish [1], skeletal system [2] and produce disturbances in serum electrolytes of the exposed fish [3]. Recently, the magnitude of pesticides utilization, and their means of application including their abuse especially in agriculture have been of much concern to environmental scientists. Alongside their uses are also the residual effect of these pesticides and particularly their concomitant effect on human health [4]. On the other hand, some amount of the chemicals used in the form of pesticides end up in the tissue of aquatic organisms and bio-accumulates with time especially in the blood [5].

Plasma in freshwater fishes, particularly in clariids, is hyperosmotic. These fishes are active hyper-osmo-regulators, as they have to face hyper-hydration and ion losses by simple diffusion. Therefore they have to maintain osmotic and ionic homeostasis by means of uphill intake of ions across the intestinal and branchial epithelium at the expenditure of energy [6]. The prevalence of hyponatremia, hypokalemia and hypocalcemia in fish under stress is the reflection of the malfunctioning of gills and kidneys or it may be due to acidity in the water medium [7]. Hyponatremia results in hypervolemia, because damaged kidneys cannot maintain osmotic gradient due to water accumulation in plasma [7]. To the best of our knowledge, very little attention is paid towards the serum electrolyte and arterial blood gases' levels in fish that could be used as a powerful biomarker in assessment of health of fish and environment in which they inhabit. Keeping in view the current status of our natural aquatic environments and the use of pesticides and their leaching impacts on these environments, the present study was conducted to investigate the effect of acute concentrations of nickel sulphate on serum electrolytes in *S. melanotheron*.

Materials and Methods

Experimental location

The study was carried out in African Regional Aquaculture Centre, an outstation of Nigerian Institute for Oceanography and Marine Research, Buguma, Rivers State, Nigeria.

Experimental fish

Seventy five *S. melanotheron* (mean length 8.02 ± 1.12 cm; mean weight 85.12 ± 2.75 g) were sourced from ponds during the low tide. The fishes were transported in six open 50l open plastic containers to the laboratory and acclimated for a period of seven days.

Preparation of test solutions and exposure of fish

Three pesticides paraquat dichloride (PARAQ), 2,2-dichlorovinyl phosphate (DDVP) and dimethoate (DMC) used in this experiment were purchased from a commercial outlet in Port Harcourt, Nigeria. *S. melanotheron* fish were exposed to each of the chemical at the concentrations of 0.00 controls, 1.00, 1.50, 2.00, 2.50 and 3.00 mg/L in triplicates. Five fishes were randomly distributed into each test tank. The experiment lasted for a period of 14 days. The water in the tanks was renewed daily. The fish were fed twice daily at 3% body weight with a commercial feed.

Determination of blood serum electrolytes

At the end of each experimental period, 2 ml of fresh blood sample

***Corresponding author:** Ogubunka SO, African Regional Aquaculture Center, Nigerian Institute for Oceanography and Marine Research, Nigeria, Tel: +234 80 2315 7558; E-mail: phinasteco@yahoo.com

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was collected by making a caudal puncture with the help of fine needle and poured in heparinized sample bottles. Serum was separated by centrifugation at 10,000rpm for 5-8 minutes in TG20-WS Tabletop High Speed Laboratory Centrifuge. Serum electrolytes such as Na^+, K^+, Ca^{2+} and Cl^- were determined by using Hitachi 902 automatic analyzer (Japan), following the method described by Gabriel [8]. All the tests were performed in triplicates.

Statistical analysis

All the data were expressed as mean and standard deviation of mean. The statistical package, SPSS Version 22 was used for the data analysis. The means were separated using two way ANOVA and the two means were considered significant at 5% ($P<0.05$).

Results

The resultant effects of paraquat dichloride on the electrolytes in the plasma of *S. melanotheron* are presented in Table 1. It was observed that sodium ion (Na^+) and K^+ increased with increasing concentrations of the pesticides. Also Ca^{2+} decreased significantly when compared to the control values. While Cl^- were within the same range of 13.0-15.0. In the plasma of fish exposed to DDVP, these ions Na^+, K^+, and HCO_3^- fluctuated significantly ($P<0.05$) when compared to the control values. While Na^+ and K^+ increased and peaked at 2.50 mg/L of the chemical. The values of calcium ions reduced significantly with increasing concentrations of the chemical. Whereas Cl^- ion were within the same range of 14.00-15.00 across the concentrations (Table 2). In the fish treated with DMC there was significant variation across the concentrations of exposure in all the ions. At the same time Na^+ and K^+ increased and peaked at 2.50 mg/L of the chemical (Table 3).

Conc.(mg/L)	Na^+	Ca^{2+}	K^+	Cl^-
0.00	37.10 ± 1.04^a	26.80 ± 2.45^c	4.20 ± 0.98^a	
0.50	47.30 ± 2.05^b	22.04 ± 2.02^c	6.70 ± 1.43^a	13.00 ± 1.87^a
1.00	51.30 ± 1.20^b	20.80 ± 1.21^c	8.60 ± 0.43^a	14.00 ± 1.91^a
1.50	64.50 ± 1.54^c	18.90 ± 2.12^b	10.70 ± 0.15^b	15.00 ± 1.01^a
2.00	69.50 ± 1.22^c	14.30 ± 1.45^b	14.80 ± 1.31^c	15.00 ± 2.01^a
2.50	75.20 ± 2.76^d	9.70 ± 1.11^a	19.10 ± 1.43^c	

Means in the same column with different superscripts are significantly different ($p<0.05$)

Table 1: Effects of paraquat dichloride on the electrolytes ions in the plasma of *S. melanotheron* (Mean ± SD).

Conc.(mg/L)	Na^+	Ca^{2+}	K^+	Cl^-
0.00	37.10 ± 1.04^a	26.80 ± 2.45^c	4.10 ± 0.72^a	
0.50	42.70 ± 2.32^a	26.03 ± 2.95^c	7.10 ± 1.21^a	15.00 ± 1.54^a
1.00	51.10 ± 1.09^b	24.43 ± 1.21^b	10.50 ± 1.91^b	14.00 ± 1.71^a
1.50	58.90 ± 1.02^b	20.20 ± 2.81^b	16.70 ± 1.24^b	15.00 ± 1.91^a
2.00	63.40 ± 1.99^c	15.50 ± 1.67^a	18.20 ± 1.43^c	14.00 ± 2.14^a
2.50	69.60 ± 2.41^c	10.20 ± 1.02^a	20.10 ± 1.11^c	

Means in the same column with different superscripts are significantly different ($p<0.05$)

Table 2: Effects of 2,2-dichlorovinyl phosphate on the electrolytes ions in the Plasma of *S. melanotheron* (Mean ± SD).

Conc.(mg/L)	Na^+	Ca^{2+}	K^+	Cl^-
0.00	37.30 ± 1.08^a	24.50 ± 2.02^c	4.40 ± 0.22^a	
0.50	46.11 ± 2.81^a	23.31 ± 2.34^c	6.60 ± 1.78^a	
1.00	48.81 ± 1.03^a	20.29 ± 1.73^b	7.20 ± 1.32^b	16.00 ± 1.98^a
1.50	51.91 ± 1.31^b	18.18 ± 2.84^a	8.10 ± 1.98^b	15.00 ± 1.91^a
2.00	53.05 ± 1.21^b	17.06 ± 1.43^a	8.80 ± 1.81^c	15.00 ± 2.65^a
2.50	58.18 ± 2.12^c	15.21 ± 1.09^a	8.90 ± 1.71^c	

Means in the same column with different superscripts are significantly different ($p<0.05$)

Table 3: Effects of Dimethoate (DMC) on the electrolytes ions in the plasma of *S. melanotheron* (Mean ± SD).

Discussion

Electrolytes are needed for osmo-regulatory purposes in the body system of living organisms, thus electrolyte balance in the body of organism is necessary for the normal function of cells and organs. Gabriel [9], revealed that the basic function of electrolytes in the body include the control of fluid distribution, intracellular and extracellular acido-basic equilibrium so as to achieve proper maintenance of osmotic pressure of body fluids and normal neuro-muscular irritability. Therefore, alterations of the electrolyte balance of an organism would adversely affect the organism concerned.

Any type of deviation in plasma electrolytes level can be used as indicator for the assessment of kidneys function. In this study, in toxicant exposed fish, an alteration in electrolytes is an indication of loss of renal function. This was confirmed by Ates [10] in rainbow trout exposed to some heavy metals in the laboratory. It was inferred that selected heavy metal acts as neuro-toxicant, as changes in form, frequency, or posture of swimming movements of treated groups of fish was observed, with changes often occurring much earlier than mortality.

It is investigated that plasma Na^{2+} levels in all freshwater fishes are higher than Ca^{2+}. It is an essential electrolyte in plasma and is found in bound state with plasma proteins [11]. It is interesting that is needed by erythrocytes to maintain their functional entity. Ca^{2+} in fish is use as a powerful tool in assessment of health of fish and environment in which they inhabit. Ca^{2+} helps in clotting of blood, takes part in contraction of muscles, controls the excitability of nerves and also is involved in certain hormone activity [6]. In contrast to Na^{2+}, the lower values of Ca^{2+} concentrations were observed in treated fish compared to control. It was suggested that the experimentally stressed fish tried to control excitability of nerves and has lost integration of voluntary muscles [6].

It is investigated that plasma levels of K^+ in tilapia fish remain unaffected by the factors affecting the gill electrolyte permeability. But the factors that cause acidosis such as stress induced by pesticide compels the muscle to release K^+ into plasma, thus resulting in increased plasma levels of K^+ [12]. Eddy [12] stated that hypo-kalemia in fish might be associated with the alkalosis, cutaneous or intestinal losses of K^+ or due to metal toxicity. Thus hypo-kalemia in pesticide treated fish is an indication of incidence of alkalosis cutaneous or intestinal loss of K^+. The alterations of electrolytes in fish under stress is the reflection of the malfunctioning of gills and kidneys or it may be due to acidity in the water medium [6,7].

Conclusion

This study also showed that each of the toxicants caused significant alterations in electrolytes profiles of the exposed *S. melanotheron*, a clear indication that their usage in the fields and water environment may be a threat to aquatic biota. Sustainable and environmental friendly farming systems must be advocated for in different parts of the country. That will help preserve both the environment and the organism.

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