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Alterations in the Levels of Ions in Blood and Liver of Freshwater Fish, *Cyprinus carpio* var. *communis* Exposed to Dimethoate

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Abstract The fingerlings of *Cyprinus carpio* var. *communis* were exposed to sublethal concentration of dimethoate for 7, 14 days to evaluate the impact of the pesticide dimethoate on different ions namely sodium, potassium, chloride, calcium, magnesium. The blood potassium, calcium, magnesium and liver chloride and magnesium levels were elevated under sublethal condition. The blood sodium, chloride and liver sodium, potassium, and calcium levels were found to be significantly decreased.

Keywords Dimethoate · Toxicity · Fish · Electrolytes

1 Introduction

The pesticides and heavy metals cause the greatest threat to the health of Indian aquatic ecosystem (Saravanan & Harikrishnan, 1999). Application of enormous number of pesticides served to ameliorate the crops from the ravages of pests and insects (Nazeemul khanee, James, & Manjuladevi, 1992). The toxicity of pesticide is one of the main cause for drastic decline of fish population in aquatic environment. According to West (1957) and Hilmy, Shabana, and Saied (1982) electrolytes are distributed in solution throughout all the body fluids. Maintenance of constant internal ion concentrations (e.g., sodium, potassium, chloride, calcium and magnesium) is essential for active regulation of water influx and ion efflux in aquatic organisms (Mayer et al., 1992). Any imbalance in the levels of these ions in animals will lead to impairment of various physiological activities (Baskin, Kuhar, Uricchio, & Harper, 1981). Freshwater fishes are hyper osmotic to their medium and so they gain water osmotically and level to loose solutes by diffusion. In the regulation of osmolarity of system, sodium, potassium and calcium ions play a significant role to keep the hyper osmotic properties of these animals (Narasimhan, Swami, & Chetty, 1983). David, Mushigeri, and Philip (2003) reported that the ions like sodium, potassium, calcium contents were decreased in the tissue of the fish, *Labeo rohita* when exposed to the pesticide fenvalerate. The elevated level of magnesium was also observed by Schreck (1981) in teleostean fishes under pesticide treatment. Ramesh (1995) also reported a two way change in the levels of electrolytes in *Cyprinus carpio* var. *communis* when exposed to an organophosphorus pesticide, Kitazin. Folmar (1993) has provided a bibliography on the effects of organic and inorganic chemical contaminants on electrolyte in teleost fishes. The present work was aimed to evaluate the impact of

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the pesticide dimethoate on ions in the fish *C. carpio* var. *communis*.

2 Materials and Methods

Healthy and active fingerlings of *C. carpio* var. *communis* were obtained from Tamilnadu Fisheries Development Corporation, Thirumoorthi Nagar, Udumalpet, Tamilnadu, India and were acclimatized to the laboratory conditions. Fishes were maintained at room temperature and fed with ad libitum daily at least one hour prior to the replacement of the tank water. The water was renewed daily and the quality of water determined and maintained as per APHA (1998). The LC50 value of the pesticide (OP) dimethoate for 24 h to the fish was determined by the method of Finney (1971) and was found to be 28 ppm. One tenth of LC50 concentration (2.8 ppm) was selected as sublethal concentration and used in the present study. Forty fishes were exposed in each control and experimental tanks to sublethal concentrations for 7th and 14th day. The water was replaced daily in both control and experimental tanks. The fresh toxicant was also added daily in the experimental tank. After completing the exposer period of 7th and 14th day, 20 fishes were randomly selected from each control and experimental tanks and sacrificed for analysis. Five replications were taken in each observation. The samples blood and liver were collected and subjected to analysis of electrolyte parameters like sodium, potassium, chloride, calcium and magnesium. Sodium was estimated by colorimetric method based on the modified method of Trinder (1951) and Maruna (1958). Potassium was estimated by Turbidometric method of Trinder and Maruna. Chloride was estimated by the modified Schufield and Lewellen's method of Tietz (1970). Calcium was estimated by *O*-cresolphthalein complexone method of Giteman (1967) using Autozyme calcium diagnostic reagent kit. Magnesium was estimated by the method of Baginski, Marie, Karcher, and Zak (1982), Pesce and Kalpan (1987) and Young (1990) using Raickem magnesium diagnostic reagent kit manufactured and supplied by reagent Applications, Inc., San Diego, California (catalogue nos. 85207 and 85244 Photometer 4010 system (Boehringer Mannheim, GMBH, West Germany).

3 Results

The sodium level in the blood and liver was found to be decreased at the end of 7th and 14th days of exposure. In blood, the maximum percent decrease of 23.74 and the minimum percent decrease of 19.19 was noted at the end of 14th and 7th days of exposure, respectively. But in liver the maximum percent decrease was 20.46 and minimum was 5.30. The potassium level increased in the experimental groups from that of controls in blood, whereas in liver the potassium levels decreased in both the periods (Table I and Figure 1). Elevation in the potassium level in blood exhibited a maximum percent increase of 37.83 and a minimum percent increase of 13.88 in

Table I Sodium, potassium and chloride level in the blood and liver of *Cyprinus carpio* var. *communis* exposed to varying periods of sublethal dimethoate toxicity

Parameters	Exposure periods (days)	Blood mEq/l				Liver mEq/g			
		Control	Treatment	Percent change	*t* test	Control	Treatment	Percent change	*t* test
Sodium	7	114.28±1.03	92.34±1.10	−19.19	25.21*	71.60±1.60	67.80±1.04	−5.30	3.44*
	14	116.26±1.20	88.65±1.01	−23.74	30.49*	75.56±1.04	60.10±1.02	−20.46	18.38*
Potassium	7	3.70±1.50	5.10±1.02	+37.83	1.33	0.98±0.40	0.37±0.26	−62.24	2.21*
	14	3.60±1.10	4.10±1.05	+13.88	0.56	0.87±0.32	0.48±0.20	−44.82	1.79
Chloride	7	103.30±1.40	99.30±1.02	−3.87	3.99*	43.30±1.06	51.40±1.30	+18.70	8.36*
	14	101.20±1.01	82.30±1.53	−18.67	17.85*	48.60±1.23	59.30±1.60	+22.01	9.18*

Values are means of ±SD of five individual observation. Degree of freedom at 4*t*=2.132

'+' Denotes percent increase over control, '−' denotes percent decrease over control

*Values are significant at 5% over control

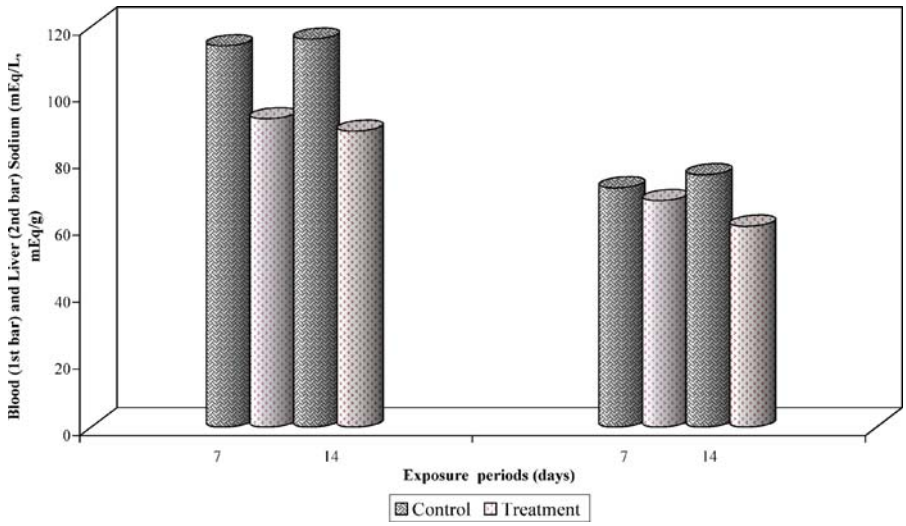

Figure 1 Sodium level in the blood and liver of *Cyprinus carpio* var. *communis* exposed to varying periods of sublethal dimethoate toxicity.

the 7th and 14th days of exposure, respectively. But in liver, the maximum percent decrease of 62.24 was noted at the end of 7th day of exposure whereas the minimum percent decrease of 44.82 was recorded at the end of 14th day of exposure (Table I Figure 2). The chloride levels showed marked fluctuations between control and experimental groups. The values declined in blood showing the maximum percent decrease of 18.67 and the minimum percent decrease of 3.87 at the end of 14th and 7th days of exposure, respectively. In liver, the chloride levels were found to be increased in the experimental groups from that of controls (Table I and Figure 3). The calcium levels showed an increasing trend in experimental groups from that of controls in both the exposure periods in the blood whereas it showed decreasing trend in liver. Analysis of *t* showed very significant changes between control and experimental groups (Table II and Figure 4). The magnesium also showed a marked elevation in both blood and liver during the exposure periods of 7th and 14th day. The *t* test analysis depicted that there was a significant changes between experimental and control groups in all the exposure periods (Table II and Figure 5).

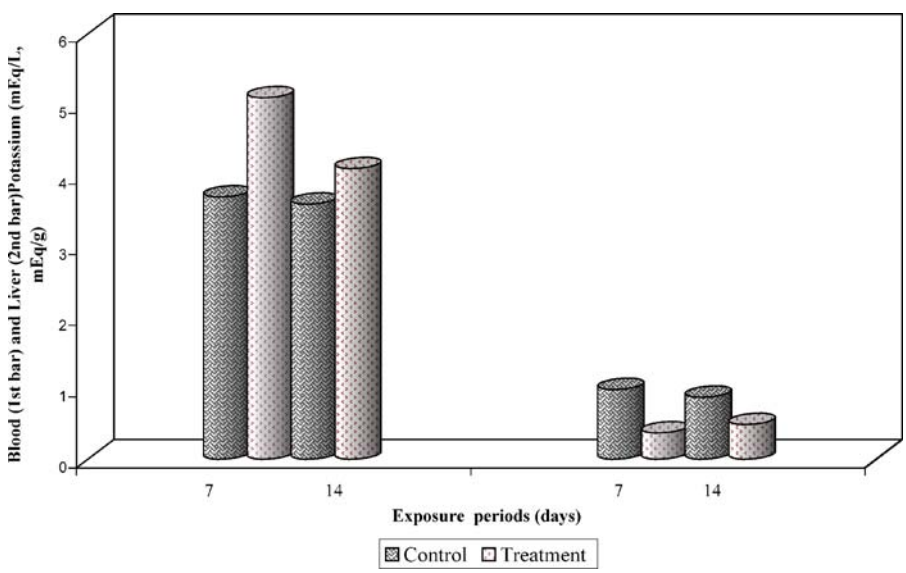

Figure 2 Potassium level in the blood and liver of *Cyprinus carpio* var. *communis* exposed to varying periods of sublethal dimethoate toxicity.

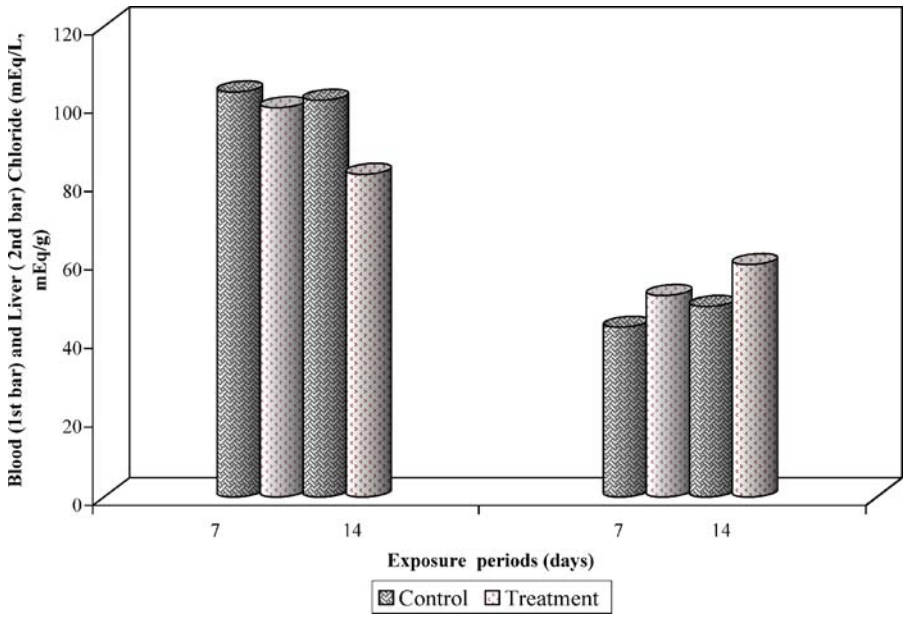

Figure 3 Chloride level in the blood and liver of *Cyprinuscarpio* var. *communis* exposed to varying periods of sublethal dimethoate toxicity.

4 Discussion

Moorthy, Reddy, Swami, and Chetty (1984) pointed out that the pesticides impair the ionic balance in various biological systems. The impairment at the gill level may be the reason for the altered ionic content (Tulsi, Yasmeen, & Ramana Rao, 1990). In the present study, the sodium and chloride levels were found to be reduced and it may be due to the reduced influx or greater efflux through the tissue membrane due to toxicity of pesticides. Similar results were also recorded by Sivaprasada Rao and Ramana Rao (1983) in the muscle, gills, liver and brain of fish, *Tilapia mossambica*. Arun Srivastava, Nasiruddin, and Anil Srivastava (1996) reported the *hyperchloremia* in the tissues of fish *Heteropneustes fossilis* exposed to the pesticide chlordecone and reported that the hyperchloremia may be due to the cortisol interferences and decreased activity of carbonic anhydrase. David et al. (2003) have observed a significant decline in sodium (Na^+) levels in the liver and gills of *L. rohita* exposed to fenvalerate. The sodium content in tissue mainly depends on the permeability functional efficiency of bio-membrane and efficient functional role of Na^+ pump, which regulates ionic content of tissue. The reduction in major electrolytes sodium and chlorides might be due to histological alterations of gills or disturbances in the membrane permeability due to dimethoate toxicity. Potassium is the main cation of the intracellular fluid and it is also an important

Table II Calcium and magnesium level in the blood and liver of *Cyprinus carpio* var. *communis* exposed to varying periods of sublethal dimethoate toxicity

Parameters	Exposure periods (days)	Blood mEq/l				Liver mEq/g			
		Control	Treatment	Percent change	*t* test	Control	Treatment	Percent change	*t* test
Calcium	7	6.40±1.07	7.20±1.30	+12.50	0.82	3.90±1.01	2.60±1.40	−33.33	1.30
	14	6.80±1.38	9.20±1.63	+35.29	1.94	3.20±1.49	2.90±1.61	−9.37	0.23
Magnesium	7	1.26±0.70	1.68±0.30	+33.33	0.95	0.29±0.15	0.38±0.13	+31.03	0.78
	14	1.28±0.63	1.44±0.22	+12.50	0.41	0.31±0.26	0.46±0.17	+48.38	0.83

Values are means of ±SD of five individual observation. Degree of freedom at 4t=2.132

'+' Denotes percent increase over control, '−' denotes percent decrease over control

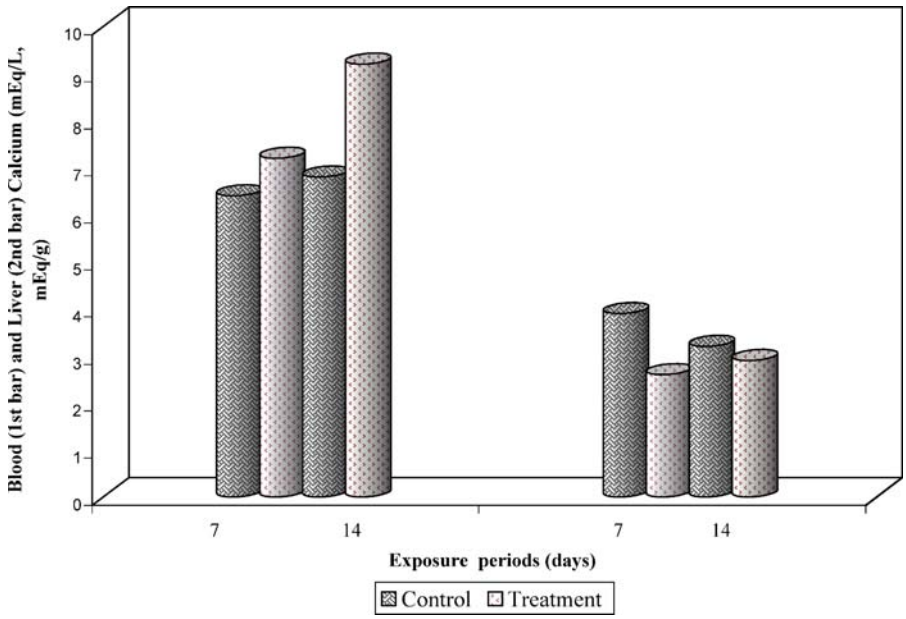

Figure 4 Calcium level in the blood and liver of *Cyprinus carpio* var. *communis* exposed to varying periods of sublethal dimethoate toxicity.

constituent of the extra cellular fluid. In the present investigation, the potassium levels showed an elevation in blood as noted by Playle, Goss, and Wood (1989). The author stated that the increase in plasma concentration of K^+ was likely to the decreased plasma volume, which would translate into the higher concentrations of this parameter. David et al. (2003) found the decrease of calcium and potassium levels in the liver of fish, *L. rohita* exposed to fenvalerate and reported that the decrease in Ca^{2+} ion level indicates the increased calcification. In the present study, the restlessness in fish during dimethoate stress might indicate alterations in the regulations of Ca^{2+} in the tissue. In the present study, the decrease of potassium content in the liver may be attributed to the derangement in respiratory system and might be accompanied by serious disturbances in muscular irritability as observed by David et al. Elevation of potassium,

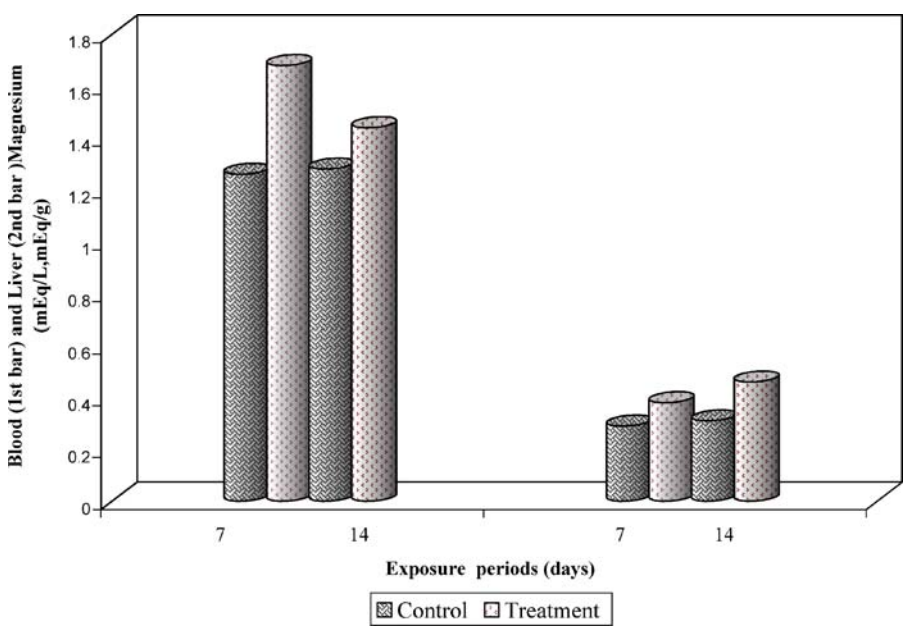

Figure 5 Magnesium level in the blood and liver of *Cyprinus carpio* var. *communis* exposed to varying periods of sublethal dimethoate toxicity.

calcium and magnesium levels in plasma concomitant with lower concentrations of potassium and calcium in liver, was observed by Eisler and Edmunds (1966) in northern puffers exposed to sublethal concentration of endrin which indicated the mobilization of cations from the liver into the serum. The increased levels of blood calcium and magnesium in the present study might be due to renal damage and dysfunction which in turn impaired the ability of fish to actively excrete excess of these ions through kidney as reported by Larsson, Bengtsson, and Svanbeg (1976).

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