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Toxicity of monocrotophos on the biochemical composition of the freshwater fish *Channa striata*

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Abstract
The freshwater fish, Channa striata fingerlings were exposed to 10% and 30% sublethal concentrations of (LC50 for 96h-0.38 ppm) monocrotophos for a period of 10, 20 and 30 days to study the effect of monocrotophos on the biochemical composition of various organs such as gill, liver, kidney, intestine and muscle. After stipulated time, the carbohydrate (67.21 in the gill, 65.15 % in the intestine, 56.71 % in the kidney, 70.88 % in the liver and 67.98 %), protein (8.76% in gill, 72.51% in intestine, 81.11% in kidney, 85.39% in liver and 89.82% in muscle) and lipid (58.83 50.78, 69.19, 60.62 and 71.13% respectively in the gill, intestine, kidney, liver and muscle) content in the various tissues of Channa striata under pesticide stress were found to be decreased when compared with control.

Keywords: monocrotophos, biochemical constituents and *Channa striata*

Introduction
Pollution due to pesticides needs considerable attention because of the toxicants, which lack the capacity to dramatically increase the rate of mortality in exposed population, may still cause their ecological death after a long time of exposure, probably as a result of the cumulative effect of impaired metabolic functions (Ghosh and Shroti, 1992). Such disrupted activities may also occur in non-target organisms. These activities lead to changes in the composition of different tissues, which may serve as sensitive criteria on the effect of chronic toxicity of the pesticides (Colianese and Neff, 1982) [6]. Aquatic toxicologists assess the physiological aspects of fishes living in polluted waters (Gingerich and Weber, 1979) [11].

The biochemical changes occurring in the body of the organisms give first indication of stress. Several investigators have reported a number of changes in biochemical parameters of aquatic organisms due to pesticidal exposure (Mule and Lomte, 1992; Muley *et al*., 1996; Kumari and Kumar, 1996; Tilak and Rao, 2003; Maruthanayagam and Sharmila, 2004; Remia *et al*., 2008; Patil and David, 2007 and Vijakumar *et al*., 2009) [21, 23, 41, 20, 30, 26, 47]. Protein being the essential substance is needed for growth and development and also serves as energy source during the stress condition. The total protein level of muscle and liver decreased in freshwater telelost fish, *Channa punctatus* exposed to Nuvacron (Sastry and Dasgupta, 1991) [36]. Decreasing trends have been reported in gill, liver, muscle and brain tissues of *Oreochromis mossambicus* exposed to Quinalphos (Durairaj and Selvarajan, 1992) [7]. Aruna Khare and Sudha Singh (2002) [34] investigated gill protein content of the fish *Clarias batrachus* exposed to 0.04 ppm of Malathion and showed a gradual decrease in protein content on 30th day. In gobid fish, *Glossogobius giuris*, Venkataramana *et al*. (2006) [46] reported a rapid decrease in protein when the fish were exposed to Malathion. Carbohydrates form one of the major sources of energy precursor under any stress condition. Total carbohydrate content decreased during the exposure to Endosulfan in the air breathing fish *Anabas scandens* with a maximum decrease in the brain tissues observed on 21st day (Yasmeen, *et al*., 1991) [50]. Decreased carbohydrate level has been noted in the liver and muscle of *Heteropneustes fossilis* exposed to butachlor (Sangeetha Sharma and Agarwal, 2004) [33]. Chlorpyrifos, an organophosphate compound decreased hepatic glylogen levels due to inactivation of enzymes involved in the carbohydrate metabolism in the fresh water fishes such as *Catla catla, Channa striata* and *Cirrhinus mrigala* (Tilak, *et al*., 2005) [43].

Lipids are generally triglylerides that can serve as metabolic reserves. Phospholipids showed a rapid decrease since it is actively degraded due to the pesticidal stress. (Harper *et al*., 1977) [13]. Sivaprasanna Rao and Ramana Rao (1979) [38] reported considerable decrease in total lipid in the tissues of *Tilapia mossambica* exposed to methyl parathion. Pant *et al.* (1987) [25] reported decrease in liver lipid content of *Barbus chonchonius* exposed to Aldiocarb for 15 and 30 days. Hence, a study on the effect of pesticide monocrotophos on carbohydrate, protein and lipid level of the fresh water fish *Channa striata* is note worthy.

Materials and Method
The fish, *Channa striata* fingerlings (Weight: 15g; Length 9 cm) were collected from the Aqua Farm near Pattukkottai, Tamil Nadu. They were acclimatized for 15 days in large cement tanks (Temperature – 28 ± 2°C**;** total hardness – 518 ± 23 mg/l; DO - 5.6 ± 0.2 mg/l; salinity - 1.2 ± 0.13 ppt and pH - 7.8 ± 0.04) previously washed with 1% potassium permanganate. The water as renewed every 24 h. The LC_{50} of monocrotophos for 96h was found out by using Probit method (Finney, 1971) [8]. For biochemical studies *Channa striata* were reared in sublethal concentrations (10% and 30% of 96 hours LC_{50} - 0.38 ppm) for a period of 10, 20 and 30 days. The total carbohydrate, protein and lipids were estimated by Roe (1955) [31], Lowery *et al* (1951) and Folch *et al* (1957) [9] respectively.

Results and Discussion
Total Carbohydrate
In the fish reared as control the carbohydrate content was

the highest in liver (24.52-25.17 mg/g), followed by muscle (8.37-8.64 mg/g), very low in gill (2.47-2.57 mg/g) and least in intestine (1.96-2.17 mg/g) The pesticides, monocrotophos appeared to cause individually, pronounced dose and time dependent decrease in the carbohydrate content of all tested tissues (Table.1 and Fig.1.5). On day 30, carbohydrate content of *Channa striata* was found to decrease respectively by 67.21 in the gill, 65.15 % in the intestine, 56.71 % in the kidney, 70.88 % in the liver and 67.98 % in the muscle of fish exposed to 30% sublethal concentration of monocrotophos. In the present study, the highest depletion of carbohydrate content was noted after 30 days of pesticidal exposure in all the tested tissues. The percentage depletion was higher on fish exposed to the 30 % sublethal concentration of than 10% SLC exposed to monocrotophos. Table shows that the change in carbohydrates was dependent significantly on the concentration of pesticides as well as period of exposure for most of the tissues.

Table 1: Levels of total carbohydrate in selected tissues of *Channa striata* exposed to sublethal concentrations of monocrotophos

	10 Days					20 Days					30 Days				
Tissues	**G**	**I**	**K**	**L**	**M**	**G**	**I**	**K**	**L**	**M**	**G**	**I**	**K**	**L**	**M**
Control	2.41 ± 0.21	1.96 ± 0.61	1.67± 0.61	25.17± 0.21	8.12± 0.12	2.57± 0.34	2.17± 0.21	1.52± 0.15	25.02± 0.18	8.64± 0.13	2.47± 0.18	1.98± 0.33	1.64± 0.19	24.52± 0.29	8.37± 0.29
10% SLC %Variation	2.10 ± 0.14 -12.86	1.62 ± 0.19 -17.35	1.17± 0.19 -29.94	22.16± 0.17 -11.95	6.45± 0.21 -20.57	2.16± 0.11 -15.96	1.47± 0.19 -32.27	1.21± 0.61 -20.39	17.21± 0.11 -31.22	5.07± 0.21 -41.32	1.87± 0.31 -24.29	1.02± 0.41 -48.48	0.98± 0.32 -40.24	12.61± 0.13 -48.57	4.27± 0.32 -48.98
30% SLC %Variation	1.45 ± 0.44 -39.83	1.23 ± 0.37 -37.24	1.04± 0.22 -37.72	14.31± 0.20 -43.15	4.16± 0.34 -48.77	1.12± 0.15 -56.42	0.89± 0.11 -58.99	0.87± 0.15 -42.76	9.52± 0.28 -61.95	3.41± 0.19 -60.53	0.81± 0.38 -67.21	0.69± 0.21 -65.15	0.71± 0.16 -56.71	7.14± 0.16 -70.88	2.68± 0.30 -67.98

Values are mean ± SD of six observations. – or + indicate percent decrease or increase over control
G – gill; I – intestine; K – kidney; L – liver; M - muscle

Protein

In *Channa striata* kept as control protein content was the highest in muscle (35.11-37.14 mg/g), followed by liver (30.20-32.14 mg/g) and intestine (25.05-27.11mg/g). Moderate values were observed in gill (20.77-21.62 mg/g), while low protein levels were seen in kidney (15.62- 17.42 mg/g). Decrease in protein levels was noted in all the tissues of fish exposed to the monoctrotophos (Table.2, Fig. 6-10). The maximum decrease of protein content was observed in the tissues of fish exposed to 30% sublethal concentration of monocrotophos reared for 30 days: 8.76% in gill, 72.51% in intestine, 81.11% in kidney, 85.39% in liver and 89.82% in muscle.

Table 2: Levels of total protein in selected tissues of *Channa striata* exposed to sublethal concentrations of monocrotophos

	10 Days					20 Days					30 Days				
Tissues	**G**	**I**	**K**	**L**	**M**	**G**	**I**	**K**	**L**	**M**	**G**	**I**	**K**	**L**	**M**
Control	20.77± 0.48	25.05±0.25	16.84±0.27	30.20± 0.20	35.11±0.36	20.91± 0.47	27.11± 0.32	15.62± 0.16	32.14± 0.18	37.14± 0.38	21.62± 0.49	25.65± 0.20	17.42± 0.10	31.64± 0.24	36.45± 0.39
10% SLC %Variation	16.91± 0.16 -18.58	21.69±0.26 -13.41	13.71±0.33 -18.59	26.18± 0.26 -13.31	30.61± 0.31 -12.82	12.46± 0.16 -40.41	19.26± 0.27 -28.96	10.71± 0.16 -31.49	19.61± 0.31 -38.98	19.32± 0.32 -49.98	8.14± 0.26 -62.35	12.61± 0.22 -50.84	7.3± 0.39 -58.09	12.16± 0.29 -61.57	10.32± 0.42 -71.69
30% SLC %Variation	10.97± 0.21 -47.18	19.21±0.37 -23.31	9.87± 0.16 -41.39	19.37± 0.29 -35.86	21.67±0.22 -38.28	8.73± 0.37 -58.25	13.09± 0.21 -51.72	6.71± 0.11 -57.04	14.32± 0.19 -55.44	12.16± 0.39 -67.26	4.74± 0.39 -78.08	9.31± 0.31 -63.70	3.95± 0.19 -77.32	6.87± 0.31 -78.29	6.39± 0.21 -82.47

Values are mean ± SD of six observations. – or + indicate percent decrease or increase over control
G – gill; I – intestine; K – kidney; L – liver; M - muscle

Lipid

The concentration of lipid in the normal fish was found to be maximum in liver (13.94-15.11 mg/g) followed by muscle (10.7-11.21 mg/g), intestine (9.21-9.97 mg/g), gill (6.13-6.51 mg/g) and least in kidney (4.45-4.61 mg/g). In the fish exposed to sublethal concentrations of monocrotophos, significant decrease were observed in the content of lipid in all the tissues (Table.3 and Fig.11-15). In fish exposed to the highest sublethal concentration of monocrotophos (30%) for 30 days, the concentration of lipid decreased to 58.83 50.78, 69.19, 60.62 and 71.13% respectively in the gill, intestine, kidney, liver and muscle. For 10% sublethal concentration of monocrotophos the decrease in lipid content was to a lesser extent. In general, the decrease in lipid content was maximum in muscle and liver compared to gill.

The carbohydrate of fishes comprised mainly glycogen and total free sugars and the fluctations in the carbohydrate content may be due to accumulation and utilization of glycogen and total free sugars at different phases of life like growth, gametogenesis and spawning. In fishes, generally the carbohydrate reserves may be rapidly utilized under unfavourable conditions and the great variations found in the tissues indicate that the level of mobilizable carbohydrate reserves may fluctuate widely and rapidly in response to fluctuations in the nutritional state of the animal. In the present study the carbohydrate content decreased in the gill tissues of *Channa striata* exposed to sublethal concentrations of monocrotophos (Fig.1). Tilak and Yacobu (2002) [42] have observed that the fenvalerate exposed *Ctenopharyngodon idellus* showed a decrease in the carbohydrate content in the various tissues. The decrease in total carbohydrate level signifies its utility possibly to meet the higher energy demands of the fish reeling under pesticide toxicity. The synthesis and utilization of carbohydrate are therefore, altered in the organism subjected to pesticide stress.

Carbohydrates which supply the major portion of the

metabolities for the energy requirements in a normal individual is oxidized for the energy requisites. Carbohydrates may be converted to glycogen or shunted in the metabolic pathway to supply the carbon chain for amino acids or converted in to fat (Priscilla, 1985). At sublethal concentration, when the liver carbohydrate content decreased the blood sugar level increased which suggests the breakdown of liver glycogen (glycogenolysis). The mobilization of glucose from the liver to the blood and its availability for utilization by the needy tissues for ensuring normal metabolic processes in the body appears inevitable when the fish is exposed to toxic medium. Many authors have reported decreased carbohydrate level in various tissues of fishes. Sapna Shrivastava *et al*. (2002) [34] observed decreased carbohydrate in the brain of *Heteropneustes fossilis* exposed to carbaryl. Sandhya Bharati and Fazle Rasool (2021) [32] reported decrease in serum glucose level in *Channa punctatus* after the exposure of malathion. Visvanathan *et al*. (2009) [48] reported that in *C. punctatus*, quantative variations in the sugar content of liver and muscle tissues due to pesticidal exposure.

In the present study the muscle carbohydrate content of *Channa striata* showed a decrease when it was exposed to sublethal concentrations of monocrotophos (Fig.5). Muley *et al*. (2007) [22] observed a fall in muscle carbohydrate level in *Channa striata* when exposed to tannery, electroplating and textile effluents. Sastry and Dasgupta (1991) [36] have shown that a high concentration of Nuvacron caused a decline in muscle carbohydrate level in *C. punctatus*. These obsevations were in conformity with the reports on the fall in muscle glycogen level in *C. punctatus*, when exposed to organophosphate pesticide, Dimethoate (Tripathi *et al.*, 2003) [44]. A greater decrease of carbohydrate content indicates greater utilization of carbohydrate to cope with enhanced metabolism under stressful situations. Despite a continuous and rapid release of glucose by glycogenolysis in the liver, to meet the energy requirement for the increased muscular activity, a fall in the overall of carbohydrate content in fishes subjected to pesticidal treatment is imminent. Proteins are mainly involved in the architecture of the cell. During chronic period of stress, they are also a source of energy (Umminger, 1977) [45]. Behavioural responses of fish exposed to sublethal concentrations of pesticide showed that they were under stress condition; fish needed more energy to detoxify the toxicants and to overcome stress. Since fish have a very little amount of carbohydrates, the next alternative source of energy is the protein to meet the increased energy demand. The depletion of protein content in liver, muscle and gill tissues may have been due to their degradation and possible utilization of degraded products for metabolic purposes. Other workers such as Malla Reddy and Basha Mohideen (1995) and Singh *et al*. (1996) [39] have also reported decline in protein constituent in different fish tissues exposed to sublethal concentrations of insecticides.

Protein is the most important constituent in living tissues, which is of considerable metabolic and structural value. Therefore, any change in this constituent indicates the stress inflicted on the metabolic functions required for maintaining a healthy physiological state. In this work the protein content of *Channa striata* at different sublethal concentrations decreased in all exposure periods (Fig.6-10). The depletion in tissue protein of *Channa striata* indicated rapid utilization of energy stores to meet the energy demands warranted by the environment. The observed depletion in tissue protein on treatment with sublethal doses of pesticide were suggestive of proteolytic activity, possibly to meet the excess energy demands under toxic conditions.

Jha and Verma (2002) [14] reported depletion in the protein content in stomach and intestine of *Clarias batrachus* exposed to pesticides endosulfan, malathion and agrofen. Sapana Yadav *et al*. (2019) [35] recorded decrease in protein content of *Anabas testudineus* exposed to sub lethal concentrations of monocrotophos. A significant decrease has been reported in the protein content of the liver and kidney in *Channa striata*, when exposed to 20% active ingredient EC. Fenvalerate (Annamani, 1986) [2]. A similar decrease in the total and soluble protein content has been observed with fenvalerate in fish (Malla Reddy and Basha Mohideen, 1989; and Tilak and Yacobu, 2002) [18, 42]. The total protein level of muscle, gill and liver of *Channa striata* were decreased after all the three periods of exposure to the sublethal concentrations of monocrotophos (Fig.6-10). Manoharan and Subbiah (1982) [19] also noted decrease in total protein content of *Barbus stigma* exposed to endosulfan.

The investigations of Koundinya and Ramamurthy (1979) revealed a decrease in protein content in *Tilapia mossambica* exposed to different pesticides. Sastry and Siddique (1984) reported that the protein content is decreased in liver, muscle, kidney, intestine, brain and gill when *Channa punctatus* has been treated with quinaphos. Yeragi *et al*. (2000) [51] observed the decreased levels of proteins in gills, testis, ovaries and muscles of marine crab *Uca marionis* exposed to acute and chronic levels of Malathion. Aruna Khare *et al*. (2000) [5] observed that the sublethal concentrations of Malathion showed a significant increase in the protein content in kidney of exposed fish during the first week and thereafter, a gradual decrease in protein content has been observed in the later periods of exposure.

Lipid is an important constituents of animal tissue, which plays a prime role in energy metabolism. Lipids are also important in cellular and sub-cellular membranes. A gradual decrease in lipid content in various tissues of *Channa striata* after chronic treatments of monocrotophos of various periods of exposure are shown in Table.3. Earlier researchers like Anusha *et al*. (1996) [3] also suggested that the decrease in lipid content in *C. carpio* may be either due to the uptake of lipid by the tissue for utilization at cellular levels or due to increased lipolysis or mitochondrial injury, which affect the fatty acid oxidation mechanism as suggested by Ware (1980) [49] and Rao *et al*. (1986) [29].

Shivprasad Rao and Raman Rao (1979) [41] studied the considerable decrease in total lipid in tissues might be due to drastic decrease in glycogen content in the same tissue which is an intermediate source of energy during toxic stress conditions . After glycogen, lipid content may be used for energy production to overcome toxic stress. Some workers support these results in which lipid content decreased in animals after exposure to pollutants. Hameed and Muthukumaravel (2006) [12] reported significant decrease in lipid of *Channa striata when* exposed to heavy metal cadmium. Amudha *et al*. (2002) observed the effect of dairy effluent on *O. mossambicus* and reported that lipid content was decreased. Similar decrease in lipid content level has also been observed by Raj Narayan Ram and Sathyanesan, (1987) [28] in *Channa punctatus* when exposed to mercurial

fungicide. Reduction of lipid content of *Channa striata* in this study may have been due to the utilization of lipids for energy demand under stress condition (Harpert *et al.*, 1977) [13].

Table 3: Levels of total lipid in selected tissues of *Channa striata* exposed to sublethal concentrations of monocrotophos

	10 Days					20 Days					30 Days				
Tissues	**G**	**I**	**K**	**L**	**M**	**G**	**I**	**K**	**L**	**M**	**G**	**I**	**K**	**L**	**M**
Control	6.47± 0.12	9.21± 0.34	4.56± 0.19	14.65± 0.26	10.7± 0.24	6.13± 0.24	9.97± 0.13	4.45± 0.17	13.94± 0.18	11.21± 0.13	6.51± 0.26	9.57± 0.29	4.61± 0.10	15.11± 0.31	10.98± 0.34
10% SLC	5.96± 0.13	8.19± 0.35	3.82± 0.19	12.14± 0.32	9.11± 0.22	4.16± 0.26	7.16± 0.61	2.97± 0.21	11.13± 0.41	8.61± 0.31	3.91± 0.34	5.62± 0.17	2.41± 0.19	9.45± 0.27	8.69± 0.32
%Variation	-7.88	-11.07	-16.23	-17.13	-14.94	-32.14	-28.18	-33.26	-20.16	-23.19	-39.94	-41.27	-47.72	-37.46	-20.86
30% SLC	4.97± 0.36	7.67± 0.34	2.31± 0.47	10.16± 0.32	6.73± 0.21	3.95± 0.31	6.16± 0.21	1.65± 0.41	8.72± 0.25	5.15± 0.15	2.68± 0.18	4.71± 0.24	1.42± 0.26	5.95± 0.31	3.17± 0.39
%Variation	-23.18	-16.72	-49.34	-30.65	-37.16	-35.56	-38.21	-62.92	-37.45	-54.06	-58.83	-50.78	-69.19	-60.62	-71.13

Values are mean ± SD of six observations. – or + indicate percent decrease or increase over control
G – gill; I – intestine; K – kidney; L – liver; M - muscle

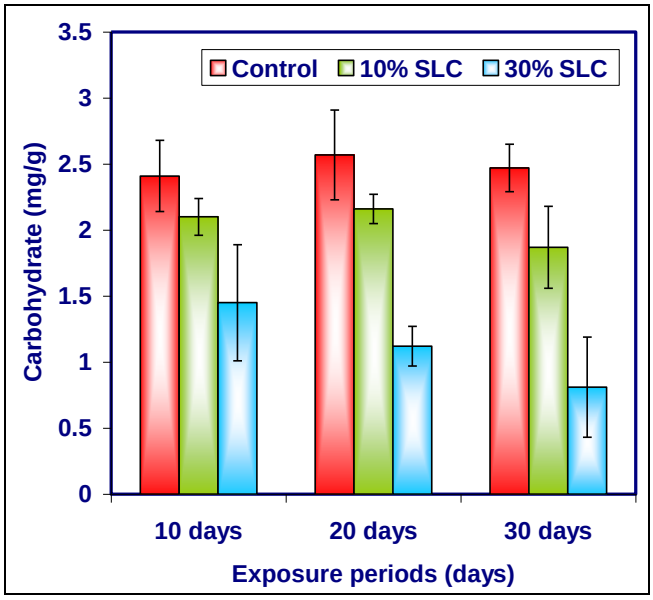

Fig 1: Total carbohydrate in the gill of *Channa striata* under sublethal concentrations of monocrotophos

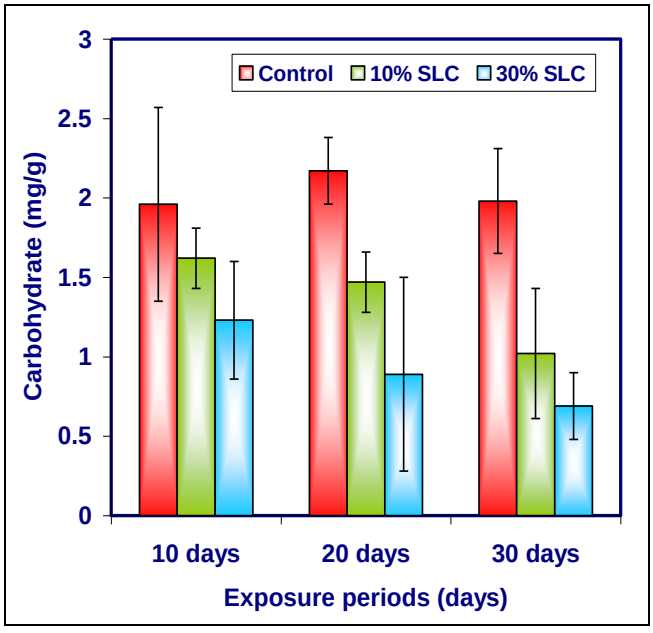

Fig 2: Total carbohydrate in the intestine of *Channa striata* under sublethal concentrations of monocrotophos

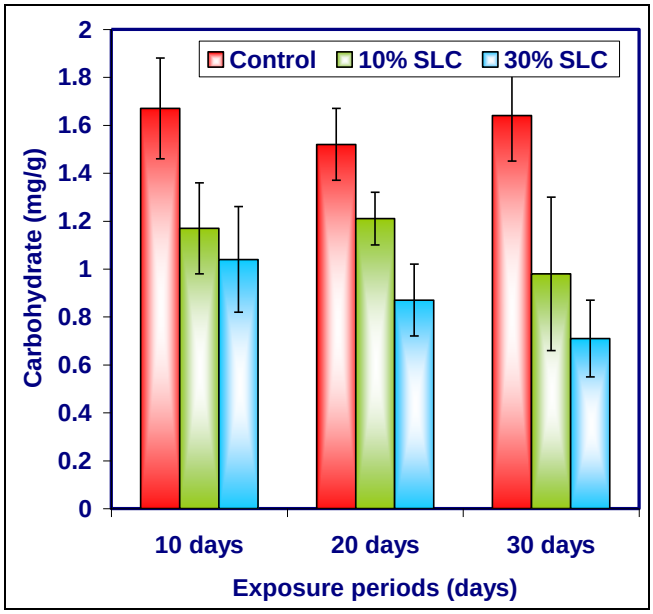

Fig 3: Total carbohydrate in the kidney of *Channa striata* under sublethal concentrations of monocrotophos

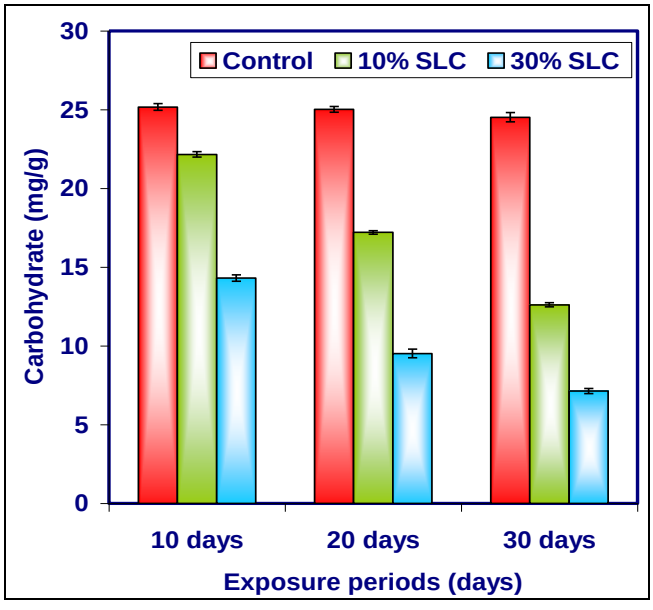

Fig 4: Total carbohydrate in the liver of *Channa striata* under sublethal concentrations of monocrotophos

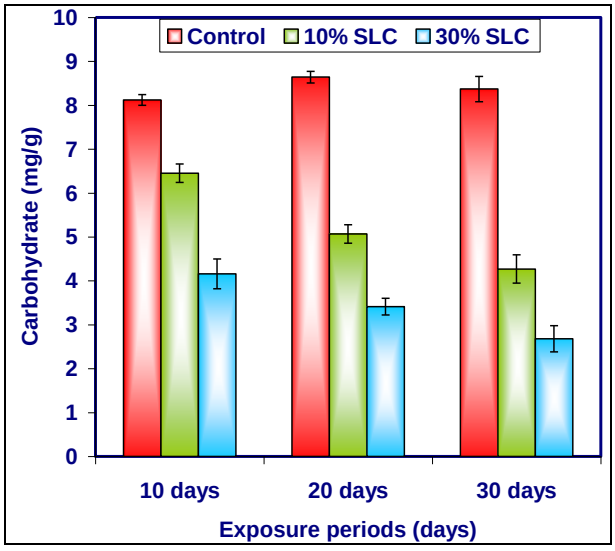

Fig 5: Total carbohydrate in the muscle of *Channa striata* under sublethal concentrations of monocrotophos

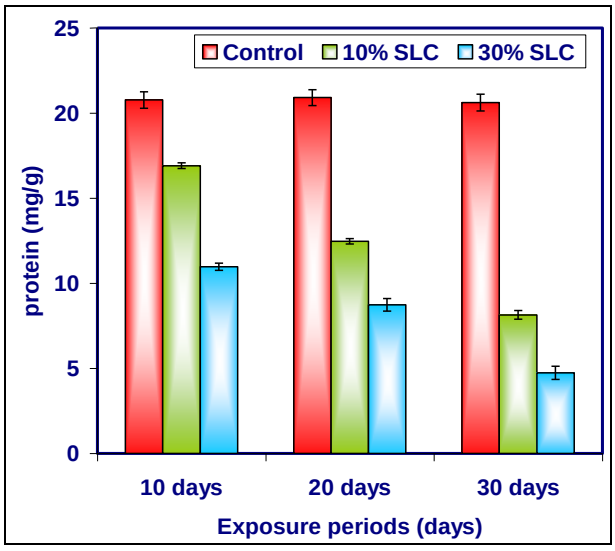

Fig 6: Total protein in the gill of *Channa striata* under sublethal concentrations of monocrotophos

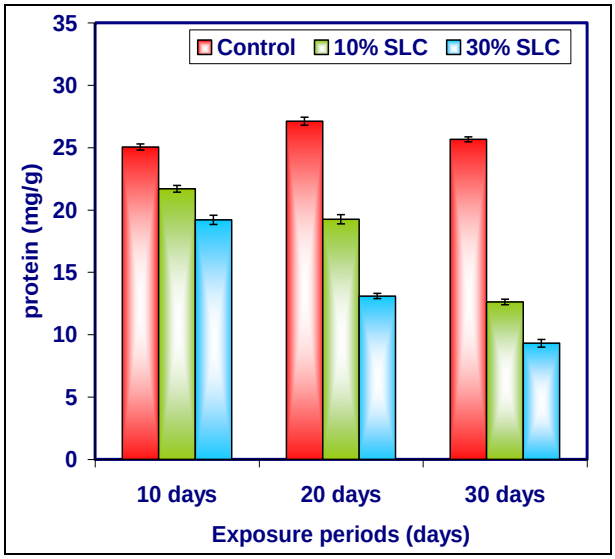

Fig 7: Total protein in the intestine of *Channa striata* under sublethal concentrations of monocrotophos

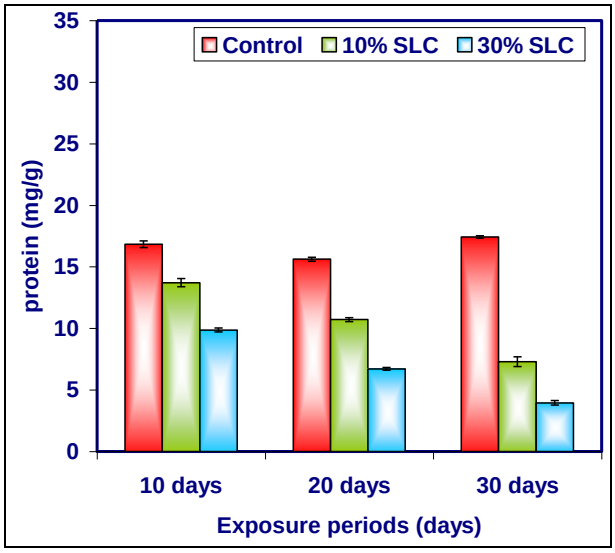

Fig 8: Total protein in the kidney of *Channa striata* under sublethal concentrations of monocrotophos

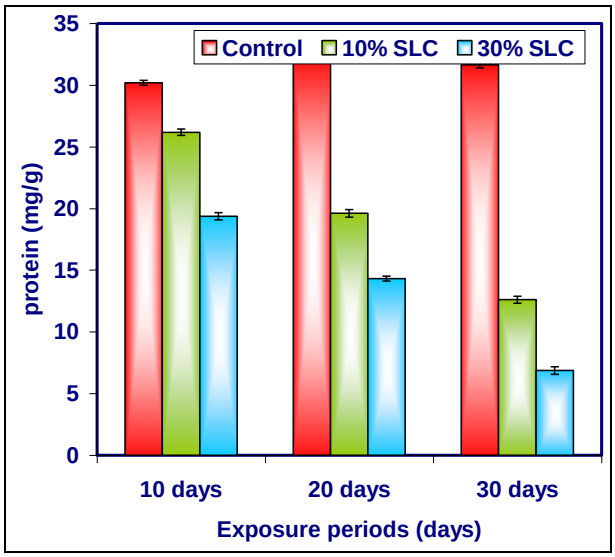

Fig 9: Total protein in the liver of *Channa striata* under sublethal concentrations of monocrotophos

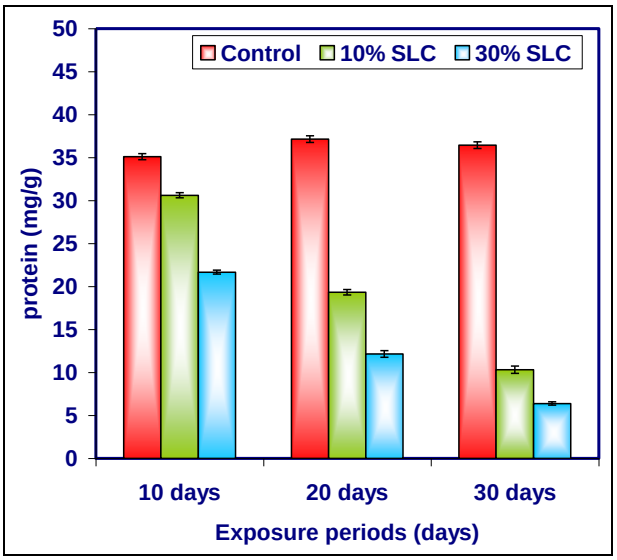

Fig 10: Total protein in the muscle of *Channa striata* under sublethal concentrations of monocrotophos

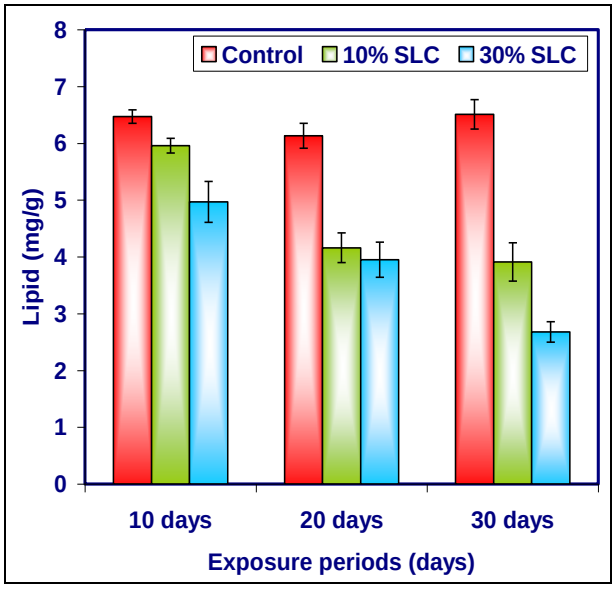

Fig 11: Total lipid in the gill of *Channa striata* under sublethal concentrations of monocrotophos

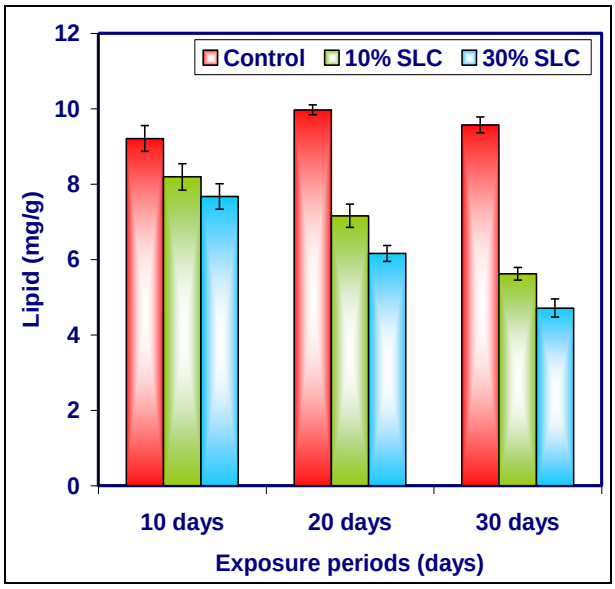

Fig 12: Total lipid in the intestine of *Channa striata* under sublethal concentrations of monocrotophos

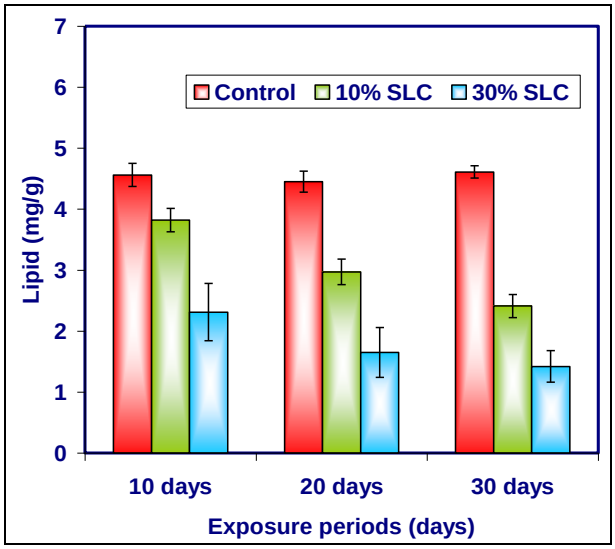

Fig 13: Total lipid in the kidney of *Channa striata* under sublethal concentrations of monocrotophos

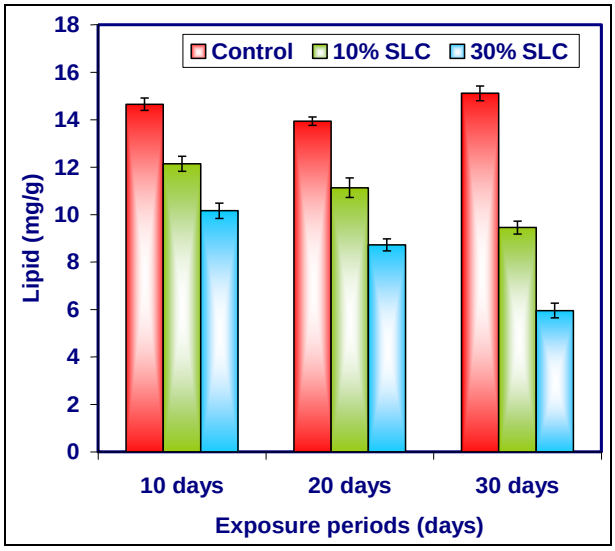

Fig 14: Total lipid in the liver of *Channa striata* under sublethal concentrations of monocrotophos

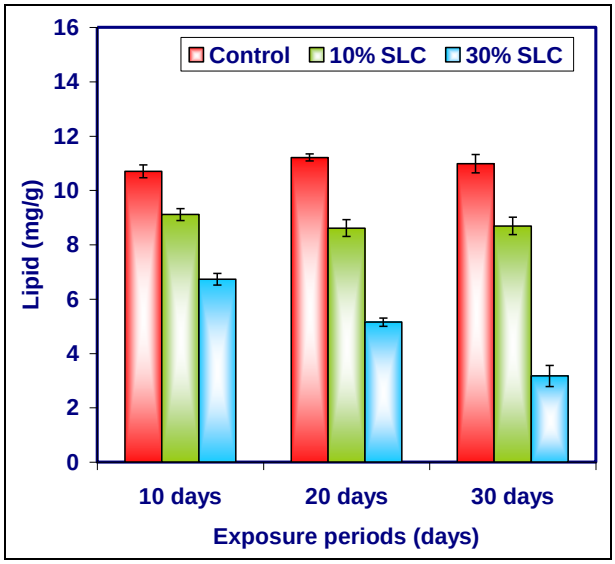

Fig 15: Total lipid in the muscle of *Channa striata* under sublethal concentrations of monocrotophos

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