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Full Length Research Paper

Toxicity bioassay and effects of sub-lethal exposure of malathion on biochemical composition and haematological parameters of *Clarias gariepinus*

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Clarias gariepinus **were exposed to different concentrations of malathion to determine the 96 h LC_{50} value and its sub-lethal effects on haematological parameters and biochemical composition were also investigated. The 96 h LC_{50} value concluded was 8.22 mg/L. Specimens of *C. gariepinus* were exposed to sub-lethal concentrations (0.5, 1.0 and 2.0 mg/L) of pesticide for 4 weeks, which revealed that the pesticide had an adverse effects on various blood parameters. Red blood cell (RBC) and white blood cell (WBC) counts, hemoglobin (Hb) concentration and haematocrit (Ht) values decreased after the exposure of malathion. Plasma glucose level was elevated as plasma protein decreased. Liver and muscle glycogen also decreased in the fish exposed to Malathion. Alanine amino transferase (ALT), glutamate oxaloacetate transaminase (GOT) and glutamate pyruvic transaminase (GPT) activities increased in the fish exposed to malathion. Magnesium and calcium ions were also affected, but the effects were insignificant.**

Key words: Malathion, bioassay, sub-lethal exposure, *Clarias gariepinus*, biochemical and haematological changes.

INTRODUCTION

Centuries ago in most parts of the world, pesticides are used to improve crop production by eradicating unwanted insects and human health by controlling undesirable plants, animals as well as disease vectors (Prakasam et al., 2001). Two billion kilograms of pesticides are applied annually to forests, gardens, homes and agricultural lands in United States of America alone (Aspelin and Grube, 1999). Among these pesticides are organophosphorus (OP) compounds commonly used as insecticides. An organophosphorus insecticide, malathion (O-dimethyl S-[1,2-di-(ethoxycarbonyl)ethyl] phosphorodithioate) is commonly used in agriculture and houses to control the variety of insects including aphids, beetles, pill bugs and scales.

Non-target animals including fish are greatly affected by the indiscriminate use of these pesticides. Fish appear to posses the same biochemical pathways to deal with the toxic effects of endogenous and exogenous agents as mammalian species does (Lackner, 1998). Since the fish constitute an important link in food chain and their contamination by pesticides imbalance the aquatic system hence, it is important to examine the toxic effects of pesticides on them.

The haematological parameters like hemoglobin, haematocrit, blood cell counts, glycemia and ion concentrations can be used to find physiological response of contaminated environment (Dethloff et al., 2001). Therefore, when a clinical diagnosis of fish physiology is applied to determine the sub-chronic effects of pollutants, the blood parameters are often measured (Venkataramana et al., 2006). The activities of some enzymes like alanine amino transferase (ALT), glutamate oxaloacetate transaminase (GOT) and glutamate pyruvic transaminase (GPT) also indicate the impacts of pollut-

Abbreviations: **RBC**, Red blood cell; **WBC**, white blood cell; **Hb**, hemoglobin; **Ht**, haematocrit; **ALT**, alanine amino transferase; **GOT**, glutamate oxaloacetate transaminase; **GPT**, glutamate pyruvic transaminase

Table 1. Number of dead specimens of *C. gariepinus* and their percentage of mortality (in parentheses) in different concentrations of Malathion at different time intervals.

Concentration (mg/L)	Time (h)			
	24	48	72	96
Control (0.0)	**-**	**-**	**-**	**-**
7.0	-	-	-	3 (10.00)
7.5	-	-	3 (10.00)	7 (23.33)
8.0	-	3 (10.00)	6 (20.00)	12 (40.00)
8.5	1 (3.33)	3 (10.00)	8 (26.66)	17(56.67)
9.0	3 (10.00)	5 (16.66)	14 (46.66)	22 (73.33)
9.5	5 (16.66)	15 (49.99)	22 (73.33)	27 (90.00)

ants on fish (Bucher and Hofer, 1990). These enzymes are normally found within the cells of liver, heart, gills and kidneys (Shalaby, 2009) but their increase in plasma indicates the tissue injury or organ dysfunction (Wells et al., 1996). However, effects of different pollutants on the biochemical and haematological parameters of fish have been documented (Bucher and Hofer, 1990; Al-Attar, 2005; Ogueji and Auta, 2007; Shalaby, 2009; Abalaka et al., 2011; Al-Kahem Al-Balawi et al., 2011).

Clarias gariepinus is an economically important freshwater fish, native to Africa and has been introduced all over the world including Saudi Arabia and form a substantial part of freshwater fishery. In the present study, an attempt was made to investigate the toxicity of malathion to this fish. The mortality of fish and changes in haematological parameters (hemoglobin concentration, cell counts and haematocrit values), biochemical changes (glucose, glycogen and protein content) and enzymes' (ALT, GOT and GPT) activities were monitored after lethal and sub-lethal exposure of this pesticide.

MATERIALS AND METHODS

Healthy and active specimens of *C. gariepinus* were procured from a fish farm located at Mozamiah, west of Riyadh. The length and weight of fishes ranged from 12 to 14 cm and 55 to 60 g, respectively. The fishes were kept in glass aquaria (160 × 55 × 60 cm) for two weeks to get acclimatized to laboratory conditions. During this period, the commercial fish food were fed twice daily to satiety. Medium of aquaria renewed daily. The water used was analyzed weekly for temperature, dissolved oxygen, hardness and pH, which were recorded as 23.5 ± 1.5°C, 7.5 ± 0.4 mg/L, 230.5 ± 4.5 mg/L as $CaCO_3$ and 7.8 ± 0.5, respectively. After two weeks of acclimatization, ten fishes were transferred in each aquarium (55 × 30 × 35 cm) containing 30 L of water. Different concentrations (7.0, 7.5, 8.0, 8.5, 9.0 and 9.5 mg/L) of malathion were prepared by adding required volume from the stock solution prepared by diluting the original formulation.

The malathion (MW: 330.4, CAS number: 121-75-5) with 57% active ingredient was obtained from Delta Company, Riyadh. A control set was run with same volume of water and same number of fish. The experiment was run in triplicates. The water was aerated with mechanical pump and feeding was stopped. Dead fishes were removed immediately and their numbers registered. The medium of aquaria was renewed daily. The 96 h LC_{50} was computed from a graph prepared by the method described by Finney (1971). The fishes were exposed for four weeks in triplicates to three different sub-lethal concentrations (0.5, 1.0 and 2.0 mg/L) selected considering the LC_{50} value, some blood and biochemical parameters of these exposed specimens were analyzed. A control set was also run for the same time and with the same number of fish but without Malathion. Three fishes from each concentration (one fish from every replicate) were removed after every week during whole experimental period. Blood samples were obtained in heparinized vials by cutting the caudal peduncle; samples of clotted blood were discarded. In case of insufficient quantity, the blood of two or more fishes was pooled.

Hemoglobin was estimated by the cyano-methemoglobin method (Blaxhall and Daisley, 1973). Haematocrit values were determined by using a micro-haematocrit centrifuge. The red blood cell (RBC) and white blood cell (WBC) count was made using Neubar haemocytometer after diluting the blood with Dace's solution and Turk's solution, respectively. For biochemical analysis, blood was centrifuged at 6000 rpm for 10 min at 4°C and the collected plasma was stored at -20°C till analyzed. Glucose, total protein, calcium (Ca), magnesium (Mg), GOT, GPT and ALT were analyzed using their respective kits (BIOMERIEUX, FRANCE). For statistical analysis, one way analysis of variance (ANOVA) was applied to test the significance of difference among the control and treated values. P values less than 0.05 were considered statistically significant.

RESULTS

Table 1 shows the mortality of fish as a function of Malathion concentrations. The 96 h LC50 value for C. gariepinus computed from the graph (Figure 1) constructed between log10 concentrations (X axis) and probit of kill (Y axis) was expressed as 8.22 mg/L. The present findings indicate that in the C. gariepinus sub-lethal chronic exposure to malathion altered various blood parameters. The fish exposed to different concentrations of malathion manifested decrease in the erythrocyte and leucocyte counts, hemoglobin concentration and haematocrit values as compared to the control fish (Table 2). A slight change in the value of different indices (MCV, MCH and MCHC) was noticed in C. gariepinus after malathion exposure. Significant hyperglycemia and hypo-proteinaemia was evident in the fish exposed to different levels of malathion (Table 3). These changes were more pronounced in the higher

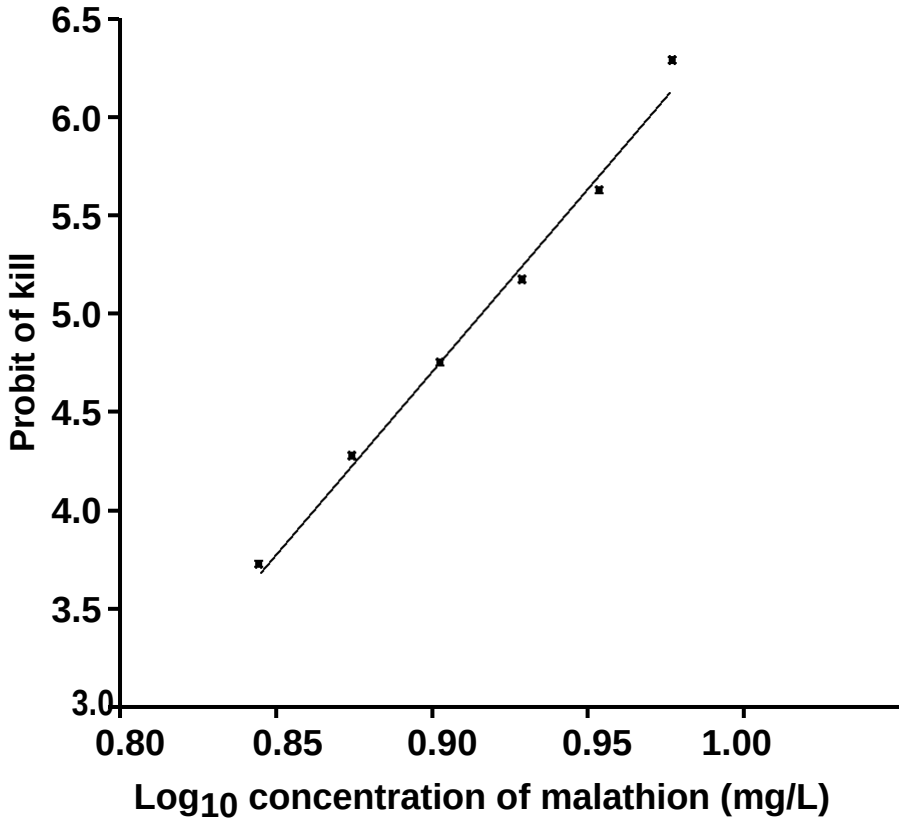

Figure. 1. Graph showing the relationship of probit of kill with $\log_{10}$ concentration of malathion used to deduce the LC_{50}.

of malathion used to deduce the LC
10
50

doses and in the last period of exposure (Table 3). Reduction in the concen-tration of Ca ions was registered in the fish exposed to high dose of malathion and in the last period of exposure whereas Mg ions remain unchanged.

It is quite apparent from the present investigation that malathion exposure to *C. gariepinus* had markedly elevated the PALT activity (Table 3) in all concentrations tested especially in the last period of exposure. The data embodied in (Table 3) also revealed that the malathion exposure had significantly ($P<0.05$) enhanced the activity of PGOT and PGPT enzymes after 2 weeks at higher doses (1.0, 2.0 mg/L) and after 4 weeks in all exposed groups.

DISCUSSION

The LC_{50} value (8.22 mg/L) recorded in the present study for *C. gariepinus* is less than the values (9.14 mg/L for *Ptychocheiilus lucius*, 11700 µg/L for black bullhead, 11.8 mg/L for *Heteropneustes. fossilis*, 15.3 mg/L for *Gila elegance* and 17.0 mg/L for *Ictalurus furcatus*) documented by Durkin (2008) and Faria et al. (2010) for various fish species. In contrast to the aforementioned values, Pathiratne and George (1998) reported a lower 96 h LC_{50} value (2.2 ppm) for *Oreochromis niloticus*. Newhart (2006) tabulated the LC_{50} values of malathion for different species of fish which ranges from 0.06 to 7620 µg/L. Malathion was found to be highly toxic to fry of *Labeo rohita* (LC_{50} value 9 µL, Patil and David, 2008); *Opheocephalus punctatus* (LC_{50} 16 µg/L, Pugazhvendan et al., 2009); walleye (LC_{50} 64 ppb), brown trout (LC_{50} 101 ppb) and cutthroat trout (LC_{50} 280 ppb) and moderately toxic to minnows (LC_{50} 8.6 ppm) and murrels (LC_{50} 5.93 ppm) as summarized by Durkin (2008). The difference in the toxic potential of the pesticides may be attributed mainly to the susceptibility of the test animals and factors like pH and hardness of water.

The disparity in the toxic potential of malathion can also be related to the differences in susceptibility and tolerance related to its accumulation, biotransformation and excretion. Discrepancies in metabolic pathways among species may result in varied patterns of bio-transformation, leading to more or less toxic metabolites (Johnsson and Toledo, 1993). The magnitude of toxic effects of pesticides also depends on length and weight, corporal surface/body weight ratio and breathing rate (Murty, 1986). Oh et al. (1991) reported three factors causing selective toxicity of pesticides for various fish

Table 2. Effects of Malathion exposure on hematological parameters of *Clarias gariepinus*.

Parameter	Concentration (mg/L)	Exposure time (week)			
		1st	2nd	3rd	4th
Erythrocytes (Cellx106/mm3)	Control (0.0)	1.66 ± 0.05	1.64 ± 0.061	1.60 ± 0.054	1.65 ± 0.046
	0.5	1.61±0.05	1.60 ± 0.042	1.60 ± 0.042	1.61 ± 0.054
	1.0	1.58 ±0.08	1.58 ± 0.053	1.46 ± 0.058*	1.43 ± 0.061*
	2.0	1.55 ± 0.06*	1.53 ± 0.061*	1.52 ± 0.045*	1.41 ± 0.046*
Leucocytes (Cellx103/mm3)	Control (0.0)	36.51 ± 0.51	37.23 ± 0.65	37.21 ± 0.71	38.54 ± 0.54
	0.5	33.02 ± 0.52	34.56 ± 0.52	32.65 ± 0.65	35.01 ± 0.62
	1.0	33.56 ± 0.44	31.89 ± 0.57*	31.12 ± 0.50*	30.01 ± 0.42*
	2.0	31.45 ± 0.61*	31.01 ± 0.43*	30.25 ± 0.59*	28.54 ± 0.24*
Haematocrit (%)	Control (0.0)	33.06 ± 0.72	34.76 ± 0.50	33.44 ± 1.02	34.21 ± 0.62
	0.5	32.54 ± 0.51	33.21 ± 0.82	32.23 ± 0.56	33.80 ± 0.96
	1.0	32.65 ± 0.92	32.35 ± 1.10	32.21 ± 1.05	31.65 ± 1.10
	2.0	31.45 ± 0.94*	31.85 ± 0.96*	30.42 ± 1.20*	30.25 ± 1.09*
Hemoglobin (g/dl)	Control (0.0)	5.65 ± 0.09	6.01 ± 0.12	5.95 ± 0.10	6.12 ± 0.61
	0.5	5.11 ± 0.11	5.15 ± 0.13	5.35 ± 0.10	5.56 ± 0.29
	1.0	4.54 ± 0.14*	4.64 ± 0.13*	5.66 ± 0.09	4.54 ± 0.11*
	2.0	4.24 ± 0.09*	4.29 ± 0.08*	4.24 ± 0.12*	4.14 ± 0.12*
MCV (fl/cell)	Control (0.0)	199.92 ± 3.75	211.96 ± 4.21	209.00 ± 3.58	207.33 ± 4.12
	0.5	202.54 ± 3.44	207.56 ± 4.21	201.44 ± 4.23	209.94 ± 5.56
	1.0	206.65 ± 4.35	204.74 ± 3.56	206.47 ± 5.21	221.33 ± 5.25*
	2.0	202.90 ± 4.33	208.17 ± 4.25	200.13 ± 5.65	209.60 ± 5.95
MCH (Pg/cell)	Control (0.0)	34.04 ± 1.75	36.65 ± 1.65	37.19 ± 2.11	37.09 ± 1.75
	0.5	31.74 ± 1.64	32.29 ± 2.33	33.44 ± 1.45	34.53 ± 2.25
	1.0	28.73 ± 2.55	29.36 ± 2.45	29.87 ± 1.75	31.75 ± 2.35*
	2.0	27.35 ± 2.32*	28.04 ± 1.45*	27.89 ± 2.45*	27.42 ± 1.46*
MCHC (%)	Control (0.0)	17.09 ± 1.35	17.29 ± 1.46	17.79 ± 1.25	17.89 ± 1.01
	0.5	15.70 ± 0.65	15.51 ± 0.95	16.60 ± 1.15	16.45 ± 0.98
	1.0	13.90 ± 1.15	14.34 ± 1.26	14.47 ± 0.85	14.34 ± 0.75
	2.0	13.48 ± 1.15	13.47 ± 1.45	13.94 ± 1.65*	13.80 ± 1.45*

*Significant difference with control (P<0.05). Values are mean ± standard error.

species which are varied inhibition of acetylcholinesterase, detoxification and absorption. In general, the toxicity varied with respect to species, size of fish and duration of exposure (Oh et al., 1991; Dutta et al., 1995). Blood parameters, generally, of fish are considered as suitable tool for evaluating the effects of chemicals. Past investigators have also identified changes in several haematological parameters as indicators of pollutants exposure specially metals (Cyriac et al., 1989).

Reduction in different blood parameters might be due to malfunctioning of the haematopoietic system caused by Malathion exposure. Similar to the present results, a decrease in the number of RBC, hemoglobin and haematocrit values of diazinon (an organophosphate pesticide) exposed fish was reported by Banaee et al. (2008, 2011) and related it to destruction of cells and/or decrease in size of cells due to the adverse effects of pesticide. Zaki et al. (2009) reported that RBC count, hemoglobin concentration and PVC values were dwindled in the fish exposed to malathion. Adeyemo (2007) reported decreased hemoglobin, RBC count and haematocrit values in *C. gariepinus* exposed to lead nitrate. Generally, toxicants exposure exerts an adverse effect on the haematopoietic organs which in turn alters

Table 3. Effects of malathion exposure on biochemical composition of *Clarias gariepinus*.

Parameter	Concentration (mg/L)	Exposure time (week)			
		1st	2nd	3rd	4th
Total Protein (g/dl)	Control (0.0)	28.75 ± 1.78	29.35 ± 1.87	29.65 ± 2.09	28.85 ± 2.05
	0.5	28.65 ± 1.86	29.65 ± 1.68	27.25 ± 1.22	26.56 ± 1.96
	1.0	27.98 ± 1.98	27.65 ± 1.02	27.05 ± 1.95	26.85 ± 1.75
	2.0	28.05 ± 1.88	27.85 ± 1.75	26.25 ± 1.86	22.60 ± 1.85*
Glucose (mg/100ml)	Control (0.0)	45.25 ± 7.25	48.35 ± 6.68	46.52 ± 6.88	45.95 ± 6.88
	0.5	55.25 ± 7.55	58.25 ± 7.25	65.55 ± 5.85*	60.25 ± 7.88*
	1.0	65.25 ± 8.68*	64.65 ± 8.25*	78.54 ± 6.75*	70.25 ± 7.52*
	2.0	70.25 ± 7.56*	72.25 ± 7.54*	90.25 ± 8.25*	95.25 ± 6.25*
Liver glycogen (mg/g)	Control (0.0)	9.12 ± 0.12	8.92 ± 0.21	8.90 ± 0.17	8.91 ± 0.18
	0.5	8.76 ± 0.17	8.25 ± 0.18	8.45 ± 0.16	8.44 ± 0.18
	1.0	7.25 ± 0.16*	7.25 ± 0.19*	7.2 5 ± 0.16*	7.35 ± 0.18*
	2.0	7.36 ± 0.15*	7.32 ± 0.17*	7.35 ± 0.15*	7.25 ± 0.18*
Muscle glycogen (mg/g)	Control (0.0)	3.45 ± 0.08	3.35 ± 0.06	3.35 ± 0.06	3.31 ± 0.05
	0.5	3.25 ± 0.06	3.25 ± 0.06	3.10 ± 0.07	2.94 ± 0.05
	1.0	2.15 ± 0.06*	2.12 ± 0.05*	2.10 ± 0.05*	2.00 ± 0.05*
	2.0	2.05 ± 0.05*	2.06 ± 0.05*	2.06 ± 0.06*	2.15 ± 0.05*
Ca (mg/dl)	Control (0.0)	180.45 ± 12.3	190.25 ± 10.2	200.45 ± 11.2	202.45 ± 10.6
	0.5	175.35 ± 10.1	165.25 ± 11.2	180.95 ± 12.3	190.65 ± 11.4
	1.0	165.25 ± 11.2	162.45 ± 12.3	155.25 ± 10.6*	160.25 ± 12.3
	2.0	155.65 ± 13.1*	155.35 ± 09.6*	150.65 ± 08.9*	143.35 ± 11.8*
Mg (mg/dl)	Control (0.0)	38.25 ± 3.12	36.03 ± 2.15	35.32 ± 4.25	36.45 ± 4.56
	0.5	42.45 ± 2.25	35.24 ± 3.25	36.24 ± 5.25	37.54 ± 4.26
	1.0	41.24 ± 5.31	37.45 ± 5.21	37.45 ± 5.23	35.24 ± 5.35
	2.0	40.23 ± 5.51	36.56 ± 3.45	36.45 ± 4.24	3.25 ± 4.45
PALT (IU/l)	Control (0.0)	50.43 ± 3.56	53.25 ± 2.65	47.53 ± 3.21	51.23 ± 3.65
	0.5	55.32 ± 4.21	62.21 ± 3.23	60.23 ± 3.54	63.12 ± 3.68*
	1.0	58.56 ± 3.21	63.21 ± 3.56*	63.21 ± 4.05*	65.32 ± 4.36*
	2.0	62.35 ± 4.03*	65.32 ± 4.12*	67.25 ± 3.87*	70.23 ± 4.06*
PGOT (IU/l)	Control (0.0)	80.25 ± 15.2	85.32 ± 13.5	85.26 ± 12.4	80.65 ± 10.5
	0.5	95.25 ± 13.3	101.25 ± 16.2	108.23 ± 11.2*	111.35 ± 11.3*
	1.0	97.25 ± 16.2*	105.35 ± 14.3*	110.45 ± 10.5*	115.65 ± 10.2*
	2.0	101.25 ± 14.2*	120.25 ± 16.2*	125.35 ± 14.2*	135.12 ± 11.2*
PGPT (IU/l)	Control (0.0)	65.12 ± 5.66	68.22 ± 8.11	68.21 ± 6.84	70.21 ± 7.66
	0.5	75.21 ± 8.55	75.44 ± 6.88	82.23 ± 8.25	80.25 ± 8.25
	1.0	85.25 ± 11.3*	86.25 ± 10.3*	83.25 ± 11.2*	92.25 ± 6.21*
	2.0	99.25 ± 11.2*	92.35 ± 12.1*	109.25 ± 11.1*	114.23 ± 11.3*

*Significant difference with control (P<0.05). Values are mean ± standard error.

blood parameters. Changes in the leukocyte system manifest in the form of leukocytosis with heterophilia and lymphopenia, which are characteristics of leukocyte response in animals exhibiting stress. Al-Kahem (1995) reported reduced WBC count in the fish exposed to chromium and acclaimed it to be a consequence of

significant decline in the number of lymphocytes and thrombocytes. Reduction in the number of lymphocytes count in the fish, *Oreochromis niloticus,* exposed to trichlorfon was attributed to fall in the delivery of these cells to the circulation because of reduced production or alternatively an increased rate of removal from circulation and subsequent rapid destruction of cells. Leukocyte count diminished in tilapia exposed to phosalone (Jaffar and Rani, 2009).

The blood cell indices like mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC) seem to be changes that are more sensitive and can cause reversible changes in the homeostatic system of fish. Fluctuations in these indices correspond with values of RBC count, hemoglobin concentration and packed cell volume. The values of blood cell indices were enhanced in common carp and other freshwater fish after the exposure of acute toxic level of pesticides (Rao, 2010). The elevated level of glucose expressed in the blood of Malathion exposed fish may be due to the mobilization of glycogen into glucose to meet the increased demand for energy. Glucocorticoids and catecholamine hormones are known to produce hyperglycemia in animals and stress stimuli elicit rapid secretion of these hormones from adrenal tissue of the fish (Pickering, 1981). Such elevation may be due to enhanced gluconeogenesis response of stressed fish in their attempt to satisfy their new energy demands (Winkaler et al., 2007).

The hyperglycemic condition in the present study may also be attributed to increased secretion of these hormones which causes glycolysis in the fish exposed to Malathion. The present result agrees with the findings of Abalaka et al. (2011) and Alkahem-Al-Balawi et al. (2011). The pesticide may change the functions of vital organs like liver and kidney, disrupting the homeostatic condition of the body which may alters the concentrations of metals. Similar observations have been reported by Al-Akel et al. (2010) in the carp, *Cyprinus carpio*, after the exposure of dietary copper and support to the present investigation. The reduction in the protein level in the fish exposed to toxicants can be attributed to the cellular destruction or necrosis with subsequent impairment of protein synthesis machineries (Bradbury et al., 1987) or due to pathological alterations in kidney leading to excessive loss of proteins (Salah El-Deen et al., 1996). However, the hypoproteinaemia in the present study may also be ascribed to the aforementioned factors. Omoniyi et al. (2002) and Shalaby (2009) have reported hypo-proteinaemia in the fish exposed to pollutants. In contrast to the present findings, a hyperproteinaemia was reported by Al-Attar (2005), Omitoyin (2007) and Abalaka et al. (2011). They were of the opinion that hyperproteinaemia may be the repercussion of water loss in plasma, elevated *de novo* synthesis or relative changes in blood protein mobilization. They also mentioned that such observed hyperproteinaemia may be indicative of efficient immune response and body physiological reaction to pollutants. An elevated level of ALT activity in fish exposed to malathion and extract of Porkiabiglosa pods was documented by Zaki et al. (2009) and Abalaka et al. (2011), respectively. These authors believe that the increased activity of enzyme in the exposed fish is suggestive of hepatic damages leading to their leakage in circulation (Mousa et al., 2008) and /or increased synthesis of enzyme in liver. Contrary to this, some authors like Okechukwu and Auta (2007) and Hedayati et al. (2010) reported that the ALT activity in the fish exposed to different pollutants was inhibited. This reduction in the enzyme activity was attributed to liver necrosis caused by toxicants and a possible damage to hepaptocytes or low sub-lethal doses of toxicants used to expose the fish. SGPT and SGOT enzymes are sup-posed to be sensitive to any change in the environment. Therefore, the exposure of fish to the pollutants expre-sses elevated level of these enzymes. Jeney et al. (1991) reported an elevated level of these enzymes (SGOT, SGPT) in the serum of fish exposed to ammonia.

Their conception was that SGPT is highly sensitive to alterations in the environmental condition. Similarly, signi-ficantly higher values of glutamate oxaloacetate acid transaminase (GOT) activities were recorded by lemaire et al. (1991) in the fish fed diet without docosahexaenoic acid (DHA). Contrary to this, the activity of GPT did not show any change. They found that hepatic parenchyma develop into generalized massive steatosis, exhibiting necrosis centers with docosahexaenoic acid free diet. Exposure of monocrotophos to *Corydoras punctatus* increased the activity of SGOT and SGPT (Agrahari et al., 2007).

In addition, Palanivelu et al. (2005) suggested that liver is rich in SGOT and SGPT, and damage to it could result in liberation of large quantities of these enzymes into the blood.

Hence, an increase in the activity of these enzymes (PGOT and PGPT) after the pollutants treatment is a sensitive indicator of cellular damage (Palanivelu et al., 2005; Alkahem Al-Balawi et al., 2011). Therefore, higher activities of these enzymes registered in the present investigation may be ascribed to damage caused to liver by malathion.

Conclusion

Malathion seems to be moderately toxic to *C. gariepinus*. The LC_{50} (8.22 mg/L) registered were within the values obtained for other species of fish. The present study enhanced the knowledge of biochemical and haemato-logical alterations in fish due to chronic sub-lethal exposure of Malathion.

The data obtained in the present investigation amply emphasized that malathion had adverse effects on the metabolism of macromolecule and haematopoietic

organs of fish. Therefore, the use of pesticide in the field may be a threat to human, fauna and flora of the environment.

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