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ASSESSMENT OF PROTEIN, GLYCOGEN AND ACTIVITY OF PHOSPHATASES OF *LABEO ROHITA* IN RESPONSE TO PHYSICO-CHEMICAL PARAMETERS OF LAKES OF BANGALORE

BELA ZUTSHI*, NAZIMA NOOR AND G. SREEKALA
Department of Zoology,
Bangalore University, Jnana Bharathi, Bangalore - 56
e-mail:Bela_Zutshi@Yahoo.Co.In

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***Corresponding author**

ABSTRACT
The analysis of physico- chemical parameters of two polluted lakes, Vengaiah lake (lake A) and Yellamallappa Chetty lake (lake B) of Bangalore was conducted with Hebbal fish farm taken as the control site. The effect of outcome of the assessed data was observed on the bio-molecules (proteins and glycogen) and enzyme activity (acid phophatase - ACP and alkaline phophatase - ALP) in the tissues - gill, muscle, liver, kidney and brain of *Labeo rohita*, a freshwater fish reared in the two lakes. A reduction in the levels of proteins and glycogen, and activity of ACP and ALP in the tissues of test fish sampled from lake (B) when compared to those of lake (A) and control was documented. Maximum reduction in percentage of protein content was in the order as; gill > brain > muscle > kidney > liver while glycogen followed the trend as kidney > liver > muscle > gill > brain. Percentage of ACP activity showed decreasing trend in tissues; brain > kidney > liver > gill > muscle but ALP activity showed an equal percentage in brain and liver followed by kidney, gill and muscle. Such alterations indicated stressful condition of the fish due to changes in biochemical constituents, metabolic pathways, dysfunctioning and cellular damage in various tissues to maintain physiological equilibrium which resulted in weakening of fish making it susceptible to diseases and a less nutritive resource. The data was statistically analysed by using graphpad prism

INTRODUCTION

With recent development in industries and sudden population growth, treated and untreated effluents and domestic sewage are constantly being discharged into fresh water bodies (lakes) which change the properties of water and adversely affect the flora and fauna of that particular water ecosystem. Pollutants, trace metals and nutrients discharged through the sewage and industrial effluents into the water bodies brings changes in the physicochemical characteristics of water. This series of changes in the physicochemical characteristics of water, have been the subject of several investigations (Mahananada *et al*., 2010). The water quality parameters like temperature, hardness, pH, dissolved gases (oxygen and CO2), salinity etc., requires to be monitored regularly, individually or synergistically to keep the aquatic habitat favourable for existence of fish (Mondal *et al*., 2010). Among environmental pollutants, metals are of particular concern, due to their potential toxic effect and ability to bioaccumulation in aquatic ecosystems (Miller *et al*., 2002). The presence of toxic metals in environmental matrices is one of the major concerns of pollution control and environmental agencies in most parts of the world (Tay *et al*., 2009) and are widely distributed in the environment with sources mainly from the weathering of minerals and soils (Merian, 1991). Fish, although an indirect target, is an extremely reliable component of an aquatic monitoring system because they integrate the effect of detrimental environmental change as consumers and occupies a relatively high position in the aquatic food chain.

Disturbances in biochemical composition such as proteins, carbohydrates and lipids due to the variation in the water parameters results into changes in the metabolic rate in the tissues of the aquatic organism under pollutant stress. Variation of protein level in fish *Nemacheilus botia* exposed to endosulfan was reported by Dhapte *et al*. (2006) and that of glycogen content in the tissues of freshwater fish, *Catla catla* exposed to the heavy metal toxicant cadmium chloride was also reported by Sobha *et al*. (2007). These changes in the metabolic processes are produced by influencing enzyme system. Gabriel and Akinrotimi (2011) noted that enzymes can be used to assess degree of responses to toxicant exposure and to provide a link between external and internal structure of aquatic organisms. Work on phosphatases has been carried out on different fishes by various scientists like Kågedal *et al*. (2001) & Sreenivasan *et al*. (2011) to know the physiological conditions of the fish. Variation in the metabolic enzyme activities in fish is directly proportional to the concentration of the toxicant (Pesce *et al*., 2009).

In the present study, the tissues selected were – muscle an important tissue of nutritive value; gill which is a vital respiratory organ with their extensive surface area directly in

contact with water and targeted by xenobiotics (Jiang *et al*., 2012); kidney, the excretory and immune organ of fish; liver , one of the vital detoxifying organs and important compartment of heavy metal accumulation (Fallah *et al*., 2011); and brain, a major component of the central nervous system and the main target of the pollutants (Mieiro *et al*., 2011).

The effect of pollutants is one of the emerging areas in toxicological monitoring and remediation programmes. The assessment of physico-chemical parameters of lakes A, B and control site and that of biochemical constituents (protein and glycogen) and enzyme activities (acid and alkaline phophatase) in the muscle, gill, kidney, liver and brain tissue of fresh water fish, *Labeo rohita* reared in these water bodies for commercial purposes were investigated. The research was aimed to assess disturbances in the metabolism of aquatic organisms and the results were statistical correlated.

MATERIAL AND METHODS

The two fresh water lakes, Vengaiah lake (Lake A - used for recreation purpose) and Yellamallappa Chetty lake (lake B - receives sewage and industrial pollutants) were selected for the present study. Hebbal fish farm was opted as control site. Water was sampled in water sampling bottles from each lake in the morning at about 07.00 to 07.30 am at an interval of once every fortnight for a period of one year for its qualitative and quantitative analysis. The various physico-chemical parameters like temperature, pH, BOD, COD, DO, TDS, conductivity, acidity, alkalinity, phosphates, sulphates, nitrates and trace metals such as mercury, lead, aluminium, cadmium, etc were determined by following standard methods by APHA *et al*. (2005) and atomic absorption spectrophotometry (USEPA, 1983).

Test fish, *Labeo rohita* were sampled at the same time as water sampling time period from control site, lake A and lake B. The fish was anaesthetized using MS222 and dissected, the tissues such as muscle, gill, kidney, liver and brain were carefully excised and transferred to a suitable medium for analysing the enzymatic activities. Proteins by Lowry's method (Lowry *et al*., 1951) and glycogen content by Anthrone reagent (Seifer *et al*., 1950) and ACP & ALP Activity were determined by using Spectrophotometric stop rate determination method (Bergmeyer *et al*., 1974). Each assay was replicated six times and the values expressed as mean ± SD. Data was analysed statistically by ANOVA followed by Tukey's test.

RESULTS AND DISCUSSION

Physico chemical parameters of water samples from control, lake A and lake B were statistically analyzed. The data represented in table 1 showed significant mean differences at $p < 0.001$ and 0.01 among control and lake A and those of lake B. All water parameters of control site were compared with lake A and lake B and inturn with the standard BIS: 10500-1991(Revised 2012).The data revealed high level of pollution in lake B when compared to lake A, control site and BIS standard due to high levels of temperature, total suspended solids, chemical oxygen demand, biological oxygen demand, conductivity, turbidity and alkalinity. The presence of an industry on its bank, agricultural runoff, idol immersion during festival season and discharge of domestic sewage and solid waste through various sources into the water body denotes the quality of water and the concentration of its physico-chemical parameters. Trace metals' content such as, aluminium, cadmium, copper, iron, lead and mercury recorded also showed relatively high concentration in water samples of

Table 1: Physico-chemical parameters of Hebbal fish farm (Control site), Vengaiah lake (A) and Yellamallappa Chetty lake (B)

Sl.no	Parameters	Standards BIS: 10500-1991(Revised 2012)	Control site (farm)	Lake A	Lake B
1.	Temperature (C°)	22-28	26 ± 0.63	26 ± 0.63	28 ± 1.26
2.	pH Value	06.50 - 08.50	7.87 ± 0.08	7.65 ± 0.16	6.85 ± 0.74
3.	Color (Pt-Co scale)	5 - 25	3.1 ± 0.63	4.3 ± 0.63	6.1 ± 0.49
4.	Odor	UOB	UOB	UOB	Fishy
5.	Turbidity, NTU	05 - 20	7.8 ± 0.15	21 ± 0.89	34.2 ± 2.14[b]
6.	Conductivity µmho /cm	300	483 ± 9.54	837 ± 42.80[a]	1207 ± 35.15[a]
7.	Total Alkalinity as $CaCO_3$, mg/l	200 - 600	202 ± 1.38	290 ± 1.60[a]	544 ± 11.07[a]
8.	Total Dissolved solids, mg/l	500 - 2000	420 ± 7.69	750 ± 1.41[a]	985 ± 2.93[a]
9.	Total Suspended solids, mg/l	100	92 ± 0.82	150 ± 0.82[a]	260 ± 4.73[a]
10.	D.O, mg/l	4.0 - 6.0	3.7 ± 0.05	3.7 ± 0.05	1.2 ± 0.08
11.	B.O.D, mg/l	2 - 6	6 ± 0.76	24 ± 1.21	113 ± 1.33[a]
12.	C.O.D, mg/l	200	76 ± 1.72	126 ± 2.25[a]	374.7 ± 2.88[a]
13.	Total Phosphorus, mg/l	-	0.35 ± 0.01	1.02 ± 0.01	2.42 ± 0.01
14.	Nitrates as NO_3,mg/l	45 - 100	2.13 ± 0.28	2.25 ± 0.20	3.87 ± 0.10
15.	Sulphates as SO_4, mg/l	200 - 400	62 ± 0.52	103 ± 1.21[a]	210 ± 0.52[a]
16.	Aluminium as mg/l	0.03- 0.2	0	0.067 ± 0.002	3.7 ± 0.089
17.	Arsenic as mg/l	0.05	0	0	0.003 ± 0.001
18.	Cadmium as mg/l	0.01	0.001	0.04 ± 0.01	0.124
19.	Copper as mg/l	0.05 – 1.5	0.013	0.03	0.32 ± 0.01
20.	Iron as mg/l	0.3 - 1	0.04 ± 0.008	0.13 ± 0.022	3.68 ± 0.004
21.	Lead mg/l	0.05	0.004 ± 0.001	0.04 ± 0.012	0.37 ± 0.020
22.	Zinc as mg/l	5 - 15	0.54 ± 0.02	1.88 ± 0.01	2.68 ± 0.01
23.	Mercury, mg/l	0.001	0	0	0.028

UOB - Unobjectionable, 0 - Below Detectable Limits; The superscripts a and b indicate statistical mean differences at $p < 0.001$ and 0.01 respectively.

Table 2: Correlation of water parameters with protein and glycogen of fish from lake B.

Sl. No.	Water parameters (Lake B)	Protein					Glycogen				
		Muscle	Gill	Kidney	Liver	Brain	Muscle	Gill	Kidney	Liver	Brain
1	Alkalinity	+[a]	-[a]	-[a]	-[a]	-[a]	-[a]	+[a]	-[a]	+[a]	-[a]
2	Conductivity	+[a]	+[a]	+[a]	-[a]	+[a]	-[a]	-[a]	-[a]	-[a]	-[a]
3	TDS	-[a]	+[a]	+[a]	-[a]	-[a]	-[a]	+[a]	+[a]	-[a]	-[a]
4	TSS	+[a]	-[a]	-[a]	-[a]	-[a]	+[a]	+[a]	-[a]	-[a]	+[a]
5	Nitrates	+[c]	+	+[a]	+[a]	+	-	-	-	+	+
6	Sulphates	+[a]	-[a]	+	+[a]	-[a]	-[a]	-[a]	-[a]	-[a]	+
7	BOD	-[a]	+[a]	+[a]	+[a]	+[a]	-[a]	+[a]	-[a]	+[a]	-[a]
8	COD	-[a]	+[a]	-[a]	-[a]	-[a]	+[a]	+[a]	-[a]	+[a]	-
9	Aluminium	-[c]	+	+[a]	+[a]	-	+	-	+	+	-
10	Arsenic	+[a]	-	+[a]	+[a]	-	-	-	-	-	+
11	Cadmium	-[a]	+	-[a]	-[a]	-	+	+	+	-	-
12	Copper	-[a]	+	+[a]	-[a]	-	-	+	+	+	-
13	Iron	+[c]	-	+[a]	+[a]	-	-	-	-	-	+
14	Lead	+[a]	-	-[a]	-[a]	-	-	-	-	-	+
15	Zinc	-[b]	+	-[a]	+[a]	-	+	+	+	-	-

All parameters are expressed in mg/l except conductivity which is expressed in µmho /cm and tissue parameters are expressed in mg/g wet weight of tissues. The superscripts a, b and c indicate statistical significant mean differences at $p < 0.001$, 0.01 and 0.05 respectively. '+' '-'and 'o' implies positive, negative and no correlation respectively.

Table 3: Correlation of water parameters with ACP and ALP activities of fish from lake B.

Sl. No.	Water parameters (Lake B)	ACP activity					ALP activity				
		Muscle	Gill	Kidney	Liver	Brain	Muscle	Gill	Kidney	Liver	Brain
1	Alkalinity	+[a]	+[a]	-[a]	-[a]	+[a]	+[a]	-[a]	-[a]	+[a]	+[a]
2	Conductivity	-[a]	+[a]	+[a]	+[a]	-[a]	-[a]	-[a]	-[a]	-[a]	-[a]
3	TDS	-[a]	+[a]	+[a]	+[a]	-[a]	-[a]	+[a]	-[a]	+[a]	+[a]
4	TSS	+[a]	+[a]	-[a]	-[a]	+[a]	+[a]	-[a]	+[a]	-[a]	-[a]
5	Nitrates	-	-	+	-	-	-[c]	-	-[c]	-[b]	-
6	Sulphates	-[a]	-[a]	+	-[a]	+[a]	+[a]	+	+[a]	-[a]	o
7	BOD	+[a]	+	-[a]	+[a]	-[a]	-[a]	-[a]	-[a]	+[a]	-[a]
8	COD	-[a]	+	+	+[a]	-[a]	-[a]	+[a]	-[a]	+[a]	o
9	Aluminium	-	+	+	+	-	-[c]	+	-[c]	+[a]	-
10	Arsenic	-	-	+	-	+	+[a]	-[b]	+[a]	-[a]	-
11	Cadmium	-	+	+	+	-	-[a]	+[c]	-[a]	+[a]	+
12	Copper	-	+	+	+	-	-[a]	-[b]	-[a]	+[a]	-
13	Iron	+	-	+	-	+	-[c]	-	+[c]	-[a]	-
14	Lead	-	-	-	-	+	+[a]	-[b]	+[a]	-[a]	+
15	Zinc	-	+	+	+	-	-[b]	+	-[b]	+[a]	0

All parameters are expressed in mg/l except conductivity which is expressed in µmho /cm and tissue parameters are expressed in μ moles PNP/mg of protein/30min wet weight of tissue. The superscripts a, b and c indicate statistical; significant mean differences at $p < 0.001$, 0.01 and 0.05 respectively. '+' '-'and 'o' implies positive, negative and no correlation respectively.

lake B when compared to BIS values and lake A. Heavy metal contamination may have devastating effects on the ecological balance of the recipient environment and on the diversity of aquatic organisms (Farombi *et al*., 2007). High conductivity and low dissolved oxygen usually associated with heavy metals and industrial effluents altered the activity of hydrolytic enzymes like esterases and phosphates of the fish exposed to them (Ambrose *et al*., 1994). The negative effects of these pollutants are detrimental to the aquatic inhabitants, including fishes (Olaifa *et al*., 2004).

A significant reduction in protein content viz., 23.67%, 26.08%, 26.57%, 39.16% and 27.74% was recorded in the liver, kidney, muscle, gill and brain respectively in the fish collected from lake (B) when compared to those of control (Fig. 1 & 2). Statistical correlation of water parameters and protein content of these tissues was carried out and expressed in table 2. But protein content in fish sampled from Lake A did not show much variation when compared to those of control. Depletion in protein level in the exposed fish could be either due to arrested metabolism or owing to its utilisation to build up new cells or enzymes in order to combat the stress (Sakar and Al lail, 2005). The rapid depletion in total protein content due to active degradation of proteins is dependent on the development of resistance towards the pollutant stress. Thus decrease of total protein might be attributed to the destruction or necrosis of cells and consequent impairment in protein synthetic machinery (David *et al*., 2004). De Smet and Blust (2001) also supported this observation by stating that exposure to cadmium caused an increase in the role of proteins for the energy production to combat stress and also due to excessive proteolysis to overcome the metabolic stress, as deposited protein in the cytoplasm may be used to replace the loss of proteins during physiological stress (Patil *et al*., 2011). In the present study, the variation of protein distribution might be due to gluconeogenesis in which protein is metabolised to yield glucose, which is utilised for energy synthesis in the form of ATP during stress conditions (Ghosh and Chaterjee, 1985) or reduction in the alkaline phosphatase activity since it plays an important role in protein synthesis (Pilo *et al*., 1972) suggesting a disturbance in its metabolic calibers and a

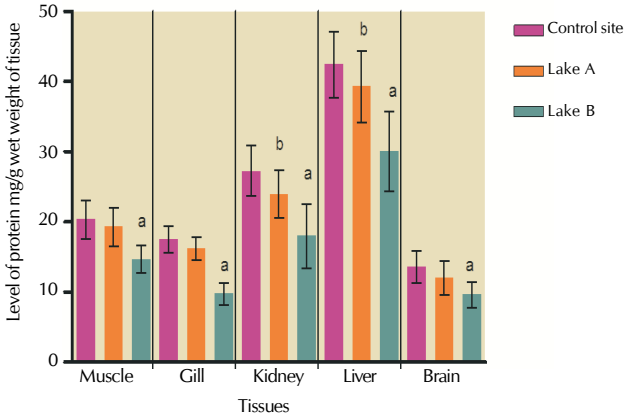

Figure 1: Levels of proetein in five different tissues of *L. rohita* sampled from Hebbal fish farm(control), Vengaiah lake (lake A) and Yellamallappa Chetty lake (lake B)

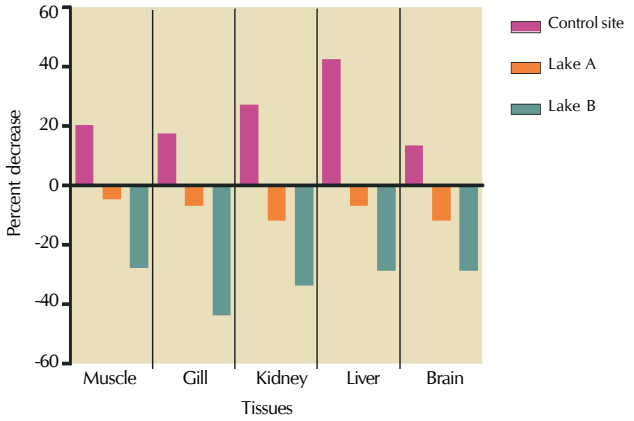

Figure 2: Percent decrease in levels of protein in five different tissues of *L. rohita* sampled from Hebbal fish farm(control), Vengaiah lake (lake A) and Yellamallappa Chetty lake (lake B)

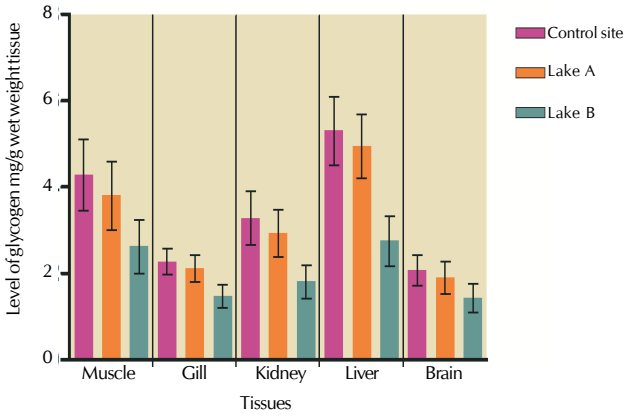

Figure 3: Levels of glycogen in five different tissues of *L. rohita* sampled from Hebbal fish farm(control), Vengaiah lake (lake A) and Yellamallappa Chetty lake (lake B)

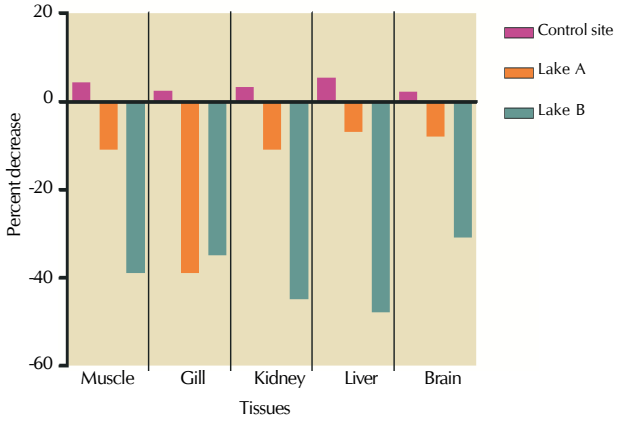

Figure 4: Percent decrease in lives glycogen in five different tissues of *L. rohita* sampled from Hebbal fish farm(control), Vengaiah lake (lake A) and Yellamallappa Chetty lake (lake B)

physiological strategy adopted by the animal to adjust itself for resistance towards the pollutant stress caused by environmental change.

Glycogen content in the fish sampled from lake B showed significantly less glycogen percentage (Fig. 3 & 4) when compared to those of control ones in the order as kidney > liver > muscle > gill > brain. An insignificant reduction of glycogen was recorded in tissues from the fish of lake A. Statistical correlation of water parameters and glycogen content of these tissues was carried out and expressed in table 2. According to Cicik and Engin (2005), cadmium stress caused alteration in the glycogen content through glycolysis or hexose monophosphate pathway in muscle and liver tissue of *Cyprinous carpio* and similar results were reported by Kori-Siakpere *et al*. (2007) in pesticide 'Paraquat' exposed African Catfish. These results are in agreement with the present work on tissues of *Labeo rohita* from lake B which was contaminated with significantly high level of trace metals (Al, Cd, Fe, Pb, Zn & traces of Hg). This depletion in glycogen content may be due to rapid glycogenolysis and inhibition of glycogenesis through activation of glycogen phosphorylase and depression of transferase (Jha and Jha,1995 (b) and also partly due to its utilization in the formation of glycoprotein and glycolipids, which are the essential constituents of various cells and other membranes (Vutukuru, 2005).

Phosphatases are mainly localized at cell membrane. The activity of ACP and ALP in these tissues of fish showed a positive correlation with each other regardless of the three water bodies. A marked decrease in the activity of phosphatases in these tissues was recorded from lake B when compared to lake A and control ones making them a stress marker as also stated by (Gabriel *et al*., 2012). A maximum decrease in activity of ACP (Fig. 5 and 6) was shown by brain tissue (26%) when compared to other tissues {kidney (20%), liver (15%), gill (11%) & muscle (10%)} in lake B due to the significant negative correlation with COD and positive correlation with sulphate content (Table 3). Activity of ACP in gill tissue showed negative correlation with nearly all water parameters excepting those of BOD and COD level. A decline in the ACP activity indicated disturbance in structure of cell organelles and lysosomal disruption which would release hydrolytic enzyme into cytoplasm leading to auto degradation of cellular proteins

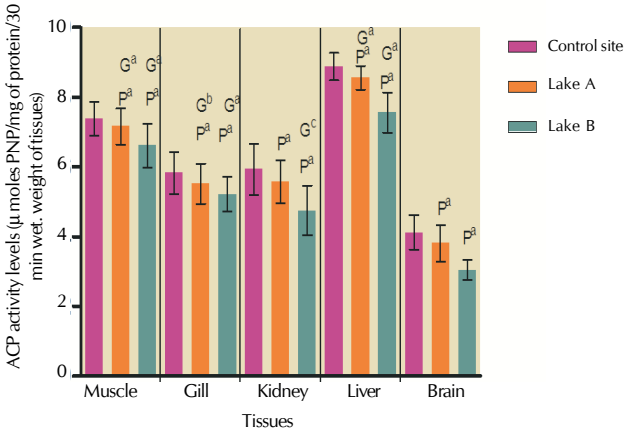

Figure 5: Levels of ACP activity in five different tissues of *L. rohita* sampled from Hebbal fish farm (control), Vengaiah lake (lake A) and Yellamallappa Chetty lake (lake B)

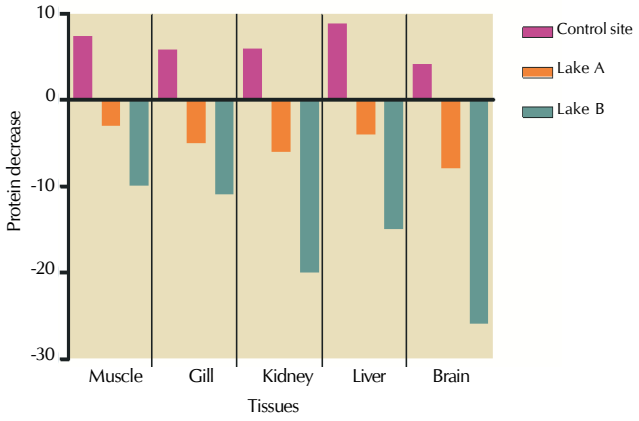

Figure 6: Percent decrease in acitivity levels of ACP in five different tissues of *L. rohita* sampled from Hebbal fish farm(control), Vengaiah lake (lake A) and Yellamallappa Chetty lake (lake B)

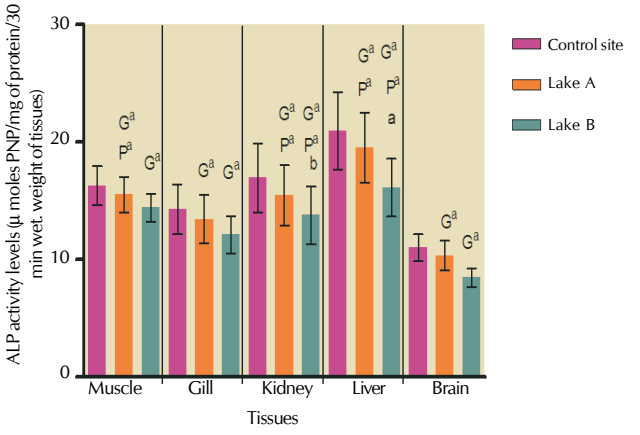

Figure 7: Levels of ALP activity in five different tissues of *L. rohita* sampled from Hebbal fish farm(control), Vengaiah lake (lake A) and Yellamallappa Chetty lake (lake B)

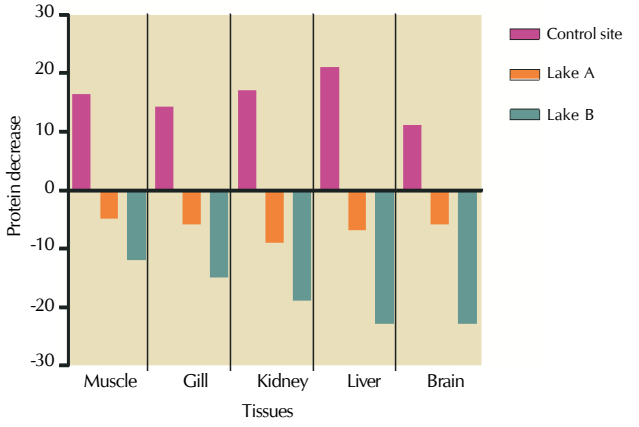

Figure 8: Percent decrease in activity levels of ALP in five different tissues of *L. rohita* sampled from Hebbal fish farm (control), Vengaiah lake (lake A) and Yellamallappa Chetty lake (lake B)

Note: The superscripts a,b and c indicate statistical sinificant mean differences at P< 0.001, 0.01 and 0.05 resectively. P and G reperecent protein and glycogen

and cell damage (Palanisamy *et al*., 2012). ACP could sequester trace metals in lysosomes of eukaryotic cells which inturn could alter the structure, permeability and integrity of lysosomal membranes resulting in enzyme diffusion into cytosol (Hedayati *et al*., 2010). Trace metals along with other chemicals present in the lake caused inhibition in the activity of various enzymes (ACP & ALP) due to distortion in the cell organelles, increased permeability of plasma membrane or cell necrosis thus disturbing the physiological state of the fish (Akanji *et al*., 2008). Mathur and Gupta (2008) reported that toxic chemicals affect the permeability of cell membranes, disturbing energy metabolism and cell functions by releasing hydrolases due to increased fragility of lysosomal membranes.

ALP activity showed a significant decreased in muscle (12%), gill (15%), kidney (19%), liver (23%) and brain (23%) and was negatively correlated with various water parameters (Fig. 7 & 8; Table 3) in the present study. Such decline in ALP activity hindered transportation of molecules and substances across their cell membrane due to the disturbances of membrane transport system suggesting leakage of enzyme across the damaged plasma membrane into extracellular fluid or organ dysfunction (Sunmonu *et al*., 2009). Biosynthesis shift and energy metabolism pathway of the exposed organism might be the cause of reduction in ALP activity (Ovuru and Mgbere, 2000). Yakubu *et al*. (2002) reported that decreased ALP activity is due to reduction in concentration or total absence of specific phospholipids required by this membrane- bound enzyme to express its full activity. This enzyme is intimately associated with protein synthesis or proteolysis (Yadav, 2001). According to Ramalingam and Vimaladevi (2002) reduction in ALP activity affected the metabolic processes such as the synthesis of nuclear proteins, nucleic acids, phospholipids, etc while enhancement of enzyme can be observed as a signal of tissue damage (Atli and Canli, 2007). Similar results of ACP and ALP activity was reported by (Humtsoe *et al*., 2007) in liver and muscle of *Labeo rohita* exposed to arsenic and by Shoba Rani *et al*. (2001) in liver, brain, muscle and gill of tilapia subjected to arsenic toxicity.

Protein, glycogen and phosphatases showed a strong positive correlation with each other showing their interdependence and level of stress. Brain gets affected due to continuous exposure of fish to the pollutants such as trace metals in lake B over a period of time. This in turn caused an increased inhibition of the enzyme activity as also reported by Ansari and Ansari (2012) in the fish exposed to pesticide Alphamethrin; neurodegenerative damage due to passage of pollutants through the fish blood-brain barrier into the brain tissue reported by Berntssen *et al*. (2003). Significant reduction of biomomecules, ACP and ALP activities in kidney which is an excretory and immune organ of fish, sampled from lake B suggested sensitivity of both enzymes related to bioaccumulation of trace metals (Palaniappan and Karthikeyan, 2009). Marr *et al*. (1995) pointed out that a metal- binding protein, the metallothionein (MT), could be induced by heavy metals in liver, and there existed a positive correlation between MT and heavy metals. MT in liver can attenuate cytotoxicity induced by heavy metals by sequestering these metals and reducing their intracellular concentration. In the present study, decreased protein, glycogen, ACP and ALP activities in liver of fish suggested high toxicant concentration in liver was beyond the regulation capacity of MT which inturn caused a reduction in the detoxification capacity of liver eventually leading to the liver damage. Gills are direct target of pollutants and toxicants in the external medium and hence more sensitive to their bio-accumulation leading to decline in biomolecules and reduction in the activities of ACP and ALP (Jiang *et al*., 2012). In muscle tissue protein, glycogen, ACP and ALP activities showed a decline which might be associated with less bioaccumulation as suggested by Jiang *et al*. (2012) as contractile proteins a major component of muscles have a high affinity for calcium and low affinity for heavy metals (Palaniappan and Karthikeyan, 2009). The variation in these components within the tissues might be because of their different physiological roles in the body of an organism.

The present study showed alteration in the physiological condition and metabolic activities of test fish, *Labeo. rohita* sampled from lake B when compared to those observed in lake A and control site. This can be attributed to the exposure of fish to the significant variation in levels of physico-chemical parameters including trace metals which act as mutagenic/ genotoxic compounds, interfering with xenbiotic metabolic pathways affecting glycolysis, the Krebs cycle, oxidative phosphorylation, protein and amino acid metabolism as well as carbohydrate and lipid metabolism. Fish flesh provides an excellent source of nutrition for human diet and it has relatively high digestibility, biological and growth promoting value but the nutritive value of the fish in question has reduced due to its exposure to various pollutants and is assumed to be unhealthy for human consumption. Therefore, management, conservation and periodic monitoring of these lakes are suggested for the survival of its flora and fauna.

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