Heapto-Somatic Index, Gonado-Somatic Index and Condition Factor of Anabas testudineus as Bio-Monitoring Tools of Nickel and Chromium Toxicity

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Abstract- The effect of sub-lethal concentration of 10-30 mg/L of nickel chloride and 7.5-37.5 mg/L of chromium chloride on hepato-somatic index (HSI), gonado-somatic index (GSI) and condition factor (CF) of Anabas testudineus (body weight: 16 2g; total length: 9 cm) was studied. Exposure of fish to nickel chloride and chromium chloride registered marked reduction in HSI ($p<0.01$), GSI ($p>0.05$) and CF ($p<0.01$) in exposed group in comparison to control one. The reduced values of above parameters found directly proportional to the metal concentration and duration of the exposure. Chromium exposure exhibited the lowest values compared to nickel exposure, indicating more toxic than nickel for fish physiology. The results may be used for selective breeding programme, sustainable fishery management and conservation of Anabas testudineus in its natural habitat.
Keywords- Growth Indices, Anabas testudineus, Metal toxicity

I. INTRODUCTION

The advances in eco-toxicology had provided a number of biomarkers, which can be used to estimate either exposure to chemicals or effects of resultant [1]. The integrated use of biomarkers and bio-indicators is an evaluation tool, since they are effective means to determine the impact of pollution in the aquatic environment [2].

The hepato-somatic index (HIS) is a bio-indicator of contaminant exposure and used in fisheries science as an indicator of energy reserves in the liver [3]. HSI is the ratio of weight of liver and body weight. Gonado-somatic index (GSI) is also a bio-indicator that supplies structural information to respect of health, reproduction of fish, breeding period of fish and maturation status of gonads [4]. GSI is the ratio of weight of gonads and body weight [5]. HSI is related with GSI because of vitelogenesis. Vitelogenesis can increase HSI and GSI [6]. Moreover, the condition factor (CF) is a quantitative and integrative bio-indicator, reflecting physiological state of fish, food availability conditions [7]. CF is sensible to stress in natural environment [8].

Production of gametes in fishes is greatly influenced by the environmental changes. Water pollution is the biggest contributor to this change. Organic and inorganic pollutants contaminate aquatic environments. Organic pollutants contaminating water include DDT, biocides, detergents and household wastes. While inorganic pollutants are nickel, chromium, cadmium, lead, mercury etc. The metallic pollution in a water body can be detected by using a fish as a bio-indicator by determining its HSI, GSI, CF etc.

Therefore, the present study was devised to determine the HSI, GSI and CF of a commercially important fish, Anabas testudineus of Arrah region to assess the impact of nickel and chromium pollution.

The information on selected biomarker individually is limited, due to incorrect interpretation. Therefore, the use of a set biomarkers and bio-indicators should be used to better assess environmental condition.

II. MATERIALS AND METHODS

The samples of climbing perch, (Anabas testudineus, Bloch) (body weight: 16 2g; total length: 9 cm) were taken from the local markets of Arrah. The samples were examined in the laboratory immediately after collection. Total length (cm) of fishes was measured by using fish measuring band whereas total weight (g) was recorded with the help of electronic balance. The sex of each specimen was identified by visual examination and confirmed after dissection and examination of the gonads following standard protocol.

The toxicity test of the $NiCl_2$ and $CrCl_3$ (AR grade) was conducted by employing the static bioassay method as recommended by standard method [9].

First of all, experiment was set up to determine the 96h-LC_{50} dose of $NiCl_2$ and $CrCl_3$. Then the fishes were exposed to selected sub lethal concentrations of $NiCl_2$ and $CrCl_3$ for the period of 30 days. The control and experimental fishes were dissected at the end of 30 days of exposure to take their individual weight and weight of their liver and ovaries to compute their hepato-somatic index, gonado-somatic index and condition factor by applying respective formula.

(1) Hepato-somatic index (HSI): To calculate HSI, the weight of liver of fish sample was measured and divided its body weight.

HSI = Weight of liver of fish/Body weight of fish x 100

(2) Gonado-somatic index (GSI): To calculate GSI, the weight of gonad of fish sample was measured and divided its body weight.

GSI = Weight of gonad of fish/Body weight of fish x 100

(3) Condition factor (CF): It is the proportion of the weight related to length, being an indirect measure of the fish energy reserves.

CF = Body weight of fish/Standard length of fish3 x 100

Statistical Analysis: Statistical software Graphpad Prism 5 was used in this work. Results were presented as mean with standard deviation. Independent and dependent t-test was applied to determine the significance of differences in HSI, GSI and CF on the fish of the control and treatment group.

III. RESULTS AND DISCUSSION

The values of hepato-somatic index (HSI) to nickel chloride/chromium chloride exposure in comparison to controlled one are in the decreasing order. The decrease was significant ($p<0.01$) under intoxication of either nickel chloride/chromium chloride in comparison to control fish (Table 1). There was very high correlation ($p<0.001$) between dose of toxicant and hepato-somatic index (Table 2).

Studies also evaluating the relative size of liver of fishes from contaminated sites express size of liver as a percentage of total body weight [10]. A significant decrease has been reported in HSI of Heteropneustes fossilis when exposed to malathion [11]. HSI also significantly decreased when exposed to organic pollutants exposure such as PAHs [12]. This decrease was likely caused by the influence of the food limitations and the stress factors. Reduced values of HSI of Heteropneustes fossilis in comparison to control to metal concentration and duration of the exposure has also been reported [13]. It is also shown that the HSI values decreased in lead and cadmium treated Cyprinus carpio and Perca fluviatilis [14]. Our results are in accordance with these findings. However, a significant increase in the HSI in the PLB-treated Salmo trutta has been reported [15]. Therefore, it seems that the decrease/increase in the HSI depends on the nature of toxicant and physiological setup of fish.

The HSI of intoxicated Anabas testudineus was lower than the control group. This suggested that Ni/Cr exposure resulted in decreased HSI. It may occur when the water polluted by metals, then these metals were absorbed through the epithelial membrane of gills, carried to the liver, resulting in the accumulation of metals in the liver disrupting the metabolism and causing the fish liver became low so that the value of HSI decreased [16, 17].

It is suggested that HSI is a biomarker that indicated the status of feeding and metabolism. The liver size indicated the high of metabolic activity while the small size of the liver could be caused by lack of food [18, 19].

The values of gonado-somatic index (GSI) to nickel/chromium exposure in comparison to controlled one are in the decreasing order. The decrease was insignificant ($p>0.05$) under intoxication of either nickel/chromium in comparison to control fish (Table 1). There was also a very high correlation ($p<0.001$) between dose of toxicant and gonado-somatic index (Table 2).

A marked decrease in GSI of Heteropneustes fossilis is reported when exposed to malathion [11]. Reduced values of GSI of Heteropneustes fossilis in comparison to control have been observed [13]. It is also shown that the GSI values decreased in lead and cadmium intoxicated Cyprinus carpio and Perca fluviatilis in comparison to their controlled specimens [14]. Thus, the results are in accordance with these findings.

The GSI of treated Anabas testudineus was lower than the control group. This showed that the metal exposure affected GSI. It might be occurred when the metals contaminated aquatic environment, then it would be absorbed by epithelial membrane, especially the gills and then brought to some organs such as liver, gonad, kidney, muscles and skin by blood. This would cause the metals accumulation in these organs. The metal accumulation in the gonad would cause damage of the gonad tissue. Thus, gonad would degenerate, the low GSI and affected the reproductive ability cause decrease of fertility [18, 19].

There is evidence that the majority of species undergo reproductive cycle and variation in the size of gonads is observed [10, 20]. Consequently, calculating the weight of gonad as a percentage of the body weight has been used for determining the reproductive maturity as well as responses to environmental dynamics.

The condition factor (CF) shows the well-being of the population during various life cycle stages and assessments of fish condition based on weight at a given length. The values of condition factor (CF) to $NiCl_2/CrCl_3$ exposure in comparison to controlled one are in the decreasing order. The decrease was significant ($p<0.01$) in $NiCl_2/CrCl_3$

intoxicated fish in comparison to control fish (Table 1). There was high correlation ($p<0.01$) between dose of toxicant and condition factor (Table 2).
A marked decrease has also been reported in CF of Heteropneustes fossilis when exposed to malathion [11]. Our results are in accordance with this finding.
The CF may also vary in either direction outside the normal range in response to chemical exposure. CF varies directly with nutrients availability [21]. There is also some argument that CF can increase in polluted and rich organic matter areas due to increased feeding sources used by tolerant species that take advantage of this resources [22].
Further, in both exposed group, chromium exposure exhibited the lowest values compared to nickel exposure, indicating more toxic than nickel for fish physiology. The statement is also supported by the statistical analysis (Table 1). However, the magnitude of difference as observed in hepato-somatic index, gonado-somatic index and condition factor was calculated insignificant ($p>0.05$) for nickel versus chromium.

Table-1 Effect of nickel chloride and chromium chloride (mg/L) on hepato-somatic Index (HSI), gonado-somatic Index (GSI) and condition factor (CF) of Anabas testudineus

Dose of toxicant (mg/L)		Hepato-somatic index (HSI)		Gonado-somatic index (GSI)		Condition factor (CF)	
NiCl2	CrCl3	NiCl2	CrCl3	NiCl2	CrCl3	NiCl2	CrCl3
Control	Control	2.04±0.13	2.04±0.13	3.24±0.43	3.24±0.43	1.09±0.08	1.09±0.08
10	7.5	1.75±0.15 (-14.26%)	1.69±0.09 (-17.16%)	3.20±0.63 (-01.54%)	3.14±0.22 (-03.38%)	1.08±0.06 (-00.92%)	1.06±0.09 (-03.03%)
15	15.0	1.71±0.28 (-16.13%)	1.64±0.19 (-19.61%)	3.02±0.39 (-06.92%)	2.89±0.09 (-11.08%)	1.06±0.05 (-02.75%)	1.05±0.07 (-04.13%)
20	22.5	1.65±0.10 (-19.12%)	1.60±0.22 (-21.57%)	2.84±0.30 (-12.62%)	2.56±0.37 (-21.23%)	0.98±0.07 (-10.09%)	0.95±0.10 (-12.84%)
25	30.0	1.63±0.13 (-20.09%)	1.54±0.07 (-24.51%)	2.63±0.32 (-19.08%)	2.35±0.51 (-27.69%)	0.86±0.06 (-21.10%)	0.81±0.09 (-25.69%)
30	37.5	1.59±0.09 (-22.06%)	1.51±0.18 (-25.49%)	2.15±0.19 (-33.85%)	1.83±0.07 (-43.69%)	0.73±0.07 (-33.03%)	0.69±0.07 (-35.78%)
t at df = 4		6.14 (p<0.01)	6.24 (p<0.01)	1.17 (p>0.05)	1.36 (p>0.05)	6.94 (p<0.01)	7.42 (p<0.01)
t for Ni vs Cr at df = 8		0.481 (p>0.05)		0.480 (p>0.05)		0.932 (p>0.05)	

Figures in parentheses indicate percent decrease in hepato-somatic Index, gonado-somatic Index and condition factor in comparison to controlled condition.

Table-2 Correlation Coefficient and Regression Equation of hepato-somatic Index (HSI), gonado-somatic Index (GSI) and condition factor (CF) of Anabas testudineus.

Parameters	Vs nickel chloride		Vs chromium chloride	
	Correlation coefficient	Regression equation	Correlation coefficient	Regression equation
Hepato-somatic index (HSI)	-0.987 (p<0.001)	y=1.824-0.008x	-0.996 (p<0.001)	y=1.732-0.006x
Gonado-somatic index (GSI)	-0.972 (p<0.001)	y=3.765-0.05x	-0.988 (p<0.001)	y=3.502-0.042x
Condition factor (CF)	-0.966 (p<0.01)	y=1.303-0.0181x	-0.969 (p<0.01)	y=1.200-0.0128x

IV. SUMMARY AND CONCLUSION

The hepato-somatic index (HSI), gonado-somatic index (GSI) and condition factor (CF) decreased in nickel chloride and chromium chloride exposed Anabas testudineus.
HSI of 2.041±0.129 during controlled condition decreased up to 1.588±0.087 (-22.06%) in a concentration of 30mg/L of nickel chloride and 1.515±0.186 (-25.49%) in 37.5mg/L of chromium chloride in this experiment. There was a significant difference ($p<0.01$) in HSI of control and treatment group.

Gonado-Somatic-Index (GSI) of 3.245±0.428 in control fish decreased up to 2.154±0.186 (-33.85%) in a concentration of 30mg/L of nickel chloride and 1.832±0.069 (-43.69%) in 37.5mg/L of chromium chloride. There was an insignificant difference ($p>0.05$) in GSI of control and treated fish.

Similarly, Condition Factor (CF) of 1.094±0.083 of controlled Anabas testudineus decreased up to 0.725±0.069 (-33.03%) in a concentration of 30mg/L of nickel chloride and 0.694±0.068 (-35.78%) in 37.5mg/L of chromium chloride in this experiment. There was a significant difference ($p<0.01$) in CF of control and intoxicated fish.

These results are novel information on this subject for a native fish species and could be useful for future comparisons with data of fishes belonging to other environments. The outcome is helpful for selective breeding programme, conservation and sustainable fishery management of this commercially important fish.

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