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Full Length Research Paper

Evaluation of metal contents in female *Oreochromis niloticus* with emphasis on potential risk of consumption and relation to some biological aspects

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The Cadmium (Cd), Copper (Cu), Magnesium (Mg), Manganese (Mn) and Zinc (Zn) levels were studied to estimate the risk of human consumption and pollution of Indus River which is important for the country. The fish samples were collected from different locations in the river Indus near Ghazi Ghat area, Pakistan and were analyzed using atomic absorption spectrophotometer (AAS). The values obtained for the five metals were in accordance with the threshold limit concentrations for fish meat imposed by European and other international normative. Cadmium was not detected in any of the sample. Regressions were performed for both size and condition factor with metal concentrations. Mg and Zn were found highly correlated with size (length and weight). Mn was found significant and Cu was the least significant with total length while these were insignificant with increasing weight. Condition factor showed significant ($P < 0.05$) relation with Mn concentration only.

Key words: Metals, Indus River, *Oreochromis niloticus*, atomic absorption, body size, condition factor.

INTRODUCTION

Heavy metal comprises a number of elements which are necessary for living organisms: that is, iron, zinc, copper, manganese, chromium etc. (Mazvila, 2001), but these metals are also the most important forms of pollution (Chovanec et al., 2003; Popek et al*.,* 2008). Heavy metal effects freshwater organisms and induces certain harmful modifications at histological and morphological levels, also decreases the growth and developmental rates resulting in increase of death rate and the decrease of birth rate (Authman, 2008). Their potential toxic effects are given by the presence in water solution at concentrations exceeding certain threshold levels and their long persistence in the aquatic ecosystems and their bioaccumulation and biomagnification in the food webs.

Metal accumulation in fish tissues poses a direct threat for human organism (Papagiannis et al., 2004). Heavy metals having penetrated into human organism through food chains might cause various disturbances or serious diseases (Idzelis et al*.,* 2007). Therefore investigation of the trace metals in fish became important to estimate freshwater pollution and the risk potential of human consumption (Dural et al., 2007).

Fish were the chosen for this survey due their potential of accumulating heavy metals in their tissues, and for being usually the most frequent used taxa in the estimation of pollution with heavy metals (Lamas et al*.,* 2007; Popek et al*.,* 2008).

The aim of this study was to determine the concentrations of five metals that is, Zn, Cu, Cd, Mn and Mg in a relatively common fish species from Indus River, Ghazi Ghat, Pakistan. The relationship between metal concentration and fish biological aspects as size and condition factor was aimed to be determined.

MATERIALS AND METHODS

Study area

Four sampling sites were identified along the river Indus near Ghazia Ghat, Pakistan and the samples were collected

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Table 1. The length, wet body weight, dry body weight and condition factors of female *Oreochromis niloticus* (n=48).

Parameter	Length (cm)	Wet body weight (g)	Dry body weight (g)	Condition factor (K)
Range	9.10~17.90	14.27~118.43	3.38~27.65	1.37~2.52
Mean	15.32	67.96	15.30	1.85
SD	1.30	17.59	4.05	0.24

SD = Standard deviation.

Table 2. The tolerable limits of some heavy metals in fish (ugg^{-1})

Parameter	Cd	Cu	Zn	Reference
IAEA-407	0.18	3.28	-	Wyse et al., 2003
TFC	0.05	20	-	TFC, 2002
Directive 2005/78/EC	0.05	-	-	EC, 2005
FAO	-	30	30	FAO, 1983 Limits

Table 3. Inorganic elemental mean concentration (ugg^{-1}; dry weight) in edible portion of female *Oreochromis niloticus.*

Element	*Oreochromis niloticus* * Wild (ugg^{-1}) wet weight	*Oreochromis niloticus* ** Hatchery reared (ugg^{-1}) wet weight
Cu	2.2 ± 0.14	15.5
Zn	17.43 ± 4.2	78.7
Mn	15.24 ± 7.6	8.9
Mg	8.23 ± 2.14	NQ
Cd	NQ	NQ

*Present study; **Salam et al. (1996); NQ = Not Quantifiable.

randomly during 2009.

Fish sampling and heavy metals residual analysis of tissue

48 fish samples of female *Oreochromis niloticus* were caught alive, placed in an ice box, transported to the laboratory and were used first for morphometric measurement and then stored in a deep freezer frozen until being processed for metal analysis. Metal values were estimated in whole body of fish samples. Samples were mineralized with analytical grade purity reagents: HNO_3 (Merck, Germany) and ultra pure water (Pak Arab Ltd., Multan, Pakistan).

Heavy metals concentrations were measured according to the atomic absorption methods for fish (AOAC, 1995). The metal concentrations (Cu, Cd, Mg, Mn and Zn) were determined using the flame atomic absorption spectrophotometer (A-1800, Hitachi, Japan). The results were expressed as μgg^{-1} wet weight.

Statistical analyses

Statistical analyses were performed using Microsoft EXCEL Program, 2007. The estimated parameters were: the mean, minimum and maximum values, standard deviation, and standard error.

RESULTS

Studied specimens ranges and means of length, wet body weight, dry body weight and condition factor are presented in Table 1. Element concentrations found in examined fish varied considerably. However, the average element concentrations were on average well below the maximum tolerance levels for human consumption established by the FAO (Table 2). Accumulation of studied elements followed this descending order: Zn>Cu>Mg>Mn. Cadmium was not detected in any of the sample studied (Table 3). Concentrations of Mg and Zn were highly significant ($P<0.001$) with increasing size (weight and length) (Tables 4 and 5); Mn was found significant ($P<0.01$) and Cu found least significant ($P<0.05$) with increasing total length (Table 5) while Mn remained least significant ($P<0.05$) and Cu was insignificant ($P > 0.05$) with wet body weight (Table 4). Condition factor was found insignificant with Mg, Mn and Zn while least significant with Cu (Table 6).

DISCUSSION

According to Schneider et al. (2000), a graph of log weight against log length forms a straight line with a slope of 'b' that is close to 3.0 for all species. The value of coefficient 2.92 in the present analysis closely fits the observed and expected value. Similar results were observed by Fafioye and Oluajo (2005) and Abdurahiman

Table 4. Regression parameters of log wet body weight (g) versus log body burden element (µg) for female *Oreochromis niloticus* (n = 48).

Wet body weight (g)	Element	r	a	b	S.E (b)	t value (b =1)
14.27 to 118.43	Mg	0.690***	3.263	0.801	0.124	-1.604
	Mn	0.312*	2.018	0.512	0.230	-3.839
	Cu	0.232^{ns}	0.493	0.779	0.482	-0.458
	Zn	0.689***	1.587	0.802	0.124	-1.597
	Cd	-	-	-	-	-

r = Correlation Coefficient; a = Intercept; b = Slope; S.E= Standard, Error; *** = P<0.001; n.s. = > 0.05.

Table 5. Regression parameters of og total length (TL, cm) versus log body burden element (µg) for female *Oreochromis niloticus* (n = 48).

Total length (cm)	Element	r	a	b	S.E (b)	t value (b = 3)
9.1 to 17.9	Mg	0.611***	0.052	2.252	0.420	-1.780
	Mn	0.428**	0.311	2.227	0.693	-1.115
	Cu	0.295*	-1.189	3.147	1.501	0.098
	Zn	0.611***	0.379	2.251	0.431	-1.738
	Cd	-	-	-	-	-

r = Correlation Coefficient; a = Intercept; b = Slope; S.E= Standard Error; *** = P<0.001; n.s. = > 0.05.

Table 6. Regression parameters of condition factor versus metal concentration (µgg-1) in wet body weight for female *Oreochromis niloticus* (n = 48).

Condition factor	Element	r	a	b	S.E (b)	t value (b = 0)
1.371 to 2.524	Mg	0.044^{ns}	8.950	-0.382	1.279	-0.299
	Mn	0.327*	33.829	-10.572	4.295	-2.462
	Cu	0.114^{ns}	5.136	-1.615	2.060	-0.784
	Zn	0.031^{ns}	18.414	-0.533	-2.546	0.209
	Cd	-	-	-	-	-

r = Correlation Coefficient; a = Intercept; b = Slope; S.E= Standard Error; *** = P<0.001; n.s. = > 0.05.

et al. (2004). The condition factor or co-efficient of correlation expresses the condition of a fish, such as the degree of well being, relative robustness, plumpness or fatness in numerical terms. For the observed weights, the condition factor (K) ranged from 1.37 to 2.52 with a mean of 1.85±0.24 (Table 1).

It is generally accepted that metal uptake occurs mainly from water, food and sediment. The element concentrations in the fish body could be related primarily to their feeding habits, but also depends on element content in food (Farkas et al., 2000). According to Bordajandi et al. (2003), the diet has a remarkable role in the bioconcentration process for some metals, mainly for the Cu and Zn. Protasowicki et al. (1983) reported that the feeding strategy influenced the content of copper and zinc in fish. The lipid content of tissues also appears to be an important variable in explaining the differences in the pollutant concentrations accumulated in the organs of fish (Braune et al., 1999).

Comparisons of sample tissue levels with international standards were used to identify potential chemicals of concern concerning the safety of fish consumption. A comparison of the elements mean levels detected in the fish in this study with the maximum allowable limits in food fish set by the FAO and IAEA (Table 2) showed that the levels of Cu and Zn were lower than the limits while the cadmium was not in detectable amounts. The implication of this finding is that the consumption of the fishes of these ponds by man could not lead to health hazards induced by metals. Raw fish flesh makes a significant contribution to the daily requirement for Zn and Cu. It contains as much copper as the meat of domestic animals and is a recommended source of Zn (Lall and Ruiter, 1995).

Pourang (1995) reported that the correlation between the concentration of zinc, copper, and manganese in pike fish with fish body length was non significant. On the contrary, Naeem et al. (2010) reported highly significant (P<0.001) relationships with total length and body weight in *Oncorhynchus mykiss.* In the present study, however,

significant relations between metal concentrations and length; and with body weight showed size dependence of these metals. Negative allometry was found in Mg and Zn with increasing body weight (b =1.0) and length (b = 3.0) indicating a decrease in the concentrations of Mg and Zn with increasing size. Positive allometry in Cu with length while negative in Mn with both length and weight, indicating a decrease in Mn concentration with increasing size whereas significant proportional increase in Cu concentration with increasing total length of female *O. niloticus.*

Fish showed no significant relation with body size and condition factor, however, all the detected metal levels were well within the tolerable limits set by different organizations. The research of this type is of practical importance, the results of which could be used in the fields of environmental protection and health care.

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