Punjab University Journal of Zoology

OPEN ACCESS

36(2): 125-130 (2021)
https://dx.doi.org/10.17582/journal.pujz/2021.36.2.125.130

Research Article

Evaluation of Growth Performance and Bioaccumulation Pattern of Metals in Catfish Species, *Channa marulius* and *Wallago attu* under Cadmium and Chromium Toxicity

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Article History
Received: November 20, 2019
Revised: May 03, 2021
Accepted: May 19, 2021
Published: August 21, 2021

Authors' Contributions
MB excuted the research. SA planned the research work. HN and LS wrote the manuscript. MH helped in statistical analysis. S Maalik and S Mushtaq helped in lab work. TA revised the manuscript.

Keywords
Carnivorous fish, Bio-accumulation, Growth, Metals, Chronic exposure

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Abstract | The aim of present study was to assess the growth performance and bio-accumulation of metals in *Channa marulius* and *Wallago attu* exposed to 1/3rd of LC_{50} of chromium (Cr) and cadmium (Cd) for 8-week. In both treatments statistically significantly, variable responses viz. wet weight gain (WG), feed intake (FI), feed conversion ratio (FCR) and specific growth rate (SGR) were determined. The control fish (unstressed) had significantly higher WG followed by Cr and Cd test mediums. The FI by *C. marulius* was significantly higher as 12.83±0.07 g in Cr followed by Cd (12.14±0.05 g) and control (9.57±0.364) medium. However, FI by *W. attu* was higher in control (15.30±0.40) followed by Cr (13.08±0.06) and Cd (11.98±0.03) exposed mediums. The cumulative FI by *W. attu* was greater than *C .marulius* in all treatments. In control, FCR of both species was better significantly than fish reared in Cr and Cd exposed test mediums. In control, SGR of *C. marulius* and *W. attu* was noted as 20.50±0.52 and 21.78±0.44, respectively that was significantly better than Cr (13.62±0.09 and 14.02±0.04) and Cd (13.55±0.05 and 13.82±0.04). The comparison between species showed that *C. marulius* amassed higher concentration of both metals as compared to *W. attu*. However, Cr accumulates at higher concentration in all organs of both fish species as compared to Cd. The amassment order for metals in both species was studied as kidney>liver>gills>skin>fins>bones>muscle.

Novelty Statement | In Pakistan, riverine system has been contaminated with varied types of toxicants such as metals which exerts negative impact on native fish species such as *Channa marulius* and *Wallago attu*. Therefore, this research provide information regarding toxic impact of metals to fish.

To cite this article: Batool, M., Abdullah, S., Naz, H., Hussain, M., Maalik, S., Mushtaq, S., Ahmed, T. and Shafique, L., 2021. Evaluation of growth performance and bioaccumulation pattern of metals in catfish species, *Channa marulius* and *Wallago attu* under cadmium and chromium toxicity. *Punjab Univ. J. Zool.*, 36(2): 125-130. https://dx.doi.org/10.17582/journal.pujz/2021.36.2.125.130

Introduction

All over the world, natural water bodies have been heavily polluted with heavy metals which release from industries, domestic and human activities (Azmat *et al.*, 2012; Yaqub, 2012).

Among metals, chromium is very important because it is vital micronutrient (Piotrowska *et al.*, 2008) and living organisms also used it as dietary supplement (Opperman *et al.*, 2008; Stout *et al.*, 2009). However, it is toxic when present in excess amount (Lushchak, 2008).

Cadmium is one of the dispensable metal, and extensively used in cement, paints, dyes and fertilizers (Jarrup, 2003). Cadmium has ability to amass in the environment due to its persistent nature (Javed, 2005). The presence of these toxicants may change the water quality parameters (Andhale and Zambare, 2012). In natural aquatic bodies, mostly organisms are exposed to low concentration of metals for long term duration. Now, scientists performed chronic tests in laboratory to check the sub-lethal metal toxicity to fish (Vosyliene *et al.*, 2003) and also evaluate physiological alterations and ultimate their effects on growth of fish.

Toxicity of metal to fish mainly depends upon the water quality such as salinity, dissolve oxygen and temperature, and other toxicants (Witeska and Jezierska, 2003). Fish is a suitable bio-indicator to assess the water quality and their physiological parameters can be served as bio-marker of water contamination (Javed, 2012). Aquatic organisms uptake these heavy metals via different ways i.e., gills, body surface and intake of contaminated feed. However, which route is more important would depend upon the prevailing environmental conditions (Depledge *et al.*, 1994).

Species-specific response to toxicants is a matter of great interest, because it is a critical factor for assessing toxicity as well. Several authors conducted research on species-specific response to a number of toxicants (Pyle and Wood, 2008).

In Pakistan, riverine system has been contaminated with varied types of toxicants which exerts negative impact on native fish such as *Channa marulius* and *Wallago attu* (Rauf *et al.*, 2009). Therefore, in order to save these local fish in natural aquatic habitats, this study was conducted to determine their growth potentials and amassment of heavy metals (chromium and cadmium) under chronic exposure to predict possible impacts of persistent metal's pollution on fish.

Materials and Methods

Two species, *C. marulius* and *W. attu* were obtained from natural breeding grounds and brought to laboratory at Fisheries research Farm, University of agriculture Faisalabad, Pakistan. Fish were placed in the cement tanks for acclimation (2 weeks) prior to start the growth trails. Fish were shifted to aquarium as the acclimation period completed. Both fish species (n=10) were grown, separately, under 1/3rd of LC_{50} concentration of chromium (Cr) and cadmium (Cd) and controlled (without metals) condition for 8 weeks with three replicates. Stocks solutions were prepared by using pure compounds (Aldrich, USA) of chromium nitrate [$Cr(NO_3)_3.9H_2O$]) and cadmium chloride ($CdCl_2$. H_2O) and further dilution were made in deionized water. Both species, were fed with crumbled feed, to satiation, twice a day at 9:00 A.M and 17:00 P.M. The average water hardness of the test aquariums were maintained at 150±1.00 mg L^{-1}, pH at7.5±0.05 and temperature at 28±0.05°C.

Table 1: Metals concentration used for this study (Batool *et al.*, 2014).

Fish species	Metal concentration (mgL^{-1})	
	Chromium	Cadmium
Channa Marulius	26.60	25.00
Wallago attu	21.67	10.00

Growth parameters

In both species of fish, statistically significantly variable responses viz. increase/decrease in wet weight gain (WG), feed intake (FI), feed conversion ratio (FCR) and specific growth rate (SGR) were determined on weekly basis.

Amassment of heavy metals

The procedure of Standard Methods for the Examination of Water and Wastewater (1989) was applied to estimate the concentrations of Cr and Cd in bone, gills, fins, kidney, muscle, liver and skin of both species by using Atomic Absorption Spectrophotometer (Perkin Elmer-Analyst 400).

Statistical analysis

Data were expressed as means ± SD for each parameter. ANOVA was applied on data to determine the statistical differences among various parameters under study (Steel *et al.*, 1996). Pearson correlation coefficients were computed to find the relationships among various physico-chemical and growth parameters of both species.

Results and Discussion

Growth parameters

Results shows that exposure of Cr and Cd significantly lower the wet WG of *C. marulius* and *W. attu* as 8.29 ± 0.07 and 8.21 ± 0.04 g, respectively in relation to control (12.68 ± 0.18 g). Species-specific response shows that *W. attu* sowed significantly higher mean WG (9.92±2.22g) than *C. marulius* (9.53±1.96g). Similarly, FI was also lower for both species reared in metals exposed medium as compared to control. Comparison between species showed that *W. attu* had better FI than *C. marulius* in control and test mediums. Both species showed high FCR ration in control followed by that of Cd and Cr. Table 2 shows the data relate to growth rate of both species. During Cr exposure, the relationship of WG for both species was significantly positive with FI while same was negative with FCR. But results were different in Cd exposed medium, WG of *C. marulius* had inverse relation with FI and FCR while significantly direct relation with condition factor. However, WG of *W. attu* had significantly positive correlation with FI and same was inverse with FCR (Table 3). Previously, a wealth of studies have indicated that heavy metals affect the growth rate of various fish (Subathra and Karuppasamy, 2007). Heavy metals (Zn, Cu and Cd) significantly affect the FI and FCR of *Perca flavescens* which ultimately effect the growth (Sherwood *et al.*, 2000).

Abdel-Hakim *et al.* (2016) reported the significant reduction in SGR, WG, FCR and survival rate of Nile tilapia (*Oreochromis niloticus*) under sub-lethal exposure of Cu, Hg, Pb and Cd. Ayegbusi *et al.* (2018) noted the decreased SGR of *Clarias gariepinus* with increase in PbCl2 sub-lethal concentrations for three weeks. Ko *et al.* (2019) observed the decrease in daily weight gain, condition factor and daily length gain of *Platichthys stellatus* when exposed to four different concentrations of waterborne Cr for 4 weeks. The decline in growth and length of *Cyprinus carpio* due to Cr exposure was reported by Shaheen and Jabeen (2015). Rahman *et al.* (2018) studied the reduced growth of *Oreochromis niloticus* under Cd stress. According to Javed (2012) metals exposure at sub-lethal level adversely affect the health and growth of fish. Bioenergetics processes of fishlike feeding, metabolism, nutrient absorption and excretion of waste material are all the important factors for evaluating the chronic effects of heavy metals (Bhavan and Geraldine, 2000).

Table 2: Effect of Cd and Cr on Growth performance of fish.

Growth parameters	Fish species	Treatments			Overall means
		Cr	Cd	Control	
WG (g)	*C. marulius*	8.17±0.098b	8.13±0.04b	12.30±0.040a	9.53±1.96B
	W. attu	8.41±0.058b	8.29±0.046b	13.07±0.098a	9.92±2.22A
	Overall Means	8.29 ±0.12B	8.21±0.08B	12.68±0.38A	
CF (K)	*C. marulius*	1.84±0.046b	1.68±0.023c	2.38±0.012a	1.97±0.30B
	W. attu	2.28±0.035b	1.52±0.025c	3.47±0.017a	2.42±0.80A
	Overall Means	2.06±0.22B	1.60±0.08C	2.92±0.54A	
FI (g)	*C. marulius*	12.83±0.067a	12.14±0.046a	9.57±0.364b	11.51±1.40B
	W. attu	13.08±0.064b	11.98±0.029c	15.30±0.404a	13.45±1.38A
	Overall Means	12.95±0.12A	12.06±0.08C	12.43±2.86B	
FCR	*C. marulius*	1.57±0.075a	1.49±0.032a	0.78±0.029b	1.28±0.35A
	W. attu	1.55±0.035a	1.44±0.023a	1.25±0.023b	1.41±0.12B
	Overall Means	1.56±0.01A	1.46±0.02A	1.01±0.23B	
SGR	*C. marulius*	13.62±0.098b	13.55±0.052b	20.50±0.520a	15.89±3.26A
	W. attu	14.02±0.040b	13.82±0.040b	21.78±0.441a	16.54±3.71A
	Overall means	13.82±0.20B	13.68±0.13B	21.14±0.64A	

The means sharing similar letters in a row and column for each treatment and fish species in a single row are statistically non-significant (p>0.05).

Table 3: Impacts of different parameters on fish growth under metals stress condition.

Metal	Fish species	Step-wise regression	r/Mr	R^2
Cr	*C. marulius*	Increase in weight (g)=2.858+0.804(Feed intake)-0.614(FCR)-1.195; S.E. = 0.054 * 0.01**	1.000	0.999
	W. attu	Increase in weight (g) =0.410+0.859(Feed intake)-0.467(FCR); S.E. = 0.269 0.040**	0.983	0.966
Cd	*C. marulius*	Increase in weight (g)=-0.443-2.345(Feed intake)-0.727(FCR)+3.793(K); S.E.= -0.886 0.076**	0.994	0.988
	W. attu	Increase in weight (g) =1.073+0.717(Feed intake)-0.767(FCR); S.E. = 0.022** 0.018**	0.999	0.998

FCR= Feed conversion ratio; * = Significant at p<0.05; ** =Significant at p<0.01; NS=Non-significant; R^2= coefficient of determination.

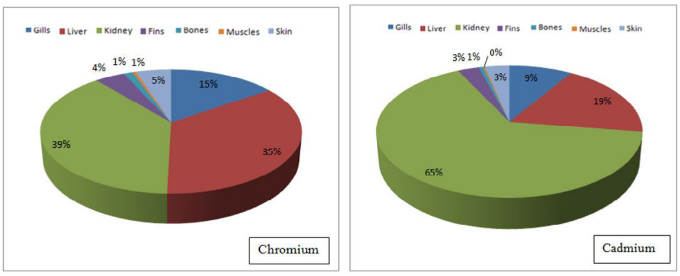

Figure 1: Metals accumulation in organs of *C. marulius* during sub-lethal exposure.

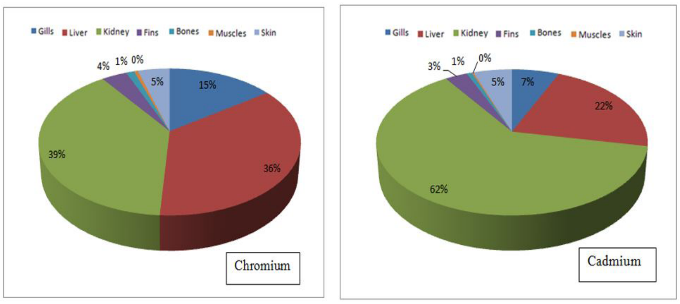

Figure 2: Metals Accumulation in organs of *W. attu* during sub-lethal exposure.

Amassment of heavy metals

Comparison between species showed that *C. marulius* amassed higher concentration of both metals as compared to *W. attu*. However, Cr accumulates at higher concentration in all organs of both fish species as compared to Cd. The amassment order for metals in both species was studied as Kidney>liver>gills>skin>fins>bones>muscle (Figure 1 and 2, Table 3). According to Muhammad *et al*. (2009) the amassment of metal was greater in liver, gills and kidney than other tissues. Amassment of metals in liver may be due to its role in metabolism/detoxification of toxicants (Zhao *et al*., 2012). Kidney plays an important role in excretion of toxicants, while gills are the direct route of ion exchange and have large surface area that eases the fast diffusion of metals from water (Qadir and Malik, 2011).

Heavy metals accumulation in aquatic animals mainly depends on the metals concentration in water body and ability of animal to digest the metals as well as feeding habits of animal. Fish have been identified as a good bio-accumulator of inorganic and organic toxicant because it stays over a long period in water (King and Jonathan, 2003). Mahboob *et al*. (2016) noted the heavy metals accumulation pattern in muscles, gills, kidney and liver of *Wallago attu* as $\text{Pb}<\text{Cr}<\text{Cu}<\text{Fe}$ sampled from the Indus river, Mianwali District, Pakistan. Jia *et al*. (2017) observed the highest concentration of toxic metals (Cd, As and Pb) in gills, liver and muscle of carnivores fish *Pelteobagrus fulvidraco* as compared to omnivores fish *Squaliobarbus curriculus* and *Carassius auratus* when both were exposed to Zn, Pb, Mn, Cu, Cd and Fe. Data showed the order of Cd accumulation in various organs was: liver > kidney > gonad > gills > muscles in all treatments. Freshwater fish species have a diverse affinity toward cadmium (Cd). The accumulation of of Cd primarily depends on the pathway of exposure either it is waterborne and dietary as well as route of uptake, time, concentration, environmental and internal conditions, along with size and age of exposed fish. Most of the fish species showed higher level of Cd in liver followed by gills and kidney while muscles always had comparatively lower level (Perera *et al*., 2015). Tilapia showed the highest accumulation of Cd in gills followed by liver and muscles (Aldoghachi *et al*., 2016).

Conclusions and Recommendations

This study concluded that burden of metals in fresh water system negatively effects the feeding behaviour and growth of fish. Furthermore, these metals can also accumulate in organs of fish. Therefore, concerned authorities must impose strict mitigation measures to control these hazardous metals.

Conflict of interest

The authors have declared no conflict of interest.

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