ELEMENT CONCENTRATIONS IN TWO FISH SPECIES WITH DIFFERENT HABITAT AND FEEDING PREFERENCES (CARP AND BURBOT) IN THE DANUBE RIVER NEAR BELGRADE

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KONCENTRACIJE ELEMENATA KOD DVE VRSTE RIBA SA RAZLIČITIM PREFERENCIJAMA STANIŠTA I ISHRANE (ŠARAN I MANIĆ) U DUNAVU KOD BEOGRADA

Apstrakt

Akvatični ekosistemi se uobičajeno smatraju krajnjim recipijentima zagađenja toksičnim metalima, čiji izvori mogu biti prirodni ili, najčešće, antropogeni. Ova klasa zagađivača predstavlja značajnu pretnju za životnu sredinu i vrste koje žive u njoj, kao i potencijalnu pretnju za ljudsko zdravlje. Osim toksičnih elemenata, i elementi u tragovima, kao i esencijalni mikronutrijenti, mogu pokazivati toksična svojstva ako su prisutni u većim koncentracijama. Dunav je recipijent zagađenja oslobođenog oko industrijskih gradova koji se nalaze duž toka ove reke. Koncentracije metala u tkvima riba zavise od većeg broja faktora, među kojima veliki značaj imaju ishrana i stanište. Koncentracije 15 elemenata (Al, As, B, Ba, Cd, Co, Cr, Cu, Fe, Hg, Mn, Mo, Se, Sr i Zn) analizirane su upotrebom ICP-OES u uzorcima jetre i škrga jedinki šarana i manića uhvaćenih u Dunavu u blizini Beograda. Elementi Li, Ni i Pb nisu detektovani u uzorcima. Mann-Whitney U test je ukazao na postojanje značajne razlike između šarana i manića u odnosu na koncentracije nekoliko elemenata, i u jetri i u škrgama. PCA analiza je pokazala da šaran i manić formiraju dve odvojene grupe na osnovu koncentracije elemenata u analiziranim tkivima. Jetra šarana karakteriše se visokim koncentracijama Cd, Cu i Zn, a škrge visokom koncentracijom Zn, dok se kod manića i jetra i škrge karakterišu visokim koncentracijama As. U škrgama šarana detektovana je viša koncentracija Zn. Šaran živi na svim dubinama i preferira staništa sa gustom akvatičnom vegetacijom i potopljenim drvećem, a u pogledu ishrane predstavlja omnivornu vrstu koja konzumira i detritus. Odrasli manić je riba bentosa koj preferira kamenitu podlogu i oportunistički je predator. Različita ishrana šarana i manića može biti uzrok razlika u koncentracijama elemenata u jetri, dok razlike u preferencijama staništa mogu ukazati na razlike u škrgama.

Ključne reči: šaran, manić, ICP-OES, toksični metali
Keywords: carp, burbot, ICP-OES, toxic metals

INTRODUCTION

Environmental pollution can be defined as the introduction of a pollutant into the air, water, or soil, which may be poisonous or toxic and is hence harmful to organisms in that environment (Nagayoti *et al*. 2010). The aquatic environment is generally the ultimate sink for metal pollutants (Velma *et al*. 2009), which is pronounced in the Danube River basin, because industrial facilities around the cities of Novi Sad, Belgrade, Pančevo, and Bor discharge various pollutants into the environment (Stanić *et al*. 2006). Metals can have negative effects on fish biology and health due to their toxicity, persistence, and bioaccumulation (Alhashemi *et al*. 2012). Gills and liver can be used as indicators for the assessment of metal accumulation (Alhashemi *et al*. 2012), because these tissues generally have higher concentrations of elements than the muscle tissue (Dural *et al*. 2007; Yilmaz 2009).

MATERIALS AND METHODS

Fourteen carp (*Cyprinus carpio*) and twenty burbot (*Lota lota*) specimens were caught at two locations in the Danube River near Belgrade, between October and December 2010. Carp was caught with portable fish nets, while burbot was caught with traps. Caught specimens were dissected with a plastic laboratory set and samples of liver and gills were taken, rinsed with distilled water, and stored at -18 ºC prior to analysis. Samples were freeze-dried using a rotational vacuum concentrator (GAMMA 1-16 LSC Germany) and sample portions between 0.2 and 0.5 g were processed in a microwave digester (speedwave™ MWS-3+; Berghof Products +Instruments GmbH, Eningem, Germany), using a 6 ml of 65% HNO_3 (Suprapur®, Merck) and 4 ml of 30% H_2O_2 (Suprapur®, Merck) at a food temperature program (100-170 ºC). After cooling to room temperature, the digested samples were diluted with distilled water to a total volume of 25 ml. The analysis of concentrations of Al, As, B, Ba, Cd, Co, Cr, Cu, Fe, Hg, Mn, Mo, Se, Sr, and Zn in samples was performed by ICP-OES (Spectro Genesis EOP II, Spectro Analytical Instruments DmbH, Kleve, Germany). The results are presented as µg/g dry weight.

To test whether variables were normally distributed, the Shapiro-Wilk test was used. Since the assumption of a normal distribution of variables was not satisfied, we applied the non-parametric Mann-Whitney test for two independent samples to compare the element levels between the two fish species (in both liver and gills). Statistical tests were done using the SPSS 20.0 software. We used the principal component analysis (PCA) as an unsupervised statistical method that summarizes the variation of a data set between samples to a set of uncorrelated components (each component is a particular linear combination of the original variables), in order to assess the differentiation among the analyzed fish tissues, based on the element level. We tried to present, in an approximate manner, clusters of individuals within smaller dimension subspaces. The untreated data for element concentrations in each tissue were used as input variables for Eigenvector Solo 7.0 software. The Varimax method was used for orthogonal factors rotation.

RESULTS

Elements Li, Pb, and Ni were not detected in the analyzed tissues. The Mann-Whitney test showed significant differences between carp and burbot with regard to element concentrations in liver for As, B, Cd, Cu, Fe, Mn, Mo, Se, Sr, and Zn, and no significant differences for Al, Ba, Co, Cr and Hg. In gills, there are significant differences between these two species in concentrations of Al, As, Ba, Cr, Mn, Se, Sr, and Zn, and no significant differences for B, Cd, Co, Cu, Fe, Hg and Mo (Table 1).

Table 1. Mean concentrations and standard deviations of 15 elements in liver and gills of carp (*C. carpio*) and burbot (*L. lota*) (in µg g^{-1} dry weight). Significant difference in concentrations of elements between species is marked by different statistical letters (*a*, *b*).

Element	Tissue	*C. carpio* (carp)	*L. lota* (burbot)
Al	liver	3.86 ± 1.96	6.36 ± 9.46
	gills	14.62 ± 16.79 *a*	31.66 ± 32.62 *b*
As	liver	0.49 ± 0.24 *a*	1.06 ± 0.52 *b*
	gills	0.29 ± 0.26 *a*	2.71 ± 1.35 *b*
B	liver	0.31 ± 0.28 *a*	0.13 ± 0.51 *b*
	gills	0.52 ± 0.66	0.60 ± 1.19
Ba	liver	0.16 ± 0.48	0.07 ± 0.19
	gills	12.61 ± 2.79 *a*	5.00 ± 3.33 *b*
Cd	liver	0.28 ± 0.40 *a*	0.03 ± 0.09 *b*
	gills	0.03 ± 0.09	0.01 ± 0.01
Co	liver	0.0001± 0.00	0.002 ± 0.005
	gills	0.0001 ± 0.00	0.0001 ± 0.00
Cr	liver	0.01 ± 0.03	0.005 ± 0.01
	gills	0.01 ± 0.03 *a*	0.11 ± 0.12 *b*
Cu	liver	33.49 ± 13.50 *a*	8.21 ± 5.02 *b*
	gills	1.90 ± 0.56	1.74 ± 0.41
Fe	liver	141.44 ± 65.23 *a*	36.97 ± 18.90 *b*
	gills	139.26 ± 38.88	162.55 ± 47.30
Hg	liver	1.63 ± 0.18	1.65 ± 0.21
	gills	0.89 ± 0.37	1.12 ± 0.31
Mn	liver	2.21 ± 0.80 *a*	0.49 ± 0.61 *b*
	gills	10.05 ± 2.74 *a*	7.21 ± 2.19 *b*
Mo	liver	0.17 ± 0.13 *a*	0.03 ± 0.07 *b*
	gills	0.06 ± 0.13	0.01 ± 0.03
Se	liver	0.36 ± 0.32 *a*	0.15 ± 0.26 *b*
	gills	0.21 ± 0.21 *a*	0.66 ± 0.50 *b*
Sr	liver	0.18 ± 0.08 *a*	0.14 ± 0.10 *b*
	gills	86.75 ± 28.58 *a*	42.96 ± 9.37 *b*
Zn	liver	325.37 ± 107.21 *a*	18.78 ± 7.71 *b*
	gills	1186.37 ± 419.46 *a*	71.09 ± 9.98 *b*

The PCA showed that carp is differentiated by the concentrations of Cd, Cu, and Zn in liver and by the concentration of Zn in gills, while burbot is differentiated by the concentration of As in both liver and gills (Figure 1).

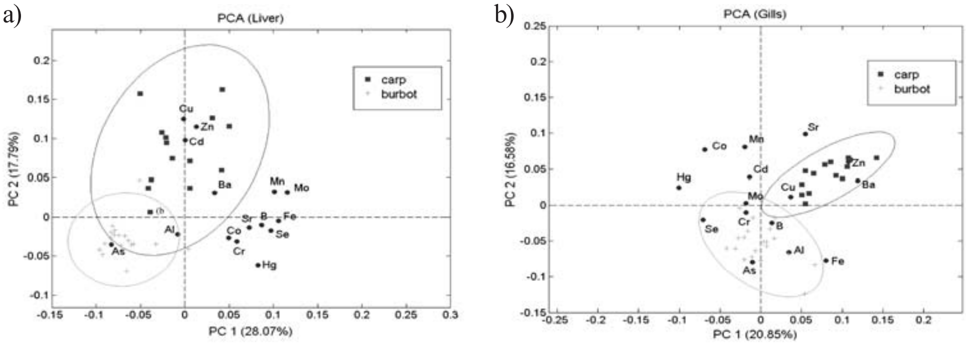

Figure 1. PCA plot of element concentration in (a) liver and (b) gills of analyzed fish species.

DISCUSSION

A higher concentration of As in liver in comparison to other fish species was also reported by Allen-Gill *et al.* (2003). On the other hand, carp is characterized by higher concentrations of Zn, which could be attributed to the tendency of Zn to inversely correlate with the trophic position of the fish (Papagiannis *et al.* 2004), and also to carp physiology and the presence of Zn-binding proteins (Liao *et al.* 2006).

The results show that carp and burbot form two distinctive groups based on the concentration of some elements in the liver, which can indicate their different feeding habits. Carp has a broad diet spectrum and is considered an omnivore/detritivore (García-Berthou 2001; Koehn 2004), while adult burbot is a predatory fish that mostly feeds on other fishes with a small portion of invertebrates in its diet (Pääkkönen and Marjomäki 2000).

These two species form two distinctive groups based on the concentration of some elements in gills as well. Because metal concentrations in gills well reflect concentrations of metals in water (Alhashemi *et al.* 2012), this separation could be explained by different habitat preferences of these species. Carp is a habitat generalist and can be found in all major aquatic habitat types (Smith 2005), while burbot utilizes several habitats during its ontogenesis – juveniles live in the littoral and adults prefer cold profundal waters (Hofmann and Fischer 2002).

CONCLUSIONS

Statistical differences were found between carp and burbot, both in liver and in gills, with regard to concentrations of As, Mn, Se, Sr, and Zn. There were no statistical differences with regard to concentrations of Co and Hg.

The PCA analysis showed that carp and burbot form two distinctive groups based on the concentration of several elements in liver and gills. Differences in concentration of elements in liver could reflect the different feeding habits of analyzed fish species, while differences in gills could reflect the different habitat preferences.

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