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CADMIUM CONTENT IN TWO CYPRINID FISH SPECIES FROM THE DANUBE RIVER

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Abstract

Two cyprinid fish species, bleak (*Alburnus alburnus* (Linnaeus, 1758)) and vimba bream (*Vimba vimba* (Linnaeus, 1758)) from the Bulgarian part of the Danube River (Lower Danube) were examined for cadmium content in their tissues and organs. The aim of the present study is to establish the content of cadmium in the water, sediments, skin, muscles, and liver of *Alburnus alburnus* and *Vimba vimba*. In the tissues and organs of the studied fish species - *A. alburnus* and *V. vimba*, the content of cadmium in samples of the liver was higher than in the muscle and skin samples, and ranged as follows: $C_{Cd/Liver}>C_{Cd/Skin}>C_{Cd/Muscles}$ (for both fish species).

The cadmium content in the analyzed samples of muscles of *V. vimba* was above the maximum acceptable concentrations. The obtained values for the content of cadmium in the muscle samples of *A. alburnus* were found to be more than 4 times lower than the obtained values for the content of cadmium in the muscle samples of *V. vimba*. In general, the content of cadmium in the tissues and organs of *A. alburnus* was lower than the content of cadmium in the tissues and organs of *Vimba vimba*. Significant correlations ($p<0.05$) were fixed for *Vimba vimba* for the relationships between $C_{Cd/Liver} – C_{Cd/Water}$ and $C_{Cd/Liver} – C_{Cd/Sediments}$.

Keywords: cadmium, *Alburnus alburnus*, *Vimba vimba*, The Danube River, Bulgaria.

INTRODUCTION

Heavy metal pollution of the aquatic environment is an important ecological issue. The content of heavy metals in fish tissues depends mainly on the level of pollution of the water and food (Canbek et al., 2007). The content of heavy metals in fish tissues can be used as the indicator for the state of the freshwater ecosystem (Canbek et al., 2007; Jovičić et al., 2014).

Heavy metal contamination of freshwater ecosystem of the Danube River was studied by different authors (Jovičić et al., 2014; Gabrashanska et al., 2004; Gati et al., 2013; Kirin et al., 2013; Kirin et al., 2014; Morina et al., 2016; Ricking and Terytze, 1999; Subotić et al., 2015; Woitke et al., 2003; Zrnčić et al., 2013; etc.).

Cadmium is a naturally occurring toxic heavy metal. In the aquatic environment, sediments serve as a reservoir for cadmium, from where it may enter the food chain via benthic-dwelling organisms (Mcgeer et al., 2012).

The content of heavy metals in fish tissues is of great interest, due to the potential risk for a human.

This study aims to present the results of examinations of cadmium contents in water, sediments, skin, muscles, and liver of *Alburnus alburnus* and *Vimba vimba*.

MATERIALS AND METHODS

In 2016 a total of 3 samples of water, 3 samples of sediments, 45 specimens of bleak (*Alburnus alburnus* (Linnaeus, 1758)) and 45 specimens of vimba bream (*Vimba vimba* (Linnaeus, 1758)) were collected and examined from the Danube River (village of Vetren, Bulgarian part).

The village of Vetren (440133'N, 270033'E) is situated on the riverside, in the northeastern part of the Danube Valley (Fig. 1).

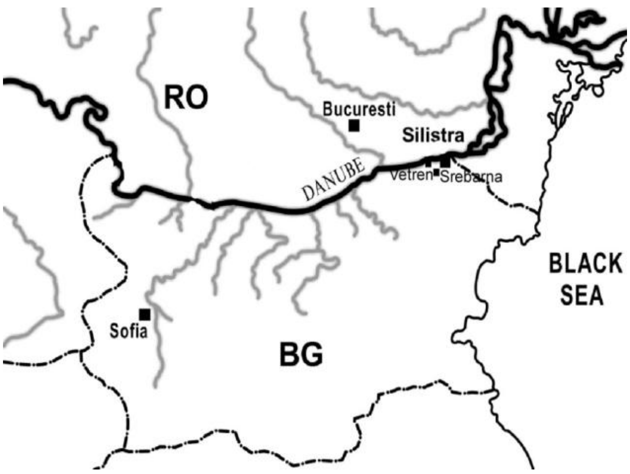

Fig. 1. *Danube River*

Alburnus alburnus and *Vimba vimba* are estimated as least concern species (LC=Least Concern; IUCN Red List Status). Bleak is freshwater, brackish, benthopelagic, potamodromous fish species. *A. alburnus* feeds mainly on plankton, including crustaceans and insects (Fröse and Pauly, 2017; Karapetkova and Zhivkov, 2000).

Vimba bream is freshwater, brackish, benthopelagic, anadromous fish species. *V. vimba* feeds mainly on small mollusks and insect larvae (Fröse and Pauly, 2017).

The bleak and vimba bream specimens were chosen for examination of cadmium content in this study were weighed (total weigh: from 10 to 22 g for bleak; from 42-513 g for vimba bream) and measured (total length: from 10 to 14 cm for bleak; from 17 to 34 cm for vimba bream). The samples of muscles, skin, and liver were collected from all specimens of fish.

The samples of water, sediment, fish tissues and organs were analyzed for content of cadmium (Cd) by ICP Spectrometry (Bíreš et al., 1995). In order to determine the relative accumulation capability of the fish tissues in comparison to water and sediments, bioconcentration factors (BCF = [Cfish tissues]/[Cwater] and BCF = [Cfish tissues]/[Csediments]) were calculated (Sures et al., 1999).

The bioconcentration factors were used for estimation of trace metal pollution in the freshwater ecosystem by examined fish species. The differences in concentration factors were discussed with respect to the bioavailability of cadmium from water and sediments.

A linear correlation coefficient (Spearman's rank correlation coefficient, r_s) was determined to test the association between water and fish tissues and organs and between sediments and fish tissues and organs.

Standard deviation and Spearman's rank correlation coefficient were calculated using Microsoft Excel and STATISTICA 6.0 program.

RESULTS AND DISCUSSION

The results of the content of cadmium (Cd) in samples of water and sediments and samples of muscles, liver, and skin of *Alburnus alburnus* and *Vimba vimba* from the Danube River are presented. Based on the results of chemical analyzes, mean concentrations (mg.kg^{-1}) in tissues and organs of both fish species, and in water and sediments, as well as the bioconcentration factor (BCF =[C tissues]/[Cwater/sediments]) were defined.

The content of cadmium in samples of sediments ($C_{Sed/Danube}$=4.307 mg.kg^{-1}) was much higher than the content of cadmium in samples of water ($C_{Water/Danube}$=0.020mg.l^{-1}) from the examined freshwater ecosystem.

From the tissues and organs of *A. alburnus,* the highest content of cadmium was determined in samples of the liver (C=0.062±0.025), followed by those of skin (C=0.057±0.026) and muscles (C=0.046±0.027). This purpose remains regarding the values of BCF, set against the levels of cadmium in water and sediments of the Danube River (Biotope Vetren).

The highest bioconcentration factor (BCF) was for liver ($BCF_{Liver/Water}$= 3.10; $BCF_{Liver/Sediments}$ = 0.014), followed by those skin ($BCF_{Skin/Water}$ = 2.85; $BCF_{Skin/Sediments}$ = 0.013) and for muscles ($BCF_{Muscles/Sediments}$ = 2.30; $BCF_{Muscles/Sediments}$ = 0.011) (Table 1).

From the tissues and organs of *V. vimba* the highest content of cadmium was determined in samples of liver (C = 1.062±1.78), followed by those for skin (C = 0.623±0.877) and muscles (C = 0.214±0.271). This purpose remains regarding the values of BCF, set against the levels of cadmium in sediments of the Danube River (Biotope Vetren). The highest bioconcentration factor (BCF) was for liver ($BCF_{Liver/Water}$ = 53.10; $BCF_{Liver/Sediments}$= 0.247), followed by those for skin ($BCF_{Skin/Water}$ = 31.15; $BCF_{Skin/Sediments}$ = 0.147) and muscles ($BCF_{Muscles/Water}$ = 10.70; $BCF_{Muscles/Sediments}$ = 0.050) (Table 2).

Table 1. Content of cadmium (mg.kg^{-1}) and bioconcentration factor (BCF) determined for the content of cadmium in tissues and organs of *A. alburnus* and in water and sediments

Alburnus alburnus	Mean±SD	Relationships	BCF	Relationships	BCF
Liver	0.062±0.025	C_{Liver}/C_{Water}	3.10	$C_{Liver}/C_{Sediments}$	0.014
Muscles	0.046±0.027	$C_{Muscles}/C_{Water}$	2.30	$C_{Muscles}/C_{Sediments}$	0.011
Skin	0.057±0.026	C_{Skin}/C_{Water}	2.85	$C_{Skin}/C_{Sediments}$	0.013
River Danube		Water (mg.l^{-1})	0.020	Sediments (mg.kg^{-1})	4.307

Table 2. Content of cadmium ($mg.kg^{-1}$) and bioconcentration factor (BCF) determined for the content of cadmium in tissues and organs of *V. vimba* and in water and sediments

Vimba vimba	Mean±SD	Relationships	BCF	Relationships	BCF
Liver	1.062±1.78	C_{Liver}/C_{Water}	53.10	$C_{Liver}/C_{Sediments}$	0.247
Muscles	0.214±0.271	$C_{Muscles}/C_{Water}$	10.70	$C_{Muscles}/C_{Sediments}$	0.050
Skin	0.623±0.877	C_{Skin}/C_{Water}	31.15	$C_{Skin}/C_{Sediments}$	0.147
River Danube		Water ($mg.l^{-1}$)	0.020	Sediments ($mg.kg^{-1}$)	4.307

The obtained values for the content of cadmium in liver, muscles, and skin of *V. vimba* were found to be much higher than the obtained values for the content of cadmium in liver, muscles and skin of *A. alburnus*. The greatest difference was observed for the content of cadmium in the liver. The content of cadmium in the liver of *V. vimba* (C = 1.062±1.78) was found to be more than 17 times higher than the content of cadmium in the liver of *A. alburnus* (C = 0.062±0.025). The content of cadmium in the skin of *V. vimba* (C = 0.623±0.877) was found to be more than 10 times higher than the content of cadmium in the skin of *A. alburnus* (C=0.057±0.026). The content of cadmium in muscles of *V. vimba* (C = 0.214±0.271) was found to be more than 4 times higher than the content of cadmium in muscles of *A. alburnus* (C = 0.046±0.027). In general, the content of cadmium in both fish specimens in samples of liver were higher than in samples of muscles and skin, and ranged as followed: $C_{Cd/Liver}>C_{Cd/Skin}>C_{Cd/Muscles}$.

A linear correlation coefficient (Spearman's rank correlation coefficient, r_s) was determined to test the association between water and fish tissues and organs, and between sediments and fish tissues and organs. Significant correlations ($p<0.05$) were fixed for *Vimba vimba* for the relationships between $C_{Cd/Liver}$ – $C_{Cd/Water}$ and $C_{Cd/Liver}$ – $C_{Cd/Sediments}$.

In aquatic environment, fish are exposed to cadmium by the water, the sediments and the food (Farag et al., 2007). In this study, the two cyprinid fish species- bleak and vimba bream were collected from the same biotope, but they inhabit different water levels and have differences in diet. Juvenile and adults of vimba bream feed on mostly benthic organisms associated with submerged vegetation throughout the year (Okgerman et al., 2013). Bleak frequently take insects from the water surface (Biro and Musko, 1995). According to Mehner et al. (2005), the diet of bleak is mainly composed of terrestrial insects and zooplankton.

These differences in their biology and way of life might be the reason for the differences in the accumulation levels of cadmium.

Cadmium accumulates mainly in the kidney and liver (Mcgeer et al., 2012). In the present study, the highest content of cadmium was determined in samples of liver and lowest- in samples of muscles (for both fish species). Similar results were observed from other authors for different fish species from the Danube River (Jarić et al., 2011; Jovičić et al., 2014; Poleksic et al., 2010; Subotić, et al., 2015).

In the scientific papers concerning content of cadmium in fish species from the Danube River they are studies where content of cadmium was below the detection threshold (Subotić et al., 2013 Subotić et al., 2015; Sunjog et al., 2012), studies where the content of cadmium was at acceptable levels (Lenhardt et al., 2012), and studies where the content of cadmium was exceeded the maximum acceptable concentrations (Gati et al., 2013; Jarić et al., 2011; Visnjič-Jeftić et al., 2010).

Sunjog et al. (2012) studied the concentrations of 16 trace elements in samples of muscle, liver, gill, gonads of *Barbus barbus* from Danube River (Serbia). In their study, the concentrations of Cd were below the detection threshold level in all samples of barbel.

Subotić et al. (2013) studied 18 heavy metal and traced elements in samples of liver, muscle, and gills of Pikeperch (*Sander lucioperca*), European catfish (*Silurus glanis*), burbot (*Lota lota*), and common carp (*Cyprinus carpio*) from the Danube River (Serbia). In their study, none of the elements exceeded the maximum acceptable concentrations, but carp had distinctly higher levels of Cd in the liver in comparison to other three species.

Subotić et al. (2015) studied the element concentrations of muscle tissue of bleak and pike from the Danube River near Belgrade. In their, study Cd was not detected in both fish species.

Authors observe higher concentrations of Hg in muscles of pike than in muscles of bleak. They explain these results with the fact that pike is predatory species.

Lenhardt et al. (2012) investigated the concentrations of 17 elements in muscle, gills, liver and gonads of silver carp (*Hypophthalmichthys molitrix*), freshwater bream (*Abramis brama*), white bream (*Blicca bjoerkna*), common carp (*Cyprinus carpio*) and wels catfish (*Silurus glanis*) from the Danube River. In their study, the concentrations of cadmium in muscles were at acceptable levels for human consumption.

Visnjič-Jeftić et al. (2010) studied the concentrations of 17 elements in samples of muscle, liver, and gill of pontic shad (*Alosa immaculata*) from the Danube River (Serbia).Their study revealed that the concentrations of Cd in samples of muscle were above maximum acceptable concentration for human consumption.

Jarić et al. (2011) investigated the concentrations of 18 elements in the muscle, gills, liver, and intestine of the sterlet (*Acipenser ruthenus*) from the Danube River (Serbia). Authors reveal that the concentrations of cadmium in the muscle were partly above acceptable levels for human consumption.

Gati et al. (2013) studied the content of heavy metals in internal and external organs of two fish species with a different habitat and trophic level (Crucian carp - *Carassius auratus gibelio* and Zander - *Sander lucioperca*) from the Danube Delta (Romania). Authors revealed that there are differences between the distribution of the metals in external and internal organs of the two investigated fish species, and that Cd is predominant in internal organs of zander. Gati et al. (2013) register for cadmium an exceeding of the European references.

The maximum cadmium level permitted for fish in muscles is 0.050 mg/kg according to the European regulation (Anonymus, 2006). Cadmium content in analyzed samples of muscles of *V. vimba* is exceeding 4 times these limits.

CONCLUSIONS

New data for cadmium content in skin, muscles, and liver of *A. alburnus* and *V. vimba,* and in water and sediments from the Danube River is presented. From the tissues and organs of the studied specimens of bleak and vimba bream, the lowest concentrations of cadmium were found in the muscles.

Cadmium content in analyzed samples of muscles of *V. vimba* was above maximum acceptable concentrations. The content of cadmium in muscles of *A. alburnus* was found to be more than 4 times lower than the content of cadmium in muscles of *V. vimba*. The content of cadmium in the samples of the liver was higher than in the samples of muscles and skin (in both fish species) and ranged as followed: $C_{Cd/Liver} > C_{Cd/Skin} > C_{Cd/Muscles}$. In general, the amendment of cadmium content in freshwater ecosystem in this study is in order: $C_{Cd/Sediments} > C_{Cd/Liver} > C_{Cd/Skin} > C_{Cd/Muscles} > C_{Cd/Water}$.

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