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NEW DATA ON CADMIUM (Cd) CONTENT IN *CHONDROSTOMA NASUS* (LINNAEUS, 1758), WATER AND SEDIMENTS FROM THE DANUBE RIVER, BULGARIA

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Abstract

In 2020, 30 specimens of common nase (Chondrostoma nasus Linnaeus, 1758) were caught. A total of 6 samples of water and sediments were collected from the Danube River, near the Kudelin village, north western Bulgaria. Tissues and organs of common nase, water and sediments from the Danube River ecosystem for cadmium (Cd) content were studied. In the samples of tissues and organs of common nase, the highest concentrations of Cd were found in the liver (C_{Cd} = 1.21 ± 0.39 mg.kg^{-1} wet weight). The concentrations of cadmium decrease in the order: liver > skin > muscles. The study presented the bioconcentration factor and the linear correlation coefficient of Spearman. The study compared the norms specified in national and international documents with obtained concentrations for cadmium in tissues and organs of common nase and water and sediments.

Key words*: fish, freshwater, heavy metals, tissues.*

INTRODUCTION

The Danube River passes over and connects ten countries' territory in Europe (Western, Central, and Eastern) (Juhásová et al., 2019). The Bulgarian section of the river includes 470 km from its lower course (Zarev et al., 2013). The lower current of the Danube River is subject to pollution of heavy metals due to different activities, including mining. The extraction and processing of ores in Eastern Europe countries (Serbia, Bulgaria, Romania) have strongly affected how developed these activities. Heavy metals are hazardous because they do not decompose in the environment but accumulate (Ilie et al., 2016). Few authors study the concentrations of heavy metals in fish, water and sediments from the Danube River in the territory of Bulgaria (Kirin et al., 2013; Kirin et al., 2014; Chunchukova et al., 2016; Chunchukova & Kirin, 2017; Chunchukova & Kuzmanova, 2017; Kirin & Chunchukova, 2017; Shukerova et al., 2017; Chunchukova et al., 2020; Zaharieva & Kirin, 2020a; Zaharieva & Zaharieva, 2020c; 2020d). The common nase investigations from the Bulgarian section of the Danube River are even less (Zaharieva & Kirin, 2020b; Zaharieva & Zaharieva, 2020a; 2020b).

The purpose of the present study is to provide new data on the cadmium (Cd) content in tissues and organs of common nase, and in water and sediments of the Danube River ecosystem, in a section located on the border of these three countries - Bulgaria, Serbia and Romania.

MATERIALS AND METHODS

In 2020, a study of 30 specimens of common nase (*Chondrostoma* nasus, Linnaeus, 1758) was performed. The common nase specimens were caught from the Danube River section immediately after the river enters the Bulgarian territory, near the Kudelin village.

Three samples of water and three sediments from the same area of the river were also collected. The Kudelin village (44°11′30″N, 22°40′5″E) is situated near the Danube River, Vidin Lowland, north western Bulgaria (Figure 1).

The fish were caught with fishing gear after a fishing permit was issued for scientific purposes. The collected fish specimens were identified in accordance with Karapetkova & Zhivkov (2006); Kottelat & Freyhof (2007). Each caught specimen of common nase was weighed and measured.

Figure 1. Danube River (Kudelin village), Vidin, north western Bulgaria (www.icpdr.org)

The metric data - TL (total length), MH (maximum height) and BW (body weight) were recorded. The mean values for TL, MH and BW, respectively 33.45 cm, 8.09 cm and 369.33 g, were calculated for 30 examined specimens.

Tissues and organs of common nase, water and sediments samples were subjected to chemical analyses to determine the cadmium (Cd) content. Liver, skin and muscles samples were prepared according to standard methods. Water and sediments samples from the Danube River were collected according to accepted standards (ISO 5667-6:2016; ISO 5667-12:2017).

The chemical analysis was performed on measuring equipment (ICP "OPTIMA 7000" Perkin-Elmer) in an accredited laboratory at the Institute of Biodiversity and Ecosystem Research (IBER), Bulgarian Academy of Sciences (BAS), Sofia.

The bioconcentration factor and the linear correlation coefficient of Spearman were calculated in the conducted study. The data were processed on MS Excel (Microsoft, 2010) and Statistica 10 (StatSoft Inc., 2011).

RESULTS AND DISCUSSIONS

The study's subject was the common nase – a freshwater fish from the family Cyprinidae. The species inhabits the Danube River and the rivers that flow into it, preferring areas with moderate currents. Fishers are interested in this species (Karapetkova & Zhivkov, 2006).

The study analysed the cadmium (Cd) content in samples of liver, skin and muscles of 30 specimens of common nase and samples of water and sediments from the Danube River near the Kudelin village. The results of the chemical analyses of the tissues and organs samples of common nase are presented in $mg.kg^{-1}$ wet weight and $mg.kg^{-1}$ dry weight (Table 1); and the results of the analyses of the water and sediments samples in $mg.l^{-1}$ and $mg.kg^{-1}$ dry weight, respectively (Table 2).

Table 1. Cadmium (Cd) in tissues and organs of *C. nasus* from the Danube River, near Kudelin village

Tissues and organs of *Chondrostoma nasus*		**Min.-Max.**	**Mean ± SD**
LIVER	$mg.kg^{-1}$ wet weight	0.62-1.61	1.21 ± 0.39
	$mg.kg^{-1}$ dry weight	1.69-4.48	3.18 ± 1.08
SKIN	$mg.kg^{-1}$ wet weight	0.04-0.19	0.10 ± 0.06
	$mg.kg^{-1}$ dry weight	0.08-0.47	0.26 ± 0.15
MUSCLES	$mg.kg^{-1}$ wet weight	0.02-0.07	0.04 ± 0.03
	$mg.kg^{-1}$ dry weight	0.08-0.28	0.16 ± 0.09

Table 2. Cadmium (Cd) in water and sediments from the Danube River, near Kudelin village

Danube River		Min.-Max.	Mean ± SD
WATER	$mg.l^{-1}$	0.001-0.011	0.008 ± 0.006
SEDIMENTS	$mg.kg^{-1}$ dry weight	0.15-4.27	1.55 ± 2.35

The highest cadmium (Cd) concentrations were reported in samples of liver (C_{Cd} = 1.21 ± 0.39 $mg.kg^{-1}$ wet weight; 3.18 ± 1.08 $mg.kg^{-1}$ dry weight) and the lowest – in samples of muscles (C_{Cd} = 0.04 ± 0.03 $mg.kg^{-1}$ wet weight; 0.16 ± 0.09 $mg.kg^{-1}$ dry weight). The cadmium concentrations in tissues and organs of common nase from the Danube River decreased in the order: liver > skin > muscles (Table 1). The following mean values of cadmium (Cd) in water and sediments from the Danube River were found: $C_{CdWater}$ = 0.008 ± 0.006 $mg.l^{-1}$ and $C_{CdSediments}$ = 1.55 ± 2.35 $mg.kg^{-1}$ dry weight (Table 2).

Cd's content in liver, skin and muscles samples of common nase was compared to the values specified in Ordinance No. 31 of 2004 on the maximum levels of contaminants in foodstuffs and by the Food and Agriculture Organization (FAO). Cd's norm in Ordinance No. 31 of 2004 is 0.05 mg/kg, and the maximum value for Cd given by the FAO is 0.2 mg/kg. It found that the Cd concentration in liver samples of common nase exceeded 24.2 times the norm specified in Ordinance No. 31 and 6.05 times the maximum value shown by the FAO. It was also found that the concentration of cadmium in skin samples exceeded the norm only in Ordinance No. 31 by twofold. Cd concentration in muscles samples of common nase was within accepted levels (Figure 2).

Figure 2. Exceedances of Cd in liver, skin and muscles of *C. nasus* from the Danube River, near Kudelin village ($mg.kg^{-1}$)

The concentrations of Cd in water samples from the Danube River were juxtaposed with the Ordinance values on environmental quality standards for priority substances and certain other pollutants of 2010 and Ordinance No. 18 of 2009 on the quality of water for irrigation of crops. The maximum permissible concentration (MPC) for Cd in Ordinance on environmental quality standards of 2010 is 0.0009 mg/l, and the norm for Cd in Ordinance No. 18 of 2009 is 0.01 mg/dm^3. The established mean values for Cd in water from the Danube River near the Kudelin village exceeded 8.89 times the MPC specified in the Ordinance on environmental quality standards of 2010. They did not exceed the norm in Ordinance No. 18 (Figure 3).

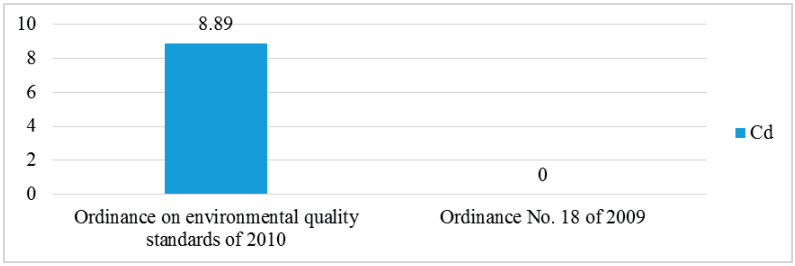

Figure 3. Exceedances of Cd in water from the Danube River, near Kudelin village (mg.l^{-1})

The cadmium concentrations in sediments samples from the Danube River were compared with the values of Ordinance No. 3 of 2008 on the norms for the permissible content of harmful substances in soils and with the Dutch Target Values. The MPC for cadmium in Ordinance No. 3 of 2008 is 2 mg/kg (at pH 6.0-7.4). The Dutch Target Values for cadmium are 0.8 mg/kg. The reported mean Cd concentrations in sediments from the Danube River near the village of Kudelin exceeded 1.94 times the Dutch Target Values and did not exceed the MPC in Ordinance No. 3 at pH 6.0-7.4 (Figure 4).

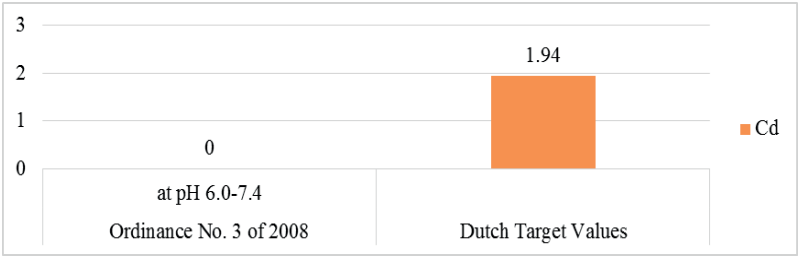

Figure 4. Exceedances of Cd in sediments from the Danube River, near Kudelin village (mg.kg^{-1})

The bioconcentration factor (BCF) in water ((BCF = [$C_{host\ tissues}$]/[C_{water}])) and sediments ((BCF = [$C_{host\ tissues}$]/[$C_{sediments}$])) was calculated. It is the highest in the liver samples and respectively the lowest in the muscle samples, both for water and sediments (Tables 3 and 4).

Table 3. Bioconcentration factor in water

***C. nasus*/Water**	**BCF_{Cd}**
C_{liver}/C_{water}	151.25
C_{skin}/C_{water}	12.50
C_{muscle}/C_{water}	5.00

Table 4. Bioconcentration factor in sediments

***C. nasus*/Sediments**	**BCF_{Cd}**
$C_{liver}/C_{sediments}$	2.05
$C_{skin}/C_{sediments}$	0.17
$C_{muscle}/C_{sediments}$	0.10

The linear correlation coefficient of Spearman (r_s = 0.94-1.0) shows very high correlations between the Cd content in the studied biological samples of common nase and those in the samples of water and sediments.

The obtained tendencies for the accumulation of cadmium in tissues and organs of common nase from the Danube River (Kudelin village) confirmed those obtained in previous studies with the fish species from the same area of the Danube River (Zaharieva & Kirin, 2020b; Zaharieva & Zaharieva, 2020b) - the highest concentrations of Cd in liver samples and the lowest - in muscles samples. According to the Zaharieva & Kirin (2020b) research with common nase from the Danube River (Kudelin biotope), the highest concentrations of Cd were found in liver (0.08 ± 0.04 mg.kg^{-1}), followed by skin (0.07 ± 0.04 mg.kg^{-1}) and muscles (0.01 ± 0.01 mg.kg^{-1}). Zaharieva & Zaharieva (2020b) provided data on Cd content in liver and muscles of common nase from the Danube River (Kudelin biotope), and they reported high Cd concentrations in liver samples (0.32 ± 0.25 mg.kg^{-1}) and low in muscles samples (0.07 ±

0.05 mg.kg^{-1}). In the present study, higher concentrations of Cd were found in the liver and skin samples than those found in the previous year's studies for the same section of the Danube River.

Research on Cd concentrations in tissues and organs of two other fish species from the Danube River (Vetren) was carried out by Shukerova et al. (2017).

The authors examined the liver, skin, and muscles of bleak (*Alburnus alburnus*) and vimba bream (*Vimba vimba*) for cadmium content and reported the highest Cd concentrations in the liver – 0.062 ± 0.025 mg.kg^{-1} (*A. alburnus*) and 1.062 ± 1.78 mg.kg^{-1} (*V. vimba*), followed by those in skin – 0.057 ± 0.026 mg.kg^{-1} (*A. alburnus*) and 0.623 ± 0.877 mg.kg^{-1} (*V. vimba*), and the lowest in muscles – 0.046 ± 0.027 mg.kg^{-1} (*A. alburnus*) and 0.214 ± 0.271 mg.kg^{-1} (*V. vimba*).

The concentrations of Cd established in the present study in tissues and organs of common nase from the Danube River (Kudelin) were lower than those reported by Shukerova et al. (2017) of *V. vimba* from the Danube River (Vetren), except those in the liver samples. They were higher than the Cd concentrations in tissues and organs of *A. alburnus* from the Danube River (Vetren), except those in the muscles.

CONCLUSIONS

In 2020, samples of fish, water and sediments were collected from the Danube River near the village of Kudelin.

There were examined tissues and organs (liver, skin, muscles) of common nase, water and sediments for cadmium (Cd) content.

The concentrations of Cd in the studied tissues and organs decreased in the order: liver (C_{Cd} = 1.21 ± 0.39 mg.kg^{-1} wet weight) > skin (C_{Cd} = 0.10 ± 0.06 mg.kg^{-1} wet weight) > muscles (C_{Cd} = 0.04 ± 0.03 mg.kg^{-1} wet weight).

Concentrations of Cd in muscle samples of common nase did not exceed the values specified in Ordinance No. 31 of the Bulgarian legislation and compared to the FAO's values.

The bioconcentration factor is the highest in the liver samples, from both water and sediments. All studied biological samples proved very high correlations between the Cd content in water and sediments.

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