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Age-specific metal and accumulation patterns in different tissues of nase (*Chodrostoma nasus*) from the Medjuvršje Reservoir

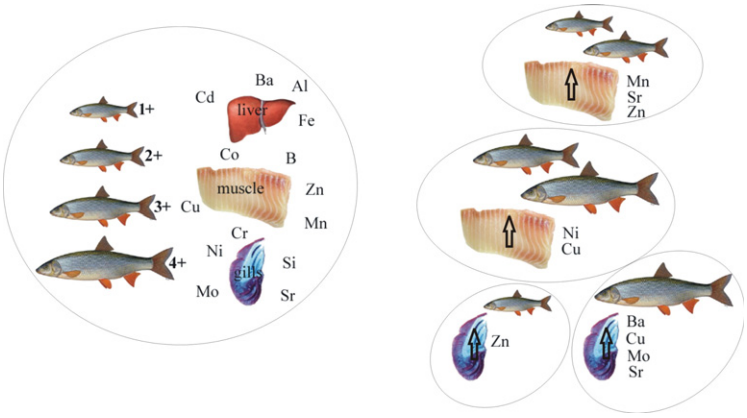
Vesna Djikanović [a,*], Stefan Skorić [b], Ivan Jarić [b], Mirjana Lenhardt [a]

[a] University of Belgrade, Institute for biological research "Siniša Stanković", Despot Stefan 142 Blvd, 11060 Belgrade, Serbia
[b] University of Belgrade, Institute for Multidisciplinary Research, Kneza Višeslava 1, 11000 Belgrade, Serbia

HIGHLIGHTS

- We assessed influence of age on metal accumulation in nase.
- Analysis comprised 14 elements in three tissues, using ICP-OES.
- Elemental accumulation differed significantly among age classes.
- Differences were likely caused by age-specific diet and physiology.

GRAPHICAL ABSTRACT



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ABSTRACT

Nase (*Chodrostoma nasus* L. 1758) specimens of four age classes (1^+ to 4^+) were caught in July 2013 in the Medjuvršje Reservoir. Concentrations of 14 metals and elements (Al, B, Ba, Cd, Co, Cr, Cu, Fe, Mn, Mo, Ni, Si, Sr, Zn) in the muscle, gills and liver were analyzed by inductively-coupled plasma optical spectrometry (ICP-OES). The highest concentrations of Al, Ba, Co, Cr, Mn, Si, Sr and Zn were detected in gills, while Cd, Cu, Fe and Mo reached the highest values in the liver. The majority of the analyzed elements were found in minimal concentrations in the muscle. Younger age classes (1^+, 2^+) were differentiated by higher concentrations of Mn, Sr and Zn in muscle tissue, while the older ones were mainly differentiated by higher concentrations for Ni and Cu. The youngest age class (1^+) was distinguished by higher concentrations of Zn, while the oldest age class (4^+) was distinguished by higher concentrations of Ba, Cu, Mo and Sr in gills. Results obtained were likely caused by differences in the physiology and feeding habits between younger ($1–2^+$) and older ($3–4^+$) age groups of nase.

1. Introduction

The Zapadna Morava River (West Morava) is 298 km long, with a total catchment area of 15.849 km^2 (28.4% of the area of the Republic

* Corresponding author.
E-mail address: djiki@ibiss.bg.ac.rs (V. Djikanović).

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of Serbia) and represents the longest watercourse in Serbia. The hydrographic network of the Zapadna Morava basin comprises 1800 tributaries. Agricultural activities (58.8% of the catchment area is under agricultural land) that contribute to the emission of various pollutants are particularly intense in the middle and lower river sections (Marković et al., 1998). The Zapadna Morava River flows through areas characterized by intensive urban, rural and industrial activities (wood, textile and metal industries) with over 200 major industrial pollution sources registered in the basin (Pandurović and Vasileva, 2000).

The Zapadna Morava River has elevated concentrations of Al, Cr, Fe, Ni, and Zn as compared to the Južna Morava River (South Morava), and especially high Cu concentrations (Morina et al., 2015). The Medjuvršje Reservoir was created in 1953, due to the construction of a 31 m high dam on the Zapadna Morava River, designed for water level control and management (Babić-Mladenović et al., 2003). Activity of HPP Medjuvršje leads to oscillations of 20 to 30 cm in the littoral zone. Particularly heavily influenced is the river stretch in the Ovčar-Kablar Gorge downstream of the dam. Continuous sediment deposition leads to the creation of small plateau and modifies the morphology of the riverbed. The bottom of the reservoir is represented by a combination of mud and gravel, with forested steep banks (Lenhardt et al., 2009). Deposition of sediments in the reservoir resulted in substantial shifts in fish assemblages, with a decrease in lithophilic and rheophilic species, such as nase (*Chondrostoma nasus* L. 1758). Following the dam construction, a number of non-native fish species were intentionally or accidentally released in the reservoir through stocking (Lenhardt et al., 2009).

Nase is a cyprinid benthopelagic, potamodromous freshwater species. Its major habitat is represented by medium- sized or large rivers, with moderate or fast-flowing water and rock or gravel bottom (Kottelat and Freyhof, 2007). Its diet is highly specialized. Following several weeks of feeding mostly on zooplankton, it starts feeding almost exclusively on algae found on rock or stone surfaces (Reckendorfer et al., 2001). The specific feeding behaviors of different age classes of nase make this fish species interesting for use as a potential indicator of pollution and accumulation in the food chain. Nase requires high habitat variability and is strongly dependent on substrate, flow velocity and depth patterns provided by gravel bars in meandering and braided river systems (Zitek et al., 2009). Its optimal habitat is represented by sites that provide adequate food and cover (Bourke et al., 1996; Perrow et al., 1996). Nase populations are potentially threatened (Schiemer and Spindler, 1989). In Serbian open waters, nase is a protected fishery species during its spawning period (Official Gazzette of RS, 2014). In the Medjuvršje Reservoir nase represents 17% of the annual catch (Report, 2014).

The aim of the current study was to assess metal concentrations in the muscle, gills and liver of nase of different age classes, in order to determine the potential influence of age-specific diet on accumulation patterns, and the possibility of using this species as an ecosystem pollution indicator.

2. Materials and methods

2.1. Study area

The field study was conducted in the Medjuvršje Reservoir (Zapadna Morava River Basin, N −43°54′43.07″, E–20°14′12.71″, 277 m altitude) (Fig. 1). The reservoir is 9.3 km long with a surface of 1.5 km^2. The maximum width and depth are 272 and 12 m, respectively, directly below the dam. The reservoir is the largest one on the Zapadna Morava River. The water quality is greatly influenced by intense emission of industrial, urban and rural wastewater. Settlements and most of the industrial facilities in the area do not have wastewater purification infrastructure. The study area is bordered by two dams, making this reservoir a closed system.

2.2. Sample collection

Twenty-four nase specimens were caught in the studied area during July 2013. Collection of fish samples was performed using a set of standing gill-nets with a mesh diameter of 10–60 mm, as well as by electrofishing (HONDA 1,2κW, 6 A). Fish specimens were anesthetized in clove solution and sacrificed with a quick blow to the head. Measurement of TL and weight (W) of each specimen was made to the nearest

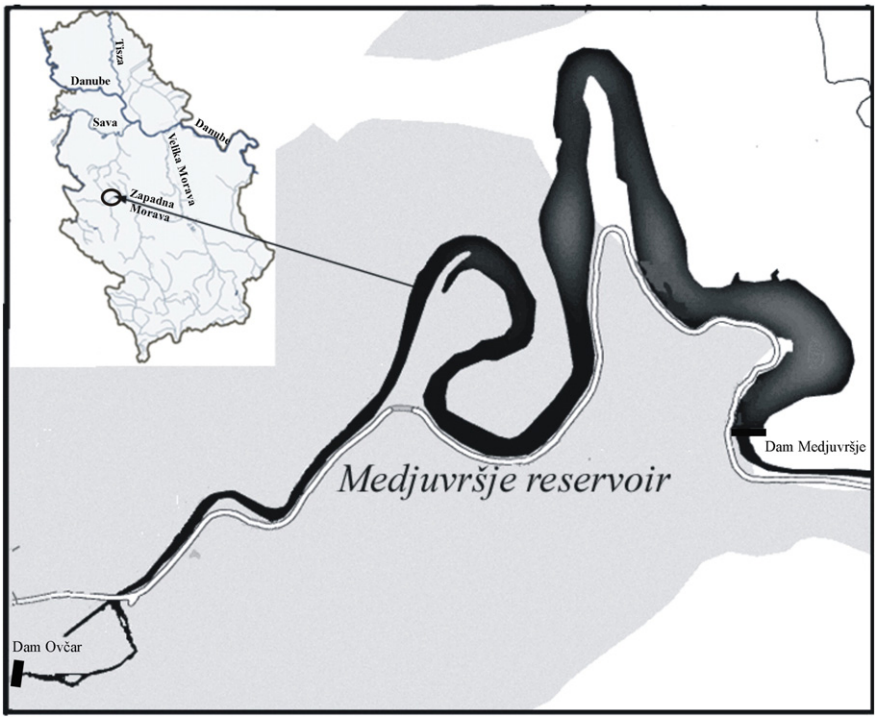

Fig. 1. Field study area — Medjuvršje Reservoir (Zapadna Morava River Basin).