Potentially toxic elements in the edible part of trout (*Salmo trutta* L.) from the upper reaches of the Raška and Studenica rivers

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Abstract: This paper reports the accumulation of potentially toxic elements (PTEs) in trout (*Salmo trutta* L.) sampled from rivers Raška and Studenica in Serbia, which are assumed to be free of pollutants. The presence of PTEs, essential elements and heavy metals, in aquatic ecosystems is usually a consequence of anthropogenic activities such as mining, agricultural drainage, sewage discharge, industrial effluent discharge, gasoline leakage from fishing boats, and accidental chemical waste spills. The appearance of these elements in water and aquatic biota can also be a consequence of natural processes such as atmospheric deposition and weathering, earth's crust erosion, and volcanic eruption. Since trout inhabits pristine upper reaches of the river, this species represents an appealing model to assess the biological impact of environmental and geochemical contamination in freshwater ecosystems. The concentrations of 14 PTEs in the edible part (EP, muscle + skin) of trout were evaluated. The data obtained in this study confirmed that freshwater, even if far from industrial and anthropogenic activities, can lead to the accumulation of PTEs related to the site's geochemical morphology.

1. Introduction

The presence of potentially toxic elements (PTEs), essential elements and heavy metals, in aquatic ecosystems is usually a consequence of anthropogenic activities such as mining, agricultural drainage, sewage discharge, industrial effluent discharge, gasoline leakage from fishing boats, and accidental chemical waste spills [1]. The appearance of these elements in water and aquatic biota can also be a consequence of natural processes such as atmospheric deposition and weathering [2], earth's crust erosion, and volcanic eruption [3].

The trout (*Salmo trutta* L.) inhabit watercourses located in mountainous and sparsely populated areas, which guarantee good water quality [4]. Since it inhabits pristine upper reaches of the river, trout species represent an appealing model to assess the biological impact of environmental and geochemical contamination in freshwater ecosystems [5].

This paper reports a contamination study of a profile of 14 PTEs of the edible part (EP) (muscle and skin) in trout (*Salmo trutta* L.) collected from pristine upper reaches of the rivers Studenica and Raška in Serbia. Furthermore, the potential risk to human health resulting from the consumption of trout was assessed.

2. Material and methods

The field study was conducted at upper riches of the rivers Studenica and Raška in summer of 2011. Sampling sites (Raška River: 43.114391N, 20.377664E; Studenica River: 43.466234N, 20.548036E) are given in Figure 1.

Figure 1. Sampling sites on Studenica and Raška rivers.

The trout were sampled using the Aquatech DC electrofisher IG 1300 (2.6 kW, 80-470 V). Ten specimens were selected from each river catch, sacrificed by a quick blow to the head and transferred on ice in a hand-held refrigerator to the laboratory.

In the laboratory, fish were measured for their total body length (to the nearest cm), weighed (to the nearest g), and subsequently dissected with a decontaminated ceramic knife. The right dorsal muscle with the skin below the dorsal fin of each specimen was dissected. Following dissection, the samples were weighed using an electronic scale (accuracy ± 0.01 g).

Before digestion in microwave Christ Alpha 2–4 LD, Harz, Germany, samples are dried in a lyophilizer Christ Alpha 2–4 LD, Harz, Germany, and measured one more time. Dried sample portions between 0.3 and 0.5 g were digested with a mixture of 65% nitric acid and 30% hydrogen peroxide (Suprapur®, Merck, Darmstadt, Germany, 10:2, v/v) at 200 °C for 20 min. After cooling to room temperature and without filtration, the solution was diluted to a fixed volume of 25 ml with ultrapure water. Fish free samples were analyzed with each batch of samples to observe contamination by the reagents used. The concentrations of Al, As, Cd, Co, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Se, Sn, and Zn were analyzed with inductively coupled plasma optical emission spectrometry (ICP-OES), using a Thermo Fisher Scientific iCAP 6500 Duo ICP (Cambridge, United Kingdom).

The mean values and standard deviations were calculated for each group, and PTEs were expressed as mg kg^{-1} wet weight (ww). Concentrations were compared with the maximum permitted concentrations (MPCs) for available elements in fish meat for utilization in the human diet, according to the national [6] and European Union [7] legislations.

3. Results and discussion

The average weight of the examined specimens from Raška River was 155.33 ± 6.6 g while the average length was 21.4 ± 2.05 cm. The average weight of the examined specimens from Studenica River was 184 ± 9.5 g while the average length was 25.3 ± 2.8 cm.

In Table 1 concentrations of PTEs in trout from Raška and Studenica rivers are shown. Except for Cr and Hg, all other PTEs were recorded in higher concentrations in the edible part of the trout sampled from the Studenica River. As expected, fish samples examined had no concentrations of PTEs above the MPC prescribed by the EU [6] and national legislation [7].

Table 1. The average PTEs concentrations and standard deviation in (EP) (muscle and skin) in trout (*Salmo trutta* L.) from Raška and Studenica rivers in mg kg^{-1} ww.

PTEs	Studenica River	Raška River
Al	0.23 ± 0.26	nd*
As	0.19 ± 0.02	0.16 ± 0.04
Cd	0.010 ± 0.005	0.005 ± 0.001
Co	0.010 ± 0.004	0.002 ± 0.003
Cr	0.13 ± 0.05	0.14 ± 0.04
Cu	0.4 ± 0.1	0.34 ± 0.19
Fe	3.52 ± 0.59	2.75 ± 0.98
Hg	0.003 ± 0.005	0.09 ± 0.07
Mn	0.26 ± 0.16	0.11 ± 0.09
Ni	0.11 ± 0.05	0.02 ± 0.02
Pb	0.31 ± 0.09	0.12 ± 0.10
Se	0.34 ± 0.07	0.32 ± 0.03
Sn	0.004 ± 0.003	0.004 ± 0.005
Zn	4.7 ± 1.8	3.38 ± 0.87

*nd – not detected

Bioaccumulation of PTEs in living organisms depends on pollution in situ, rate of detoxification and metabolism [8]. Anthropogenic activities are considered the primary source of PTEs pollution in aquatic ecosystems [9]. Bearing in mind that the trout is sampled from pristine upper parts of rivers Raška and Studenica, the presence of some PTEs can be explained by the geomorphology of the studied sites, which could have led to the release of many PTEs [9].

4. Conclusions

The data obtained in this study confirmed that freshwater, even if far from industrial and anthropogenic activities, can lead to the accumulation of PTEs related to the site's geochemical morphology.

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