Pollution of small lakes and ponds of the Western Balkans - assessment of levels of potentially toxic elements

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Contents

Abstract Small lakes and ponds are among the most sensitive ecosystems, vulnerable to changes that have little or no effect on larger water bodies. Therefore this problem should be given more attention around the world. Anthropogenic impacts, which have been extensively researched in larger water bodies, have barely been examined in small lakes and ponds. Considering that most of the studies are related to lakes bigger than 50 ha, a significant knowledge gap was left regarding small lakes and ponds. The same situation is in the Western Balkans, where studies related to pollutants in small lakes and ponds are limited. This chapter presents an overview of studies related to the contamination of small lakes and ponds of the Western Balkans, with special reference to pollution with potentially toxic elements (PTEs) in small lakes and ponds. Since massive fish mortality happened several times, an assessment of PTEs in fish species *Carassius gibelio* from small

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Aleksandrovac Lake in Serbia is presented. The results indicate that fish muscle (meat) was exposed to the lower pressure of PTEs pollution than liver and gills, suggesting that, despite massive fish mortality, there was no risk for human health by fish consumption.

Keywords Western Balkans, pollution, small lake, pond, potentially toxic elements, Aleksandrovac Lake

1 Introduction

Small water bodies, including ponds and small lakes, are freshwater ecosystems of high ecological relevance [1]. They occur in practically all terrestrial environments, from polar deserts to tropical rainforests [2], and, on a global scale, cover a greater area than lakes [3]. In Europe, they constitute a significant part of the continental freshwater resources [4].

Ponds are small standing waters that vary in size from 1 m^2 to about 2-5 ha in area [5]. The Ramsar Convention adopted a cut-off between ponds and lakes of 8 ha [6]. Additionally, there is no strict definition of what constitutes small or large lake. Given that in Europe the size of lakes is considered significant, according to the Water Framework Directive, 50 hectares provide a de facto cut-off point for small lakes [7]. Their typical characteristics, such as shallow waters and small size, imply a different ecological functioning [8, 9]. Ponds also vary in origin. For example, some natural ponds are the result of glacial activity, and others may be formed as oxbow ponds. There are also many man-made ponds, for example, mill ponds or ponds established for sediment retention or water storage [10].

Small lakes and ponds constitute an important component of freshwater ecosystems. They support higher proportions of biodiversity compared to larger freshwater systems [11] and can be substantially more biologically active than large lakes [12]. It is known that ponds support a disproportionately high species richness and variety of communities given their small size [13]. A wide range of studies have confirmed that, particularly for macrophytes, aquatic micro- and macroinvertebrates, and amphibians, small water bodies are areas of high biodiversity [7]. Also, they support specific and important hydrological, chemical, and biological processes [10].

The fundamental ecological research of ponds and small lakes influenced the growing concern and awareness regarding their abundance, importance for freshwater biodiversity, their role in contributing to ecosystem services, and their sensitivity and vulnerability to anthropogenic disturbances [3, 14]. It has become increasingly clear that there is a growing interest in ponds and small lakes in the early twenty-first century, which is reflected by increasing scientific activity, especially regarding biodiversity [4]. They are ecologically very important and represent powerful model systems for studies in ecology, evolutionary biology, and conservation biology, and can be used as sentinel systems to monitor global change [2].

A number of human activities threaten small lake and pond ecosystems - draining/infilling, eutrophication, contamination, acidification, and invasion of exotic species. Still, they are also threatened by global changes, in particular by increasing temperature and UV radiation [4, 15, 16]. Furthermore, anthropogenic impacts which have been extensively researched in larger waters have barely been examined in small lakes and ponds. Small lakes and ponds are vulnerable to changes that have little or no effect on larger water bodies. Therefore, this problem should be given more attention worldwide.

This chapter represents an overview of studies related to the contamination of small lakes and ponds of the Western Balkans, with special reference to pollution with potentially toxic elements (PTEs). Additionally, an assessment of PTEs in fish species from small Aleksandrovac Lake in Serbia is presented.

2 Small lakes and ponds of the Western Balkans

The precise number of ponds and small lakes in Europe cannot be estimated, nor for the area of the Western Balkans. The available literature data are contradictory. According to Kristensen & Globevnik [10], Europe has at least 600 000 natural lakes, with only around 100 000 having an area greater than 10 ha. Biggs et al. [7] stated that in the whole of Europe, the number of small lakes and ponds is likely between five and ten million. On the other hand, the proportion of loss of the ponds in the European landscapes is estimated higher than 50% [4].

The study of ponds was neglected in the second half of the twentieth century, only gaining momentum in the twenty-first century, particularly in Europe because of the work of the European Pond Conservation Network. The protection of small water bodies and the biodiversity they support is a concern since they are vulnerable to changes that have little effect on larger water bodies [10].

Small water bodies have not been studied systematically in the Western Balkans; nevertheless, specific research topics were related to a specific issue or group of organisms/taxa/species. A survey of ponds and their loss in the Žumberak-Samoborsko gorje Nature Park was conducted by Hutinec & Struna [17], while Sremački et al. [18] conducted environmental monitoring and assessment of protected wetland and lake water quality in Croatia and Serbia. Ranđelović et al. [19] performed phytocenological research of Batušinačke ponds in the vicinity of Niš. Tasevska et al. [20] researched rotifers. The zooplankton communities in the small lakes of the Western Balkans were investigated by Ostojić et al. [21, 22, 23], Špoljar et al. [24, 25], Kuczyńska-Kippen et al. [26], and Mancinelli et al. [27], while Ranković et al. [28] analyzed the phytoplankton community as an indicator of water quality. The following authors studied cyanobacteria: Svirčev et al. [29], Đorđević & Simić [30], and Simić et al. [31]. Temunović et al. [32] explored the diversity of water beetles (Hydradephaga, Coleoptera) in temporary ponds of Lonjsko polje, while Vilenica et al. [33] investigated the suitability of man-made water bodies as habitats for Odonata. The diversity of aquatic insects in small water bodies has been studied by many authors [34, 35, 36, 37, 38, 39], while research regarding fish was conducted by Pavlović et al. [40] and Khanom et al. [41]. Given the size of the Balkan Peninsula's territory, there are still unexplored small water bodies.

3 Pollution of small lakes and ponds

Certainly, shallow lakes and ponds are among the most sensitive ecosystems [42, 43]. Biggs et al. [7] indicated that pollutants might have a higher impact on ponds than larger waters because of ponds' small water volumes and less potential for pollutant dilution and retainment. Additionally, climate change can increase water temperature, decrease water level, and these changes together can increase the effect of pollutants in small water bodies [44].

Small water bodies, small lakes and ponds have not been omitted when it comes to threats by human activities. Those activities have increased nutrient loading, acid rain, invasion of nonnative species, and contamination. Contaminants of small water bodies include agricultural and amenity pesticides, veterinary and human medicines, personal care products, biocides, polyaromatic hydrocarbons (PAHs), and metals (also termed “heavy metals” or “potentially toxic elements”).

Among the most important contaminants in small water systems are PTEs, and they are highly susceptible to inputs of even small amounts of these pollutants from their surroundings [7, 45, 46]. A key specificity of metals is that they are present in the earth’s geological structures and enter aquatic ecosystems both by natural processes (atmospheric precipitation, geologic weathering, soil, and rock erosion) and through anthropogenic sources (industrial effluents, traffic, mining wastes, and agricultural waste products) as well as by synergistic combinations of the two.

It is a well-known fact that PTEs seriously contaminate the environment causing global health problems. Within a lake or pond system, the contamination depends on both the concentration of elements and the processes that occur within the water, sediment, and biota. It was also observed that the intensity of water exchange, which is lower in lotic ecosystems, affects metal bioaccumulation [47]. Contamination with PTEs may have stressful effects on the ecological stability of the recipient, species richness, and diversity and may cause lethal effects to the members of biota [48]. Once released in the aquatic ecosystem, it can be distributed and accumulated in the different parts of the aquatic biota, including flora and fauna. PTEs are one of the greatest threats to aquatic biota due to possible bioaccumulation and biomagnification in food chains [49], toxicity at high concentrations, and neurological impacts. Furthermore, some of them are carcinogenic [50]. Fish are on the top of the food chain and accumulate the highest concentrations of PTEs in the aquatic systems [51], and therefore represents the largest source of mercury in human food.

4 Overview of the literature related to pollutants in small lakes and ponds of the Western Balkans

Oertli et al. [4] indicated that small lakes and ponds receive less scientific attention than other water bodies in general. Research on contamination of small lakes and ponds with different pollutants is less emphasized in recent scientific literature. Brönmark & Hansson [15] predicted that in developing countries, such as Western Balkan countries, threats that derive from pollutants might become more of a problem in the next 25 years. Despite this, in 2021 pollutants in small lakes and ponds in Western Balkan countries are still under-examined.

There is very extensive literature on the effect of anthropogenic impacts resulting from the suite of processes leading to the phenomenon labeled “eutrophication” [52]. It causes turbid and toxic water from cyanobacterial blooms, degradation of lake ecosystems, and biodiversity [53]. Acidification was a major focus in the scientific literature from the middle of the 1980s to the middle of the 1990s [15]. Thereafter, research papers on acidification appeared less frequently, and today acidification is considered mostly a political issue. Also, the problem of nonnative species, as a result of human activities, is reflected in an increasing number of scientific papers published in this area. When it comes to PTEs, research activities are related to larger water bodies (large rivers and lakes).

In the Western Balkans, studies related to pollutants in small lakes and ponds are limited. Most studies deal with pollutants in larger lakes and reservoirs. Numerous studies are dealing with the determination of cyanotoxins and toxicity in small lakes. The largest number of studies of this type is in Serbia — Svirčev et al. [29], Đorđević & Simić [30], Simić et al. [31], Đorđević et al. [54], Svirčev et al. [55], Simić et al. [56], and Drobac et al. [57]. When it comes to persistent organic pollutants (POPs) and polycyclic aromatic hydrocarbons (PAH), studies dealing with these pollutants were performed by Sakan et al. [58], Romanić et al. [59], Grba et al. [60], Drvošćak et al. [61], Kljaković-Gašpić et al. [62], Sula et al. [63], etc.

Table 1 summarizes available literature data on PTEs pollution studies related to lakes and ponds in the Western Balkans. It is important to emphasize that in the Western Balkans, four large lakes (Skadar, Ohrid, Prespa, and Dojran) are shared by two or more countries. Therefore, studies of pollution with PTEs in these countries (i.e., Montenegro, North Macedonia, and Albania) are mainly limited to these lakes.

As seen in Table 1, only the studies Djikanović et al. [48], Svirčev et al. [55], Branković et al. [87], Rašković et al. [93], Đikanović et al. [94, 95], Milošković et al. [96], and Nikolić et al. [97] included small lakes (if we consider 50 ha as the cut-off point for small lakes). Still, not a single study was related to pollution with PTEs in ponds. All these studies are related to the four small lakes in Serbia — Međuvršje, Šumarice, Aleksandrovac, and Bubanj. Study Branković et al. [87] deal with PTEs in water, sediment, and different macrophytes, while studies Svirčev et al. [55], Rašković et al. [93], Đikanović et al. [94], Đikanović et al. [95], Milošković et al. [96], and Nikolić et al. [97] are related to fish contamination with PTEs.

Table 1 Overview of literature data on PTEs in lakes and ponds of the Western Balkans

Study	Medium/Organism	Country/Location	Size
Malaj et al. [64]	water sediment, emergent vegetation, fish	Albania/Ohrid Lake	> 50 ha
Dalo et al. [65]	sediment, *Phragmites australis*	Albania/Ohrid Lake	> 50 ha
Has-Schön et al. [47]	*Cyprinus carpio*, *Silurus glanis*	Bosnia and Herzegovina/Buško Blato	> 50 ha
Has-Schön et al. [66]	*Salmo trutta*, *Leuciscus turskyi*, *Chondrostoma phoxinus*, *Aulopyge hügeli*	Bosnia and Herzegovina/Buško Blato	> 50 ha
Has-Schön et al. [67]	*Cyprinus carpio*, *Tinca tinca*, *Lepomis gibbosus*, *Carassius auratus gibelio*, *Salmo dentex*, *Anguilla anguilla*	Bosnia and Herzegovina/Svtava Lake	> 50 ha
Popović et al. [68]	water, sediment, *Cyprinus carpio*, *Hypophthalmichthys molitrix*, *Silurus glanis*, *Esox lucius*	Bosnia and Herzegovina/Saničani Lake	> 50 ha
Ivanković et al. [69]	sediment	Bosnia and Herzegovina/Blidinje Lake	> 50 ha
Vukosav et al. [70]	water, sediment, *Salmo trutta*, *Oncorhynchus mykiss*, *Squalius cephalus*	Croatia/Plitvice Lake	> 50 ha
Horvatinčić et al. [71]	water, sediment	Croatia/Plitvice Lake	> 50 ha
Gashi et al. [72]	water	Kosovo/Batllava Lake	> 50 ha
Malsui et al. [73]	water, sediment	Kosovo/Batllava Lake	> 50 ha
Sahiti et al. [74]	water, *Cyprinus carpio*	Kosovo/Batllava and Radoniqi Lake	> 50 ha
Latifi et al. [75]	*Cyprinus carpio*	Kosovo/Batllava and Badovci Lake	> 50 ha
Vrhovnik et al. [76]	water, sediment, *Vimba melanops*, *Rana temporaria*	North Macedonia/Kalimanci Lake	> 50 ha

(continued)

Table 1 (continued)

Vrhovnik et al. [77]	sediment	North Macedonia/Kalimanci Lake	> 50 ha
Vrhovnik et al. [78]	sediment	North Macedonia/Kalimanci Lake	> 50 ha
Tziritis et al. [79]	water	North Macedonia/Micro Prespa Lake	> 50 ha
Petrović et al. [80]	sediment, *Trapa natans*	Montenegro/Skadar Lake	> 50 ha
Kastratovic et al. [81]	*Phragmites australis*	Montenegro/Skadar Lake	> 50 ha
Kastratović et al. [82]	water, sediment, *Phragmites australis*, *Ceratophyllum demersum*, *Lemna minor*	Montenegro/Skadar Lake	> 50 ha
Rakočević et al. [83]	*Scardinius knezevici*, *Alburnus scoranza*, *Cyprinus carpio*, *Rutilus prespensis*, *Anguilla anguilla*, *Perca fluviatilis*	Montenegro/Skadar Lake	> 50 ha
Vukašinović-Pešić et al. [84]	*Viviparus mamillatus*	Montenegro/Skadar Lake	> 50 ha
Vukašinović-Pešić & Blagojević [85]	macrophytes, molluscs, fish	Montenegro/Skadar Lake	> 50 ha
Branković et al. [86]	water, sediment, macrophytes	Serbia/Gruža Lake	> 50 ha
Branković et al. [87]	water, sediment, macrophytes	Serbia/Gruža, Bubanj*, Šumarice* lakes	> 50 ha * < 50 ha
Milošković et al. [88]	water, sediment, macrophytes, fish	Serbia/Gruža	> 50 ha
Milošković et al. [89]	*Sander lucioperca*, *Silurus glanis*, *Esox lucius*	Serbia/Bovan Lake	> 50 ha

(continued)

Table 1 (continued)

Milošković et al. [90]	*Sander lucioperca*, *Silurus glanis*, *Esox lucius*, *Carassius gibelio*, *Abramis brama*	Serbia/Bovan Lake	> 50 ha
Sakan et al. [58]	sediment	Serbia/Barje, Ćelije, Vrutci, Garaši, Bojnik, Bovan lakes	> 50 ha
Sunjog et al. [91]	water, sediment, *Squalius cephalus*	Serbia/Zlatar, Garaši lakes	> 50 ha
Jaćimović et al. [92]	*Perca fluviatilis*, *Ameiurus melas*	Serbia/Sava Lake	> 50 ha
Rašković et al. [93]	*Squalius cephalus*	Serbia/Međuvršje*, Kruščica lakes	> 50 ha * < 50 ha
Đikanović et al. [94])	*Chondrostoma nasus*, *Rutilus rutilus*, *Abramis brama*, *Barbus barbus*, *Carassius gibelio*, *Squalius cephalus*, *Perca fluviatilis*, *Silurus glanis*, *Esox lucius*	Serbia/Međuvršje Lake	< 50
Đikanović et al. [95]	*Chodrostoma nasus*	Serbia/Međuvršje Lake	< 50
Djikanović et al. [48]	sediment, macrophytes, fish	Serbia/Međuvršje Lake	< 50
Svirčev et al. [55]	water, sediment, fish	Serbia/Aleksandrovac Lake	< 50
Milošković et al. [96]	*Alburnus* spp.	Serbia/Gruža, Međuvršje*, Vlasina, Zavoj lakes Skadar, Ohrid, Prespa, Dojran lakes	> 50 ha * < 50 ha
Nikolić et al. [97]	sediment, *Perca fluviatilis*	Serbia/Vlasina, Perućac, Zaovine, Međuvršje*, Garaši, Sava lakes	> 50 ha * < 50 ha

5 Creating awareness of the significance of pollution of small lakes and ponds through assessment of levels of PTEs in small Aleksandrovac Lake in Serbia

Looking at the literature overview, it is evident that most of the studies are related to lakes bigger than 50 ha, which leaves a significant gap in knowledge for the small lakes and ponds. Guided by this data, we decided to present the investigation of PTEs in fish species from Aleksandrovac Lake, located in South Serbia.

Aleksandrovac Lake (Fig. 1) is a man-made lake on the Aleksandrovac River, formed in 1964, at first, for irrigation purposes. It is characterized as oligosaline, shallow lake (maximum depth 4 m, average 2 m) with a surface area of 12 ha. Over time, already highly eutrophic Aleksandrovac Lake suffered almost anaerobic conditions, so it was completely restored and refilled in 2010. Despite this, massive fish mortality happened several times. In December 2012, the mortality of nearly the entire fish population was recorded (more than 1.7 tons), including *Cyprinus carpio*, *Ctenopharyngodon idella*, *Hypophthalmichthys molitrix*, *Abramis brama*, *Silurus glanis*, *Carassius gibelio*, *Aspius aspius*, and *Squalius cephalus*.

Fig 1 Map of Aleksandrovac Lake

5.1 Sampling and methodology

Bioindicator species distinguished by its flexibility and tolerance to environmental conditions and pollution, *Carassius gibelio* was sampled immediately after massive fish mortality at Aleksandrovac Lake on 20th December 2012. Twenty specimens were packed in special polyethylene bags 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, below the dorsal fin, liver, and gills of each specimen were dissected, weighed using an electronic balance (± 0.1 g), and stored at -20 °C before analysis.

The concentrations of 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 analytical procedure was described in our earlier research paper Milošković et al. [98]. The mean values and standard deviations were calculated for each group, and element concentrations were expressed as mg kg^{-1} wet weight (ww).

Although the muscle tissue (meat) of *Carassius gibelio* was used for element analysis, concentrations of the elements were compared with the maximum permitted concentrations (MPCs) in fish meat for utilization in the human diet, established by the European Union [99], FAO [100], and Serbian national legislation [101].

The metal pollution index (MPI), which refers to element concentration in fish tissues, was calculated using the following equation [102]:

$$MPI = (cf1 \times cf2 \times cf3 \times \ldots \times cfn)^{1/n} \quad (1)$$

where cfn = concentration of the element n in the sample.

5.2 Potentially toxic elements in fish tissues

Concentrations of PTEs in three tissues of *Carassius gibelio* are summarized in Table 2. The highest concentrations of Al, As, Cu, Cr, Mn, Ni, Pb, Se, Zn, and Cd in gills, Co, Sn, and Fe in liver, and Hg in muscle were recorded. The distribution pattern was gills - liver - muscle for Al, As, Cu, Cr, Mn, Ni, Pb, Se, and Zn, gills-liver - muscle for Cd, liver - gills - muscle for Sn and Fe, liver - muscle - gills for Co and muscle - gills - liver for Hg.

Table 2 The average PTEs concentrations and standard deviation in the muscle, liver, and gills of *Carassius gibelio* in mg kg^{-1}ww and prescribed MPCs in fish meat

Elements	Muscle	Liver	Gills	MPC		
				MPC EU [99]	MPC FAO [100]	MPC RS [101]
Al	0.78 ± 0.09	ND	3.25 ± 0.8			
As	0.12 ± 0.05	ND	0.22 ± 0.09	0.1-4.0		2.0
Cd	0.005 ± 0.001	0.007 ± 0.0002	0.007 ± 0.0001	0.05	0.05	0.1

(continued)

Table 2 (continued)

Co	0.001 ± 0.002	0.02 ± 0.005	ND			
Cr	0.33 ± 0.18	0.3 ± 0.1	0.39 ± 0.1			
Cu	0.17 ± 0.08	0.46 ± 0.1	0.56 ± 0.32	30		30*
Fe	3.03 ± 1.4	87 ± 16.25	36 ± 9.81			30*
Hg	0.10 ± 0.02	ND	0.0005 ± 0.0001	0.5	0.5	0.5
Mn	0.30 ± 0.21	0.17 ± 0.06	8.64 ± 2.44			
Ni	0.006 ± 0.006	0.002 ± 0.001	0.04 ± 0.003			
Pb	0.22 ± 0.05	0.13 ± 0.06	0.43 ± 0.31	0.3	0.5	0.4
Se	0.21 ± 0.07	0.12 ± 0.04	0.32 ± 0.13			
Sn	0.0007 ± 0.001	0.14 ± 0.05	0.12 ± 0.05			
Zn	12.7 ± 0.64	8.61 ± 1.9	75.13 ± 15.16		100	100*

ND – not detected, *MPCs in canned products

Since it was introduced in European freshwaters in the 1970s, *Carassius gibelio* has been economically important for fisheries in Serbia [103]. The negative impact of PTEs on human health was analyzed by comparing the concentrations of these elements with the appropriate MPCs [99, 100, 101]. Concentrations of As and Fe in gills were above MPC prescribed by Serbian legislation, while Pb in gills was above MPC prescribed by Serbian legislation and EU. There were no PTEs in fish muscle (fish meat) above MPCs, suggesting no risk for humans consuming fish despite massive fish mortality.

The MPI is more reliable for expressing the pollution status of fish than accumulation patterns since it considers all metals synchronously. The concentrations of PTEs affected the MPI values (Fig. 2), which points out that the muscle was exposed to the lower pressure of PTEs pollution than liver and gills. The reason for higher values of MPI for gills may be the fact that gills are the primary site of element uptake from water, especially if elements are bound to particulate matters. It is recommended that gills should be removed before using fish in the human diet due to elevated concentrations of the most toxic elements — As and Pb.

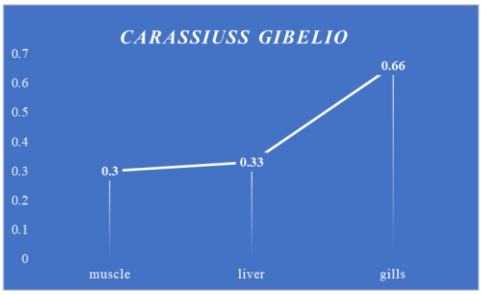

Fig. 2 Metal pollution index (MPI) values of the total element accumulation levels in the muscle, liver, and gills tissues in *Carassius gibelio*

Svirčev et al. [55] collected data a month before massive fish mortality happened in Aleksandrovac Lake. Their results represent concentrations of PTEs in muscle, liver, and gills of undetermined fish species, so we cannot compare the concentrations of PTEs in our study with their published results. We can solely emphasize that values of PTEs were higher in the study Svirčev et al. [55]. Svirčev et al. [55] excluded the possibility of metal poisoning and assumed that toxic metabolites produced by cyanobacterium *Cylindrospermopsis raciborskii* caused the fish mortality in Aleksandrovac Lake.

Aleksandrovac Lake came into the public spotlight after over 1.7 tons of fish were killed. Before fish mortality, the problems in this lake were solved occasionally and insufficiently. Recognizing in time the importance of small lakes and ponds is the basis for continuous long-term monitoring and legal regulations which can provide protection of small water bodies. This is a global problem that needs to be solved in the future in order to preserve small water bodies.

6 Conclusions

This chapter provides an insight into the pollution status of lakes and ponds in the Western Balkan countries. Analysis of available literature shows that most studies are related to lakes bigger than 50 ha, which leaves a significant knowledge gap for the small lakes and ponds. Presented results of the investigation of PTEs in fish species from small Aleksandrovac Lake in Southern Serbia indicate that fish muscle (meat) was exposed to the lower pressure of PTEs pollution than liver and gills. That suggests, despite massive fish mortality, there was no risk for human health by fish consumption. In the future, more comprehensive studies need to be done globally to conserve small water bodies, especially shallow lakes and ponds.

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References

1. Lorenz S, Rasmussen JJ, Süß A et al (2017) Specifics and challenges of assessing exposure and effects of pesticides in small water bodies. Hydrobiologia 793:213-224. https://doi.org/10.1007/s10750-016-2973-6
2. Céréghino R, Biggs J, Oertli B et al (2008) The ecology of European ponds: defining the characteristics of a neglected freshwater habitat. Hydrobiologia 597:1-6. https://doi.org/10.1007/s10750-007-9225-8
3. Downing JA, Prairie YT, Cole JJ et al (2006) The global abundance and size distribution of lakes, ponds, and impoundments. Limnol Oceanogr 51(5):2388-2397. https://doi.org/10.4319/lo.2006.51.5.2388
4. Oertli B, Céréghino R, Hull A (2009) Pond conservation: from science to practice. Hydrobiologia 634:1-9. https://doi.org/doi 10.1007/s10750-009-9891-9
5. Pond Conservation Group (1993) A future for Britain's ponds: an agenda for action. Pond Conservation Group, Oxford
6. Ramsar Convention Secretariat (2013) The Ramsar Convention Manual: a guide to the Convention on Wetlands (Ramsar, Iran, 1971), 6th ed. Ramsar Convention Secretariat, Gland, Switzerland
7. Biggs J, von Fumetti S, Quinn-Kelly M (2017) The importance of small waterbodies for biodiversity and ecosystem services: implications for policy makers. Hydrobiologia 793:3-39. https://doi.org/10.1007/s10750-016-3007-0
8. Oertli B, Joye DA, Castella E et al (2002) Does size matter? The relationship between pond area and biodiversity. Biol Conserv 104:59-70. https://doi.org/10.1016/S0006-3207(01)00154-9
9. Søndergaard M, Jeppesen E, Jensen JP (2005) Pond or lake: does it make any difference? Archiv für Hydrobiologie 162:143-165. https://doi.org/doi 10.1127/0003-9136/2005/0162-0143
10. Kristensen P, Globevnik L (2014) European small water bodies. Biology and Environment: Proceeding of the Royal Irish Academy 2014. https://doi.org/10.3318/BIOE.2014.13
11. Biggs J, Nicolet P, Mlinaric M et al (2014) Report of the workshop on the protection and management of small water bodies, Brussels, 14th November 2013. The European Environmental Bureau (EEB) and The Freshwater Habitats Trust: 23p
12. Downing JA (2010) Emerging global role of small lakes and ponds: little things mean a lot. Limnetica 29(1):9-24
13. Williams P, Whitfield M, Biggs J (2004) Comparative biodiversity of rivers, streams, ditches, and ponds in an agricultural landscape in Southern England. Biol Conserv 115:329-341. https://doi.org/10.1016/S0006-3207(03)00153-8
14. Bartout P, Touchart L, Terasmaa J et al (2015) A new approach to inventorying bodies of water, from local to global scale. Journal of The Geographical Society of Berlin 146:245-258. https://doi.org/10.12854/erde-146-20
15. Brönmark C, Hansson L (2002) Environmental issues in lakes and ponds: Current state and perspectives. Environ Conserv 29(3):290-307. https://doi.org/10.1017/S0376892902000218
16. Rannap R, Lohmus A, Briggs L (2009) Restoring ponds for amphibians: a success story. Hydrobiologia 634:87-95. https://doi.org/10.1007/s10750-009-9884-8

17. Hutinec JB, Struna S (2007) A survey of ponds and their loss in Žumberak-Samoborsko gorje Nature Park, northwest Croatia. Natura Croatica: Periodicum Musei Historiae Naturalis Croatici 16(2):121-137
18. Sremački M, Obrovski B, Petrović M et al (2020) Comprehensive environmental monitoring and assessment of protected wetland and lake water quality in Croatia and Serbia. Environ Monit Assess 192(3):1-11. https://doi.org/10.1007/s10661-020-8141-5
19. Ranđelović V, Matejić J, Zlatković B (2007) Flora i vegetacija Batušinačkih bara kod Niša. Paper presented at the 9th Symposium on Flora of Southeastern Serbia and Neighbouring Regions, University of Niš, Niš, 1-3 September 2007
20. Tasevska O, Špoljar M, Gušeska D et al (2017) Summer rotifer assemblages in three reservoirs in the Republic of Macedonia. Acta Zool Bulg 8:77-84
21. Ostojić A (2004) Faunistic compostion of the zooplankton of Lake Bubanj. Kragujevac J Sci 26:107-110
22. Ostojić A, Obradović M, Radoičić D (2012) Faunistic composition of zooplankton in the Šumarice lake (Kragujevac, Serbia). Kragujevac J Sci 34:87-96
23. Ostojić A, Radojević I, Obradović M et al (2012) A checklist of freshwater zooplankton on the territory of Kragujevac city (Serbia) and it's surrounding areas. Water Research and Management 2(3):35-42
24. Špoljar M, Tomljanović T, Lalić I (2011) Eutrophication impact on zooplankton community: a shallow lake approach. The holistic approach to environment 1(4):131-142
25. Špoljar M, Dražina T, Lajtner J et al (2018) Zooplankton assemblage in four temperate shallow waterbodies in association with habitat heterogeneity and alternative states. Limnologica 71:51-61. https://doi.org/10.1016/j.limno.2018.05.004
26. Kuczyńska-Kippen N, Pronin M, Špoljar M (2019) Specificity of zooplankton communities inhabiting small water bodies in two regions of Europe: Poland vs. Croatia. In: Abstracts of Biocenozy wód płynących w kontekście zmian hydrologicznych, Uniwersytet im. Adama Mickiewicza, Szczecin, 25-27 September 2019
27. Mancinelli G, Mali S, Belmonte G (2019) Species richness and taxonomic distinctness of zooplankton in ponds and small lakes from Albania and North Macedonia: the role of bioclimatic factors. Water 11(11):2384. https://doi.org/10.3390/w11112384
28. Ranković B, Simić S, Bogdanović D (2006) Phytoplankton as indicator of water quality of lakes Bubanj and Šumarice during autumn. Prirodno-matematički fakultet, Univerzitet u Kragujevcu
29. Svirčev Z, Simeunović J, Subakov-Simić G et al (2013) Cyanobacterial blooms and their toxicity in Vojvodina lakes, Serbia. Int J Environ Res 7(3):745-758
30. Đorđević N, Simić S (2014) Cyanobacterial blooms in oligosaline and alkaline microaccumulation before and after rehabilitation. Pol J Environ Stud. 23(6):1975-1982
31. Simić S, Đorđević N, Milošević Dj (2017) The relationship between the dominance of Cyanobacteria species and environmental variables in different seasons and extreme precipitation. Fund Appl Limnol 190(1):1-11. https://doi.org/10.1127/fal/2017/0975
32. Temunović M, Šerić Jelaska L, Durbešić P (2007) Diversity of water beetles (Hydradephaga, Coleoptera) in temporary ponds of Lonjsko polje Nature Park, Croatia. Entomologia Croatica, 11(1-2):13-24

33. Vilenica M, Pozojević I, Vučković N et al (2020) How suitable are man-made water bodies as habitats for Odonata? Knowl Manag Aquat Ec 421:13. https://doi.org/10.1051/kmae/2020008
34. Pešić S (2000) Weevils (Coleoptera: Curculionoidea) of the lakes of Kragujevac (first communication). Acta ent serb 5(112):13-28
35. Stanić S, Kekić V, Pavlović-Lučić S (2002) A contribution to knowledge of Drosophilidae (Diptera) fauna in Kragujevac basin. Acta ent serb 7(1/2):151-154
36. Pešić S (2012) Aquatic weevil (Coleoptera: Curculionoidea) assembly response to the different ecological conditions in artificial lakes in central Serbia. Arch Biol Sci 64(4):1523-1531. https://doi.org/10.2298/ABS1204523P
37. Turić N, Merdić E, Hackenberger Kutuzović B et al (2011) Diversity of aquatic insects (Heteroptera: Nepomorpha, Gerromorpha and Coleoptera: Hydradephaga, Hydrophilidae) in the karst area of Gorski kotar, Croatia. Natura Croatica: Periodicum Musei Historiae Naturalis Croatici 20(1):179-188
38. Belmonte G, Alfonso G, Beadini N et al (2018) An inventory of invertebrate fauna of Albania and Macedonia Lakes. Thalassia Salentina 40(2):27-38
39. Pozojević I, Vučković N, Dorić V et al (2021) Contribution to the knowledge of the water mite (Acari: Hydrachnidia) fauna of Croatia-New data and records from a permanent pool in the Dinaric karst region. Persian J Acarol 10(1):1-7. https://doi.org/10.22073/pja.v10i1.62352
40. Pavlović M, Simonović P, Stojković M et al (2015) Analysis of diet of piscivorous fishes in Bovan, Gruža and Šumarice Reservoir, Serbia. Iranian Journal of Fisheries Sciences 14(4):908-923
41. Khanom M, Rouf M, Ahsan N et al (2020) Morphological characteristics, growth and age structure of allochthonous fish pumpkinseed, *Lepomis gibbosus* in Bara Lake, Croatia. Bulgarian Journal of Agricultural Science 26(1):213-222
42. Jeppesen E, Søndergaard M, Meerhoff M et al (2007) Shallow lake restoration by nutrient loading reduction - some recent findings and challenges ahead. Hydrobiologia 584:239-252. https://doi.org/10.1007/s10750-007-0596-7
43. Erwin KL (2008) Wetlands and global climate change: the role of wetland restoration in a changing world. Wetl Ecol Manag 17(1):71-84. https://doi.org/10.1007/s11273-008-9119-1
44. EEA ETC/ICM (2010) Climate change impacts on water quality and biodiversity. Background Report for EEA European Environment State and Outlook Report 2010. Report from the EEA European Topic Centre on Inland, Coastal and Marine Waters. http://icm.eionet.europa.eu/ETC_Reports. Accessed 30 March 2021
45. Rasmussen JJ, Wiberg-Larsen P, Baattrup-Pedersen A et al (2012) Stream habitat structure influences macroinvertebrate response to pesticides. Environ Pollut 164:142-9. https://doi.org/10.1016/j.envpol.2012.01.007
46. Beketov MA, Kefford BJ, Schafer RB et al (2013) Pesticides reduce regional biodiversity of stream invertebrates. P NATL ACAD SCI USA 110 (27):11039-43. https://doi.org/10.1073/pnas.1305618110
47. Has-Schön E, Bogut I, Vuković R et al (2015) Distribution and age-related bioaccumulation of lead (Pb), mercury (Hg), cadmium (Cd), and arsenic (As) in tissues of common carp (*Cyprinus carpio*) and European catfish (*Silurus glanis*) from the Buško Blato reservoir (Bosnia and Herzegovina). Chemosphere 135:289-296. https://doi.org/10.1016/j.chemosphere.2015.04.015

48. Djikanović V, Skorić S, Spasić S et al (2018) Ecological risk assessment for different macrophytes and fish species in reservoirs using biota-sediment accumulation factors as a useful tool. Environ Pollut 241:1167-1174. https://doi.org/10.1016/j.envpol.2018.06.054
49. Maceda-Veiga A, Monroy M, de Sostoa A (2012) Metal bioaccumulation in the Mediterranean barbel (*Barbus meridionalis*) in a Mediterranean River receiving effluents from urban and industrial wastewater treatment plants. Ecotoxicol Environ 76:93-101. https://doi.org/10.1016/j.ecoenv.2011.09.013
50. Van den Roovaart J, van Duijnhoven N, Fribourg-Blanc B et al (2017) Emissions of pollutants to Europe's waters - sources, pathways and trends, ed. Künitzer, A., ETC/ICM Technical Report 3/2017, Magdeburg: European Topic Centre on inland, coastal and marine waters, 96 pp
51. Dallinger R, Prosi F, Segner H et al (1987) Contaminated food and uptake of heavy metals by rainbow trout (*Salmo gairdneri*): a field study. Oecologia 73:91-98
52. Phillips G, Wilby N, Moss B (2016) Submerged macrophyte decline in shallow lakes: What have we learnt in the last forty years? AQUAT BOT 135:37-45. https://doi.org/10.1016/j.aquabot.2016.04.004
53. Bartram J, Ballance R, World Health Organization & United Nations Environment Programme (1996) Water quality monitoring: a practical guide to the design and implementation of freshwater quality studies and monitoring programs / edited by Jamie Bartram and Richard Ballance. London:E & FN Spon. https://apps.who.int/iris/handle/10665/41851
54. Đorđević N, Simić S, Ćirić A (2015) First identification of the cylindrospermopsin (CYN) - producing cyanobacterium *Cylindrospermopsis raciborskii* (Woloszyńska) Essnayya & Subra Raju in Serbia. Fresen Environ Bull 24(11a):736-3742
55. Svirčev Z, Obradović V, Codd GA et al (2016) Massive fish mortality and *Cylidrospermopsis raciborskii* bloom in Aleksandrovac Lake. Ecotoxicology 25(7):1353-1363. https://doi.org/10.1007/s10646-016-1687-x
56. Simić S, Komárek J, Đorđević N (2014) The confirmation of the genus *Glaucospira* (Cyanobacteria) and the Occurrence of *Glaucospira laxissima* (G. S. West) comb. nova in Serbia. Cryptogamie Algologie 35(3):259-267. https://doi.org/10.7872/crya.v35.iss3.2014.259
57. Drobac D, Tokodi N, Lujić J et al (2016) Cyanobacteria and cyanotoxins in fishponds and their effects on fish tissue. Harmful Algae 55:66-76. https://doi.org/10.1016/j.hal.2016.02.007
58. Sakan S, Ostojić B, Đorđević D (2017) Persistent organic pollutants (POPs) in sediments from river and artificial lakes in Serbia. J Geochem Explor 180:91-100. https://doi.org/10.1016/j.gexplo.2017.06.008
59. Romanić S, Vuković G, Klinčić D et al (2018) Organochlorine pesticides (OCPs) and polychlorinated biphenyls (PCBs) in Cyprinidae fish: Towards hints of their arrangements using advanced classification methods. Environ Res 165:349-357. https://doi.org/10.1016/j.envres.2018.05.003
60. Grba N, Krčmar D, Maletić S et al (2016) Organic and inorganic priority substances in sediments of Ludaš Lake, a cross-border natural resource on the Ramsar list. Environ Sci Pollut R 24(2):1938-1952. https://doi.org/10.1007/s11356-016-7904-6
61. Dvoršćak M, Fingler S, Mendaš G et al (2019) Distribution of organochlorine pesticide and polychlorinated biphenyl residues in lake sediment cores from the Plitvice Lakes National Park (Croatia). Arch Environ Contam Toxicol 77(4):537-548. https://doi.org/10.1007/s00244-019-00668-z

62. Kljaković-Gašpić Z, Herceg Romanić S, Bituh T et al (2018) Assessment of multiple anthropogenic contaminants and their potential genotoxicity in the aquatic environment of Plitvice Lakes National Park, Croatia. Environ Monit Assess 190(11). https://doi.org/10.1007/s10661-018-7028-1
63. Sula E, Aliko V, Barceló D et al (2020) Combined effects of moderate hypoxia, pesticide and PCBs upon crucian carp fish, *Carassius carassius*, from a freshwater lake - in situ ecophysiological approach. Aquat Toxicol, 105644. https://doi.org/10.1016/j.aquatox.2020.105644
64. Malaj E, Rousseau DPL, Du Laing G et al (2011) Near-shore distribution of heavy metals in the Albanian part of Lake Ohrid. Environ Monit Assess 184(4):1823-1839. https://doi.org/10.1007/s10661-011-2081-z
65. Dalo E, Sadikaj R, Sahiti H (2019) Assessment of accumulation of heavy metals and lipid peroxidation in common reed (*Phragmites australis*) in the Albanian Part of Lake Ohrid. Journal of Ecological Engineering 20(4):114-120. https://doi.org/10.12911/22998993/102794
66. Has-Schön E, Bogut I, Rajković V et al (2008) Heavy metal distribution in tissues of six fish species included in human diet, inhabiting freshwaters of the Nature Park “Hutovo Blato” (Bosnia and Herzegovina). Arch Environ Con Tox 54(1):75-83. https://doi.org/10.1007/s00244-007-9008-2
67. Has-Schön E, Bogut I, Kralik G et al (2008) Heavy metal concentration in fish tissues inhabiting waters of “Buško Blato” reservoar (Bosnia and Herzegovina). Environ Monit Assess 144(1-3):15-22. https://doi.org/10.1007/s10661-007-9627-0
68. Popović M, Nedić D, Pećanac B et al (2019) The toxic element concentration in fish tissues from Saničani Lake, an urban environment, in Bosnia and Herzegovina. Biol Trace Elem Res 197:271-278. https://doi.org/10.1007/s12011-019-01982-2
69. Ivanković A, Jurković J, Habul EV et al (2016) Contribution to the knowledge of the Blidinje Lake sediment (Bosnia and Herzegovina). Austin J Earth Sci 2(3):1016
70. Vukosav P, Mlakar M, Cukrov N et al (2013) Heavy metal contents in water, sediment and fish in a karst aquatic ecosystem of the Plitvice Lakes National Park (Croatia). Environ Sci Pollut R 21(5):3826-3839. https://doi.org/10.1007/s11356-013-2377-3
71. Horvatinčić N, Briansó JL, Obelić B et al (2006) Study of pollution of the Plitvice Lakes by water and sediment analyses. Water, Air, and Soil Pollution: Focus 6 (5-6):475-485. https://doi.org/10.1007/s11267-006-9031-8
72. Gashi F, Frančišković-Bilinski S, Bilinski H et al (2017) Assessing the distribution of trace elements in water from Batllava Lake (Kosovo). Sustain Water Resour Manag 3(1):1-12. https://doi.org/10.1007/s40899-017-0077-8
73. Malsiu A, Shehu I, Stafilov T et al (2020) Water quality and sediment contamination assessment of the Batllava Lake in Kosovo using fractionation methods and pollution indicators. Arab J Geosci 13:412. https://doi.org/10.1007/s12517-020-05408-5
74. Sahiti H, Bislimi K, Dalo E et al (2018) Effect of water quality in hematological and biochemical parameters in blood of common carp (*Cyprinus carpio*) in two lakes of Kosovo. Natural and Engineering Sciences 3(3):323-332. https://doi.org/10.28978/nesciences.468987
75. Latifi F, Haziri I, Rama1 A et al (2017) Assessment of heavy metal contamination in some organs of the common carp growing in lakes in Kosovo. Veterinaria 66(3):139-144

76. Vrhovnik P, Arrebola JP, Serafimovski T et al (2013). Potentially toxic contamination of sediments, water and two animal species in Lake Kalimanci, FYR Macedonia: Relevance to human health. Environ Pollut 180:92-100. https://doi.org/10.1016/j.envpol.2013.05.004
77. Vrhovnik P, Šmuc NR, Dolenec T et al (2013) An evaluation of trace metal distribution and environmental risk in sediments from the Lake Kalimanci (FYR Macedonia). Environ Earth Sci 70(2):761-775. https://doi.org/10.1007/s12665-012-2166-1
78. Vrhovnik P, Šmuc NR, Dolenec T et al (2013) Impact of Pb-Zn mining activity on surficial sediments of Lake Kalimanci (FYR Macedonia). Turk J Earth Sci 22:996-1009. https://doi.org/10.3906/yer-1205-1
79. Tziritis EP (2014) Environmental monitoring of Micro Prespa Lake basin (Western Macedonia, Greece): hydrogeochemical characteristics of water resources and quality trends. Enviro Monit Assess 186(7):4553-4568. https://doi.org/10.1007/s10661-014-3719-4
80. Petrović D, Jančić D, Furdek M et al (2016) Aquatic plant *Trapa natans* L. as bioindicator of trace metal contamination in a freshwater lake (Skadar Lake, Montenegro). Acta Bot Croat 75(2):236–243. https://doi.org/10.1515/botcro-2016-0031
81. Kastratović V, Krivokapić S, Đurović D et al (2013) Seasonal changes in metal accumulation and distribution in the organs of *Phragmites australis* (common reed) from Lake Skadar, Montenegro. J Serb Chem Soc 78(8):1241-1258. https://doi.org/10.2298/JSC121026153K
82. Kastratović V, Bigović M, Jaćimović Ž et al (2018) Levels and distribution of cobalt and nickel in the aquatic macrophytes found in Skadar Lake, Montenegro. Environ Sci Pollut Res 25(27):26823-26830. https://doi.org/10.1007/s11356-018-1388-5
83. Rakocevic J, Sukovic D, Maric D (2018) Distribution and relationships of eleven trace elements in muscle of six fish species from Skadar Lake (Montenegro). Turk J Fish Aquat Sci 18(5):647-657. https://doi.org/10.4194/1303-2712-v18_5_01
84. Vukašinović-Pešić V, Blagojević N, Vukanović S et al (2017) Heavy metal concentrations in different tissues of the snail *Viviparus mamillatus* (Küster, 1852) from lacustrine and riverine environments in Montenegro. Turk J Fish Aquat Sci 17(3):557-563. https://doi.org/10.4194/1303-2712-v17_3_12
85. Vukašinović-Pešić V, Blagojević N (2018) Metal pollution: evidences from plants, aquatic invertebrates and fish from Lake Skadar. In: Pešić V, Karaman G, Kostianoy A (ed) The Skadar/Shkodra Lake environment. The Handbook of Environmental Chemistry, vol 80. Springer International Publishing, Springer Nature Switzerland AG, pp 141-151
86. Branković S, Pavlović-Muratspahić D, Topuzović M et al (2010) Concentration of some heavy metals in aquatic macrophytes in reservoir near city Kragujevac (Serbia). Biotechnology & Biotechnological Equipment 24:223-227. https://doi.org/10.1080/13102818.2010.10817840
87. Branković S, Pavlović-Muratspahić D, Topuzović M et al (2011) Environmental study of some metals on several aquatic macrophytes. African Journal of Biotechnology 10(56):11956-11965. https://doi.org/10.5897/AJB10.2655
88. Milošković A, Branković S, Simić V et al (2013) The accumulation and distribution of metals in water, sediment, aquatic macrophytes and fishes of the Gruža Reservoir, Serbia. B Environ Contam Tox 90(5):563-569. https://doi.org/10.1007/s00128-013-0969-8
89. Milošković A, Dojčinović B, Simić S et al (2014) Heavy metal and trace element bioaccumulation in target tissues of three edible predatory fish species from Bovan reservoir (Serbia). Fresen Environ Bull 23(8a):1884-1891

90. Milošković A, Simić V (2015) Arsenic and other trace elements in five edible fish species in relation to fish size and weight and potential health risks for human consumption. Pol. J. Environ. Stud. 24(1):199-206. https://doi.org/10.15244/pjoes/24929
91. Sunjog K, Kolarević S, Kračun-Kolarević M et al (2016) Assessment of status of three water bodies in Serbia based on tissue metal and metalloid concentration (ICP-OES) and genotoxicity (comet assay). Environ Pollut 213:600-607. https://doi.org/10.1016/j.envpol.2016.03.008
92. Jaćimović M, Lenhardt M, Višnjić-Jeftić Ž et al (2015) Elemental concentrations in different tissues of European perch and bullhead from Sava Lake (Serbia). Slov Vet Res 52(2):57-65
93. Rašković B, Poleksić V, Skorić S et al (2018) Effects of mine tailing and mixed contamination on metals, trace elements accumulation and histopathology of the chub (*Squalius cephalus*) tissues: Evidence from three differently contaminated sites in Serbia. Ecotox Environ Safe 153:238-247. https://doi.org/10.1016/j.ecoenv.2018.01.058
94. Đikanović V, Skorić S, Gačić Z (2016) Concentrations of metals and trace elements in different tissues of nine fish species from the Međuvršje Reservoir (West Morava River Basin, Serbia) Arch Biol Sci 68(4):811-819. https://doi.org/10.2298/ABS151104069D
95. Djikanović V, Skorić S, Jarić I et al (2016) Age-specific metal and accumulation patterns in different tissues of nase (*Chodrostoma nasus*) from the Medjuvršje Reservoir. Sci Total Environ 566-567:185-190. https://doi.org/10.1016/j.scitotenv.2016.05.072
96. Milošković A, Milošević Đ, Radojković N et al (2018) Potentially toxic elements in freshwater (*Alburnus* spp.) and marine (*Sardina pilchardus*) sardines from the Western Balkan Peninsula: An assessment of human health risk and management. Sci Total Environ 644:899-906. https://doi.org/10.1016/j.scitotenv.2018.07.041
97. Nikolić D, Skorić S, Lenhardt M et al (2019) Risk assessment of using fish from different types of reservoirs as human food - A study on European perch (*Perca fluviatilis*). Environ Pollut 113586. https://doi.org/10.1016/j.envpol.2019.11358
98. Milošković A, Dojčinović B, Kovačević S et al (2016) Spatial monitoring of heavy metals in the inland waters of Serbia: a multispecies approach based on commercial fish. Environ Sci Pollut R 23(10):9918-9933. https://doi.org/10.1007/s11356-016-6207-2
99. EU (2006) Commission Regulation (EC) No. 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs (Text with EEA relevance). Official Journal of the European Union No. 1881/2006 364:5-24. https://eurlex.europa.eu/eli/reg/2006/1881/oj (Accessed 23.02.2021)
100. FAO (1983) Compilation of legal limits for hazardous substances in fish and fishery products. FAO Fish Circ 464:5-100
101. Official Gazzette of RS (2011) Regulation on quantity of pesticides, metals, metalloids, and other toxic substances, chemotherapeutics, anabolics, and other substances which can be found in food. Official Gazzette of RS No 28/2011. Retrieved from www.pravno informacioni sistem.rs/SlGlasnikPortal/prilozi/5.html&doctype=reg&abc=cba&eli=true&eliActId=427071&regactid=427071
102. Usero J, González-Regalad E, Gracia I (1997) Trace metals in the bivalve mollusks *Ruditapes decussates* and *Ruditapes philippinarum* from the Atlantic Coast of Southern Spain. Environ Int 23(3):291-298. https://doi.org/10.1016/S0160-4120(97)00030-5
103. Smederevac-Lalić M, Višnjić-Jeftić Ž, Pucar M et al (2011) Fishing circumstances on the Danube in Serbia. Water Research and Management 1(4):45-49