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# Potentially toxic elements in pikeperch (*Sander lucioperca* L.) from the Gruža reservoir: Health risk assessment related to fish consumption by the general population and fishermen

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*Abstract:* The aim was to evaluate concentrations of 14 potentially toxic elements in three tissues (muscle, liver and gills) of pikeperch (*Sander lucioperca*) and to assess health risk (the potential non-cancerogenic – tTotal target hazard quotient (*TTHQ*) and cancerogenic – target carcinogenic risk factor (*TR*) health risk) associated with the consumption of pikeperch from the Gruža Reservoir by the general population and fishermen. A value of Fulton's condition factor (*CF*) of less than one in our study indicated the poor general health of pikeperch. According to metal pollution index (*MPI*), the liver was exposed to the highest pressure of metal pollution. Levels of elements were lower than the national levels and international threshold levels, thus suggested a very likely absence of contamination risk of fish with elements in the Gruža Reservoir. Higher *TTHQ* was observed for fishermen (0.25) compared to the general population (0.20). Higher value of *TR* for As compared to *TR* for Pb was detected, both for the general population and for fishermen. In general, there was no risk to human health from pikeperch consumption, but fishermen were at slightly higher health risk to develop cancer if they consume pikeperch meat compared to the general population.

*Keywords:* water supply reservoir; piscivore fish; fish tissues; Serbia.

## INTRODUCTION

Numerous health benefits from consuming fish that provide many essential nutrients such as high-value proteins, various vitamins and minerals and polyunsaturated omega-3 fatty acids, and the danger of excessive intake of potentially

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toxic elements, such as arsenic, mercury, cadmium and lead, due to the consumption of contaminated fish meat are in confrontation.[1] Fish and fish products are among the food categories that contribute most to human exposure to dietary contaminants.[2] In an era where the emphasis is on healthier principles in human nutrition based on fish consumption instead of other types of meat, it is important to assess the risk of potentially toxic elements (PTEs) of the fish used in the human diet.

The globally present problem of PTEs water pollution has not bypassed Serbia, and Teodorović[3] highlights a large number of „hot spots" of extreme pollution. Among aquatic biota, fish species are the most sensitive taxa to the long-term effects of pollution.[4] The uptake and bioaccumulation of PTEs in fish depend on the biological characteristics of fish (*e.g.*, length and weight, age, behaviour or nutrition), the properties of PTEs, as well as properties of aquatic ecosystems.[5,6] Inland waters are sinks for pollutants (urban, industrial, and agricultural runoff), and according to Brönmark and Hansson[7] stagnant waters (reservoirs) are usually impacted by PTEs due to point sources. Lentic ecosystems (*i.e.*, rivers) often carry concentrations of PTEs under detection limits compared to lotic (*i.e.*, reservoirs).[8] The problem of PTEs pollution is more present in reservoirs due to lower self-purification capacity and pollutant dispersion in those ecosystems.[9]

Gruža Reservoir is located in central Serbia. This reservoir was formed by building a dam on the Gruža River in 1984, with the main purpose of supplying drinking water to the city of Kragujevac and its surroundings. Contradictory, the reservoir is also used for recreational purposes. It represents the largest water surface in Central Serbia, with an area of 934 ha. With a low water depth (average reservoir depth of 6.5 m), more than two-thirds of the reservoir has the characteristics of a lowland reservoir.[10] The maximum depth of the reservoir is 31 m. The reservoir suffers a strong anthropogenic influence. It is surrounded by an agricultural area where agricultural measures in the form of pesticides and herbicides are constantly applied. The reservoir also receives unprocessed wastewater from illegally built surrounding touristic settlements.

A study on the accumulation of Fe, Pb, Cd, Cu, Mn, Hg and As in water, sediment, five macrophytes (*Typha angustifolia*, *Iris pseudacorus*, *Polygonum amphybium*, *Myriophyllum spicatum* and *Lemna gibba*) and muscle tissue of five fish species (*Sander lucioperca*, *Abramis brama*, *Carassius gibelio*, *Silurus glanis* and *Arystichtys nobilis*) has already been carried out in order to investigate the level of pollution in the reservoir.[11] The results of this study indicated higher concentrations of all examined elements in sediment than in water. Among the examined fish species, pikeperch (*Sander lucioperca*) showed the highest tendency to accumulate Pb and Hg in muscle tissue. The lack of data on the distribution of PTEs in tissues of pikeperch as the most valuable fish species in Gruža

Reservoir, as well as the potential health risks, is the reason for conducting our research.

Widely distributed in Europe and Asia pikeperch (*Sander lucioperca* L.) is an indigenous fish of the Danube basin.[12] As a common piscivore in fish communities of many European lakes with low water transparency,[13] it also inhabits almost all eutrophic lakes in Serbia. As a member of the first quality group, pikeperch is an extremely valued fish species in Serbia.[12,14] Additionally, pikeperch is highly desirable for human consumption due to its nutritional characteristics, including the composition of proteins and fatty acids and low-fat content (1–2 %) in muscle tissue.[15]

The fish catch by recreational fishermen is 1.5 higher than commercial fishing catch in Serbia.[16] When it comes to pikeperch, there is also a decline in commercial fishing. On the other hand, this species is particularly interesting for recreational fishermen. Illegal fishing of this species is also evident in the Gruža Reservoir, due to the meat's quality and high market price. Pikeperch is an important fish species in the diet, and certainly the entire catch from the Gruža Reservoir is used for human consumption.

Having in mind all of the above, this study aimed to evaluate in more detail concentrations of Al, As, Cd, Co, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Se, Sn and Zn in three tissues (muscle, liver and gills) of pikeperch. Also, the main aim of this study was to assess health risks (the potential non-cancerogenic *TTHQ* and cancerogenic *TR* health risk) associated with the consumption of pikeperch from the Gruža Reservoir by the general population and fishermen.

## EXPERIMENTAL

### *Fish sampling and sample preparation*

The field study was conducted at the Gruža Reservoir in central Serbia in the autumn of 2013. The sampling site coordinates are 43.927888 N, 20.678524E (Fig. 1).

Fish ($n$ = 20) were sampled using standing gillnets (50 m–30 mm mesh size, 130 m–50 mm mesh size, 100 m–100 mm mesh size) that were left overnight. Immediately after removing the nets from the water, each pikeperch individual was sacrificed with a quick blow to the head and then dissected. Before dissection, total length (*TL*; to the nearest mm) and body weight (*BW*; to the nearest g) were measured. The evaluation of fish health was done using Fulton's condition factor (*CF*) with the following formula by Ricker:[17]

$$CF = 100BW / TL^3 \quad (1)$$

Fish dissection was done with a decontaminated ceramic knife. Tissue samples (right dorsal muscle below the dorsal fin, right gills – second arch and liver) were washed with distilled water and transported on ice in a portable hand-held refrigerator to the laboratory.

In the laboratory, samples were weighed using an electronic scale (accuracy ±0.01 g) and stored at –20 °C prior to analysis. Before digestion in microwave Christ Alpha 2-4 LD, Harz, Germany, samples were 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 volume ratio) 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.

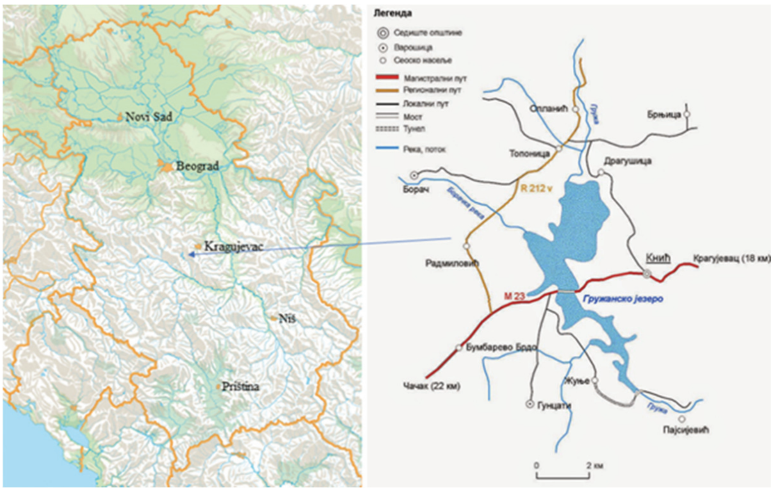


Fig. 1. Map of the sampling site (43.927888N, 20.678524E) at the Gruža Reservoir.

*Potentially toxic element analysis*

The concentration of elements in tissues of pikeperch was measured using an inductively-coupled plasma optical emission spectrometry (ICP-OES), using a Thermo Fisher Scientific iCAP 6500 Duo ICP (Cambridge, UK). The following wavelengths were used for the ICP-OES analysis (nm): Al 391.402, As 188.032, Cd 226.602, Co 221.618, Cr 204.542, Cu 322.764, Fe 257.921, Hg 183.940, Mn 260.353, Ni 234.606, Pb 222.354, Se 199.093, Sn 245.162 and Zn 207.194. Standard muscle reference material (DORM-4, National Research Council of Canada) was digested and analyzed in triplicate to support quality assurance and control. The following assigned/measured values for DORM-4 reference material in mg kg$^{-1}$ are given in Table I. Recovery ranged from 95.6 to 107.14 %.

TABLE I. Certified values of reference material DORM-4 and values experimentally obtained. Data are mean ± *SD*

| Element | Certified values, mg kg$^{-1}$ | Results obtained, mg kg$^{-1}$ | Recovery, % |
|---|---|---|---|
| As | 6.80±0.64 | 6.62±0.48 | 97.35 |
| Cd | 0.306±0.15 | 0.323±0.019 | 105.56 |
| Cr | 15.9±0.9 | 15.20±0.4 | 95.60 |
| Fe | 341±27 | 333.96±25.87 | 97.93 |
| Pb | 0.416±0.053 | 0.443±0.011 | 106.49 |
| Hg | 0.410±0.055 | 0.400±0.064 | 97.56 |
| Ni | 1.36±0.22 | 1.35±0.45 | 99.26 |
| Se | 3.56±0.34 | 3.61±0.59 | 101.40 |
| Sn | 0.056±0.010 | 0.060±0.013 | 107.14 |

Mean values and standard deviations were calculated for each group, and element concentrations were expressed as mg kg$^{-1}$ dry weight (dw). These concentrations were recalculated to wet weight (mg $kg^{-1}$) element concentrations, which were used to calculate the metal pollution index (*MPI*), compare the concentrations of Cd, Hg, Pb, As, Cu and Zn in fish muscles with maximum permissible concentrations (*MPC*) in fish meat determined by the national legislation of Serbia[18] and the European Union,[19] and to assess the risk to human health. According to these legislations, the MPCs for As, Cd, Cu, Hg, Pb and Zn are 2.0, 0.05, 30.0, 0.50, 0.30, and 100.0 mg $kg^{-1}$ ww, respectively.

*Metal pollution index (*MPI*)*

The *MPI* was calculated to compare the total metals content of fish muscles, gills and liver with each other using the following equation by Usero *et al.*:[20]

$$MPI = (c_1\ c_2\ \cdots c_n)^{1/n} \tag{2}$$

where *c* is the concentration of the metal *n* in the sample (mg $kg^{-1}$).

*Liver/muscle Hg index* – $L_{Hg}/M_{Hg}$

The liver/muscle Hg index was calculated as the ratio of the concentration of Hg in the liver and muscles:[21]

$$L_{\text{Hg}} / M_{\text{Hg}} = CL(\text{Hg}) / CM(\text{Hg}) \tag{3}$$

*Se:Hg mole ratio*

The Se:Hg mole ratio was calculated using the method of Burger *et al.*[26] The molar concentration of Hg was calculated by dividing the concentration of Hg (in mg $kg^{-1}$) from muscle tissue by the molecular weight of Hg (200.59). The molar concentration of Se was calculated by dividing the concentration of Se (in mg $kg^{-1}$) from muscle tissue by the molecular weight of Se (78.9).

*Health risk assessments*

*Target hazard quotient* – THQ. The *THQ*, a methodology taken from the US EPA Region III Risk-based Concentration table,[22] is described by the following equation:

$$THQ = 10^{-3}\, EF \times ED \times FIR \times C \,/\, (RFD \times WAB \times TA) \tag{4}$$

where *EF* is the exposure frequency (365 days/year); *ED* is the exposure duration (70 years), equivalent to the average lifetime; *FIR* is the food ingestion rate for freshwater fish for Serbia – 20 g/person per day for the general population and 25 g/person per day for fishermen;[23] *C* is the element concentration in pikeperch (mg $kg^{-1}$); *RFD* is the oral reference dose (Hg = 0.0005, Cd = 0.001, Pb = 0.004, Cu = 0.04, Zn = 0.3, Cr = 1.5, Mn = 0.14, Al = 0.0004, As = 0.0003, Fe = 0.04, Co = 0.0003, Ni = 0.02 mg $kg^{-1}$ per day);[22,24,25] *WAB* is the average body weight of an adult (70 kg); and *TA* is the average exposure time (365 days/year×*ED*).

Total *THQ* (*TTHQ*) was calculated using the following formula:

$$TTHQ = \Sigma THQ \tag{5}$$

*Target carcinogenic risk factor* – TR. The target carcinogenic risk factor (*TR*) for arsenic and lead was estimated using the equation:

$$TR = 10^{-3}\, EF \times ED \times FIR \times C \times CSFo \,/\, (WAB \times TA) \tag{6}$$

where *CSFo* is the oral carcinogenic slope factor (mg $kg^{-1}$ per day) which is 1.5 for As and 0.0085 for Pb.[22]

*Statistical analysis*

All values are expressed as mean(s) ± standard deviation (*SD*). At the beginning of the statistical analysis normality of data was tested using the Shapiro-Wilk test. In cases when data followed a normal distribution, we tested significant differences among groups using the one-way ANOVA, followed by Tukey's HSD posthoc test. On the contrary, we used the non-parametric Kruskal–Wallis *H* test, followed by the Mann–Whitney *U* test to assess differences among investigated groups. The significance level ($\alpha$) was at 5 %. All analyses were carried out using the SPSS 19.0 statistical package program for Windows (SPSS Inc., Chicago, IL, USA).

RESULTS AND DISCUSSION

The weight of the pikeperch specimens examined was 2,158.00±767.13 g, while the total length was 58.40±7.51 cm. The CF was 0.87±0.16. CF factor, as a measure of fish health, can be considered as a response to the quality of the environment. The *CF* value of less than one in our study indicates the poor general health of pikeperch in the Gruža Reservoir. According to Lafamme *et al.*,[27] Rajotte and Coutre[28] and Zhelev *et al.*[29] *CF* decline was determined at highly contaminated sites. On the other hand, Kroon *et al.*[30] pointed out that *CF* as a biomarker should be examined in terms of its specificity and suitability. Overall, the value of the *CF* factor in this study can be seen as the first warning alarm of poor environmental conditions in the Gruža Reservoir. However, we cannot single out PTEs as the main and only reason for this condition.

The highest concentration of Hg was observed in muscle, the highest concentrations of As, Cd, Co, Cu, Fe, Se and Zn in the liver, while the highest concentrations of Al, Cr, Mn, Ni, Pb and Sn were detected in the gills (Table II). On the contrary, the lowest concentrations of Cd, Co, Cr, Cu, Fe, Mn, Se, Sn and Zn in the muscle, the lowest concentrations of Al, Ni and Pb in the liver, as well as the lowest concentrations of As and Hg in the gills were detected. Statistical tests showed no significant differences between pikeperch tissues in terms of Pb and Cr concentrations. A significant difference was recorded between all pikeperch tissues regarding Co, Cu, Fe, Ni, Se and Zn concentrations (Table II). Muscle tissue contained significantly higher concentrations of Hg and significantly lower concentrations of Mn and Se compared to the other two tissues. Gills contained significantly higher concentrations of Al, and liver had significantly higher concentrations of As and Cd compared to the other two tissues.

Pikeperch muscle was the tissue with the lowest potential for PTEs bioaccumulation, which is confirmed by all, to date, performed studies on pikeperch fish species in Serbia.[15,31–35] According to Meena *et al.*,[36] the reason may be a low level of binding proteins in the muscle tissue. On the other hand, Hg has a high potential for bioaccumulation and biomagnification in food chains.[37,38] Predator fish species show important accumulation and indicator potential for Hg, with the highest concentrations in muscle tissue.[39,40] As the top predator in the

Gruža Reservoir, pikeperch accumulated Hg in significantly higher concentrations in muscle tissue compared to the other two tissues.

TABLE II. Element concentrations (mg $kg^{-1}$ dw) and metal pollution index (*MPI*) in muscle, liver and gills of pikeperch (*Sander lucioperca*) in Gruža Reservoir. Values are presented as mean ± *SD*; different letters in row denote significant differences in element concentrations among the pikeperch tissues, $p < 0.05$

| Element | Muscle | Liver | Gills |
|---|---|---|---|
| Al | $1.917 \pm 0.607^a$ | $1.098 \pm 0.577^a$ | $47.068 \pm 26.512^b$ |
| As | $0.766 \pm 0.149^a$ | $1.798 \pm 0.302^b$ | $0.630 \pm 0.195^a$ |
| Cd | $0.016 \pm 0.004^a$ | $0.312 \pm 0.126^b$ | $0.019 \pm 0.009^a$ |
| Co | $0.005 \pm 0.002^a$ | $0.431 \pm 0.128^c$ | $0.091 \pm 0.035^b$ |
| Cr | $0.719 \pm 0.318$ | $1.204 \pm 0.435$ | $1.283 \pm 0.762$ |
| Cu | $0.438 \pm 0.080^a$ | $7.947 \pm 0.802^c$ | $2.465 \pm 0.711^b$ |
| Fe | $6.391 \pm 3.863^a$ | $436.389 \pm 212.493^c$ | $222.349 \pm 80.996^b$ |
| Hg | $0.280 \pm 0.090^b$ | $0.026 \pm 0.021^a$ | $0.001 \pm 0.001^a$ |
| Mn | $0.359 \pm 0.134^a$ | $4.613 \pm 0.927^b$ | $4.657 \pm 2.287^b$ |
| Ni | $0.084 \pm 0.080^b$ | $0.015 \pm 0.013^a$ | $0.330 \pm 0.131^c$ |
| Pb | $0.870 \pm 0.438$ | $0.756 \pm 0.312$ | $1.005 \pm 0.482$ |
| Se | $1.163 \pm 0.191^a$ | $3.66 \pm 0.494^c$ | $1.663 \pm 0.383^b$ |
| Sn | $0.020 \pm 0.007^a$ | $0.697 \pm 0.059^b$ | $1.226 \pm 0.531^b$ |
| Zn | $17.713 \pm 3.094^a$ | $78.866 \pm 9.414^c$ | $41.464 \pm 9.491^b$ |
| *MPI* | 0.30 | 1.31 | 0.69 |

Se:Hg mole ratio in pikeperch from Gruža Reservoir was the highest in the gills (4,227.68), followed by the liver (353.85) and the lowest in the muscle tissue (10.35). Additionally, Se:Hg ratio in all three tissues was much higher than 1. This indicated that pikeperches from Gruža Reservoir were protected against Hg toxicity, since Se:Hg molar ratio that is above 1 protects against toxicity of this element.[41,42]

The highest concentrations of Cu, Fe and Zn were found in the liver of pikeperch, which agrees with results from studies by Mazej *et al.*[43] and Kenšová *et al.*[44] On the other hand, lower concentration of Cu, Fe, Zn and Mn in muscle tissue compared to the other two tissues is in accordance with the findings of Subotić *et al.*[45] who stated that low level of these elements reflects the low level of binding proteins in this tissue.

Higher concentrations of Cd in pikeperch liver can be explained by the fact that this element has a very long elimination half-time, and therefore accumulates in large amounts in parenchymatous tissues such as liver.[46] Our results are not in accordance with the findings of Altındağ and Yiğit[47] and Mazej *et al.*,[43] who found no difference between Cd levels in the gills and liver. Given that the Gruža Reservoir is surrounded by agricultural land, our results are in agreement with the observation of Arumugam *et al.*[48] regarding the anthropogenic origin of Cd and As from agricultural fields, which dissolved in the water column remains for a long time in the environment.

According to Zhou *et al.*[49] and Ruelas-Inzunza *et al.*[50] gills are the organ with the highest tendency to accumulate Pb, which was also confirmed in our study. However the difference between the three tissues was not significant. The presence of Pb in the tissues of *S. lucioperca* is probably due to the traffic on the main road on the bridge that crosses the reservoir and the presence of motor boats on the surface of the reservoir.

Concentrations of Hg and As in the muscle tissue of pikeperch in this study were higher than in the previous study[11] and this can be explained by the fish size because the fish specimens in this study are much larger.[51]

In comparison with the national legislation of Serbia[18] and the legislation of the European Union,[19] concentrations of As, Cd, Cu, Hg, Pb and Zn in muscles of all pikeperch individuals were below the prescribed *MPC*s. The fact that the levels of elements As, Cd, Cu, Hg, Pb and Zn were lower than the national and international threshold levels suggest a very likely absence of risk of contamination of fish with elements in the Gruža Reservoir. In the reservoirs Zlatar,[35] Bovan[32,52] and Garaši[15] concentrations of elements in the muscle of the pikeperch were also below the *MPC*s. A recent study of Nikolić *et al.*[53] reported concentrations of Hg and Cd above the *MPC* in the muscle of pikeperch in some $4^+$ age group and emphasized biomagnification of these elements.

According to *MPI*, the liver was exposed to the highest pressure of metal pollution (Table II). The lowest *MPI* value was recorded for muscle tissue. According to *MPI*, the gills were exposed to the higher pressure of metal pollution than muscle tissue, probably due to direct contact of gills with pollutants in the water.[54] This was also recorded for the same species in the Garaši Reservoir.[15,53] The liver of pikeperch was exposed to the highest pressure of metal pollution (highest *MPI*) as seen in pikeperch samples from the Zlatar Reservoir.[35] *MPI* values recorded in this study for all three pikeperch tissues were lower than in the same tissues of pikeperch from the Garaši Reservoir,[15,53] but higher than in the tissues of pikeperch from the Zlatar Reservoir.[35]

Liver/muscle Hg index was 0.093. According to Havelková *et al.*,[21] in fish from heavily contaminated localities, the target organ for Hg accumulation is liver, while in fish from slightly contaminated localities, the main target organ for Hg accumulation is muscle. Consequently, a higher liver/muscle Hg index value is high in heavily contaminated sites. In our study, liver/muscle index value was low, indicating a slightly contaminated site. According to the above, we can conclude that Gruža is still a slightly polluted reservoir with Hg. Compared with pikeperch from the other researched reservoirs in Serbia, the concentration of Hg in the muscle tissue of pikeperch from Gruža Reservoir was higher than in the muscle tissue of pikeperch from Bovan Reservoir,[32] but lower than in the muscle of pikeperch from Garaši Reservoir[15] and Zlatar Reservoir.[35]

Higher *TTHQ* was observed for fishermen (0.25) compared to the general population (0.20), Fig. 2. Arsenic had the highest contribution to the overall *TTHQ* value, both in the general population and fishermen. The contribution of As to the overall *TTHQ* value was 71.40 %. According to the results of *THQ* for all the elements as well as *TTHQ*, the general population is under lower health risk compared to the fishermen.

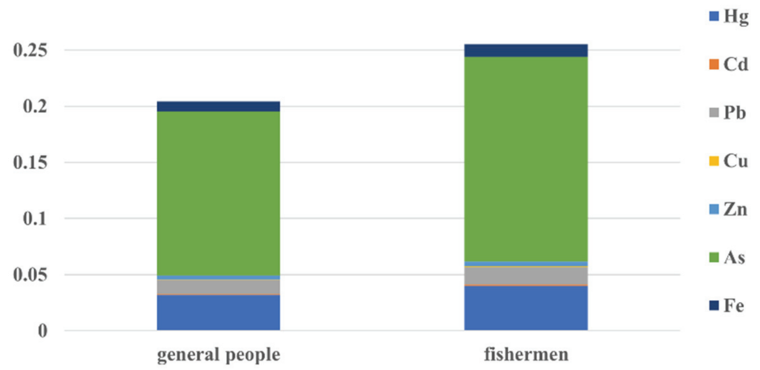


Fig. 2. Total elemental *THQ* values due to consumption of pikeperch for general population and fishermen.

The *TTHQ* values ranged from 0.20 to 0.25, which is much lower than the threshold value (*TTHQ* < 1), indicating the absence of significant noncarcinogenic risk.[55] The values of *TTHQ* in our study were lower than in the study of the Garaši Reservoir, with values above 0.5[15] and the Zlatar Reservoir with values of 0.297 and 0.405.[35] In the two mentioned studies, the major contributor to *TTHQ* was Hg. According to the authors, the reason may be the lower reference dose for this element compared to other elements. In our study, the main contributor to *TTHQ* was As. Since agricultural activities are regularly carried out near the reservoir, we can assume that As originates from the uncontrolled use of pesticides and herbicides.

Higher values of *TR* for As compared to TR for Pb were detected, both for the general population and for fishermen (Table III). Fishermen are more susceptible to develop cancer, if they consume pikeperch meat, compared to the general population.

No cancerogenic risk due to intake of As and Pb from the meat of pikeperch from the Gruža Reservoir was recorded since the TRs for these elements were lower from $10^{-6}$ or were equal to $10^{-6}$.[56] Compared to our results, a lower risk of cancer development due to As and Pb intake from pikeperch meat was recorded in the Garaši Reservoir.[15] Also, a lower risk of developing cancer due to intake of As from pikeperch meat was recorded in the Zlatar Reservoir.[35]

TABLE III. Target carcinogenic risk factor ($TR \times 10^6$) of As and Pb for the general population and fishermen due to consumption of pikeperch (*Sander lucioperca*)

| Group | As | Pb |
|---|---|---|
| General population | 1.97 | 4.20 |
| Fishermen | 2.46 | 5.25 |

## CONCLUSION

Based on the obtained results, we can conclude that despite obvious anthropogenic pressure in Gruža Reservoir and elevated concentrations of As and Hg in water,[11] pikeperch did not show contamination with PTEs. *CF* value indicated the poor general health of pikeperches indicating poor water quality. However, none of the elements exceeded *MPC*s and there was no noncancerogenic and cancerogenic risk to humans' health. Meat of pikeperch can be safely used by the general population and fishermen. Still, fishermen are at slightly higher health risk to develop cancer if they consume pikeperch meat compared to the general population. Due to the absences of analysis of age, gender and diet of pikeperch in this study, the conclusions of this study should be viewed with caution. Further studies including this analysis are needed.

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## ИЗВОД

## ПОТЕНЦИЈАЛНО ТОКСИЧНИ ЕЛЕМЕНТИ У СМУЂУ (*Sander lucioperca* L.) ИЗ АКУМУЛАЦИЈЕ ГРУЖА: ПРОЦЕНА ЗДРАВСТВЕНОГ РИЗИКА ОПШТЕ ПОПУЛАЦИЈЕ И РИБАРА УСЛЕД КОНЗУМАЦИЈЕ

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Циљ ове студије био је да се одреде концентрације 14 потенцијално токсичних елемената у три ткива (мишићи, јетра и шкрге) смуђа (*Sander lucioperca*) и да се процени здравствени ризик (потенцијално неканцерогени ризик – укупни циљни ризик од опасности (енгл. Total target hazard quotient – *TTHQ*) и канцерогени ризик - циљни канцерогени фактор ризика (енгл. Target carcinogenic risk factor – *TR*) повезан са конзумацијом смуђа из акумулације Гружа. Вредност Фултоновог кондиционог индекса мања од један у нашој студији указује на лоше опште здравствено стање смуђа. Према индексу загађења металима (енгл. metal pollution index – *MPI*) јетра је била изложена највишем притиску загађења металима. Концентрације елемената су биле ниже од прописаних националним

и међународним законодавством, указујући на непостојање ризика услед конзумације контаминиране рибе из акумулације Гружа. Примећен је већи *TTHQ* за рибаре (0,25) у односу на општу популацију (0,20). Утврђена је већа вредност *TR* за As у поређењу са *TR* за Pb, како за општу популацију тако и за рибаре. Генерално, није забележен ризик за здравље људи услед конзумације смуђа, али су рибари под незнатно већим здравственим ризиком да развију рак у поређењу са општом популацијом.

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