# HUMAN EXPOSURE TO 17 ELEMENTS THROUGH MUSSELS CONSUMPTION

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## IZLOŽENOST LJUDI DELOVANJU 17 ELEMENATA PUTEM KONZUMIRANJA DAGNJI

*Apstrakt*

Elementi dospevaju u životnu sredinu iz prirodnih izvora i posredstvom ljudske aktivnosti. Toksični elementi, odnosno njihova sve veća zastupljenost u vazduhu, vodi, sedimentu i zemljištu, postali su globalni problem. Pojedini elementi potencijalno su opasni po biljke, životinje i ljude, posebno zbog svoje toksičnosti, sposobnosti da se bioakumuliraju kao i zbog njihove bionerazgradive prirode. Kao glavni uticaji mogu se navesti kontaminacija ekosistema i zdravstveni problemi koje mogu izazvati kod ljudske populacije. Ovi problemi su uzrok povećane zabrinutosti javnosti širom sveta.

S obzirom na rastuću populaciju ljudi na planeti i sve veći broj stanovnika koji žive na obalama mora, morski organizmi, kao jeftin i veoma lako dostupan oblik hrane, počinje sve više da se koriste u ishrani ljudi. Jedan od komercijalno veoma važnih proizvoda u svetu danas je morska dagnja *Mytilus galloprovincialis*. Ručno sakupljanje i uzgajanje ove vrste školjki mnogih zemalja datira iz ranog perioda. Vremenom se sa divljih žetvi prešlo na različite tehnike uzgajanja, što je doprinelo, pre svega, većoj produktivnosti morske dagnje. Najveći svetski proizvođač školjki *M. galloprovincialis* je Kina, dok je u Evropi najveći proizvođač Španija.

Crna Gora je Mediteranska zemlja koja se nalazi u jugoistočnoj Evropi, na obalama Jadranskog mora. Dagnja *M. galloprovincialis* je nativna vrsta u ovoj oblasti i postoje naznake da je gajena na ovom području još pre sto godina. Komercijalni uzgaoj i proizvodnja ove dagnje datira od pre 30-tak godina, a danas se ona uspešno uzgaja na više manjih farmi, prvenstveno stacioniranih unutar Bokokotorskog zaliva. Zbog povoljnih uslova u Bokokotorskom zalivu za akvakulturu *M. galloprovincialis* smatra se da njihova proizvodnja ima veliki potencijal za budući razvoj ovog područja.

Dagnje *Mytilus galloprovincialis* predstavljaju jeftinu visoko proteinsku hranu sa niskim sadržajem masti i kalorija, što ih čini potencijalno zdravijom hranom od drugih komercijalno dostupnih proizvoda. Dagnje su, takođe, odličan izvor omega-3 masnih kiselina, vitamina B12, B1 (tiamin), B2 (riboflavin), B3 (niacin) i B9 (folna kiselina), vitamina A i C, selena, gvožđa, cinka, joda, kalcijuma, natrijuma, bakra, magnezijuma, mangana, kalijuma, itd. i izuzetno su korisne za ljudsko zdravlje. Samo 100 grama dagnji obezbeđuje kod odraslih osoba oko 18,5%, 39-67%, 68% i 1260% dnevnih potreba za folnom kiselinom, gvožđem, selenom i vitaminom B12, respektivno. Međutim, dagnje mogu biti kontaminirane različitim zagađujućim materijama koje mogu kod čoveka izazvati trovanje i različite bolesti. Istraživanja mineralnog sastava pojedinih morskih organizama izuzetno je važno i neophodno, jer su pojedine vrste, uključujući i dagnje, postale svetski delikates kod ljubitelja plodova mora. Stoga je poznavanje elementarnog sastava dagnji od suštinskog značaja za procenu dostupnosti hranjivih materija, ali i sa apekta procene i smanjenja potencijalno negativnih efekata po zdravlje ljudi koje može izazvati prekomerna konzumacija kontaminiranih dagnji.

Cilj ovog rada bio je da se utvrdi uticaj 17 ispitanih elemenata (Fe, Zn, Mn, Sr, I, As, Cr, Ba, Cu, Ni, Sb, Sn, Cd, V, Co, Zr i MeHg) na zdravlje potrošača dagnji *M. galloprovincialis* iz Bokokotorskog zaliva, Crna Gora. Procenjeni rizik od ispitanih elemenata sugeriše da nedeljna potrošanja od 100 grama dagnji tokom ljudskog života neće izazvati negativne posledice po ljudsko zdravlje.

*Ključne reči: Mytilus galloprovincialis, Ispravnost hrane, Procena rizika po zdravlje ljudi, Bokokotrski zaliv, ED-XRF.*
*Keywords: Mytilus galloprovincialis, Food safety, Health risk assessment, Boka Kotorska Bay, ED-XRF.*

## INTRODUCTION

Many minerals are constituents of the body composition of organisms. They play many fundamental roles, and many of them are essential to the normal vital functions of a live organisms. Generally, the elements can be classified into major, present in higher concentrations, and micro, nonessential, and toxic elements, present in lower amounts (Soetan et al., 2010; Stanković et al., 2012). Risk assessment of essential elements has to take into account the two ends of the toxicity spectrum: that associated with intakes that are to high (toxicity), and that associated with intakes that are to low (nutritional deficiencies). Nonessential and toxic elements can also be found in some marine species, and they are available in waters from natural sources, such as rocks, and as a result of different human activities (Jović et al., 2011; Maulvault et al., 2013). These elements tend to accumulate in species from higher trophic levels, like fish and shellfish (Stanković et al., 2012).

Almost all elements considered as essentials and nonessentials, i.e. those provided through the diet and required to maintain normal physiological functions, or the toxic elements, or those without a significant biological role can be found in seafood and mussels (Stanković et al., 2012; Maulvault et al., 2013). Permanent consumption of contaminated seafood can cause poisoning and promote diseases. Therefore, it is very important to know the elemental composition and the content of elements in the food in order to minimize the potential adverse health effects. Hence, the aim of this research was to determine the impact on consumer health and the possible alert regarding adverse health effects that may be caused by the examined elements (Fe, Zn, Mn, Sr, I, As, Cr, Ba, Cu, Ni, Sb, Sn, Cd, V, Co, Zr and MeHg) ingested through consumption of *Mytilus galloprovincialis*mussel .

## MATERIALS AND METHODS

Mussel samples were collected at seven stations in Boka Kotorska Bay, Montenegro, on the Southeastern part of Adriatic coast. From five locations the colected mussel samples were wild (Tivat Arsenal, Opatovo, Sv Stasija, Perast, Herceg Novi) and from two spots the mussels were cultivated (Krašići and Kukuljina), Fig. 1.


**Figure 1.** Sampling stations in Boka Kotorska Bay, Montenegro: 1. Krašići, 2. Kukuljina, 3. Tivat, 4. Opatovo, 5. Sv Stasija, 6. Perast and 7. Herceg Novi

At each sampling site around 2 kg of mussels were collected, then placed in nylon bags containing seawater and transported to the laboratory. The largest 25–30 individuals of the approximately same size were washed and cleaned out, raw opened, and the flesh was scraped out of the shells, which was then freeze-dried at -40 °C for 48 h, weighed, homogenized and ground to a fine powder. The powdered sample was pressed with a hydraulic press by applying a pressure of 7 t for 20 s. No binder material was applied. The resulting pellets had a diameter of 32 mm and a uniform mass of 400 ± 3 mg. The samples prepared in this manner, in the form of pressed pellets, were dedicated to the energy dispersive X-ray fluorescence analysis (ED-XRF).

The measurements were performed by using a MiniPal 4 ED-XRF spectrometer (PANalytical, Almelo, Netherlands). The accuracy of the applied method and of the calibration curves obtained was checked by the measurement of a standard reference material SRM 2976 (Mussel homogenate, NIST).

## RESULTS AND DISCUSSION

Health risk assessment to mussels consumers’ was performed based on the target hazard quotient (THQ) developed by the United States Environmental Protection Agency (US EPA, 1989). THQ is well recognized and used parameter by a scientific community for the risk assessment of heavy metals in contaminated foods (Jović and Stanković, 2014), and is expressed by the following equation:

$$THQ = \frac{EF * ED * MS * C}{RfD_0 * BW * AT} * 10^{-3}$$

EF: exposure frequency (365 days/year); ED: exposure duration (70 years); MS: food meal size (14.3 g/day, i.e. one meal of 100g mussels per week); C: element content in mussels (mg/kg wet weight); $RfD_0$: oral reference dose (µg/g/day) provided by the EPAs’ Integrated Risk Information System online database (IRIS, 2014); BW: body weight (adults 60 kg); AT: averaging time.

Calculated THQ values of individual elements through mussels’ consumption from sampling locations in Boka Kotorska Bay are shown in Table 1.

**Table 1.** Target hazard quotient values of elements due to consumption of the mussels from Boka Kotorska Bay

| | Target hazard quotient (THQ) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Krašići | Kukuljina | Tivat | Opatovo | Sv.Stasija | Perast | H. Novi |
| Fe | 0.020 | 0.061 | 0.033 | 0.012 | 0.008 | 0.008 | 0.011 |
| Zn | 0.012 | 0.018 | 0.033 | 0.019 | 0.011 | 0.013 | 0.022 |
| Mn | 0.024 | 0.026 | 0.029 | 0.026 | 0.024 | 0.024 | 0.029 |
| Sr | 0.004 | 0.003 | 0.006 | 0.002 | 0.003 | 0.002 | 0.003 |
| I | 0.177 | 0.161 | 0.111 | 0.177 | 0.144 | 0.111 | 0.186 |
| As | 0.468 | 0.329 | 0.329 | 0.329 | 0.357 | 0.344 | 0.371 |
| Cr | 0.344 | 0.384 | 0.344 | 0.357 | 0.357 | 0.344 | 0.357 |
| Ba | 0.003 | 0.003 | 0.003 | 0.002 | 0.002 | 0.002 | 0.002 |
| Cu | 0.009 | 0.009 | 0.013 | 0.009 | 0.006 | 0.008 | 0.008 |
| Ni | 0.005 | 0.012 | 0.009 | 0.006 | 0.004 | 0.005 | 0.006 |
| Sb | 0.227 | 0.237 | 0.175 | 0.216 | 0.247 | 0.247 | 0.227 |
| Sn | 0.0001 | 0.0001 | 0.0002 | 0.0001 | 0.0001 | 0.0003 | 0.0001 |
| Cd | 0.058 | 0.041 | 0.050 | 0.066 | 0.041 | 0.037 | 0.045 |
| V | 0.005 | 0.005 | 0.007 | 0.004 | 0.001 | 0.019 | 0.003 |
| Co | 0.071 | 0.118 | 0.111 | 0.104 | 0.071 | 0.036 | 0.124 |
| Zr | 0.566 | 0.875 | 0.205 | 0.104 | 0.104 | 0.104 | 0.104 |
| MeHg | 0.003 | 0.014 | 0.014 | 0.016 | 0.037 | 0.016 | 0.003 |

THQ values for all elements are lower than 1, what signifies that the level of exposure is lower than the reference dose, which assumes that a daily exposure at this level (one meal of 100g mussels per week) is not likely to cause any negative health effect during a lifetime in a human population. From Table 1 it can be seen that THQ values for Zr in the mussels from the sites Krašići and Kukuljina are higher than the THQ values for all of the rest elements. Both geogenic and anthropogenic sources for Zr exist, but the first generally being more abundant (Abollino et al., 2002). Increased THQ value for Zr primarily can be attributed to its native origins and its incorporation in sediment particles, and as such are taken by mussels through water filtration. In the case of wild mussels from the sites Tivat, Opatovo, Sv Stasija, Perast and H. Novi the limiting factors based on the obtained THQ values are Cr and iAs. THQ values for Zr, Cr and iAs at assumed level of mussels were still below 1 indicated that no health risk was present.

## CONCLUSION

The risk assessment of investigated elements through mussels’ consumption suggests that a weekly exposure to 100g mussels during a human lifetime is not likely to cause negative health effects. Calculations based on Fe, Zn, Mn, Sr, I, Ba, Cu, Ni, Sb, Sn, Cd, V, Co and MeHg concentrations present in the mussels *M. galloprovincialis* suggest that a large amount of mussels would have to be consumed to exceed the permissible values for target hazard quotient. In the case of cultivated mussels from Krašići and Kukuljina the limiting factor is Zr, while in the case of wild mussels (rest of the locations) the limiting factors are Cr and iAs. On the basis of the medical literature data in relation to the Zr concentrations in mussels from the Bay their consumption in quantities higher than obtained does not necessarily has implications to human health during a human lifetime.

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