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Comparative study of nickel levels in water and musculature of "Zebra" mussel (*Dreissena polymorpha*) from Ovcharitsa dam, Stara Zagora region, Bulgaria

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ABSTRACT

Nickel is often found in aquatic ecosystems due to its widespread use in households and industry. The aim of this study is comparative research the levels of the heavy metal nickel (Ni) in water and musculature of "Zebra" mussel /*Dreissena polymorpha*/from Ovcharitsa Dam, Stara Zagora Region, Bulgaria. The individual samples of water and musculature were collected in August and November 2012 and January and March 2013. International standards of ISO and BSS for sample preparation of water and musculature of mussels analyze were used. Concentration of Ni in the analyzed samples was determined by atomic adsorption spectrometry. The concentrations of nickel, registered in Ovcharitsa Dam during the study period were significantly lower than the norms stipulated in the Directive 2008/105/EO and Directive 2013/39/EO from of the European legislation. In the existing standards of Bulgarian and European legislation lacks clearly defined limits on the levels of this metal in the body of mussels. In this case, as a landmark was used the average value for the study period. The highest concentrations exceeding the X average is observed on the heavy metal nickel in the musculature samples of "Zebra" mussel delivered during March 2013 (1.37 mg/kg). The established values of the element nickel were significantly lower in the water of the studied water body compared with the musculature of *Dreissena polymorpha*. Because accumulating the highest levels of these elements in time, these mussels could be used as an excellent indicator of pollution with heavy metals.

Key words: water, musculature, *Dreissena polymorpha*, water body, heavy metals

Introduction

The environmental conditions are not static and human interference stimulates the occurrence of unwanted changes in the nature by means the load of the hydro ekosystems with substances of a different nature. Heavy metals occupy a key position in this regard. At the levels exceeding the stipulated norms, these elements exert strong toxic effect. The ions of heavy metals, in the form of a number of organic and inorganic compounds enter to the body of aquabionts by means food, skin and gills.

The accumulation of heavy metals is characterized by specificity regarding the place of accumulation in the aquatic organisms. At the large percentage of cases, higher concentrations were recorded in the liver, kidney, gills and the gonads of hydrobionts. Low levels are distinctive for the musculature of studied aquatic species (Mohamed & Gad, 2005, Nastova-Georgioska et al., 2006).

The element nickel (Ni) is considered an essential for the microorganisms, plants and animals (including aquatic) as it is an integral part of numerous transports, regulatory and enzymatic proteins.

According to Khan & Mohamed (2006) nickel interacts with the iron contained in the hemoglobin and helps for the

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transmission of oxygen, stimulates the metabolism and is regarded as a key metal for various enzyme systems, typical for plant and animal organisms. The nickel participates in the transmission of the genetic code and also is presented in some enzyme systems that metabolize sugars. Except under the plants and animals, in very low Ni is essential for humans (Wintz et al., 2002). Its importance is determined by its ability to activate the enzyme as arginase, trypsin, acetyl Co A carboxylase and synthetase (Yokoi et al., 2002), which are characteristic for both terrestrial organisms and hydrobionts.

Even low levels of nickel, exceeding the established norms have powerful impact on the animal species (Atchison et al., 1987, Barceloux, 1999; Phipps et al., 2002). His presence in excess is reflected negatively on growth, reproduction and behavior of aquatic organisms (Wong et al., 1993). These changes can lead to nascence of several diseases in humans (Sreedevi al et., 1992), although its effects, due to its accumulation in the higher trophic levels in terrestrial ecosystem are considered as unlikely.

In the hydro ecosystems nickel is absorbed mainly on the unicellular forms (bacteria, algae, etc.) and invertebrates. Aquatic invertebrates are a major food resource for fishes and therefore an important link in the transport chain of Ni to fishes (Wong et al., 1991). The toxic effects of this metal on fishes are well assessed (Pane et al., 2003a, 2003b, 2004a, 2004b, 2005, 2006, Brix et al., 2004), while information for the invertebrate organisms is very limited (Sreedevi et al., 1992; Martinez-Tabche et al., 1999; Rathore & Khangaron, 2002).

Mussels are known with its role as of biofilters accumulating in themselves xenobiotics and heavy metals. They have the ability to take on toxicant directly at the filtration of water during respiration and through food, and wherefore are often used worldwide to assessment of ecological and biochemical status of water bodies.

Hydrobionts such as mussels are extremely sensitive in terms of changing even on a negligible degree of tracking parameters of water, which makes them an indispensable bioindicator often used for monitoring of the hydro ecosystems. The "Zebra" mussel (*Dreissena polymorpha*) is one of the most - widespread aquatic organisms having the ability to accumulate heavy metals for a short period of time. Therefore this kind has been widely used to assess the content of these elements both in Europe and in North America.

The "Zebra" mussel is an invasive species to Ovcharitsa Dam, which is located near the "Maritsa-East-2" and is one of the risks in Bulgaria on the state of the environment. This calls in recent times to are carried numerous studies on water and fauna of the water bodies in this region.

This fact determined the aim of this research, which is a comparative study on the levels of the heavy metal nickel (Ni) in water and musculature of "Zebra" mussel /*Dreissena polymorpha*/ from the Ovcharitsa Dam, Stara Zagora Region, Bulgaria.

Materials and Methods

The study was conducted on the territory of Ovcharitsa Dam (Figure 1), which is located in Radnevo Municipality, Stara Zagora Region, Bulgaria.

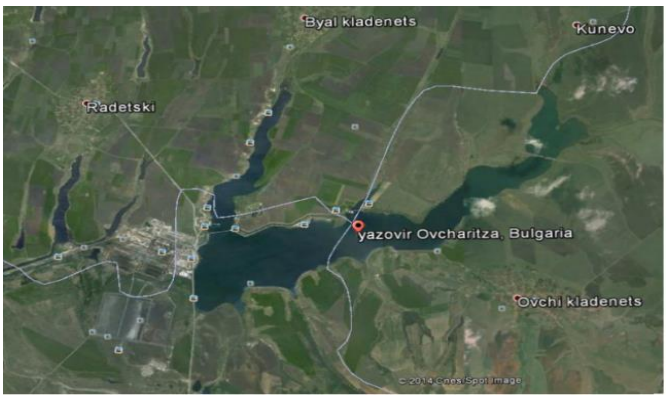

Figure 1. *Ovcharitsa Dam, Radnevo Municipality, Stara Zagora Region, Bulgaria.*

While conducting this study was determined the content of heavy metal nickel (Ni) in samples of water and musculature of "Zebra" mussel /*Dreissena polymorpha* /, taken from the studied water body.

Individual samples of water and musculature are prepared, archived and stored in the mounts of August and November 2012 and January and March 2013.

Water samples taken during the study period from the Ovcharitsa Dam are stored for analysis by addition of k.HNO_3. Musculature samples are prepared for analysis by wet mineralization in Microwave oven Perkin Elmer 3000.

The content of heavy element Ni in acidic solutions was determined by atomic absorption spectrometer (AAS) "A Analyst 800" Perkin Elmer on a cuvette and flame system by mixture of burning acetylene-oxygen, according to BDS ISO 11047.

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Statistical analysis and data processing is carried out by applying the software packages: MICROSOFT OFICE and STATISTICA 6.0., using ANOVA test.

Results

The results concerning the content of Ni in the water and musculature of *Dreissena polymorph*a during the four months of the study are presented in Figures 2 and 3.

The results relating to the nickel content (Figure 2) in water samples showed the availability only of traces of it (0.0025 mg/l) at the rate of 0.02 mg/l for the average annual values (YAV) of this metal in accordance with European requirements for inland surface waters by 2008. Registered values are far lower from MCA for this type of water from 0.34 mg/l and compared to the last Directive 2013/39 / EC of 12 August 2013. As a result of the conducted research relating to the nickel content of the musculature of *Dreissena polymorpha* and changes in those concentrations in the time was found gradually increase in the values, as the highest by them was registered in March 2013 (Figure 3).

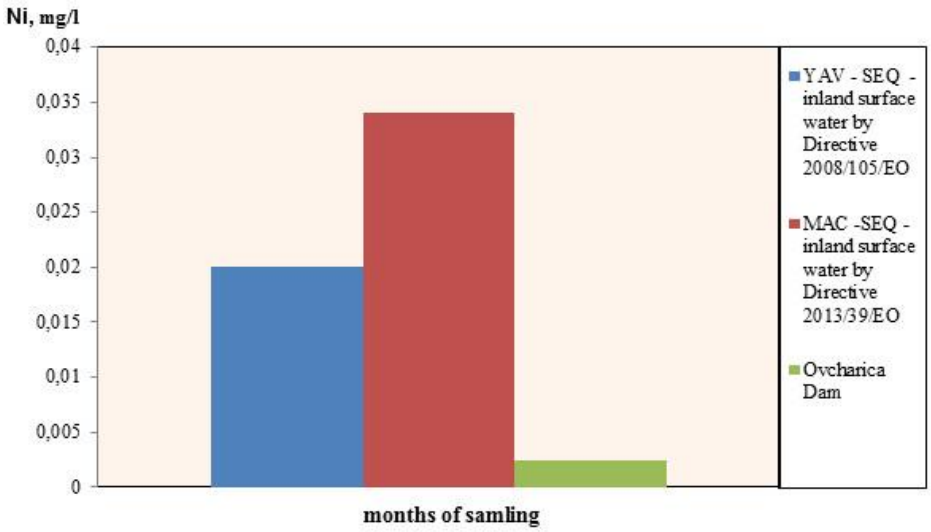

Figure 2. *Content of Ni in the water of the Ovcharica Dam. MAC - maximum allowable concentration; YAV - annual average value.*

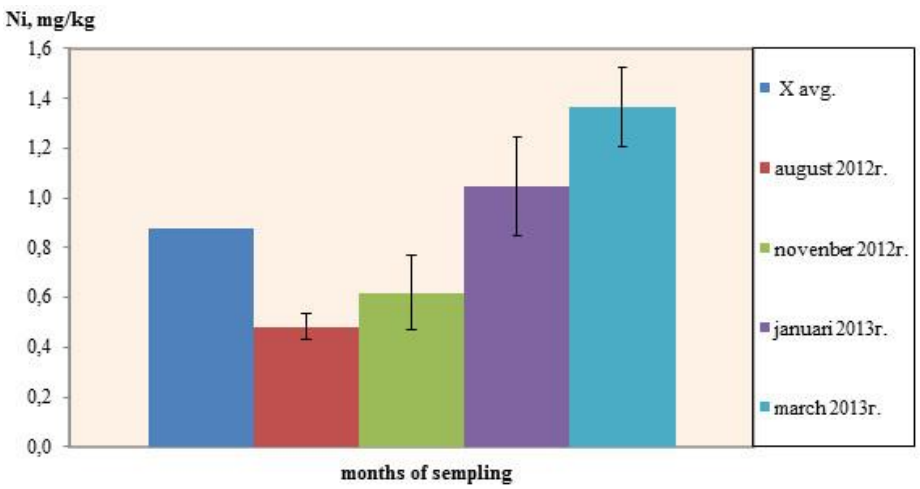

Figure 3. *Content of Ni in musculature of Dreissena polimorpha, inhabiting Ovcharica Dam during the months of sampling.*

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In the existing standards of Bulgarian and European legislation lacks clearly defined limits on the levels of this metal in the body of mussels. In this case as a landmark was used the average value calculated for the study period. Quantities of nickel measured during March 2013 exceed this concentration with 35.6%. The results established in the samples from January also exceed the average value, but to a lesser extent. The lowest levels were registered in August 2012 (44.9% below the average).

Discussion

The Ovcharitsa Dam is located in an area exposed to strong anthropogenic load and it's ecological and biochemical status is largely determined by the content of nickel, which belongs to the heavy metals with high toxicity to hydrobionts. Nickel is an essential trace element necessary for the activity of many enzyme systems and normal production of blood cells in aquatic organisms (Georgiev et al., 2011). Above a certain levels of this heavy metal can cause a destruction of the gill lamellae of mussels, fishes and other hydrobionts. The increase in the levels of Ni often leads to a reduction of muscle glycogen, accompanied with an increase in glucose and lactic acid in the blood (Eisler, 1998). The increased concentrations of this metal in mussels are often an indication of the pollution of water bodies.

The living organisms in the face of these invertebrates react and to temporary deviations of monitored parameters. To have been determined the actual condition of the Ovcharitsa Dam were initially established quantities of this element in water samples, then were analyzed musculature samples of "Zebra" mussel.

The results, recorded in water of Ovcharitsa Dam showed only of traces of nickel. In Directive 2008/105 / EC of 16.12.2008 are not provided standards for maximum allowable concentrations of Ni, but the measured values are far below the YAV (87.5%). This result proves the absence of permanent pollution. Measured concentrations are with 92.6% under MCA stipulated in Directive 2013/39 / EC, which certifies the lack of momentary pollution.

The levels of Ni, reported in musculature of "Zebra" mussel during January and March 2013 exceed the average value calculated for the study period. This result corresponds to the low values of Ni, registered in the waters of Ovcharitsa Dam during the same period.

Rivera et al. (2007) at its study conducted in a period 2003 - 2004 follows the seasonal changes in the concentrations of a number of heavy metals (including Ni) in fresh tissue of freshwater mussels. The results obtained in this study are similar to those recorded in the present - low values of metals in the summer, followed from an increase of levels during the cold months of the year. The highest levels of nickel, exceeding the calculated average value for the period in the studied musculature of mussels *Dreissena polymorpha* are registered in the analysis of samples delivered during the months of January and March 2013 as the highest value was recorded in March – 1.37 mg/kg. Levels of Ni, reported in samples of musculature of "Zebra" mussel, inhabited Ovcharitsa Dam during the study period were several times higher than recorded in the waters of the same water body. Because the value of nickel in water of research water body can show the current status of the hydro ekosystems, more reliable biological indicator is appeared the organism (musculature) of the mussel *Dreissena polymorpha*. Accumulating higher levels of heavy metals in time, these mollusks could be used as an excellent indicator for pollution with heavy metals.

References

Atchison G, Henry M, Sanherinrich M. 1987. Effects of metals on fish behavior, Environ. Biol. Fish, 18: 11-25.

Barceloux D, 1999. Nickel. *Clin. Toxicol*., 37: 239-258.

Brix K, Keithly J, De Forest D, Laughlin J. 2004. Acute and chronic toxicity of nickel to rainbow trout (*Oncorhynchus mykiss*). Environ. Toxicol. Chem., 23: 2221-2228.

Directive 2008/105/EC of the European Parliament and of the Council on environmental quality standards in the field of water policy, amending and subsequently repealing Council Directives 82/176/EEC, 83/513/EEC, 84/156/EEC, 84/491/EEC, 86/280/EEC and amending Directive 2000/60/EC of the European Parliament and of the Council, 2008, Official Journal of the European Union, L 348, 84-97.

Directive 2013/39/EU of the European Parliament and of the Council amending Directives 2000/60/EC and 2008/105/EC as regards priority substances in the field of water policy, 2013, Official Journal of the European Union, L 226, 1-17.

Eisler R. 1998. Nickel hazards to fish, wildlife and invertebrates: a synoptic review, United States geological survey, biological resources division, biological sciences report 1998-0001. Patuxent Wildlife Research Center, United States Geological Survey, Laurel, Maryland, 95.

Georgiev D, Velcheva I, Gecheva G, Petrova S, Mollov I. 2011. Water pollution and impacts on ecosystems, University Publishing "Paisii Hilendarski", Plovdiv, p. 151.

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Khan S, Moheman A. 2006. Effect of heavy metals (cadmium and nickel) on the seed germination, growth and metals uptake by chilli (*Capsicum frutescens*) and sunflower plants *(Helianthus annus*), Poll. Res., 25(1): 99–104.

Lyubenova M, Kalchev R. 2009. Ecotoxicology, Publishing House "An-Dee", Sofia, p. 57.

Martinez-Tabche L, Mora B, Olivan L, Faz C, Grajeda Y, Ortega A. 1999. Toxic effect of nickel on hemoglobin concentration of Limnodrilus hoff meisteri in spiked sediments of trout farms. Ecotoxicol. Environ., Saf., 42: 143-149.

Mohamed S, Gad S. 2005. Distribution of some heavy metals in tissues of *Oreochromis niloticus*, *Tilapia Zillii* and *Clarias Lazera* from Abu Za'Baal Lakes and their impacts on some biochemical parameters and on the histological structures of some organs. Egipt. J. Aquat. Biol. & Fish., 9(1): 41-80.

Nastova-Georgioska R, Kostadinova G, Petrov G. 2006. Accumulation of heavy metals in ekotrofological chain of *Barbus Meridionalis Risso* (black barbel) from the Vardar River in Macedonia, Ecology and Future, 1: 28-35.

Pane E, Richards J, Wood C. 2003a. Acute waterborne nickel toxicity in the rainbow trout (*Oncorhynchus mykiss*) occurs by a respiratory rather than ionoregulatory mechanism. Aquat. Toxicol., 63: 65-82.

Pane E, Smith C, Mc Geer J, Wood C. 2003b. Mechanisms of acute and chronic waterborne nickel toxicity in the freshwater cladoceran, Daphnia magna, Environ. Sci. Technol., 37: 4382-4389.

Pane E, Haque A, Goss G, Wood S. 2004a. The physiological consequences of exposure to chronic, sublethal waterborne nickel in rainbow trout (*Oncorhynchus mykiss*): exercise vs resting physiology, J. Exp. Biol., 207: 1249-1261.

Pane E, Haque A, Wood C. 2004b. Mechanistic analysis of acute, Ni-induced respiratory toxicity in the rainbow trout (*Oncorhynchus mykiss*): an exclusively branchial phenomenon, Aquat. Toxicol., 69: 11-24.

Pane E, Bucking C, Patel M, Wood C. 2005. Renal function in the freshwater rainbow trout (*Oncorhynchus mykiss*) following acute and prolonged exposure to waterborne nickel. Aquat. Toxicol., 72: 119-133.

Pane E, Patel M, Wood C. 2006. Chronic, sublethal nickel acclimation alters the diffusiveproperties of renal brush border membrane vesicles (BBMVS) prepared from the freshwater rainbow trout. Comp. Biochem. Physiol., 143: 78-85.

Phipps T, Tank S, Wirtz J, Brewer L, Coyner A, Ortego L, Fairbrother A. 2002. Essentiality of nickel and homeostatic mechanisms for its regulation in terrestrial organisms, Environ. Rev., 10: 209-261.

Rathore R, Khangarot B. 2002. Effects of temperature on the sensitivity of sludge worm Tubifex tubifex Muller to selected heavy metals. Ecotoxicol. Environ. Saf., 53: 27-36.

Ravera O, Beone G, Trincherini P, Riccardi N. 2007. Seasonal variations in metal content of two *Unio pictorum mancus (Mollusca, Unionidae)* populations from two lakes of different trophic state, J. Limnol., 66(1): 28-39.

Sreedevi P, Sivarmakrishna B, Suresh A, Radhakrishnaiah K. 1992. Effect of nickel on some aspects of protein metabolism in the gill and kidney of the fresh water fish *Cyprinus carpio*, Environ. Poll.,70: 59-63.

Wintz, M, Fox T, Vulpe C. 2002. Functional genomics and gene regulation in biometal research. Bull. Environ. Contam. Toxicol., 30: 765 – 768.

Wong C, Wong P, Tao H. 1991. Toxicity of nickel and nickel electroplating water to the fresh water cladoceran mona macrocopa. Bull. Environ. Contam. Toxicol., 47: 448-454.

Wong C., Chu K , Tang K, Tam T, Wong L. 1993. Effects of chromium, copper and nickel on survival and feeding behavior of Metapenaeus ensis larvae and postlarvae (Decapoda: Penaeidae). Mar. Environ. Res., 36(2): 63-78.

Yokoi K, Uthus E, Nielson F. 2002. The essential use of nickel affects physiological functions regulated by the cyclic - GMP signal transduction system, Proceedings of the 7th international symposium on metal ions in biology and medicine, St. Petersburg, Russia, 5– 9.