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Chara tomentosa as bioindicator of heavy metal pollution in Ohrid Lake

ALMA IMERI[1]*, LIRIKA KUPE[1], ELISABETH GROSS[2], ALMA SHEHU[3], JULIAN SHEHU[1]

[1] Department of Plant Science and Technology, Faculty of Agriculture and Environment, Agricultural University of Tirana, Albania

[2]Laboratoire Interdisciplinary des Environments Continentaux (LIEC) UMR 7360 CNRS, Université de Lorraine

[3] Department of Chemistry, Faculty of Natural Sciences, University of Tirana, Albania.

*Corresponding author e-mail: bioalma_79@yahoo.com

Abstract

We use aquatic plants to analyze the heavy metal pollution of a lake environment; they have a number of advantages over the standard chemical methods of the analysis of metal presence in lakes. The macrophyta *Chara tomentosa* L., sampled from Lake Ohrid in Macedonian part, has been used as a bio-indicator. It can accumulate metals from water. Bioaccumulation of heavy metals (Cu, Cd, Ni, Fe and Pb) was examined by atomic absorption spectrophotometer in Ohrid lake samples of two different depths. This is a first experience for this specie in Ohrid Lake, and I am interested with these results to monitor, at some other sites. The experimental results clearly shows that Fe and Ni were the metals found in higher concentration followed by Cr and Cu whilst Pb and Cd were found in low levels. Concentration of all studied metals resulted to be higher in plant species collected at 5 m depth compared to that sampled at 10 m depth ($\alpha = 0.05$) except for Pb and Cd, which contents did not represent significant variation in different depths ($\alpha = 0.05$). *Chara tomentosa* can accumulate heavy metal ions from the sediment as well as from the water were they grow.

Key words: *Chara tomentosa*, bioaccumulation, heavy metals, Ohrid Lake.

Introduction

The ability of aquatic plants to accumulate heavy metals is increasingly being used to monitor changes arising from environmental pollution [9]. The mechanism of metals uptake is not entirely selective, meaning that plants, through roots and other organs, take in all the accessible ions from the environment, although all of them are not necessary for plant metabolism [13].

All aquatic macrophytes are in contact with potential pollutants across their whole body. Being similar to all primary producers, macrophytes react to changes in the quality of the environment in which they live (water/sediment), and are good bioindicators of surface water condition. The chemical analysis of aquatic plants leads not only to an understanding of the current situation but also to the evaluation of the tendencies of environmental changes in time and space. In this way, conditions are created for monitoring the quality of the lake ecosystem over a longer period and timely action to prevent the consequences of unfavorable trends can be carried out [14].

The aquatic macrophyte which was chosen as an indicator plant in this paper is *Ch. tomentosa L.* because it can consistently accumulate metals during the growing season [23]; it tolerates large amounts of metal without adverse impact on its growth and development; it is not linked to one specific location, so it is the real representative of the area; it is not easily available for collection also it is widely spread in Ohrid lake it can be collected with ven grab, and the plant specimens are similar in size and age, making it easy to select a representative sample. Its disadvantage is that it does not have a long enough lifetimes to fully exhibit the phenomenon of bioaccumulation. Therefore, the assessment of different depth is significant to study the risk of aquatic ecosystem. Bioaccumulation of heavy metals (Cu, Cd, Ni, Fe and Pb) was examined by atomic absorption spectrophotometer in two different depths on Ohrid Lake.

Material and methods

Field Sampling

The sampling of *Chara tomentosa* from Ohrid Lake were based on the principles and procedures outlined in standard methods for the examination of heavy metals in water [2]. Samples were done on September 2016, in two different depths, and this is the first experiment for *Chara* as bioaccumulation.

Chemical treatment of algae samples

Plant samples were first washed thoroughly with deionizer water and dried at 105 ± 5^{o}C. Dried samples were grinded using a grinding mill and then weighted for further treatments. Wet digestion was applied in homogenous algae sub-samples. About 1.0 g of dried sample was transferred to the half pressure Teflon tubes and 10 ml of nitric acid (9:1) was added. The closed tubes were put at room temperature for 48 h. After that samples were digested for three h at 80-90^{o}C and for 1 h at 200^{o}C, to ensure a complete digestion. After the complete digestion, tubes were opened and the acid was evaporated till a very small volume. After cooling, the samples were transferred quantitatively to 25 ml volumetric flasks with deionizer water and then were centrifuged for 10 minutes at 3500 rpm. Concentration of heavy metals, such as Ni, Cr, Fe, Cu, Pb and Cd, in the final solutions was determined by Atomic Absorption Spectroscopy, with electro thermal atomization, using a novAA® *400* AAS (Analytic Jena AG) instrument. Sample analyses were carried out at the scientific laboratory of the Chemistry Department of the Faculty of Natural Sciences, Tirana.

Results and discussion

Heavy metals are environmental pollutants, and their toxicity is a problem of increasing significance for ecological, nutricional, evolutionary and environmental reasons. The term “heavy metal” refers to any metallic element with high specific gravity and is often toxic or poisonous even at low concentrations.

The concentrations of heavy metals estimated on Ohrid Lake in two different depths are given in Figure 1. The concentrations of heavy metals varied.

Iron **(**Fe) is essential for plant and animal metabolism. Fe overload in man is not common but may occur due to genetic defect. Such overload results in oxidative degradation of lipids, destruction of intercellular and extracellular proteins and DNA damage. Water showed permissible limits for safe consumption of humans and aquatic life in freshwater and polluted lakes.

Contamination of soil and water by chromium (Cr) is of recent concern. Toxicity of Cr to plants depends on its valence state: Cr ^{VI} is highly toxic and mobile whereas Cr ^{III} is less toxic. Since plants lack a specific transport system for Cr, it is taken up by carriers of essential ions such as sulfate or iron. Toxic effects of Cr on plant growth and development include alterations in the germination process as well as in the growth of roots, stems and leaves, which may affect total dry matter production and yield. Cr also causes deleterious effects on plant physiological processes such as photosynthesis, water relations and mineral nutrition. Metabolic alterations by Cr exposure have also been described in plants either by a direct effect on enzymes or other metabolites or by its ability to generate reactive oxygen species which may cause oxidative stress.

Small amount of Ni is needed by human body to produce red blood cells, however, in excessive amounts, it can become mildly toxic. Short term over exposure to Ni is not known to cause any health problems, but long term exposure can cause decreased body weight, heart and liver damage and skin irritation. Average concentration of Ni was 2008. 7-1202. 3 mg/kg this shown that on depth the quantity of Ni is decreased. It is essential for human life, but in high doses it may cause anemia, liver and kidney damage, stomach and intestinal irritation etc. The average concentration of Cu observed were, in water (0.00 ± 0.00 mg/l, 0.001 ± 0.001 mg/l) which was within the limits of [28]. Traces of Cu in drinking water may be due to the lining of copper pipes, as well as from additives used to control algal growth.

Lead in the environment arises from both natural and anthropogenic sources. Exposure can occur through drinking water, food, air, soil and dust from old paint containing Pb. High levels of exposure may result in biochemical effects in humans which in turn cause problems in the synthesis of hemoglobin, effects on the kidneys, gastrointestinal tract, joints and reproductive system, and acute or chronic damage to the nervous system.

Cadmium derives its toxicological properties from its chemical similarity to Zn an essential micronutrient for plants, animals and humans. Cd is biopersistent and once absorbed by an organism, remains resident for many years (over decades for humans) although it is eventually excreted. High exposure leads to obstructive lung disease and can even cause lung cancer. Cd produce bone defects in humans and animals. Cd was below detectable limit (0.32 mg/kg and 0.29 mg/kg) in water of both depths.

Conclusion

Metal bioaccumulation depends upon numerous biotic and biotic factors, such as pH, temperature and ions dissolved in water. Content of some heavy metals were determined in algae species grown in different depths of Ohrid Lake, 5 m and 10 m deep respectively. Fe and Ni were the metals found in higher concentration followed by Cr and Cu whilst Pb and Cd were found in low levels (figure 1).

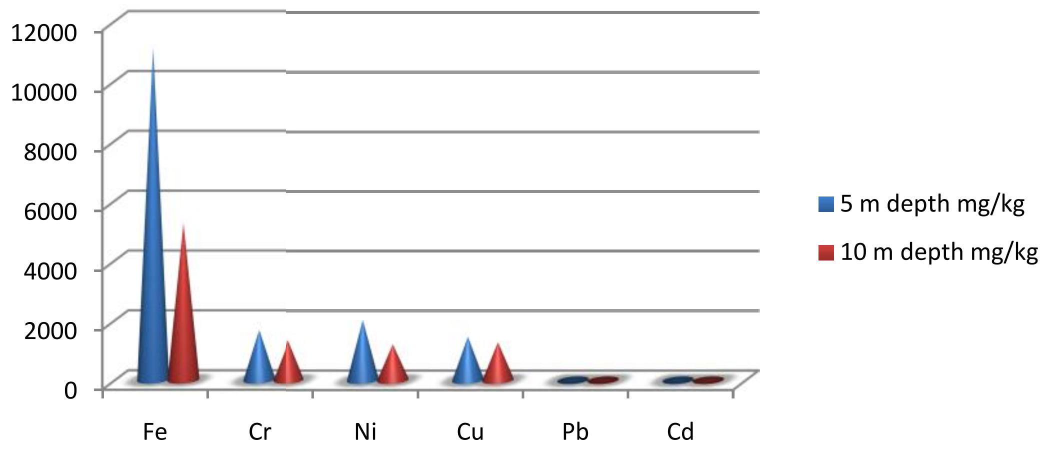

Figure 1: Heavy metal content in *Chara tomentosa* (5m and 10 m)

Concentration of all studied metals resulted to be higher in plant species collected at 5 m depth compared to that sampled at 10 m depth (α = 0.05) except for Pb and Cd, which contents did not represent significant variation in different depths (α = 0.05). Algae can accumulate heavy metal ions from the sediment as well as from the water were they grow. Former studies [23], show that significant variation on heavy metals concentrations exist in different depths of waters of Ohrid Lake, being decreased as the depth increases. The availability of iron and nickel in the surrounding environment and their accumulation in aquatic organisms like macrophytes were obvious and can be correlated with the mineral deposit in the adjacent area, such as the existence of Fe-Ni damp due to the former mining activity. The results obtained indicate the important role of macrophytic vegetation in aquatic ecosystems, with respect of bioremediation and bioindication, and confirm presumption that chemical analysis of test-species can give very important data, which can be used to evaluate the ecological status of the investigated aquatic ecosystem.

Refrences

1. Albers P.H, Camardese M.B: **Effects of acidification on metal accumulation by aquatic plants and invertebrates**. Environmental Toxicology and Chemistry 1993, 12: 959-967.

2. APHA:**Standard methods for the examination of water and wastewater:** *19th Ed. American Public Health Association*; 1995.

3. Ater M, Ali N.A, Kasmi H: **Tolerance and accumulation of copper and chromium in two duckweed species: Lemna minor L. and Lemna gibba L**. Journal of Water Science 2006, 19: 57-67.

4. Ayeni O.O, Ndakidemi P.A, Snyman R.G, Odendaal S: **Chemical, biological and physiological indicators of metal pollution in wetlands** (Review). Scientific Research and Essays 2010, 5: 1938-1949.

5. Branković S, Pavlović-Muratspahić D, Topuzović M, Glišić R, Stanković M**: Concentration of Some Heavy Metals in Aquatic Macrophytes in the Reservoirs Near City Kragujevac (Serbia)**. Biotechnology & Biotechnological Equipment 2010, 24:223-227.

6. Deng H, YE Z.H, Wong M.H: **Accumulation of lead, zinc, copper and cadmium by 12 wetland plant species thriving in metal-contaminated sites in China**. Environmental Pollution 2004, 132: 29-40.

7. Deng H, YE Z.H, Wong M.H: **Lead, zinc and iron (Fe(II)) tolerances in wetland plants and relation to root anatomy and spatial pattern of ROL**. Environmental and Experimental Botany 2009, 65: 353-362.

8. Dixit S, Gupta S.K, Tiwari S: **A nutrient overloading of a freshwater lake in Bhopal, India.** *Earth Day* 2005, Issue 21.

9. Elles M.P, Blaylock M.J, Huang J.W, Gussman C.D: **Plants as a natural source of concentrated mineral nutritional supplements**. Food Chemistry 2000, 71: 181-188.

10. Hawker D, Connell D: **An evaluation between bioconcentration factor and aqueous solubility**. Chemosphere 1991, 23: 231-241.

11. Iram S, Ahmad I, Riaz Y, Zahara: **A Treatment of Wastewater by Lemna minor**. Pakistan Journal of Science 2012, 44: 553-557.

12. Jamnická G, Hrivnák R, Oťaheľová H, Skoršepa M, Valachovič M: **Heavy metals content in aquatic plant species from some aquatic biotopes in Slovakia**. In: Proceedings 36th International Conference of IAD, Austrian Committee Danube, Research/IAD, Vienna 2006, pg. 366-370.

13. Jastrzębska M, Cwynar P, Polechoński R, Skwara T: **The Content of Heavy Metals (Cu, Ni, Cd, Pb, Zn) in Common Reed (Phragmites australis) and Floating Pondweed (Potamogeton natans).** Polish Journal of Environmental Studies 2010, 9:243-246.

14. Kastratović V, Krivokapić S, Đurović D, Blagojević N: **Seasonal changes in metal accumulation and distribution in the organs of Phragmites australis (common reed) from Skadar Lake, Montenegro**. Journal of the Serbian Chemical Society 2013, 78: 1241-1258

15. Kastratović, V.: Aquatic macrophytes of Skadar Lake as bioaccumulators of heavy metals-role in monitoring water system and the possibility of remediation. PhD Thesis, Faculty of Natural Sciences and Mathematics,University of Montenegro, Podgorica, 2013: 150 pp.

16. Lasat M.M. Phytoextraction of metals from contaminated soil**: A review of plant/soil/metal interaction and assessment of pertinent agronomic issues.** Journal of Hazardous Substance Research 2, 2010, 1-25.

17. Marchand L, Mench M, Jacob D.L, Otte M. L: **Metal and metalloid removal in constructed wetlands, with emphasis on the importance of plants and standardized measurements.** A review. Environmental Pollution 2010, 158: 3447-3461.

18. Matthews D.J, Moran B.M, Otte M.L**. Screening the wetland plant species Alisma plantago-aquatica, Carex rostrata, and Phalaris arundinacea for innate tolerance to zinc and comparison with Eriophorum angustifolium and Festuca rubra Merlin**. Environmental Pollution 2005, 134: 343-351.

19. Pavlović S, Pavlović D, Topuzović M: **Comparative Analysis of Heavy, Metal Content in Aquatic Macrophytes in the Reservoirs Gruža, Bubanj and Memorial Park**. Kragujevac Journal of Science 2005, 27: 147-156.

20. Prasad M.N, Greger M, & Aravind P: Biogeochemical cycling of trace elements by aquatic and wetland plants: Relevance to phytoremediation. In Taylor & Francis Group, LLC (Ed.), Trace elements in the environment pp. 451; 2006.

21. Sajwan K.S, Ornes W.H, Youngblood T.V, Alva A.K: **Uptake of soil applied cadmium, nickel and selenium by bush beans**. Water, Air and Soil Pollution 1996, 91: 209-217.

22. Saxena A, Shrivastava P Swarup A: **Heavy metal pollution in a tropical wetland**. *Lakes and Res* 1998.

23. Shehu A, Duka S, Vallja L, Hodaj A: **Estimation of occurrence and spatial distribution of heavy metals in Ohrid and Prespa lakes, Albania.** *International journal of ecosystems and ecology science (IJEES)* 2014, Vol.4, No. 3, pg. 451-456.

24. Shrivastava P, Saxena A, Swarup A: **Heavy metal pollution in sewage fed Lake of Bhopal.** (M.P.) *India. Lakes and Res* 2003, 8: 1- 4.

25. Thiesen M.O, Blincoe C: **Isolation and partial characterization of nickel complexes in higher plants**. Biological Trace Element Research 1988, 16: 239-251.

26. Tiffin L.O: **Translocation of nickel xylem exudate of plants**: Plant Physiology; 1971: 48: 273-277.

27. USEPA: **Method 3051a.** Microwave assisted acid digestion of sediments, sludge's, soils and revision 1, 2007.

28. WHO: **Guidelines for Drinking Water Quality**, *3rd, World Health Organization, Geneva*; 2004.

29. Zayed A: **Phytoaccumulation of trace elements by wetland plants Duckweed**. Journal of Environmental Quality 1998, 27: 715-721.

30. Zhou Q, Zhang, J, Fu J, Shi J, Jiang G: **Biomonitoring an appealing tool for assessment of metal pollution in the aquatic ecosystem**. Analytica chimica acta 2008, 606: 135-150.