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Akumulacija potencijalno toksičnih metala kod vrsta *Plantago lanceolata* i *Plantago major* na različitim tipovima zemljišta

Teški metali i njihova akumulacija poslednjih decenija nalaze se u fokusu istraživanja usled njihovog potencijalno negativnog delovanja na životnu sredinu. Poreklo ovih elemenata može biti prirodno i antropogeno. Prirodno se ovi elementi oslobađaju atmosferskim delovanjem na stene, vulkanskim erupcijama i sl. Iako predstavljaju uobičajene konstituentne stena, neke od njih sadrže povećane koncentracije teških metala, kao što je to slučaj sa ultramafitima, feromagnezijumskim stenama koje u sebi sadrže visoke koncentracije Fe, Mg, Ni, Cr, Co i sl., koji se posledično javljaju i u zemljištu koje se razvija iznad njih. Pored visokih koncentracija određenih teških metala, ultramafitska zemljišta se odlikuju i niskim koncentracijama nutrijenata (N, P, K) i lošim odnosom kalcijuma i magnezijuma (Ca/Mg), što predstavlja dodatan izazov za opstanak biljaka na ovakvom tipu podloge. Antropogene aktivnosti su, takođe, važan izvor teških metala, i to pre svega, vađenje i prerada rude, industrijski otpad, kanalizacioni mulj, đubriva itd.

Plantago major i *P. lanceolata* su dva najzastupljenija predstavnika roda *Plantago* u Srbiji, koja se odlikuju širokom distribucijom i pretežno ruderalnim karakterom, s tim da se javljaju i na suvim livadama brdsko-planinskih regiona. Vrste roda *Plantago*, a posebno *P. major* i *P. lanceolata* se vekovima koriste u tradicionalnoj medicini za lečenje respiratornih, kožnih infekcija, poremećaja cirkulacije i sl. Budući da istraživane vrste mogu uspešno naseljavati i podloge sa povećanim sadržajem teških metala, važno je poznavati njihov potencijal za akumulaciju, kako bi se obezbedila njihova sigurna primena u medicinske svrhe. Cilj ovog istraživanja je određivanje koncentracija teških metala u biljnim tkivima *Plantago lanceolata* i *P. major* na lokalitetima sa različitim stepenom antropogenog zagađenja u blizini Istraživačke Stanice Petnica, u gradu

Valjevu, kao i na Divčibarama na ultramafitskoj geološkoj podlozi.

Koncentracije Pb, Mn, Cu, Co, Mg, Ni, Fe, Zn u uzorcima zemljišta i nadzemnim delovima biljaka sa osam lokaliteta analizirani su metodom atomske apsorpcione spektrometrije. Najviša koncentracija olova u zemljištu zabeležena je na parking u Valjevu (135 mg/kg), dok je u uzorcima biljnog materijala sa datog lokaliteta koncentracija Pb bila ispod nivoa detekcije, a slaba mobilnost olova uočena je i na svim ostalim analiziranim lokalitetima, sa koncentracijama Pb u biljnim tkivima ispod nivoa detekcije. Koncentracije Zn u nadzemnim delovima obe analizirane vrste niže su od koncentracija ovog elementa u zemljištu i variraju u opsegu od 32 do 81 mg/kg. Najviša koncentracija Cu izmerena je u uzorku zemljišta sa parkinga kod Doma zdravlja u Valjevu (343 mg/kg) i ona prevazilazi i remedijacionu vrednost propisanu nacionalnom legislativom, dok koncentracije u biljnim tkivima variraju u opsegu od 22 do 44 mg/kg. Najviše koncentracije Co, Ni, Mn i Fe izmerene su u uzorcima zemljišta na Divčibarama i direktno su uslovljene geohemijskim karakteristikama ultramafitskog masiva. Koncentracije ovih elemenata u analiziranim biljnim tkivima višestruko su niže u odnosu na izmerene koncentracije u zemljištu, što ukazuje na sprečavanje usvajanja i transporta u nadzemne delove biljaka, kao osnovne strategije tolerancije toksičnih koncentracija datih metala. Koncentracije Cd u zemljištu iznad nivoa detekcije zabeležene su na samo dva lokaliteta u Valjevu sa maksimalnom koncentracijom od 1.4 mg/kg, dok su koncentracije ovog elementa u svim analiziranim biljnim tkivima bile ispod ni-

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voa detekcije. Iako se u literaturi navode visoke koncentracije određenih teških metala u biljnim tkivima obe analizirane vrste, u našoj studiji one nisu zabeležene.

Koncentracije analiziranih metala u biljnim tkivima dominantno su bile niže u odnosu na zabeležene koncentracije u zemljištu, što može biti i rezultat njihove niže dostupnosti, ali i strategije isključivanja kod datih vrsta. Usled velikog broja faktora koji mogu uticati na usvajanje teških metala iz zemljišta, neophodno je vršiti kontrole njihovih koncentracija u tkivima biljaka koje se koriste u tradicionalnoj medicini.

Accumulation of Potentially Toxic Metals in *Plantago lanceolata* and *Plantago major* from Different Soil Types

Heavy metals and their accumulation have been the focus of science research in recent decades due to their potentially negative impact on the environment. The origin of these elements can be natural and anthropogenic. In the case of natural origin, these elements are released by atmospheric influence on rocks, volcanic eruptions, etc. Although heavy metals represent common constituents of rocks, some rocks contain even increased concentrations of those, as is the case with ultramafics, ferro-magnesium rocks that contain high concentrations of Fe, Mg, Ni, Cr, Co, etc., which consequently occur in the soil that develops above rocks. In addition to high concentrations of these heavy metals, ultramafic soils are also characterized with low concentrations of nutrients (N, P, K) and a poor ratio of calcium and magnesium (Ca/Mg), which makes an additional challenge for the survival of plants on this type of substrate. Anthropogenic activities are also an important source of heavy metals, primarily ore extraction and processing, industrial waste, sewage sludge, fertilizers etc.

Plantago major i *P. lanceolata* are the two most common representatives of genus *Plantago* in Serbia, characterized by wide distribution and predominantly ruderal character, with the fact they also occur on dry meadows of hilly-mountainous regions. *Plantago* species, especially *P.*

major and *P. lanceolata* have been used for centuries in traditional medicine for the treatment of respiratory and skin infections, circulatory disorders etc. Considering that the studied species can successfully inhabit substrates with increased contents of heavy metals, it is important to know their accumulation potential, to ensure their safe use for medical purposes. The aim of this project was the determination of concentrations of heavy metals in plant tissues of *Plantago lanceolata* and *P. major* in localities with different gradations of anthropogenic pollution near the Petnica Science Center, in the city of Valjevo, as well as in Divčibare on ultramafic geological substrate.

Concentrations of Pb, Mn, Mg, Cu, Co, Ni, Fe, and Zn in the soil samples and aboveground parts of plants from eight different localities were analyzed by atomic absorption spectrometry. The highest concentration of lead in the soil was noted on the parking lot in Valjevo (135 mg/kg), while in the samples of plant material from the given locality the concentration of Pb was below the detection level, and weak mobility of lead was also recorded in all other analyzed localities, with concentrations of Pb in all of the plant tissues below the detection level. Zn concentrations in the aboveground parts of both analyzed species are lower than the concentrations of this element recorded in the soil and vary in the range from 32 to 81 mg/kg. The highest concentration of Cu was measured in a sample of soil from the parking lot near the Community Health Center in Valjevo (343 mg/kg), which exceeds the remediation value prescribed by national legislation, while concentrations in plant tissues vary in the range of 22 to 44 mg/kg. The highest concentrations of Co, Ni, Mn and Fe were measured in soil samples in Divčibare, and are directly conditioned by the geochemical characteristics of the ultramafic massif. The concentrations of these elements in the analyzed plant tissues are multiple times lower than the measured concentrations in the soil, which indicates the prevention of uptake and transport to aboveground parts of plants as a basic strategy for toleration of toxic concentrations of given metals. Only at two localities in Valjevo the concentrations of Cd in the soil were above the level of detection, with a maximum concentration of 1.4 mg/kg, while the concentrations of this element in all analyzed plant tissues

were below the level of detection. Although high concentrations of certain heavy metals in plant tissues of both analyzed species are reported in the literature, they were not observed in our study.

The concentrations of the analyzed metals in plant tissues were significantly lower in relation

to the recorded concentrations in the soil, which may be the result of their lower availability, but also the exclusion strategy in the given species. Due to a large number of factors that can affect the uptake of heavy metals from the soil, it is necessary to control their concentrations in the tissues of plants used in traditional medicine.