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Metal removal from mining-impacted water by a green technology using Salvinia natans

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Abstract. *Salvinia natans* is a free-floating macrophyte having the ability to accumulate high amounts of metals. The objective of this study was to evaluate the impact of *Salvinia n.* on surface water quality affected by the mining activities conducted in the proximity of the water courses. Heavy metal pollution index (HPI), heavy metal evaluation index (HEI) and water quality index (WQI) were used as tools to investigate the quality of water after the phytoremediation process. *Salvinia n.* showed a good ability to remove various metals from mining-impacted waters. Removal efficiencies of 85.7%, 80.7%, 73.4% and 62.8% were obtained for Cd, As, Pb and Cu, respectively after 72h of treatment, while the WQI values improved with a maximum of 45.6% after phytoremediation. Therefore, *Salvinia n.* can be recommended as an effective biofilter to improve the surface water quality from contaminated mining areas.

Methodology

1. Sampling area

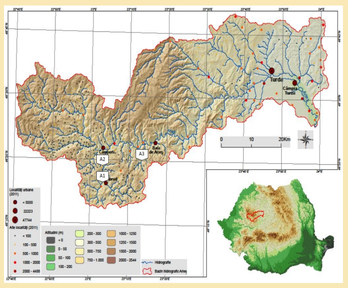

Fig. 1. Sampling area

Fig. 2. *Salvinia n.*

2. Metal extraction

- 3 g of *Salvinia n.* was put in 100 mL of contaminated surface water with different metal contents (low metal content (A1), medium metal content (A3) and high metal content (A2) for 72h at room temperature. Also, a control sample was tested.
- Metal concentrations in surface water were determined before and after phytoremediation process by inductively coupled mass spectrometry (ICP-MS), using an ELAN DRC II Spectrometer (Perkin Elmer, United States). The spectrometer was initially calibrated using a 10 mg/L multi-element calibration standard 3 and 10 mg/L multi-element calibration standard 5 (Certipur Merck) for ICP-MS, respectively.
- Metal content was determined from the air-dried plant after the phytoremediation experiment. The biomass was digested with a mixture of 65% HNO_3 and 20% H_2O_2 at a volume rate of 15:6 (v/v).
- Various indices were calculated in order to evaluate the positive impact of *Salvinia n.* onto water quality: HPI, HEI, WQI.

3. Water quality assessment

The Heavy Metal Pollution Index (HPI)

$$HPI = \frac{\sum_{i=1}^{n}(Q_i W_i)}{\sum_{i=1}^{n} W_i} \quad (1)$$

$$Q_i = \frac{M_i}{S_i} \times 100 \quad (2)$$

where, Q_i is the sub-index of the *i*th parameter, W_i is the unit weightage of the *i*th parameter and *n* is the number of the considered chemical parameters. M_i and S_i are the concentration of the monitored *i*th parameter and the standard maximum allowable values (mg/L), according to the Romanian Regulation and to the European Directive concerning water quality.

The Heavy Metal Evaluation Index (HEI)

$$HEI = \sum_{i=1}^{n} \frac{M_i}{S_i} \quad (3)$$

where M_i is the determined concentration of the *i*th parameter and S_i represents the maximum allowable concentration (MAC) of the parameters. In the present study, S_i values were considered according to the Romanian and International Regulations, namely the Minister Order 161/2006/OD and Directive 2008/32/CE, regarding the quality of surface water resources.

Water Quality Index (WQI)

$$W_i = \frac{w_i}{\sum_{i=1}^{n} w_i} \quad (4)$$

$$q_i = \frac{C_i}{S_i} \times 100 \quad (5)$$

$$SI_i = W_i \times q_i \quad (6)$$

$$\mathrm{WQI} = \sum_{i=1}^{n} SI_i \quad (7)$$

where, w_i is the weight of each parameter, W_i is the relative weight, q_i represents the quality rating for each physico-chemical parameter, C_i and S_i represent the concentration and the guideline value according to the drinking water quality guidelines established by the Minister Order 161/2006/OD and the Directive 2008/32/CE, SI_i represents the subindex of the *i*th parameter.

Results and discussions

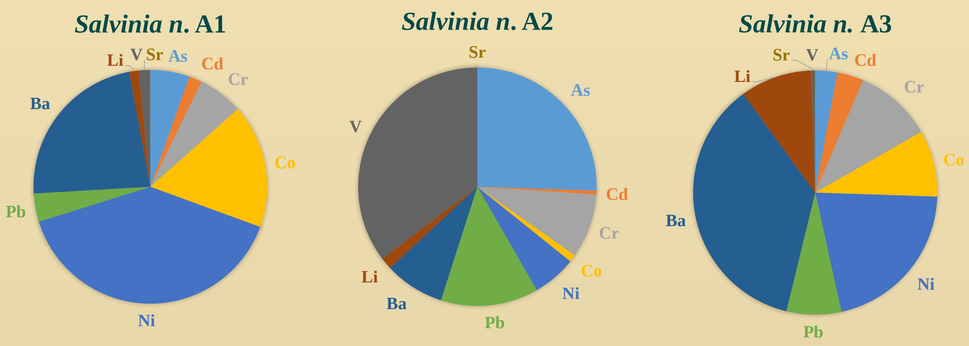

Fig. 3. *Salvinia n.* metal removal rates from surface water with various metal content

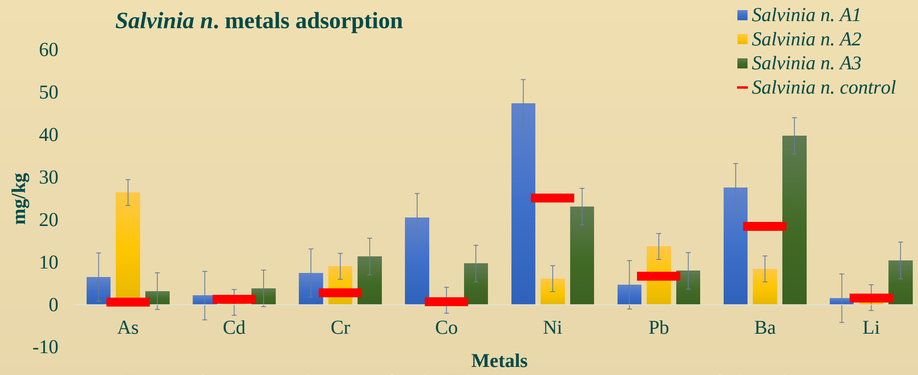

Fig. 4. *Salvinia n.* metal content after the 72h experiment, in comparison with the *Salvinia n.* control metal content

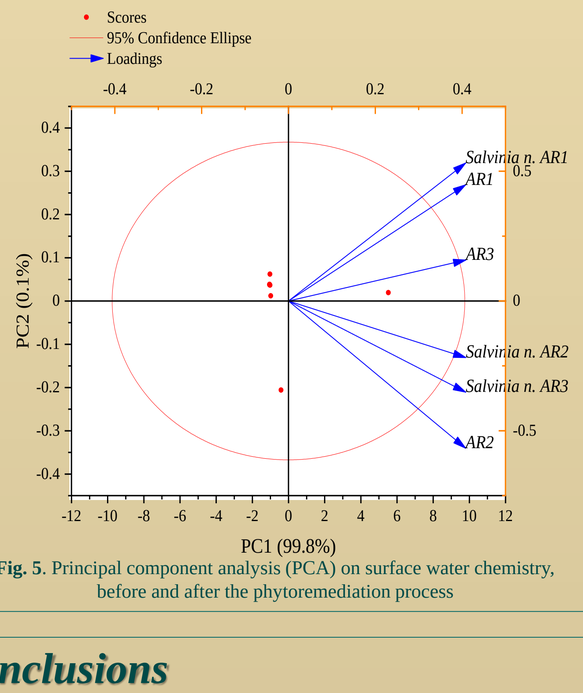

Fig. 5. Principal component analysis (PCA) on surface water chemistry, before and after the phytoremediation process

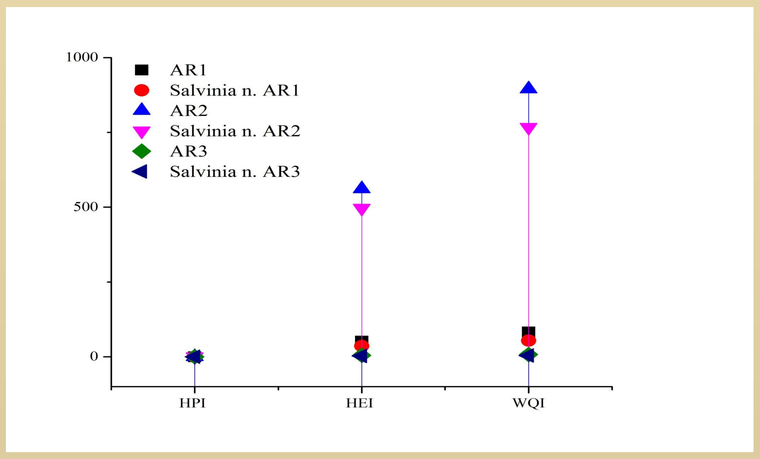

Fig. 6. Quality indices of surface water, before and after the phytoremediation process

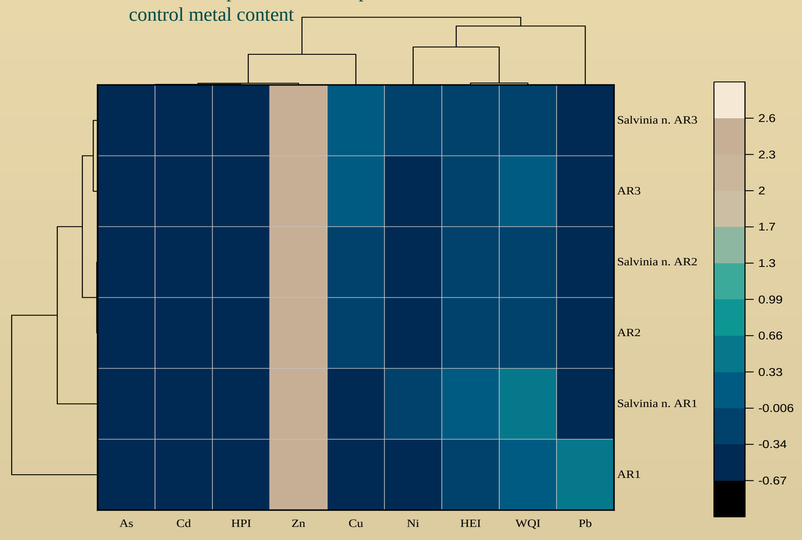

Fig. 7. Surface waters metal content, before and after the phytoremediation process, in comparison with quality indices

Conclusions

- Surface waters with various metal content were subjected to the process of phytoremediation. 100 mL of surface water was put in contact with 3 g of *Salvinia n.* for 75h.
- The results of the present paper indicate that *Salvinia n.* removed metals with an efficiency of 85.7%, 80.7%, 73.4% and 62.8% for Cd, As, Pb and Cu, respectively, after 72h of treatment. Comparing with the control experiment, *Salvinia n.* showed higher adsorption capacity for As, Ni, Ba and Co.
- PCA analysis revealed that the typology of the surface water remained unchanged after the 72h phytoremediation process, indicating no negative influence on the water quality.
- Regarding the water quality, after 72h treatment, the WQI values improved with a maximum of 45.6%, while HEI values decreased with 42.1% and HPI with 61.7%, revealing the high efficiency of *Salvinia n.* in the surface water treatment.

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