

# THE IMPACT OF TAILING OUTFLOW ON THE AVAILABILITY OF POTENTIALLY TOXIC ELEMENTS (Zn, Cu, Pb, Cd) IN SOILS NEAR TO FORMER MINE STOLICE (SERBIA)

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This paper shows the impact of the tailing outflow on the availability of potentially toxic elements (PTEs - Zn, Cu, Pb, Cd) in the soils in Korenita river catchment (western Serbia).

A tailing dump of the former mine Stolice is located in the Korenita river catchment, from which outflow more than 100 000 m<sup>3</sup> of sludge in the 2014 flood accident. As a result of the accident, these soils can become contaminated by the heavy metals and metalloids, and bioavailable with possible ecological risk to plants.

The aim of the paper was to determine the total content of Zn, Cu, Pb and Cd in flooded soils, as well as their availability to plants and possible ecological risk.



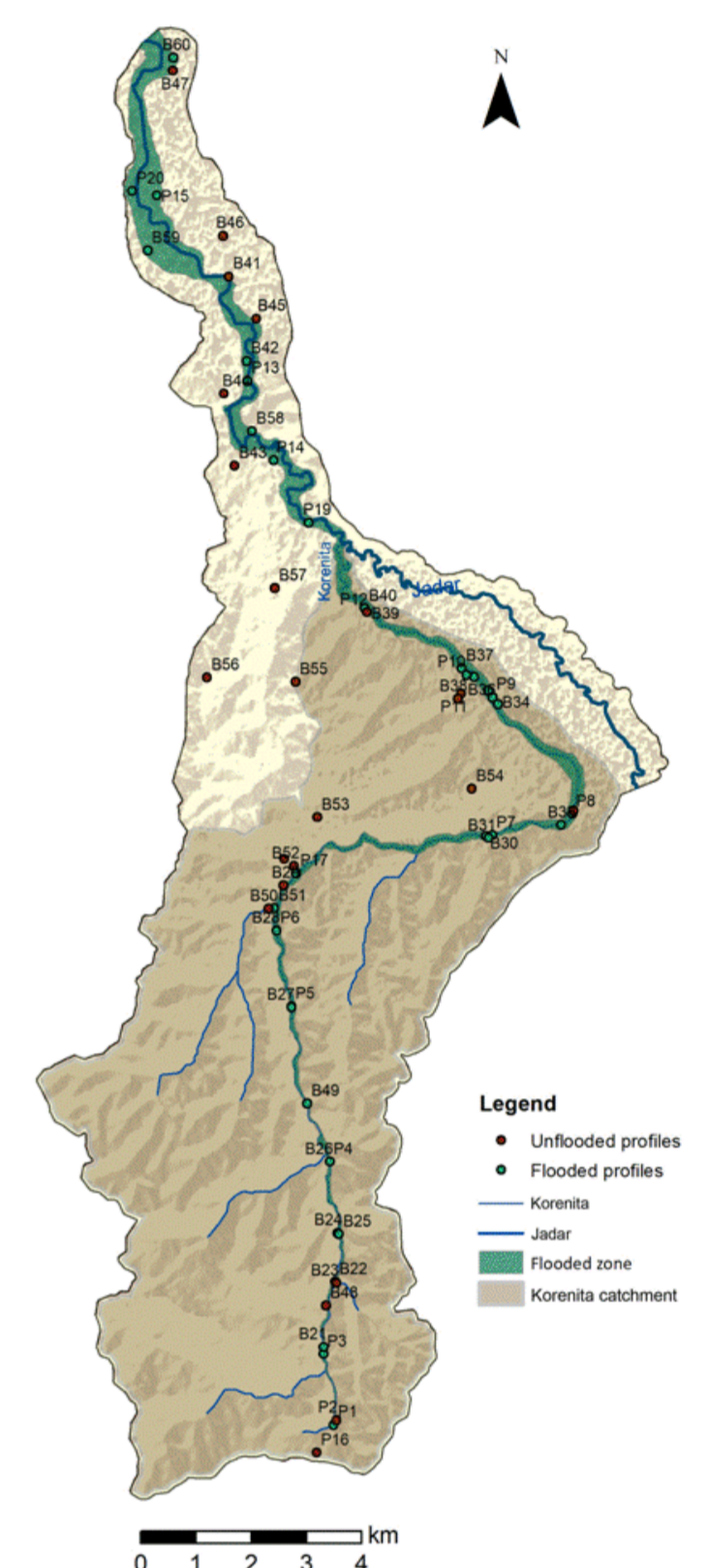
**Fig 1** Study area location

Soil samples were taken by fixed depth from the open pedological profiles (Fig 3), in order to determine soil properties, the total content of PTEs (potentially toxic elements) in aqua regia, and available forms (in 1M ammonium acetate).

The extraction by 1M ammonium acetate was used to determine easily soluble forms of the elements (BBodSchV 1999 - German Federal Soil Protection and Contaminated Sites Ordinance), which are mostly available to plants.



**Fig 2** Korenita river catchment

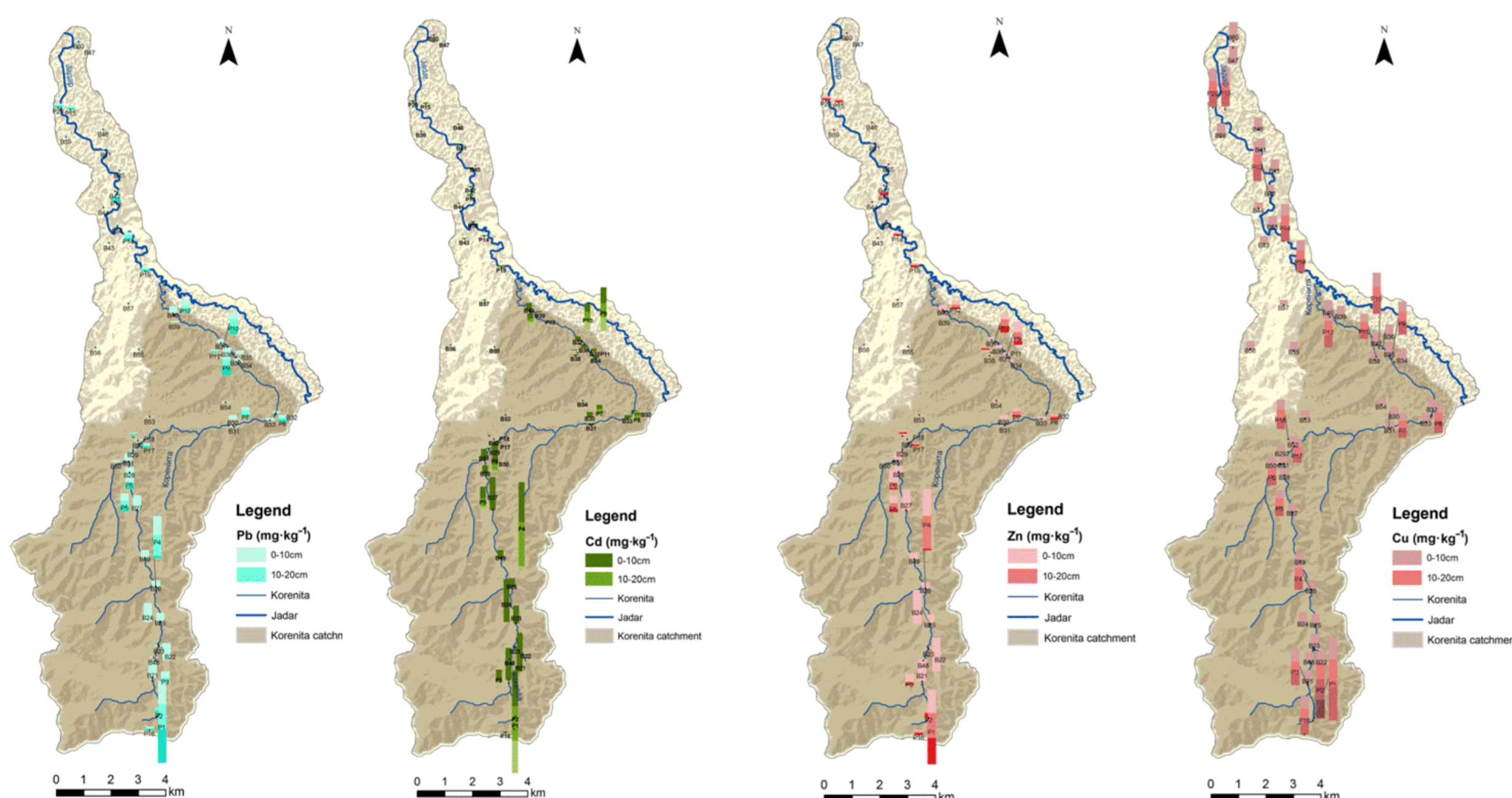


**Fig 3** The position of flooded and unflooded profiles

## RESULTS

The total content of Zn, Pb and Cd in flooded soils are statistically significantly higher in all studied topsoil layers (0-20cm) than in non flooded soils (Table 1), with the mean values higher than the maximum permissible concentration (MPC) (Official gazette 30/2018) (Fig. 4).

The contents of Cu in all soils are lower than MPC, but in the layer of 0-10cm, the content of Cu in flooded soils is statistically significantly higher than in unflooded soil.



**Table 1** Average contents and range of total content of Pb, Cd, Zn and Cu (mg×kg<sup>-1</sup>) in the studied soils

	Pb (mg×kg <sup>-1</sup> )	Cd (mg×kg <sup>-1</sup> )	Zn (mg×kg <sup>-1</sup> )	Cu (mg×kg <sup>-1</sup> )
cm				
Flooded				
0 – 10	147.12±122.81**	3.14±3.54**	516.11±575.3**	18.39±5.39*
Range (n=31)	15.26 – 378.56	0.10 – 11.26	50.33 – 1999.9	11.40 – 30.56
10 – 20	150.2±154.06**	2.84±3.71**	475.69±600.57**	20.10±7.83 <sup>ns</sup>
Range (n=12)	34.33 – 502.62	0.10 – 11.58	61.09 – 1931.01	12.95 – 43.49
Unflooded				
0 – 10	23.45±7.42	0.14±0.11	65.55±14.96	15.78±4.64
Range (n=27)	11.19 – 43.21	<d.l. – 0.39	44.35 – 98.75	7.82 – 30.21
10 – 20	24.16±7.72	0.12±0.06	77.84±18.79	19.05±4.12
Range (n=7)	12.8 – 37.8	0.01 – 0.21	53.31 – 112.82	12.45 – 25.49

\*\* p<0.01; \* p<0.05; ns-non significant

**Fig 4** The total content of Pb, Cd, Zn and Cu in the studied soils

The available forms of Zn, Pb and Cd are statistically significantly higher in flooded soils (Table 2), and are higher or around the MPC. The available forms of Cu are not statistically significantly different between flooded and unflooded soils, and are lower than MPC. Statistically significant correlations were determined between available forms Pb – Zn (0.442\*), Zn – Cd (0.682\*\*) and Cd – Pb (0.554\*\*), indicating their common origin from the tailing material (Table 3). On the other hand, Cu has no correlation with other elements.

**Table 2** Average contents and range of available forms of Pb, Cd, Zn and Cu

	Pb	Cd	Zn	Cu
cm				
(mg×kg <sup>-1</sup> )				
Flooded				
0 – 10	0.182±0.219*	0.034±0.030*	2.021±3.740*	0.091±0.084 <sup>ns</sup>
Range (n=31)	0.001 – 0.788	0.001 – 0.104	0.001 – 14.465	0.001 – 0.278
Unflooded				
0 – 10	0.058±0.080	0.014±0.019	0.191±0.288	0.089±0.084
Range (n=20)	0.001 – 0.278	<d.l. – 0.063	0.001 – 1.064	0.001 – 0.261

\* p<0.05; ns-non significant

**Table 3** Correlation matrix between the content of available forms of Pb, Cd, Zn and Cu

	Pb	Cd	Zn	Cu
Pb	1	0.554**	0.442*	-0.360
Cd		1	0.682**	-0.061
Zn			1	0.033
Cu				1

\*\* Correlation is significant at the 0.01 level (2-tailed).

\* Correlation is significant at the 0.05 level (2-tailed).

## CONCLUSION

The study has shown that the content of HMs in the flooded soils, and primarily Zn, Cd and Pb was significantly higher than in the unflooded soil and that it represents a potential danger to the environment. On the other hand the available forms of Zn, Pb and Cd are statistically significantly higher in flooded soils but are lower than MPC. pH values of flooded soils are in a range of 7.3 – 8.2 affecting lower available forms of Zn, Pb and Cd. The extracted available forms refer only to cationic forms and still contribute to the knowledge of the soil contamination in the catchment of Korenita river. Further studies should focus on the analysis of the content of elements in water and vegetation.