

BIOMONITORING ATMOSPHERIC POLLUTION WITH HEAVY METALS IN THE COPPER MINE VICINITY LOCATED NEAR RADOVIŠ, REPUBLIC OF MACEDONIA

Biljana Balabanova¹ Trajče Stafilov², Katerina Bačeva², Robert Šajn³

¹Faculty of Agriculture, Goce Delčev University, POB 201, 2000 Štip, Macedonia

²Institute of Chemistry, Faculty of Science, Sts. Cyril and Methodius University, POB 162, 1000 Skopje, Macedonia

³Geological Survey of Slovenia, Dimičeva ulica 14, 1000 Ljubljana, Slovenia

INTRODUCTION

The main object of this study was examination of atmospheric pollution with heavy metals due to copper mining Bučim near Radoviš, Republic of Macedonia (Figs. 1 and 2). Moss samples (*Hyloconium splendens* and *Pleurozium schrebery*) were used for biomonitoring the possible atmospheric pollution with heavy metals in mine vicinity. Sixteen elements (Al, As, Ba, Ca, Cd, Co, Cr, Cu, Fe, K, Mn, Na, Ni, Pb, Sr, and Zn) were analysed.

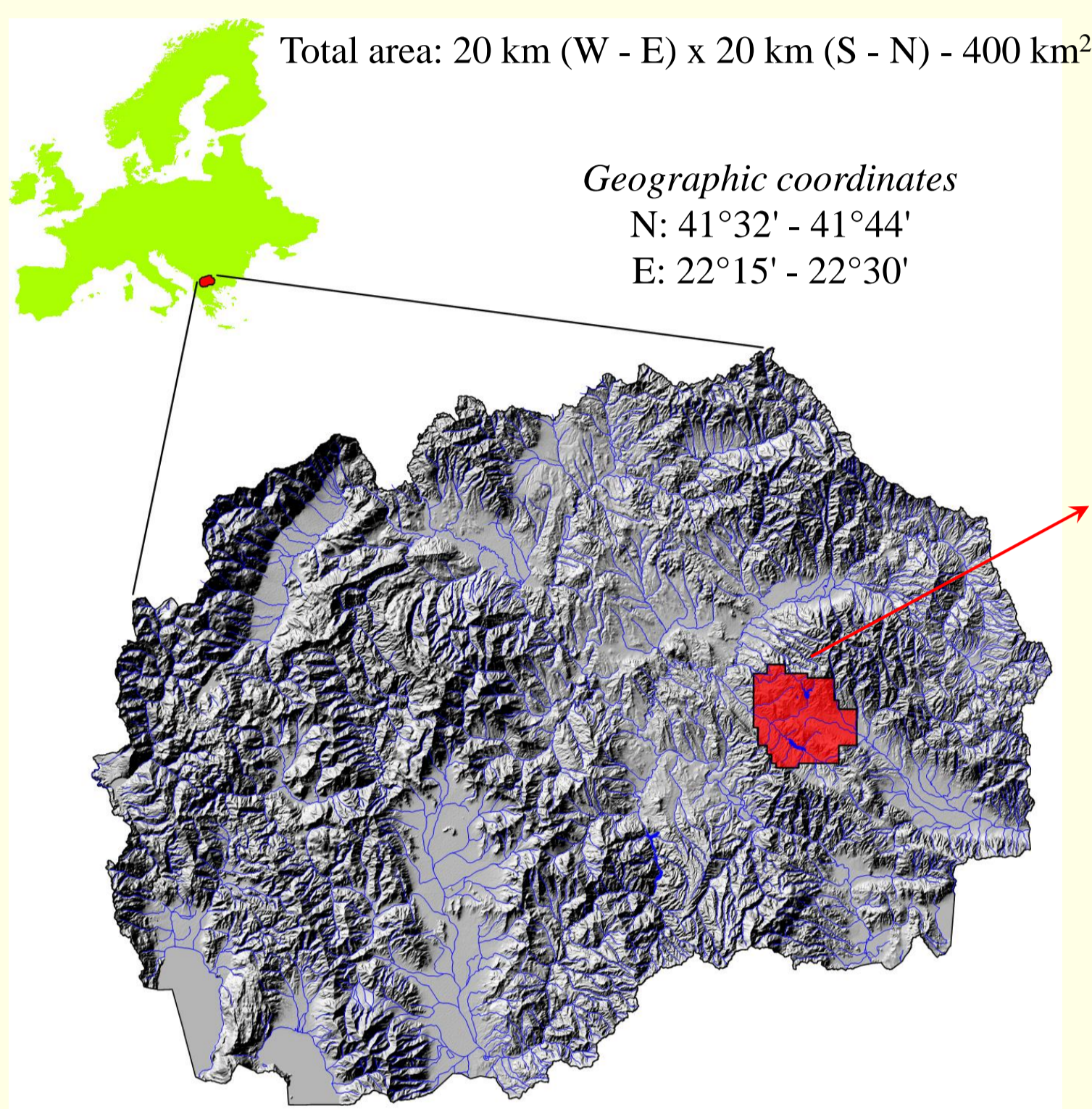


Fig. 1. The investigated region in the R. Macedonia

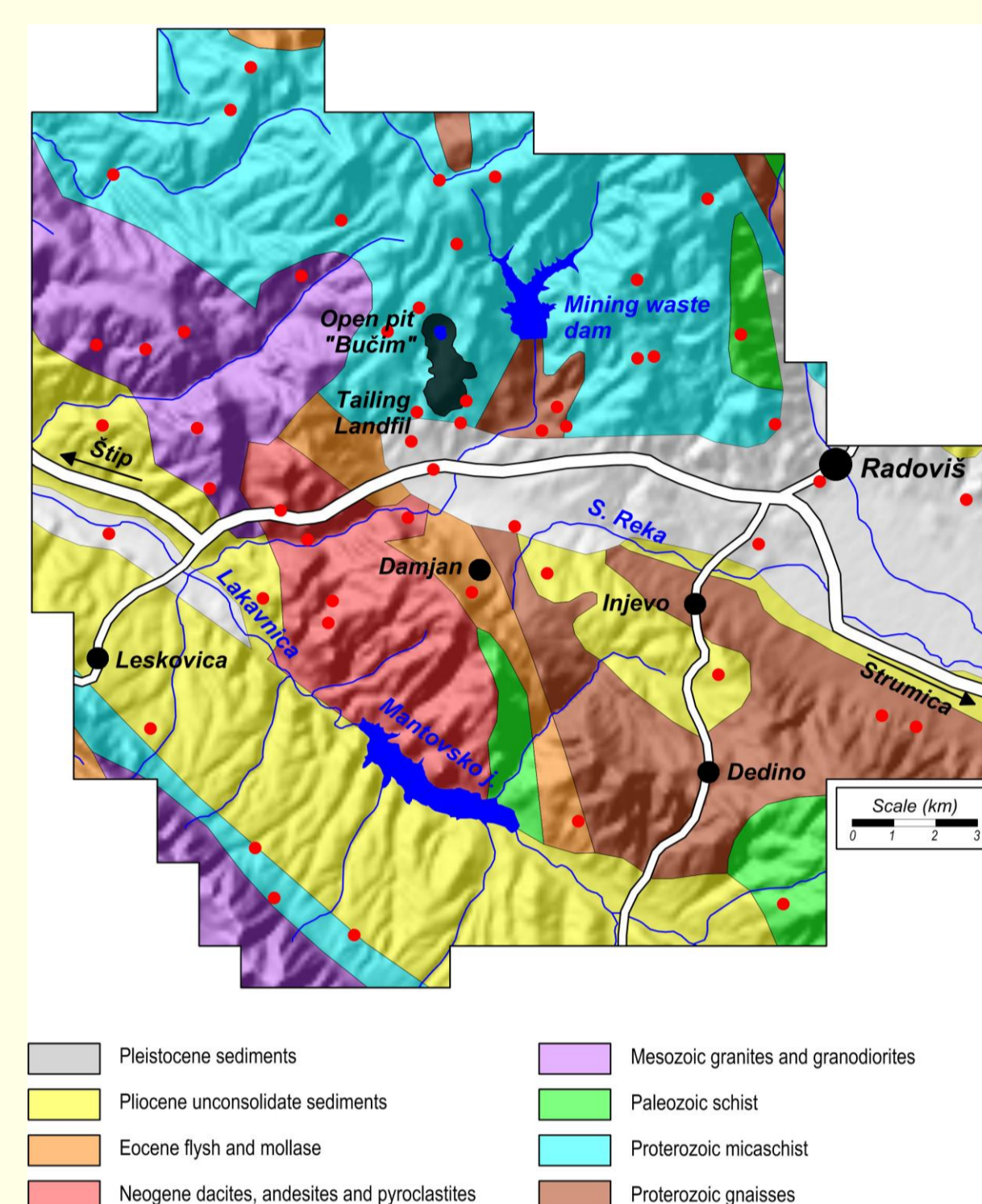


Fig. 2. Geological and sampling network map

RESULTS

Three factors were identified, one anthropogenic and two geogenic, interpreted as Factor 1, Factor 2 and Factor 3, which includes 90 % of variability of treated elements (Table 1, Fig. 3).

Table 1. Matrix of dominant rotated factor loadings (F>0.60)

	F1	F2	F3	Com
Al	0.89	0.30	0.19	97.5
As	0.60	0.28	0.14	55.2
Ba	0.06	0.04	0.65	53.7
Cd	0.90	0.15	0.09	90.9
Cr	0.47	0.65	0.15	74.2
Cu	0.71	-0.12	0.11	72.7
Fe	0.90	0.20	0.26	97.9
K	-0.05	0.14	0.64	57.3
Na	0.34	-0.07	0.60	56.0
Ni	0.15	0.83	-0.04	72.4
Pb	0.78	0.12	-0.23	80.6
Sr	-0.05	0.78	0.19	67.1
Zn	0.73	0.09	0.28	79.7
Var	52.1	22.1	15.6	89.9

F1, F2, F3-Factor loading; Var-Variance (%); Com-Communality (%)

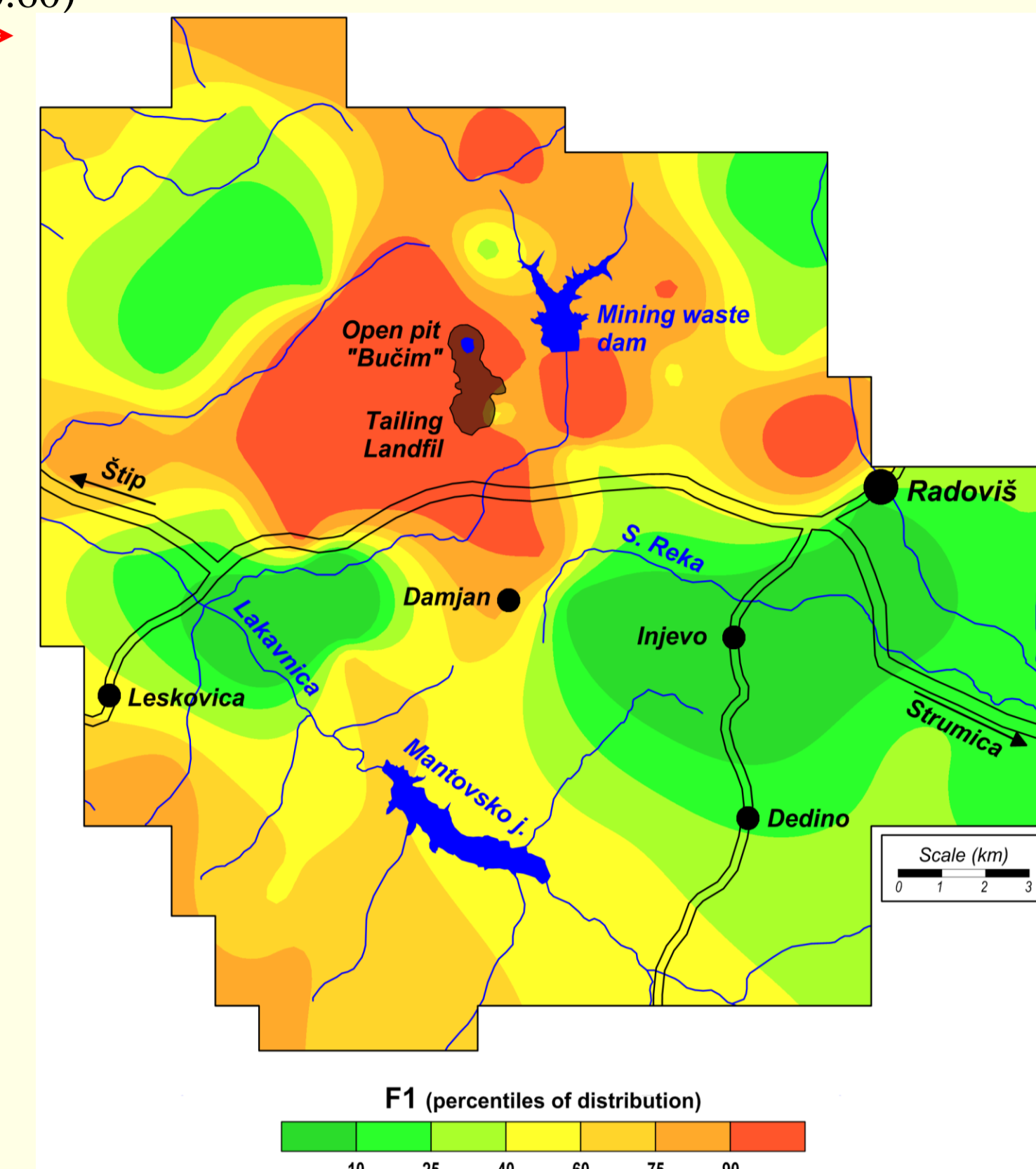


Fig. 3. Spatial distribution of Factor 1 scores (Al, As, Cd, Cu, Fe, Pb and Zn) in moss samples

EXPERIMENTAL

Sampling

The collection of moss samples was performed according to the protocol adopted within the European Heavy Metal Survey.

Sample preparation

Microwave digestion system

Step	Temperature/°C	Time/min	Power/W	Pressure/bar
1	180	5	500	20
2	180	10	500	20

Analyses

Analyses were performed with atomic emission spectrometer with inductively coupled plasma, ICP-AES (Varian, 715ES), for Al, Ba, Ca, Cr, Cu, Fe, K, Mn, Na, Ni, Pb, Sr, Zn and electrothermal atomic absorption spectrometer, ETAAS (Varian, SpectrAA 640Z) for Cd, Co, As.

Data processing

The obtained values were statistically processed using nonparametric and parametric analysis. Multivariate (factor analysis) method was used to reveal the associations of the chemical elements.

The universal kriging method with linear variogram interpolation was applied for the construction of the areal distribution maps.

The contents of these heavy metals in moss were compared with the median moss content of these elements for the whole territory of the R. Macedonia (Table 2 in order to determine whether there was an increased content of each in the study area. Arsenic, cadmium and lead were singled out.

Table 3. Comparison analysis of median values for copper content in moss samples (in mg kg⁻¹)

Study area				Republic of Macedonia [1]	
Whole territory		Close vicinity of Bučim mine			
Md	min-max	Md	min-max	Md	min-max
10	2-198	91	29-198	22	3-83

Table 2. Comparison of median values of element content in moss between data of present work and data of the whole territory of Macedonia (in mg kg⁻¹)

Element	Bučim mine region (present work)		Republic of Macedonia [1]	
	Median	Range	Median	Range
Al	1721	472-8511	3736	825-17600
As	1.6	0.1-13.7	0.80	0.12-8.0
Cd	0.49	0.18-1.75	0.16	0.0016-2.95
Cu	10	2.1-198	22	3-83
Fe	2630	742-12356	2458	424-17380
Pb	6.8	2.7-40.2	6.0	1.5-37.2
Zn	28.3	17-53	39	14-203

The copper content in moss samples collected in close vicinity of mine show much higher content which is 5 times greater than the content of Cu in moss samples collected from the whole territory of Macedonia (Table 3).

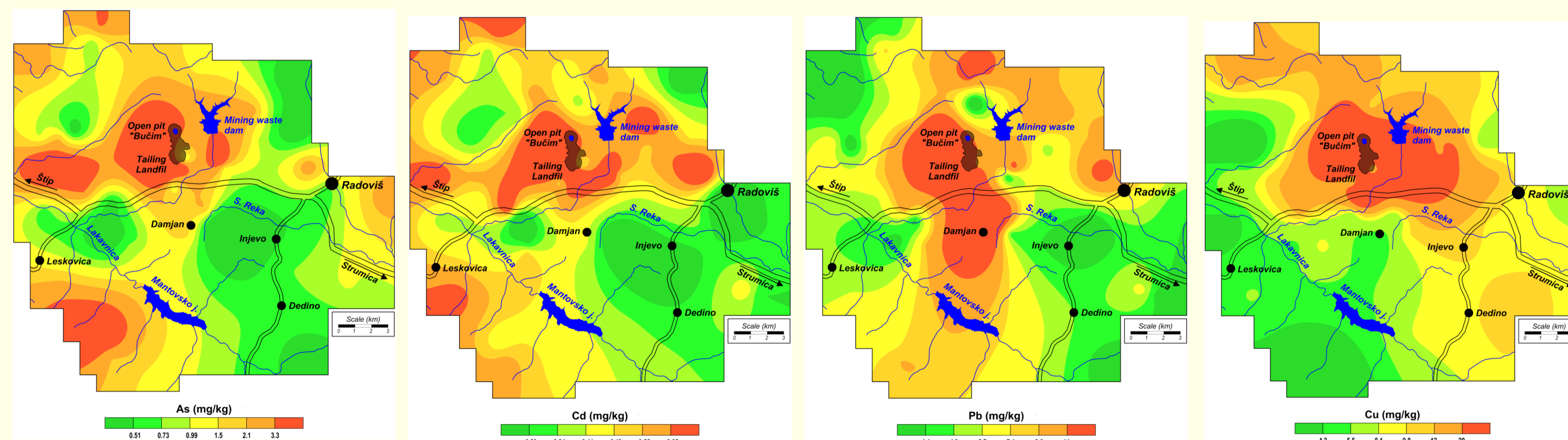


Fig. 4. Maps of spatial distribution of As, Cd, Cu and Pb

CONCLUSION

From the distribution map of Factor 1 scores and distribution maps for all elements from this Factor (Figs. 3 and 4) it is clearly visible that the higher contents of these elements are deposited in close vicinity of the mine. Distribution of these elements at greater distances from the mine is not determined. This confirms the influence of the presence of the copper mine and flotation plant on increasing content of these metals in the atmosphere. Increasing content of anthropogenic elements in moss samples in the close vicinity of the mine, precisely near villages Bučim and Topolnica, assumed as most polluted settlements. Maximum values for the content of As, Cd, Cu, Fe, Pb and Zn are obtained from moss samples close to village Bučim.

Reference

1. L. Barandovski, M. Cekova, M. V. Frontasyeva, S. S. Pavlov, T. Stafilov, E. Steinnes, V. Urumov, Atmospheric deposition of trace element pollutants in Macedonia studied by the moss biomonitoring technique, *Environmental Monitoring and Assessment*, **138**, 107-118 (2008).