MONITORING DEPOSITION OF ANTHROPOGENIC INTRODUCED ELEMENTS IN AIR. CASE STUDY: COPPER MINE ENVIRON

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Abstract

The total deposited dust was used as sampling media for monitoring the distribution of heavy metals in an area with intensively exploited copper minerals (Bučim copper mine, R. Macedonia). The content of Cu and Pb was determinate using atomic emission spectrometry with inductively coupled plasma (ICP-AES). Within the study area, three sampling spots (settlements) were selected: villages Bučim and Topolnica and the town of Radoviš. In the copper mine environ, there are some values above the national maximum permitted value for deposited dust (300 mg m^{-2} d^{-1}). Larger amounts of dust are deposited in the villages Bučim and Topolnica (annual average values of 489 mg m^{-2} d^{-1}, and 309 mg m^{-2} d^{-1} respectively) with a maximum value (815 mg m^{-2} d^{-1}) obtained in the Bučim village. Higher contents of Cu and Pb were obtained from deposited dust samples collected from Topolnica village (max. value 1183 mg kg^{-1} and 184 mg kg^{-1}, respectively).). In the town of Radoviš deposited dust was not above the maximum permitted amount for deposited dust, but higher content of Cu and Pb contents were found (max. values 1171 mg kg^{-1} and 189 mg kg^{-1} respectively).

Keywords: Total deposited dust, monitoring, heavy metals, copper mine, Republic of Macedonia

Introduction

Heavy metals in the atmosphere originated mainly from dust dispersion from metal refining, fossil fuel combustion, vehicle exhausts, and other human activities and stay in the atmosphere until they are removed by a variety of cleansing processes (Vallero, 2008; Agarval, 2009). Particular emphasis is given on ore deposits, mining, processing and flotation plants as significant anthropogenic sources of dust. Copper mine with open ore pit type present a potentially emission source of heavy metals in air. Main processes that allow it are: minerals blasting, drilling and crushing, their loading and transportation to processing and flotation plants. From other hand, large amounts of ore waste and flotation tailings are deposited at open, continuously exposited to air flow and winds caring-out. People are directly exposed to the effects of heavy metals through inhalation of airborne micro particles from atmospheric dust (Jarup, 2003; Godish, 2004).

Atmospheric total deposition (deposited dust) is very useful mechanism for monitoring the fate of anthropogenic elements introduced into the atmosphere (Čačković et al., 2009). Fine powder with a high content of heavy metals is generated as a result of emissions from the processing of ores and metallurgical process and is distributed as a result of wearing the wind. Many investigations have focused on the chemical composition and the content of toxic substances in deposited dust (Morselli et al., 2003; Avila and Rodrigo, 2004; Polkowska et al., 2005; Vike, 2005, Stafilov et al., 2011).

In order to determine the amount of fine dust contained in the air, samples of total deposited matter (deposited dust) were collected at three locations in the area of Bučim copper mine, R. Macedonia.

Study area

The study area occupies the "Bučim" mine environ, located in the eastern Republic of Macedonia part (Fig. 1). The mine and the ore processing plant have been functioning since 1979 and it is assumed that the mine has about 40 million tons of ore reserves. Ore tailings are dropped out at open site near the mine, occupies a surface of 0.80 km^2. The ore tailings deposit has about 130 million tons of ore tailings. Exposure of this great mass of ore tailings to constant air flow and wind leads to the distribution of fine dust in the air.

Geological description. The Bučim-Damjan-Borov Dol area is divided into two tectonic blocks. The Bučim tectonic block and the southern tectonic block Damjan are a part of the Vardar zone. The blocks are divided by a fault of first order in the SE direction. Despite the disposition in two different tectonic blocks, the metallogenic area is unified based on the similarities of Tertiary magmatism and the analogous ore mineralisations. The Bučim copper-porphyry deposit with additional gold mineralisation is found in the northern block (Stefanova et al., 2004).

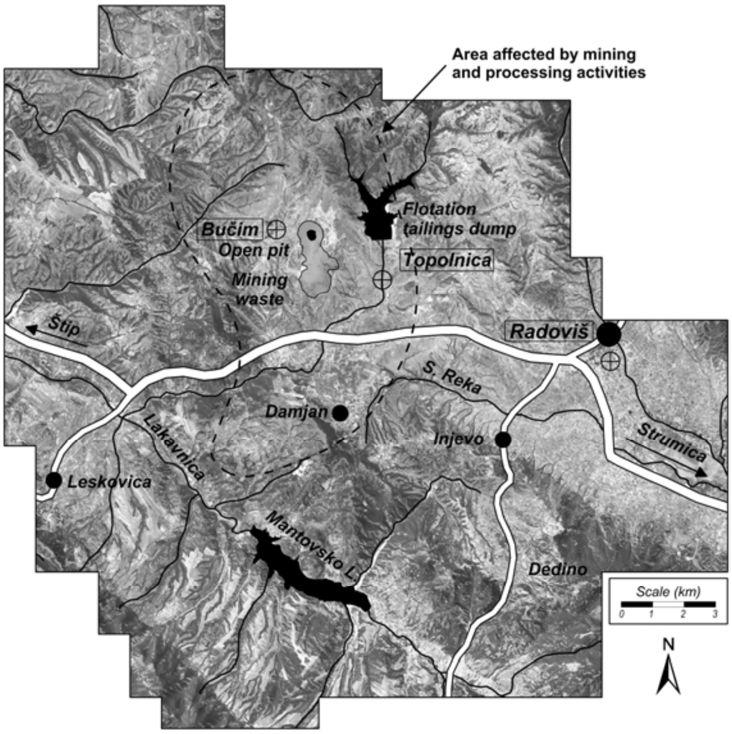

Fig. 1. Location of study area and sampling points for deposited dust

Experimental

Monthly samples of deposited dust were collected at three monitoring sites in copper mine environ: the town of Radoviš and the villages Bučim and Topolnica during 2009 (Fig. 1). Samples were collected using the dust deposition gauges. The obtained results were expressed in mg m^{-2} d^{-1} (i.e. the mass of dust deposited per m^2 per day). A deposit gauge, which comprises a 28±1 cm diameter funnel inserted into a plastic container (at least 5-10 liters in size) through a rubber stopper. Stand approximately 2 m tall and a canister which holds the plastic container to protect it from sunlight. After 30±2 days, any deposited matter in the funnel was washed into the plastic container using distilled water.

The collected rainwater of each sample was evaporated near dryness and then 3-5 mL of nitric acid, *p.a.* (MERCK, Germany) was added and transfers in to the 25 mL volumetric flasks. The content of Cu and Pb in digested samples was determined using ICP-AES (Varian 715-ES). The optimal instrumental parameters for this technique were previously given (Stafilov et al., 2011).

Results and discussion

The obtained values for the contents of the investigated elements were statistically processed using basic descriptive statistics. From the results obtained in this investigation it is evident that a large amounts of deposited dust were recorded in the close vicinity of the mine (villages Bučim and Topolnica) in some periods of the year the values are above the maximum permitted amount of dust powder (300 mg m^{-2} d^{-1}). Maximum value for the total deposited dust (815 mg m^{-2} d^{-1}) was obtained in August in the Bučim village. The annual average for the total deposited dust in the vicinity of the Bučim village is 489 mg m^{-2} d^{-1}, for Topolnica the 309 mg m^{-2} d^{-1} and accounted for Radoviš is 97 mg m^{-2} d^{-1} (Fig. 2).

As it can be seen from the data presented in Table 1, the median values for Cu in samples of deposited dust taken from the Radoviš area is 396 mg kg^{-1} and the ranges (from 94.8 to 1171 mg kg^{-1}, with high variation in monthly values) for the Topolnica village the median values in samples of deposited dust is 150 mg kg^{-1} with ranges (from 52.5 to 1183 mg kg^{-1}) and for the Bučim village the median values in deposited dust samples is 145 mg kg^{-1} and the ranges from 85.3 to 317 mg kg^{-1}. From these results can be seen that the maximum value for the content of Cu was obtained from Topolnica village (settlement near by the flotation tailings landfill) as presented in Fig. 3.

Table 1. Statistical parameters for annual values for the content of copper and lead in samples of deposited dust (in mg kg^{-1})

Element	N	Sampling site: Vill. Bučim		Vill. Topolnica		Radoviš	
		Median	Range	Median	Range	Median	Range
Cu	12	145	85.3-317	150	52.5-1183	396	94.8-1171
Pb	12	25.7	12.1-56.6	26.8	7.20-184	69.5	20.1-189

Similar results were obtained for the content of Pb. Previously investigations separated Cu and Pb as anthropogenic introduced elements in the study area (Balabanova et al., 2009; 2010; 2011; Stafilov et al, 2010). Maximum value for Pb was obtained from the town of Radoviš (189 mg kg^{-1}). Variability in monthly values for lead contents is due to the fact that higher contents of this anthropogenic element are continuously introduced in air with traffic and industry characteristic for the town. Despite the large amounts of total deposited dust from Bučim village, high values for the Pb content were not found (Fig. 4).

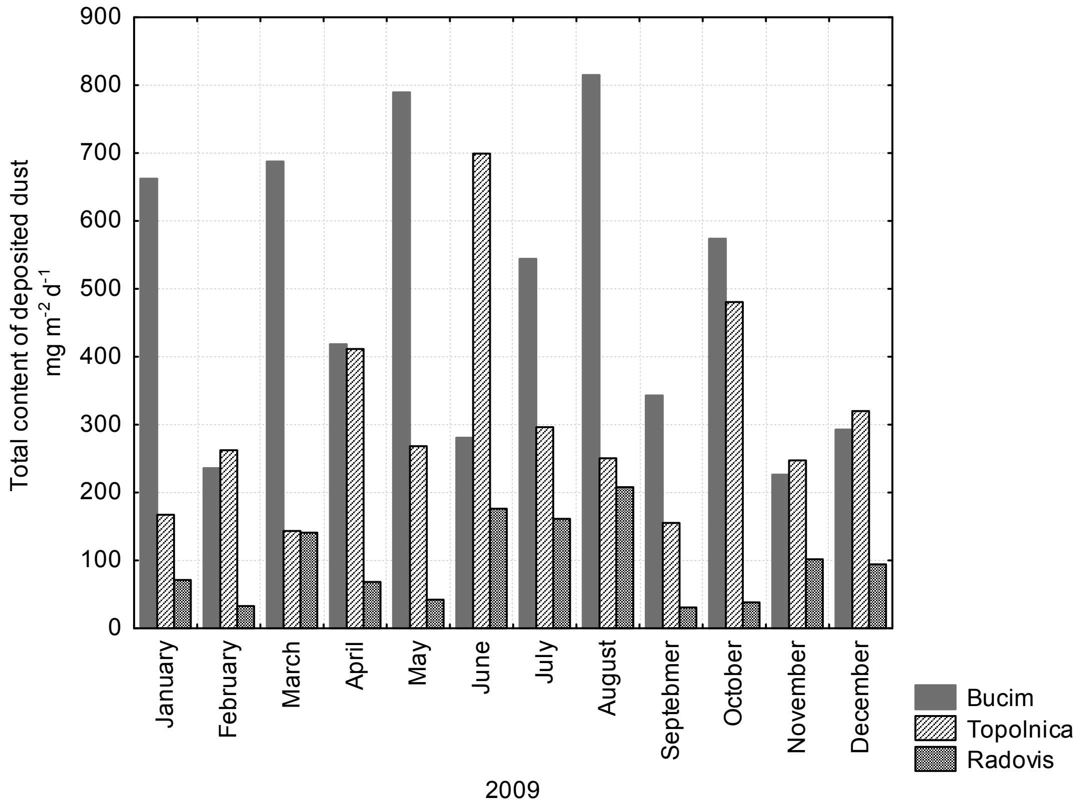

Fig. 2. The total content of deposited dust

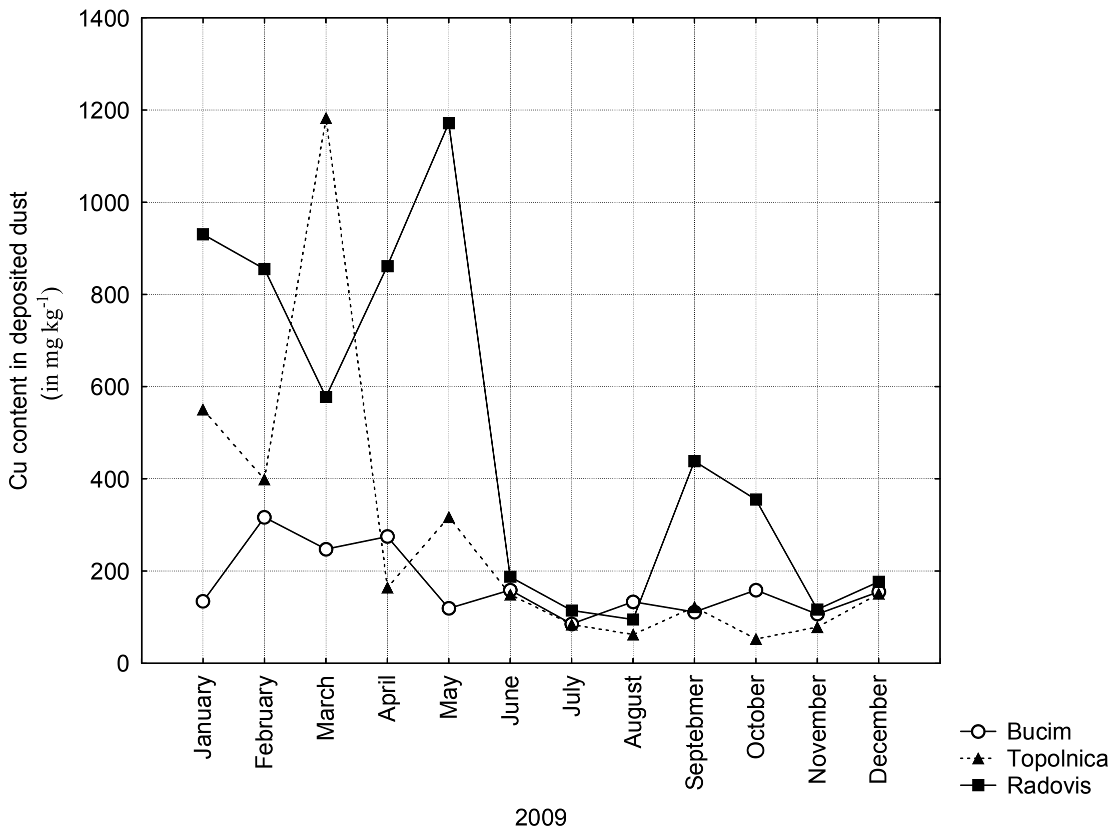

Fig. 3. Trends of copper content in deposited dust through the whole year

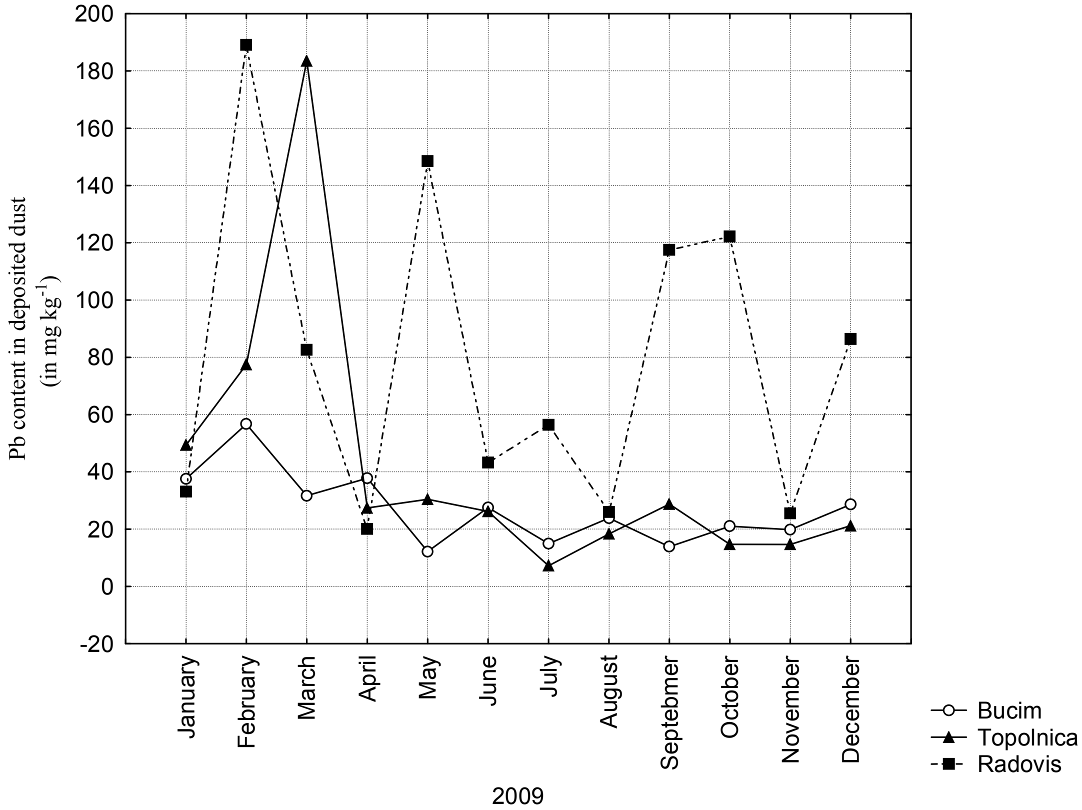

Fig. 4. Trends of lead content in deposited dust through the whole year

Conclusion

Conducted monitoring with deposited dust samples fortify that anthropogenic introduced elements (Cu and Pb) deposit in higher contents in close vicinity of their hot spots (open ore pit, ore waste and flotation tailings landfill). In the copper mine environ, there are some values above the national maximum permitted amount of sedimental dust (300 mg m^{-2} d^{-1}); annual average for the total deposited dust in the vicinity of the Bučim village - 489 mg m^{-2} d^{-1}, for Topolnica - 309 mg m^{-2} d^{-1} and for Radoviš - 97 mg m^{-2} d^{-1}. Maximum value for the Cu content was obtained from Topolnica village (settlement near by the flotation tailings landfill). In the town of Radoviš deposited dust was not above the maximum permitted amount for dust powder, but higher contents of Cu and Pb were obtained (with monthly variations in results). The high contents of Cu and Pb are not only due to mining works, but also the town works, traffic, industry and developed technological processes which aloud emission of higher amounts of these heavy metals in air.

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