

## Influence of Ironworks, Mining and Metallurgy on the Distribution of Chemical Elements in Central Bosnia and Herzegovina

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### Introduction

Central Bosnia is a centre of metallurgy, ironworking, smelting and mining. All three ironworks and smelters (Zenica, Vareš and Ilijaš) are situated in this area but in this proposal, an emphasis is on the two of them, the largest one, Ironworks Zenica, and Ironworks Vareš. Both of them are operating more than 100 years with production of few million tones of iron and steel per year before the last war.

### Study area Zenica

Zenica, 170.000 inhabitants, is located in the valley of the river Bosna, about 70 km north from Sarajevo. Construction of the iron and steelworks started in 1892, during Austro-Hungarian period, and until the end of 50's, becomes the biggest construction site in the former Yugoslavia. Expansion of production reached the record of 1.72 million tons of pig iron and 1.91 million tons of crude steel in 1986. At the beginning of 90's production was completely stopped but production was continued with less capacity at the end of last century.

The area of 52 km<sup>2</sup> is covered with a sampling grid that includes: urban zone, industrial zone and wider valley of the River Bosna. The entire area is separated into cells by the sampling grid with a density of sample per km<sup>2</sup> but in the urban zone, sampling density is increased. At 62 different sites, 124 samples of topsoil (0–5 cm) and bottom soil (20–30 cm), also two samples of attic dust are collected.

Two geogenic and one anthropogenic geochemical association are established on the basis of: visually indicated similarity of geographic distribution of elemental patterns in the topsoil and bottom soil; comparisons of basic statistics, correlation coefficient matrices; results of cluster and factor analyses and comparisons of enrichment ratios.

Two natural geochemical associations (Al, Ca, Ce, K, La, Li, Nb, Rb, Sc, Ta, Ti, Th, V and Y) and (Co, Cr, Na, Ni and Mg) are influenced mainly by lithology, but the third anthropogenic association (Ag, Bi, Cd, Cu, Hg, Mo, Pb, Sb and Zn) is result of historical activities of the ironworks Zenica, but also coal mining and other anthropogenic influences in the past.

High concentrations of Co, Cr and Ni are result of weathering processes and critical level of the mentioned elements is found on c. 2 km<sup>2</sup> in topsoil and c. 3.3 km<sup>2</sup> in bottom soil. Natural critically polluted area is located on surrounding hills, outside from the urban zone and main share in total natural pollution is principally with Ni and Cr. Anthropogenic pollution that associate high concentrations of As, Cd, Cu, Hg, Pb and Zn, exceed critical level on c. 2 km<sup>2</sup> in both soil horizons. For the mentioned association is significant that polluted area is situated in the Zenica basin and area among the river. Critically polluted area is mainly situated on the Miocene coal layers on the NW side of the study area and refers to As distribution.

### Study area Vareš

Vareš is situated in a valley of the river Stavnja with 20.000 inhabitants. In this region, iron ore mined and smelted from Antique period but with arrival Austrians to Bosnia, Vareš admire revival in economy aspect. Construction of the ironworks and metal foundry in Vareš started in 1891, and until 1991 has operated within one company called "Mine and Ironworks Vareš".

Three Fe ore deposits Smreka, Droškovac, and Brezik are situated in municipality of Vareš. Open pit's reserves and resources in the mentioned three Fe ore deposits are approximately 169 million tones, in 1991. Apart the Fe in hematite and siderite there are present another oligoelements such as Cu, Pb, Zn, As, Sb and Sn.

Lead, zinc and barite Veovača open pit is situated about 10 km of the town. Sulphide mineralization is associated with layers of barite and have volcanogenic – sedimentary genesis. Pb – Zn mineralization is associated with Droškovac Fe deposits. Together with main minerals galena, sphalerite and barite are associated another minerals such as pyrite, marcasite, tetraedrite, antimonite, chalcopyrite, cinnabar, realgar, calcite, quartz, limonite, covellite etc. From the

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abandoned open pit and waste deposit "Veovača" is significant seeping of some chemical elements that have great influence on environmental pollution around of open pit and along the river Stavnja.

In the determined locations along the river are collected stream sediments, alluvial sediments, topsoil (0–5 cm) and bottom soli (20–30 cm). In two locations close to former ironworks, two samples of attic dust are collected. The attic dust as sampling material has the advantage that its composition remains constant and chemically unchanged with time.

Based on a comparison of statistical parameters, correlation coefficients between chemical elements, and spatial distribution of particular elements in sampling materials, two natural and two anthropogenic geochemical associations were identified. Two natural geochemical associations (Al, Ca, Hf, Nb, Sc, Ta, Ti, Zr) and (Ce, La, Na, Rb, Th, Y) are influenced mainly by lithology. One anthropogenic association (Bi, Cd, Cu, Fe, Mo, Sn, W, Zn) is the result mainly of iron metallurgy in the past and second anthropogenic association (Ag, As, Cd, Mn, Pb, Sb, Hg) is the result mainly of seeping from the Veovača mine landfill.

## Conclusion

Compare the concentrations of As, Cd, Cu, Hg, Mo, Pb and Zn in pilot samples of topsoil and attic dust, and also according to legislations, relatively low pollution with heavy metals in Zenica basin is found. Similarly is considered that anthropogenically critical polluted soils (2 km<sup>2</sup>) is unimportant compare to critically polluted area around ironworks Jesenice (13 km<sup>2</sup>)

First research phase of influence of the Vareš ironworks, as well as the Veovača mine landfill in Stavnja catchments area, high pollution with heavy metals around ironworks is shown. Most worry are critically high concentrations of heavy metals on alluvial sediments, downstream of the Stavnja.

In following phases is necessary to determine quantity of heavy metals that still is transported from the Vareš ironworks and also from the mine landfills Smreka, Veovača, Brezik and Droškovac. Significant is their influence on groundwater and source of drinkable water for wider region.

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