

## Pollution in Slovenia Owing to Mining and Metallurgy

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### Introduction

Slovenia has long been known for its numerous mines and ore processing. From the times of the Roman Empire to present, 49 mines and open pits are opened, among them four large (Idrija, Mežica – Topla, Litija and Žirovski vrh). There are also 25 ore processing plants and smelters that are operating mostly in vicinity of larger mines (Idrija, Žerjav, Celje). However, due to lack of written sources, we probably have not succeeded in making a complete list of them. There were 33 iron works operating in the vicinity of mines and open pits, three large ones have further developed and are still operating (Jesenice, Ravne na Koroškem and Štore).

As the ore processing capacities have far exceeded the capacities of the Slovenian mining, ore has long been imported and thus only processed in Slovenia. On the basis of the results of our investigations in the vicinity of larger mines and smelters, we estimate in Slovenia critical limit for heavy metals content exceed sum up to 76 km<sup>2</sup>.

### Present geochemical investigations

The objective of the presented geochemical investigations is establishing the extension of environmental pollution with heavy metals, and distinguishing between natural (geogenic) and anthropogenic components of the pollution.

In the area of Celje, a town with about 50.000 inhabitants, very high contents of Ag, As, Cd, Cu, Mo, Pb, S, Sb and Zn is found, which source is smelting of zinc ore between 1873 and 1970. Concentrations of heavy metals in topsoil exceed the official limit of critical concentration in 18 km<sup>2</sup>. Distribution of cadmium in the upper level of soil is a good example of strong anthropogenic impact. The average cadmium content around Celje (1.9 mg/kg) is approximately 3 times above the Slovenian average, while in the town centre (7.5 mg/kg) it is even 15 times above the Slovenian average.

In the area of Jesenice, about 20.000 inhabitants, we investigated the impact of centuries long lasting ironworks activities in a narrow alpine valley. We identified anthropogenic enrichment (Cd, Cu, Hg, Mn, Pb in Zn) in the upper horizon of soil. By soil sampling in the area of 113 km<sup>2</sup> was established that the concentrations of heavy metals in topsoil exceed the official limit of critical concentration in 13 km<sup>2</sup> of the research area. In the area around Jesenice, the average content of cadmium (2.1 mg/kg) is 4 times above the Slovenian average.

In the Mežica valley, 300 years of lead and zinc ore mining and smelting had a very negative impact to the environment. The area is strongly polluted with Ag, As, Cd, Cu, Hg, Mo, Pb, S, Sb, Sn and Zn. By soil sampling in the total area of 101 km<sup>2</sup> is established that the concentrations of heavy metals in topsoils exceed the official limit of critical concentration in 24 km<sup>2</sup> of the research area. In the investigated area, the average content of cadmium in the upper level of soils (2.6 mg/kg) is more than 5 times above the Slovenian average.

In Idrija and its close surroundings, influences to the environment have been studied of natural dispersion of mercury combined with half of millennium of mining. 160 km<sup>2</sup> around the Idrija mercury mine are investigated and mercury concentrations in soil exceed the critical values for soil (10 mg/kg) on 21 km<sup>2</sup>. Estimated soil mercury mean for the studied area (8.6 mg/kg) is 5 times above the Slovenian average.

The Drava watershed, with confluents, is important area of mining and smelting activities, have begun in antic period, developed in Middle century and have achieved the maximum in the middle of the last century. Numerous mines and smelters: Bleiberg-Kreuth, Cave del Predil and Mežica have left great consequences on chemical composition of the Drava alluvial sediments. The study area can be divided into two zones: Drava canyon from Slovene/Austrian border up to the town Maribor where dominant alpine characteristics of landscape and zone from the Maribor until the confluence of Mura and Drava rivers, where the river valley is wide and has all characteristic of Pannonian basin.

On the territory of recent flooded lowland, averages of Cd (Alpine region: 7.1 mg/kg; Pannonian region: 5.4 mg/kg), Pb (Alpine region: 410 mg/kg; Pannonian region: 430 mg/kg) and Zn (Alpine region: 1600 mg/kg; Pannonian region: 1300 mg/kg) exceed the average of mentioned elements on river terraces approximately 10–26 times regard to sep-

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arate elements and location of sampling. In whole studied area c. 133 km<sup>2</sup>, is critically polluted with heavy metals, especially with zinc, according to legislations of Slovenia and Croatia.

### **Future geochemical investigations**

The future geochemical research is directed mostly towards the surroundings of smaller abandoned mines, metallurgical plants, and corresponding mine tailings.

The objective of the investigations will be geochemical survey in the vicinity of abandoned mines and mining plants:

- 1) estimation of geochemical characteristics of the geological environment before any human interference.
- 2) estimation of the pollutants load originating in mining and processing of mineral raw materials.

The research will also try to establish the anthropogenic load of heavy metals, such as: Cadmium, Copper, Mercury, Lead and Zinc, in surface materials.

Special emphasize will be given to the introduction of new principles and methodologies of geochemical research, in regional as well as detailed scale, particularly to comparing primary and recent conditions. The results of the research will contribute to the assessment of potential vulnerability and hazard in the areas in the vicinity of mining and metallurgical plants, as well as metallurgical slag and mine tailings.