

HEAVY METAL POLLUTION OF SOILS FROM BAIJA-MARE – CASE STUDY: CUPROM INDUSTRIAL AREA

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Abstract

Industrialization of Baia-Mare area has had a major effect on the environment. Many contaminants were released and accumulated in soils causing important heavy metal pollution. This study presents a historical approach of the reasons that led to the contamination of soils and the present situation of industrial areas in Baia-Mare. The pollution of soils with heavy metals is a worldwide problem and the state of the environment should be improved in each case study. Former CUPROM industrial area requires remediation measures because of the historical soil contamination with heavy metals, mainly Cu, Pb and Zn. The revitalization of the case study area is necessary and further studies on the remediation possibilities must be carried out. The aim of this study is to characterize this industrial zone and to identify the soil pollution.

Key words: environment, industrial sites, heavy metals, soil pollution.

INTRODUCTION

Activities like mining, smelting or petrochemical refining are the main sources of pollution at global scale. Studies proved the harmful effects that heavy metals and other elements have on the environment quality and human health. In order to protect the life of citizens, many governments established the limits of different elements in soils and sediments for residential and industrial zones (Paulette et al., 2015).

Pollution of soils and the problems generated by it, interest more and more researchers. For the environment, the historical pollution caused by industry has deleterious consequences on the ecosystem, the quality of life and human health. Heavy metals can contaminate the soils through different pathways: solid waste disposal, industrial applications, sludge, vehicular exhaust, wastewater irrigation or agricultural production (Cioruta et al., 2013).

Soil is “the surface layer of the earth shell and it is formed from mineral particles, organic matters, water, air and living organisms”. It is very important for the survival of the ecosystem and for the human needs. Pollution of soil affects it from both qualitative and quantitative sides. It is a resource that is non-renewable and a connection between air, water and earth having the following functions:

- Origin of raw materials;
- Biomass production and nutriment;
- Filter, transform and deposit different substances;
- Physical environment for humans;
- Platform for biodiversity, species, genes and habitats;
- Geological and archaeological patrimony (National Report on the State of Environment, 2011).

Because of its structure and properties, soil acts as a filter and can retain and deposit toxic substances. In Europe, the most common

pollutants are mineral oils and heavy metals like: copper, lead, cadmium, arsenic, chromium, nickel, zinc, mercury. These have a great impact on the environment and human health (Panagos et al., 2013; EEA, 2014; Liedekerke et al., 2014; Moldoveanu, 2014). Situated in the north-west part of Romania, Maramures County is well known for the metallurgical industry and non-ferrous mining. The environment has been polluted with the gas emissions and dust that contained Zn and Cu. So many years of mining activities in the Maramures County led to a historical pollution that affect citizens' health. Zn exposure can cause diseases like hypertension, arteriosclerosis, heart disease while Cu can determine lung cancer, nasal septum perforation, pulmonary interstitial fibrosis and interstitial fibrosis. After the closing of the copper smelter in 2008 and the lead smelter in 2012, it was reported an improvement in the air

quality, but soil still has a high level of heavy metals (Oros, 2010; Butean et al., 2014).

The main sources of pollution in Baia Mare area are SC Cuprom SA, SC Romplumb SA and CNMPN Remin SA. After reducing or stopping the activities, the dumps that formed due to metal extraction and processing of ores, are considered "hot spots". These hot spots exist even inside the city of Baia Mare. Microorganisms are capable of making heavy metals soluble and the pollutants can be absorbed by plants' roots and transported in the upper parts entering the food chain and causing different maladies to animals and humans (Coman et al., 2010; Cociorhan, 2011; Big et al., 2012).

There are several hot spots of soil pollution in the Maramures County (Figure 1).

This study will analyse the Cuprom industrial area (Table 1) with its characteristics and historical pollution.

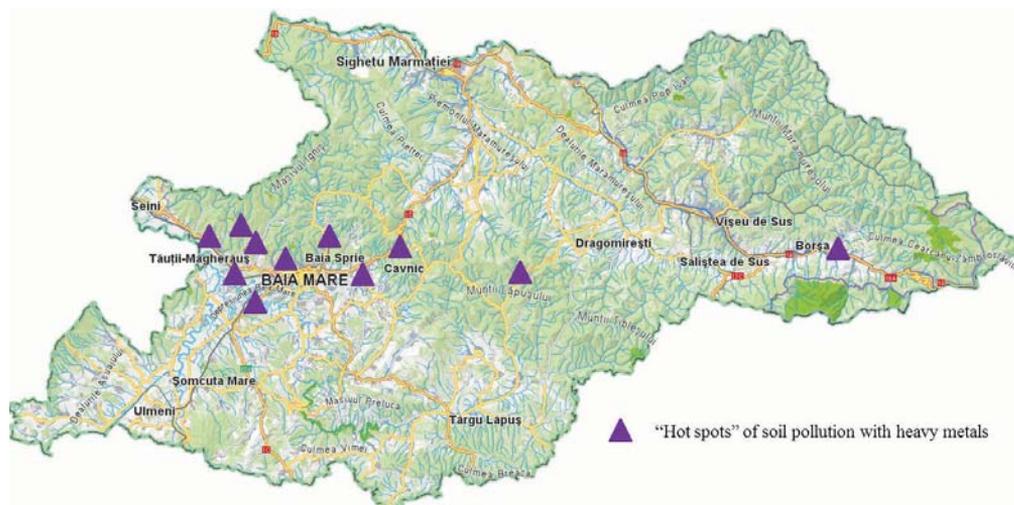


Figure 1. Mining zones where soil pollution reaches the highest level from the Maramures County (map realized according to the data provided by ANPM at <http://apmmm.anpm.ro/sol-subsol>)

Table 1. Case study overview (<http://apmmm.anpm.ro/sol-subsol>)

Name of owner of the site	Location of contaminated site	Type of polluting activity	Nature of pollution source	Nature of pollutants	Contaminated area (ha)
CUPROM SA Bucharest Subsidiary Baia Mare	Baia Mare	Metallurgical industry, copper production	Suspension smelting installations of copper concentrates	Heavy metals, sewage, sludge, acidic solutions, petroleum products	58,0

Description of the studied area

Baia Mare is located in the Maramures County, in the Baia Mare depression and on the banks of Sasar River. Its coordinates are 47°20'00" and 48°00'15" North latitude and 22°52'30" and 25°07'30" East longitude, at 228 meters above sea level. It is a town situated almost entirely at the north peaks of Eastern Carpathians. The location of the Baia Mare depression is at the contact of Someseana platform and the Eastern Carpathians. The region was part of a marine basin at the end of Pliocene and during Neogene there was an intense volcanic activity. So mountain massifs of 50 km called Varatec - Gutai - Oas developed, containing gold and silver ores and non-ferrous metals like zinc, lead, copper (Maramures County Environmental Profile, 2013).

The area of Baia Mare is a typical area of hydrographic convergence that resulted from merging of valleys and the confluence of rivers Lapus and Somes (Muntean et al., 2012).

Baia Mare is an urban settlement dating from the XIV century, well known because of the mining activities in the area and as a result of operating non-ferrous ores. The first reliable informations are from the fourteenth century, although medieval beginnings of such activities are much earlier, the second half of the thirteenth century (<http://www.baiamare.ro/ro/Descopera-Baia-Mare/Orasul-Baia-Mare/Istoria-orasului/Istoria-orasului/>).

The city of Baia Mare is first specified by Charles I of Hungary in the written papers from 1328 as "*Rivulus Dominarum*" which means the Ladies' River because of the image of the wives of miners that were involved in the gold sand washing operation in riverbeds of the region (Constantinescu et al., 2015).

For most of the Baia Mare citizens, mining was the main source of subsistence and it was a traditional profession since ancient times (Modoi et al., 2010).

After mining become unprofitable and the fall of the communist regime, mines were closed and conserved due to European Union terms.

MATERIALS AND METHODS

The present study analyses the data collected from field documentation and it represents a

theoretical approach. It focuses on the data that is related to contamination of soils with heavy metals from the Baia Mare region as a consequence of mining activities and on the information on how industrial activities from the SC Cuprom SA affected the environment. The collected data was processed and the characterization of Baia Mare and Cuprom were obtained.

RESULTS AND DISCUSSIONS

Context

Romania is well known for the mining activities for centuries. The impact on the environment of the long-term extraction and mining is huge and the features of the affected zones are: destruction of soil quality, fertile soil layer, agricultural terrains, forests, noise pollution, radioactive pollution, air pollution, deterioration of landscape, changes in the flow of groundwater, residual water, mine wastes disposal with great effect on flora and fauna, erosion of soils. There is a need of pollution reduction to limit the risks of pollution spreading (Coman et al., 2009; Berar et al., 2010).

Maramures Environmental Protection Agency compiled a list of contaminated and partially contaminated sites that counts 30 sites polluted with heavy metals due to the activities of mining and metallurgy on an area of 602.42 ha (Table 2) (Maramures County Environmental Profile, 2013).

Table 2. Surface areas of contaminated sites in Maramures County (Maramures County Environmental Profile, 2013)

Tailing ponds (ha)	Arsenious pyrites deposits (ha)	Metallurgic industry (ha)	Mine sterile dumps (ha)	Total (ha)
428.94	12.29	67.74	93.4	602.42

One of the major environmental problems in Baia Mare city are the waste mine deposits that are very close to the residential areas, agricultural lands and surface water. These deposits occupy large areas and have big volumes. They deteriorate the landscape and affect the ecosystem, flora, fauna, people and also affect the ground and surface waters. The heavy metals and metalloids that pollute the

areas for long term are: Zn, Cu, Pb, Cd, As and Ni (Damian², 2008; Modoi et al., 2014).

The minerals that can be found in the soils of Baia Mare are the following:

- Native elements: Cu, Ag, Au, As, S;
- Sulphide minerals: arsenopyrite, galena, pyrite, stibnite, chalcopyrite, sphalerite;
- Tungstates: scheelite, wolframite;
- Sulphosalts: jamesonite, pyrargyrite, tetrahedrite, semseyite;
- Gangue minerals: quartz, barite, adularia, clay minerals, rhodonite, carbonates (Oprea et al., 2010).

The Romanian Ministry of the Forest, Waters, and Environment establishes in the Order no. 756/1997 for approving the Regulations regarding the evaluation of environment pollution, the normal, alert and intervention limits for soils elements. It also defines terms like maximum level of pollution (sensitive and less sensitive soils), environmental impact, threshold alert and intervention, types of land uses etc.

History

Ferrous steel industry and non-ferrous metallurgy are components of metallurgical industry. Steel industry provides raw material for manufacturing a wide spectrum of products. In Romania, this branch of industry has a long tradition in history, witnesses of the evolution are the bronze weapons and products of iron coming from workshops and kilns. There were several metallurgical centres: Galati, Targoviste, Hunedoara, Otelul Rosu, Baia Mare, Zlatna, Copsa Mica, Severin, Focsani, Resita, Slatina, Braila, Brasov, Nadrag, Campia Turzii, Drobeta Turnu Severin that proved how important was the industrial sector for the country economy. Most of them lowered or closed production after 1999 (Martinescu and Capusneanu, 2010).

The plant from Baia Mare was built in 1907 near Baia Mare, in a place called Ferneziu (Figure 2). At the beginning, it was a private company that produced sulphuric acid. The Phoenix owners bought the glass factory and the surroundings, which was the same place where the plant was located. Later, between 1927 and 1942, the plant extended and started the electrolytic copper production and precious metals business – gold and silver. In the years

of 2003 – 2004, Cuprom bought the Phoenix Baia Mare plant and the Company of Laminated Electric Cable that was founded in 1972. Because of the modernization process and the new technologies that were implemented and also because of the financial investments, it became the biggest copper production company from Romania and one of the largest from Eastern Europe. This lasted until September 2008 when the company faced bankruptcy after the price of copper collapsed suddenly (Cuprom SA, Reorganization plan, 2010).



Figure 2. Phoenix plant
(<http://dorinstef.blog.com/files/2010/06/Combinatul-Phoenix.jpg>)

Cuprom SA was a leading company in recycling, refining and transforming copper. It was the unique company that produced electrolytic copper, continuous cast copper rod and enamelled wire in Romania. It also had applications in secondary smelting, casting, refining, bunching, drawing and enamelling facilities

(http://www.cuprom.ro/lang_en/cuprom.html).
The geographical coordinates of the Cuprom Company are 47°39'17" N, 23°36'12" E.

Soil pollution

Because of the emissions in the air from the Romplumb that was processing lead and Cuprom (Figure 3) that was processing copper, the soil from Baia Mare is polluted in high concentrations with Pb, Cu, Zn, Cd and As (Sustainable Development Strategy of Baia Mare, 2009, Oprea et al., 2011).

Baia Mare Municipality identified the main polluting sources and the major pollutants in the city. The man-made sources of pollution that affected the quality of soils in the area

were non-ferrous metallurgy and extraction of non-ferrous ore. RBG Phoenix SA and SC Romplumb were the companies that contaminated the environment with the leavigation ponds, mine rock dumps and mine waters from the galleries that were discharged. High concentrations of heavy metals were found in the perimeter of these plants, values that exceed the admissible limits (Baia Mare Municipality, Local Agenda 21, 2002).

In 2002, former Cuprom SA (Figure 3), RGB Phoenix Baia Mare was on the hot spot list of Greenpeace for water pollution. The causes of pollution stated by the organization were wastewater discharges loaded with heavy metals. Greenpeace asked for an effective operation of waste water treatment plant (Greenpeace, 2002).



Figure 3. Satellite view of Cuprom area (<https://www.google.ro/maps/@47.6545769,23.601314,1415m/data=!3m1!1e3?hl=en>)

The distribution of the total surfaces of 58 ha that SC Cuprom SA Bucharest Subsidiary Baia Mare had in its patrimony was:

- Built area – 106417 m²;
- Surface of interior roads and concrete platforms – 164777 m²;
- Surface of transport routes – 103467 m²;
- Networks and platforms area – 36689 m²;
- Surfaces covered by dumps (landfills) – 47200 m²;
- Green areas – 168652 m² (Regional Environmental Protection Agency Cluj-

Napoca, Integrated environmental permit no. 79 - NV 6 from 29.10. 2007). Damian et al. (2008) investigated the soil pollution with Pb, Cd, Cu and Zn of Cuprom area in the upper horizon and up to 1.2 meters depth. The results showed a Pb concentration of 904 – 995 ppm, a Cu concentration between 400 – 5823 ppm, Cd has values between 80 – 39 ppm, while Zn values range between 536 – 252 ppm. In the organic horizon, the total content of Cu is important in the aluviosols and luvisols that are specific for this area and the highest values are in area of gaseous emissions. Soil pH varies between 3.54 – 4.98.

The Cuprom chimney (Figure 4), with a height of 351.5 metres, is the tallest artificial building in Romania and the 3rd in Europe (<http://skyscraperpage.com/cities/?buildingID=56681>). This makes it very valuable for a future redevelopment of the area.



Figure 4. Cuprom chimney, a landmark of Baia Mare (<http://www.panoramio.com/photo/76619862>)

Nowadays, all the buildings that used to have specific functions are neglected or damaged. The whole scenery looks terrifying. Important surfaces of soils that belong to Cuprom area are degraded and vegetation does not develop in this type of land (Figure 5). Invasive species have started to grow and populate the soil.

According to national press, Cuprom area is in the interest of the Municipality of Baia Mare to be rehabilitated and integrated in the community. The price of 3 million euros seems to be affordable for the investors and the location of this area is great for future development.

Baban (2012) proposed the rehabilitation of the industrial platform Cuprom by keeping some of the old elements and converting them into new attractions and functions (Figure 6). The chimney would be kept for touristic purposes while the rest of the area would be converted in an eco-industrial park and a platform for waste management.



Figure 5. The current status of the Cuprom site

The most important step in the reconversion of the area is the decontamination and greening of the land.

Best techniques for the treatment of the polluted soil must be applied and a combination of different techniques might be very effective in this case.

There are not only environmental problems caused by pollution, but also social and economic effects. Most affected by pollution seems to be the forests from the vicinity of the pollution sources.

The agricultural land on a surface of 7 – 8 km round is less fertile or even infertile.

The drinking water is contaminated by the heavy metals and organic substances. If

compared with other places, the life of humans and animals is shorter with 2 to 12 years.

The constructions in the surrounding areas are more dirty and rusty than others from clean regions (Pop, 2014).



Figure 6. Example of proposed situation for area rehabilitation (designed by arh. Alexandru Baban, 2012)

CONCLUSIONS

For Baia Mare, a city with a population of more than 100000 citizens, the remediation of the contaminated areas is an important issue. The serious environmental pollution caused by mining activities lead to health problems for the population. Dangerous types of contaminants like Pb, Cu, Zn, Cd require finding good solutions for decontamination of these zones. After closing the mines and plants, thus reducing the specific activities, the air became less polluted, but the soil remained highly contaminated. The area of former plant Cuprom needs urgent measures of reconversion because of its valuable location and due to the fact that

is part of the city and must be integrated, not rejected. The industrialization and urbanization of Baia Mare had negative effects on the environment due to the pollution of important areas in the surroundings. Nowadays, the city must recover from the historical pollution and there are a lot of investments to be made in cleaning the polluted environment.

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