

A DEEP DIVE INTO THE CHRONIC AIR POLLUTION REALITY IN BAIA MARE: PART I: SOURCES OF HISTORICAL ENVIRONMENTAL POLLUTION IN BAIA MARE AND THEIR CONTRIBUTION TO AIR POLLUTION

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Abstract

The city of Baia Mare is located in the Baia Mare Depression, a region which is characterized by intense anthropogenic activity. Due to the long-lasting local mining and metallurgical tradition, this area was among the most problematic in the country in terms of historical pollution and its consequences. In Baia Mare, pollution is chronic (historical), but also diversified, with several notable sources. The present paper, the first part of a complex three-piece study, aims to provide an overview of the historical sources of air pollution in Baia Mare, while the second part will highlight the air quality evolution in Baia Mare between 1995 and 2006, and the third and final piece will analyse the effects of this chronic pollution on human health. This article is a historical, descriptive and analytical investigation of the main sources of historical environmental pollution (including air pollution) in Baia Mare. The aim of the study is to highlight the activities carried out by these polluting companies and to emphasize the contribution of these activities and various technological processes to air pollution in Baia Mare, between 1995 and 2006. The industry in Maramures County, where Baia Mare is located, had a significant contribution to the country's lead, copper, gold and silver production. At the same time, due to the nature of their activities, these industrial branches were heavy polluters. The historical environmental pollution (including air pollution) in Baia Mare had three major sources: the National Company of Precious and Nonferrous Metals (NCPNM) - Remin Corporation; Cuprom Corporation; Romplumb Corporation. NCPNM - Remin Corporation processed polymetallic deposits of lead, zinc, copper and ferro-manganese deposits, and the company was an important producer of gold, silver, lead, zinc and copper concentrates. The basic activity of Cuprom Corporation consisted of extracting nonferrous metals by pyrometallurgically processing cuprous and gold concentrates. The main activity performed by Romplumb Corporation was obtaining decopperised lead by pyrometallurgically processing lead-cuprous concentrates. The activities of the three major companies led to the systematic exceedances of limit values set for the pollutants resulting from various technological processes, namely suspended particulate matter, heavy metals and SO₂. All three companies were active for decades and, until the early 2000s, environmental protection was not a priority in the technological process management of these three metallurgical centres.

Unfortunately, after the year 2000, investments in green technologies were insufficient and, starting with 2008, the economic crisis also affected the three companies mentioned above. Currently, NCPNM - Remin and Romplumb Corporations are insolvent and Cuprom Corporation is bankrupt.

Keywords: Baia Mare, historical pollution, air pollution, mining, metallurgical industry

1 PURPOSE OF THE STUDY AND BACKGROUND

Baia Mare City is located in the Baia Mare Depression, a region which is characterized by intense anthropogenic activity. Due to the long tradition in local mining and metallurgical activities, this is one of the country's most problematic regions in terms of historical pollution and related effects, and numerous studies were conducted here (Donisa et al, 2000; Culicov et al, 2002; Coman, 2006; Cordos et al, 2006; Cordos et al, 2007; Miclean et al, 2008; Damian et al, 2008; Levei et al, 2009; Damian et al, 2010; Modoi et al, 2010; Gurzau et al, 2012; Mihali et al, 2013; Chira et al, 2014; Dorotan et al, 2015; Bud et al, 2016).

In Baia Mare, pollution is chronic (historical), and there are multiple pollution sources.

This paper, which is the first part of a complex three-part study, aims to present an overview of historical air pollution sources in Baia Mare, while the second paper will focus on the evolution of air quality within city limits between 1995 and 2006, and the third will analyse the effects of this chronic pollution on the local population's health.

This paper is a historical, descriptive and analytical investigation of the main historical pollution sources (including air) in Baia Mare City. Our work updates and expands the body of information provided by previous papers mentioned above on the topic of environmental pollution in Baia Mare. It aims to highlight the activities conducted by local polluting companies and their contribution to air pollution in Baia Mare, between 1995 and 2006.

2 AREA DESCRIPTION

The physico-geographical context and the region's rich natural resources have provided auspicious conditions for human communities from the earliest times. Evidence shows this territory was inhabited by primitive people as early as the Upper Palaeolithic.

Baia Mare is located in Romania's north-western region, within the limits of Baia Mare Depression, which is part of the Western Hills unit, more specifically the North-western Hills. Its coordinates are 47°39' - 47°48' northern latitude and 23°10' - 23°30' western longitude. Geomorphologically, the city is situated in the transition sector from depression to hills and mountains, the altitude of which rises from north to east (Fig.1) (Ielenicz, 2000, p.20).

Baia Mare Depression is located in the contact area of the Someş Platform and the Eastern Carpathians, on the southern side of volcanic mountains Țibleş and Gutâi, at the foot of which Baia Mare is located. This eruptive chain had a particularly tumultuous geological past. Until the end of Pliocene, the region was part of a vast marine basin, which subsequently evolved into a lake. Intense Neogene volcanic activity resulted in the emergence of massive volcanic masses (lava spills, pyroclasts) and the formation of a mountain chain, which in the Călimani-Harghita sector is less compact and not as high as the surrounding sectors (Rosu, 1973, p.58-61). The Baia Mare Depression formed due to the sinking of a Trans-Carpathian flysch sector and of the post-tectonic cover of the crystalline-Mesozoic area in western Maramureş. Its evolution spanned across the Badenian and Pliocene (Rosu, 1973, p.340-341; 347-348).

The basin's rich ore deposits are the result of the eruptions that occurred in the 3 Neogene phases, i.e. Pontian, Sarmatian and Tortonian (Rosu 1973, p.18; p.58; p.38-44). The minerals consist of complex metal sulphides (containing lead, zinc, copper, etc.), and they are often associated with gold and silver; the former is also found in free state. Additionally, the region is rich in andesites, basalts and dacitic tuffs.

3 HISTORICAL AIR POLLUTION SOURCES IN BAI MARE

As Baia Mare is an old mining and metallurgical centre, its major problems in terms of air quality were derived from industrial activities.

The industry in Maramureş County has contributed, over a long period of time, to Romania's production of lead, copper, gold and silver, as mining and nonferrous metallurgy activities have had a long-lasting tradition here. Due to the nature of their activity, these industrial branches have been heavy polluters.

Baia Mare's historical environmental pollution (including air) had 3 main sources (Fig.1):

- The National Company of Precious and Nonferrous Metals (NCPNM) - Remin Corporation;
- Cuprom Corporation;
- Romplumb Corporation.

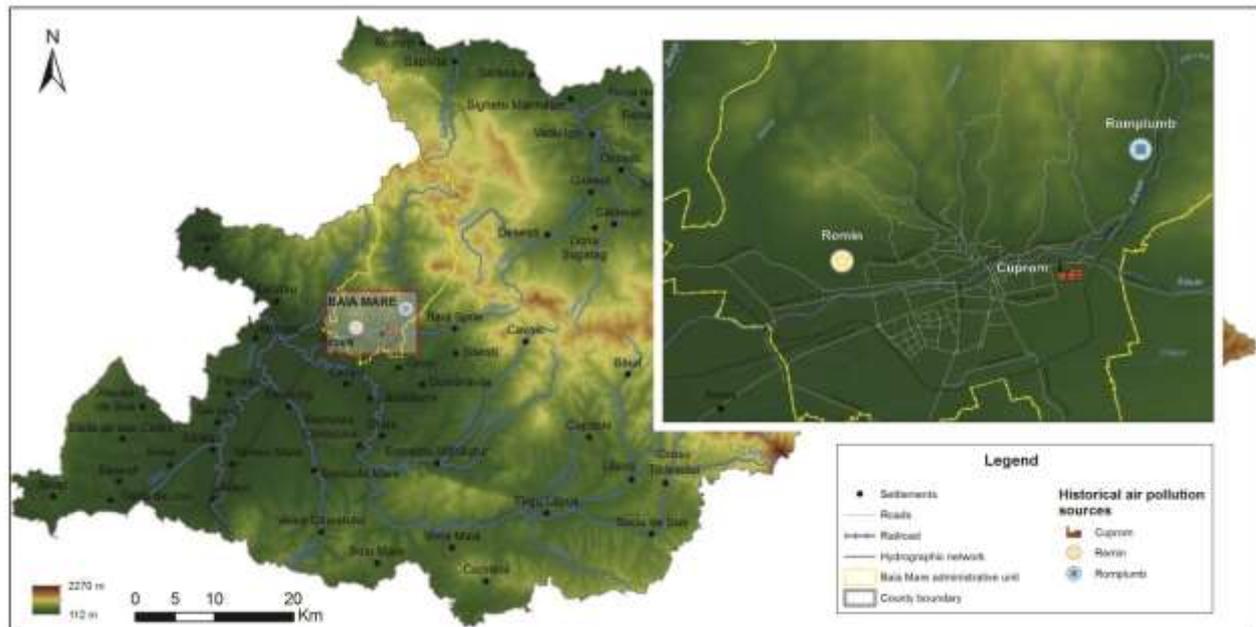


Fig.1. Baia Mare and its historical air pollution sources

3.1 The National Company of Precious and Nonferrous Metals (NCPNM) - Remin Corporation

The National Company of Precious and Nonferrous Metals (NCPNM) Remin Corporation exploited and processed polymetallic lead, zinc, copper and ferro-manganese deposits, and was a major producer of gold, silver, lead, zinc and copper concentrates. The company was fully state-owned capital, maintained continuous operation, and employed about 6.000 before halting ore exploitation in 2006 and filing insolvency in 2009 (C.N.M.P.N. Remin S.A. Baia Mare, 2016). Before 1989, the company had 30.000 employees. Remin Corporation was the main economic agent in Maramureş County up to 2006.

The National Company of Precious and Nonferrous Metals (NCPNM) Remin Corporation mines started their activity in very different historic periods, some several centuries ago (Baia Sprie, Sasar, Baiut mines), while others after 1948 (Herja, Suior, Ilba and Nistru mines). Ore production, especially metal, increased rapidly between 1948 and 1980, after which remained relatively constant at 5 million tonnes/year.

Starting with 1990, all mines cut down production, which, even though reached 1.4 million tonnes in 2003, still had a notable contribution to the national nonferrous metal production industry (lead 65%, zinc 75%, copper 27%, gold 52% and silver 54%).

3.1.1 Activities Conducted By the Company

The most important industrial activities were:

- a). Exploration and exploitation of nonferrous ore in Baia Sprie, Baiut, Cavnic, Turt, Suior, Aurum (Ilba, Nistru, Sasar), Borsa and Rodna;
- b). Exploitation of iron-manganese ore in Razoare quarry;
- c). Processing of nonferrous ore and production of selective and collective concentrates: Central Flotation Plant, which processes nonferrous ore sourced from Cavnic, Herja-Baia Sprie, Turt and Suior; Baiut, Cavnic, Borsa and Rodna flotation plants.
- d). Detailed geological exploration works.

Numerous physical and chemical procedures were required for mining activities and the processing of mineral substances, resulting in:

- The useful elements, which were shipped to processing plants in order to make full use of their potential;
- Tailings, which were stored in large areas (dozens or hundreds of hectares), thus strongly disturbing local ecosystems.

3.1.2 Contribution of Remin Corporation's Activity to Air Pollution Between 1995 And 2006

The main air pollution sources consisted of the following activities conducted by Remin Corporation:

- Quarry blasting, loading-unloading of tailings and precious metals, ore preforming, shipping, mine ventilation units;
- Dry ore processing;
- Various phases of technological processes;
- Thermal power stations.

The pollutants that resulted from these activities were:

- Particulate matter with a high content of free silicon dioxide and of the heavy metals contained in the ore;
- Sedimentary particulate matter;
- Gases with high carbon monoxide and nitrate content.

The underground microclimate of nonferrous mineral ores was harmful due to the free silicon dioxide particles (SiO_2) – silicogenic dust, resulting from rock and ore deposit displacement, as well as due to the gases released by the quarry blasting, from the operation of internal combustion engines, oxidation processes, underground fires, etc.

Particulate matter from tailings and slag dumps were and still are carried by air currents over distances of several kilometres, covering spontaneous and agricultural vegetation, affecting the fauna and disrupting the daily activities of nearby communities.

The systematic exceedances of pollutant limits resulted in numerous cases of occupational disease (especially silicosis) among Remin Corporation employees who worked in ore mines.

Observations and measurements conducted at Remin Corporation tailings dumps and ponds, quarries and processing plants showed that they too were important air pollution sources.

The tailings dumps were located in the vicinity of major mining operations, such as the main wells or coastal galleries, in order to reduce transportation duration as much as possible.

In 2006, the Maramures Environmental Protection Agency (EPA) stated that 115 of the county's 297 tailings dumps belonged to Remin Corporation. These dumps covered an area of 55.8 ha of the total of 93.45 ha of all the county's dumps, and 74 of them were ecologically restored (APM Maramures/Maramures EPA, 2006).

Regarding tailings ponds, in 2006, Remin Corporation had a total of 13, of which 6 were in reserve (closed), 4 were undergoing ecological restoration processes, and 3 were operational. Of the 13 tailings ponds, 12 were located in Maramures County, and one in Bistrita Nasaud County (Ministerul Mediului/Ministry of Environment, 2006).

In 2014, the Remin tailings dump state of affairs was no different from that of 2006. Attila Korodi, Minister of Environment at the time, stated that, in Maramures County, about 300 tailings dumps had been accounted for, out of a total of over 500 (Korodi, 2014). These 300 tailings dumps stored more than 4 million tonnes of tailings and totalled 93.45 ha. In 2015, according to the county's environmental quality report, issued by Maramures EPA, the dumps' state had remained unchanged in terms of numbers, area, ownership of Remin Corporation, restoration works (APM Maramures/Maramures EPA, 2015). In the same county, in 2016, 17 tailings ponds were listed in the county's EPA records, 16 of which were inactive (Hojda-Infomm, 2016).

Currently, Remin Corporation is insolvent and undergoing conservation and closure works in the mining areas for which production halt and transition to conservation actions were approved (C.N.M.P.N. Remin S.A. Baia Mare, 2016; Stiri din Maramures 2mnews, 2017). In all 69 mines belonging to the company, spanning across three counties – Maramures, Satu Mare and Bistrita Nasaud, production was ceased, conservation and closure actions are being implemented, and ecological restoration is underway in several areas. The company has no operational tailings ponds (C.N.M.P.N. Remin S.A. Baia Mare, 2016).

3.2 Cuprom Corporation

3.2.1 General Overview of Cuprom Corporation

Cuprom Corporation operations spanned over 53 ha and the company was based in Baia Mare's eastern industrial area (Fig.1). The company's main activity consisted of pyrometallurgical processing of copper and gold concentrates which resulted in the extraction of nonferrous metals.

From 1998 onwards, the company was privately owned, maintained continuous operation, and employed about 420 people before the decline.

The Baia Mare nonferrous metallurgical plant was founded in 1907 under the name "Phoenix", initially as a sulphuric acid and chemical processing plant (Teremtus-Gazeta de Maramures, 2015). It also featured a copper concentrate processing line and a smelting section for precious metals, gold and silver. Since its inauguration, the plant was one of the largest such units in Europe, both in terms of production volume and technology. In the early years of the twentieth century, Baia Mare had a yearly production of more than 300 kg of gold and 3.4 tonnes of silver. In 1925, the plant's owners bought the city's glass factory and expanded the metallurgical plant by adding a lead oxide production line, and in 1931 a lead pipe and sheet production unit was installed. In 1925, the processing of nonferrous ores was carried out in a Water Jacket-type hearth furnace.

In the years leading up to the Second World War, the Baia Mare plant saw an increase in metal production, due to the changing military needs at that time. When the nationalization process started, the plant's owner, an industrialist called Weiser, gave up his property to the state. The plant was upgraded technologically between 1950 and 1980. After 1960, the copper oxide production line was established and, in the 1960s, the Finnish copper melting technology, Outokumpu, was imported. Romania was the first country in the world, in addition to Finland, to use this technology (Teremtus-Gazeta de Maramures, 2015). In that period, over 80% of the world's copper production was obtained using the Outokumpu technology. This technology involved the processing of 260.000 tonnes of concentrate per year. In 1970, the plant was upgraded again when a copper bar and plate production unit was added, licensed in England.

Between 1950 and 1980, many of the plant's technological processes were mechanized, the workshops were upgraded, the industrial platform's sewerage system was built, etc., all of which was aimed at increasing the plant's efficiency.

In 1978, the oxygen production unit was inaugurated. The plant's modernization process came to a halt after this investment (Teremtus-Gazeta de Maramures, 2015). Internationally, plants with similar activities invested in environmentally friendly technologies, while in Baia Mare years of massive historical pollution followed.

In 1998, the Phoenix Baia Mare metallurgical plant, the only gold refiner in South-eastern Europe, became the property of Allied Deals, an Anglo-Indian corporation that filed for bankruptcy 4 years later (Teremtus-Gazeta de Maramures, 2015). Investments in environmental protection were not a priority.

In 2003, the plant was renamed Cuprom Baia Mare, after the merger between the Phoenix metallurgical plant and the Elcond Zalau plant, two of the most important Romanian companies in the nonferrous industry. The company's turnover increased until the beginning of 2008. Unfortunately, the economic crisis and certain management deficiencies affected the company's activity, which filed for insolvency in 2008 and bankruptcy in June 2015 (Teremtus-Gazeta de Maramures, 2015).

3.2.2 Cuprom Corporation Operations Between 1995 And 2006 And Their Contribution to Air Pollution

Cuprom Corporation used classical copper concentrate processing technology (both locally-produced and imported) to obtain electrolytically refined copper, precious metals and sulphuric acid (using the sulphur contained in the raw material).

The technological process to obtain electrolytically refined copper was based on several operations:

- Preparation and processing of cuprous concentrates for suspension melting;
- Conversion of cuprous metals;
- Thermal refining of converter/blister copper;
- Electrolytic refining of copper;
- Processing of anodic sludge;
- Copper bar production;
- Slag processing.

With regard to sulphuric acid (H_2SO_4), its production based on the SO_2 gases that resulted from suspension smelting and conversion installations was carried out in several stages:

- Special (wet) purification of sulphurous gases;
- Drying of sulphur gases;
- Catalytic oxidation of SO_2 to SO_3 ;
- Absorption of sulphur trioxide (SO_3);
- Storage of sulphuric acid (H_2SO_4);
- Evacuation of sludge and neutralization of waste water.

Cuprom Corporation had installations that produced liquid sulphur dioxide (SO_2) and flotation reagents (e.g. sodium xanthate). It must be noted that all technological processes were monitored with measuring and control equipment in order to ensure malfunction prevention and, when necessary, a prompt response. The gas and residual powder collection, filtration and evacuation activities of Cuprom Corporation were organically linked to production processes. As a result, it had a high number of dispersion chimneys, the technical data of which are listed in Table 1:

Table 1. Dispersion chimneys on the Cuprom Corporation platform (Source: Coman, 2006)

No.	Chimney type	Height (m)	Diameter (m)
1	Drying chimney, level I	26	0.6
2	Drying chimney, level II	36	0.8
3	High dispersion chimney	351.5	13.5-bottom; 2.5-top
4	Lead oxide gas chimney	40	0.4
5	Laminate burning gas chimney	60	0.8
6	Copper bar burning gas chimney	40	0.4
7	Steam boilers and superheated water chimney	27	0.4
8	Primary forge chimney	15	0.2
9	Secondary forge chimney	16	0.2
10	Cast iron cupola furnace chimney	12	0.5
11	Liquefied sulphur dioxide chimney	16	0.5

The complexity and scale of the platform's activity required, as shown in Table 1, 11 dispersion chimneys of different sizes and discharge capacities. The 351.5m high chimney, completed in 1995, was fitted with equipment designed to continuously record, process, and temporarily store information on emissions. Even though the raising of the chimney, a \$ 27 million investment made by the Romanian Government with the support of the International Bank for Reconstruction and Development, resulted in a more effective dispersion of pollutants, it was not an ecological and sustainable solution, and it did not solve the region's pollution problem (Coman, 2006).

The technological processes of Cuprom Corporation's platform also resulted in uncontrolled emissions that were not captured by the installed systems, i.e. they were therefore released directly into the atmosphere. Moreover, the work space atmosphere was contaminated with gases emitted by faulty or underperforming

installations. While the materials the company used were stored in proper, closed enclosures, the solid industrial waste was deposited in tailings dumps, directly on the soil, which took up considerable space and became pollution sources. Particles from these waste dumps were displaced by wind and scattered over long distances, damaging the local flora, fauna and human health. Table 2 lists the waste dumps that were designated over several decades on company premises.

Table 2. Solid waste dumps on the premises of Cuprom Corporation (Source: Coman, 2006)

No.	Tailings dump name	Tailings dump area (ha)
1	Pyrite ash dump north of the railroad	1.6
2	Pyrite ash dump south of the railroad	1.4
3	Slag dump (concentrate)	0.8
4	Solder waste dump (concentrate)	0.08
5	Granulated slag dump	0.25
6	Gradually cooled slag dump	0.18
7	Others (debris, construction materials, bricks)	0.25
TOTAL		4.56

3.3 Romplumb Corporation

3.3.1 General Overview of Romplumb Corporation

With a total area of 15.6 ha, Romplumb Corporation operated in the northwest of Baia Mare (Fig.1), in a microdepression of Firiza Valley. The company's main activity was the pyrometallurgical processing of lead and copper concentrates in order to obtain decopperised lead. The company was state-owned, maintained continuous operation and, in 2006, employed about 750 (Romplumb website).

The pyrometallurgical activity of processing mining concentrates in order to obtain lead, gold and silver was conducted by the company for more than 160 years. According to in-house archives, the plant was established in 1844 after the centralization of all the small local smelters that carried out their activity by processing concentrates in open flame furnaces, which is always economically advantageous. For example, in 1900, its production totalled around 3.4 tonnes of silver, 0.3 tonnes of gold and 600 tonnes of lead.

In 2011, Romplumb Corporation had its environmental permit withdrawn, and in 2012 the company filed for insolvency (Romplumb website; Vischi-Infomm, 2016).

3.3.2 Romplumb Corporation Operations Between 1995 And 2006 And Their Contribution to Air Pollution

The company's main activity was processing lead-based concentrates, metallurgical by-products and lead waste.

The main technological phases were:

- Agglomeration roasting of the lead concentrate; this phase was carried out on two parallel rotating table-type agglomeration installations, which became operational in 1934 and 1954, respectively;
- Reductive melting of lead aggregates and lead-rich metallic waste; this phase entailed the use of two furnaces with Water Jacket-type tanks – one was functional, while the second was the backup –, which were installed in 1933;
- Crude lead decopperising 100-ton units.

The company platform's active pollution sources can be divided into two categories: controlled and uncontrolled. For the former, pollutant emissions could be captured and directed to depolluting facilities. The latter, by contrast, consist of emissions that originated from leaks, technical or sampling procedures,

technological fluid transport pipelines, raw material loading and by-product disposal. There were also other minor uncontrolled emission sources.

The air pollution generated by Romplumb Corporation was caused by the wear and degradation of certain installations that had been installed in the 1950s, on the one hand, and by the particularly low dispersion of high concentrations of noxious matter, on the other hand.

The pollutants generated by this industrial unit consisted in:

- Particulate matter containing heavy metals: lead, cadmium, arsenic, copper, etc.
- Gases containing SO₂, CO and CO₂.

Table 3 lists the sources of controlled emissions that were present on the company's platform:

Table 3. Sources of controlled emissions at Romplumb Corporation (Source: Coman, 2006)

Source	Quantity (units)	Characteristics
Emission dispersion chimney	1	H=80 m (since 1947)
Emission dispersion chimney in the "Agglomeration-Melting" unit	1	H=120 m (since 2004)
Ventilation gas evacuation chimney in the melting unit	2	H=8 m (pre-treated gases)
Ventilation gas evacuation chimney in the slag granulation unit	1	H=18.5 m
Gas and particulate matter evacuation chimney in the smelting unit	1	H=15 m

Romplumb Corporation was a notable source of particulate matter pollution (with high lead content) and SO₂, and the effects were greatly amplified by the significant lack of air mass mobility. Details on the air pollution caused by the three sources presented above will be featured in Part II of this three-part paper.

4. CONCLUSIONS

In Baia Mare City, old mining and metallurgical centre, the historical environmental pollution (including air pollution) was caused by three main sources: the National Company of Precious and Nonferrous Metals (NCPNM) - Remin Corporation; Cuprom Corporation; Romplumb Corporation.

The activity of the NCPNM - Remin Corporation was based on the exploitation and processing of polymetallic deposits of lead, zinc, copper and iron-manganese deposits, and the company was an important producer of gold, silver, lead, zinc and copper concentrates. Cuprom Corporation processed copper and gold concentrates pyrometallurgically in order to extract nonferrous metals. Romplumb Corporation's main activity consisted of the pyrometallurgical processing of lead-cuprous concentrates in order to obtain decopperised lead. All three companies were active for decades and, until the early 2000s, environmental protection was not a priority in the management of technological processes at the three metallurgical centres. Unfortunately, after the year 2000, investments in green technologies were not sufficient and, after 2008, the economic crisis strongly affected the activity of the three companies.

The activities carried out by the three large companies led to the systematic exceedances of limit values set for the pollutants resulting from various technological processes, i.e. particulate matter, heavy metals and SO₂. Currently, Remin Corporation and Romplumb Corporation filed for insolvency, while Cuprom Corporation filed for bankruptcy.

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