RETROSPECTIVE STUDY OF ENVIRONMENTAL POLLUTION WITH HEAVY METALS IN THE COPŞA MICĂ – MEDIAŞ REGION

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Abstract. The present study's goal is to provide a retrospective research of the environmental situation in the Copsa Mica - Medias Region, County of Sibiu (RO) and to propose a strategic plan for future perspective.

We relate to the pollution source of the region that deals with the production of lead and zinc from concentrates or mining raw material, as well as with the processing of cadmium, bismuth, antimony, copper, gold and silver extracted from the raw concentrate.

The objectives of the proposed study were: (1) to underline the causes generating the emission of specific pollutants in the environment in the past, present and future, (2) to estimate the impacts on the environment by continuing this industrial activity and (3) to formulate a strategic plan meant to assess a better perspective for the community, based on updated environmental legislation.

We established that the arsenic, cadmium, copper, lead, nickel and zinc are the main pollutants emitted by the local industry.

Key words: nonferrous industry, heavy metals, Copsa Mica - Medias region, factor analysis, area-based Strategic Environmental Assessment

1. Introduction

The pollution around a non-ferrous industrial center is characterized by various factors as emission of specific gases, particulate trace metals (i.e. As, Cd, Cr, Cu, Fe, Ni, Pb, Sb, and Zn) and organic compounds in the atmosphere, the soils pollution (at least 60 cm depth in the soil profile) that affect also the vegetation around, surface and underground water polluted by the waste leak offs-from the disposal closeness to the town, and by discharging of industrial waste in the neighboring running water [1, 2].

The Copsa Mica – Medias Region is an extremely polluted area as a smelter complex producing non-ferrous heavy metals (Table 1) has been operating in the town of Copsa Mica starting from 1939 [3]. Previously, (until 1994) it exist a carbosin factory, which was barred under the efforts of international environmental organizations such as UNIDO.

R-mode factor analysis is one of the major types of multivariate statistical analysis used in environmental studies, which investigates the relationships among the variables measured for each subject in the environmental data sets [4].

2. Study area

The old city of Copsa Mica (15th century attested) is located almost in the center of Romania, 46°07' N and 24° 16' E, in the northwestern part of Sibiu County, on the Tarnava Mare River bank. The climate is moderated temperate continental, properly to the northwestern part of Romania.

The town developed at high speed during 1950 and 1980, because of its geographical location on the crossroads of traditional Romanian and European railroads, and also based on the local industry. In the same time, the regional environmental pollution increased, rising the environmental damage by heavily affecting the natural carrying capacity of land. The main sources of environmental pollution are the energy sector, non-ferrous and chemical industry. The town is a little one, with 5112 inhabitants (year 2002 [5]) and an urban population density of 395 people/km^2 downtown, that increases up to 1868 people/km^2 within a built-up area of 200 ha of the suburbs.

The extensive local pollution, added to the historical environmental fate, keeps degrading the environment within the investigated area [3]. Starting with the 1970s, the factories in the region stopped the collaboration with the international producers. The non-ferrous factory continued to develop its producing capacities only by national collaboration, closing any link to the international technology market. In time, the technologies it used perished, without being substituted.

We lack documented information about emissions from the factory before 1989. Therefore, the study categorizes environmental consequences of the input data starting from 1989. The production level varies greatly (Table 1), as some production lines were cancelled, while for other products, the quantity delivered on the annually market increases. This normally affects the number of employees, having a major influence in the economical welfare of the city – increase in the rate of unemployed, and in the rate of people leaving the town.

3. Sampling and analysis

The Tarnava Mare River water samples were collected up - and down-stream of the Copsa Mica town in the period of 1990-2004. The pH and the temperature were also measured. Water samples were collected in one-liter polyethylene bottles. All samples were filtered and acidified with nitric acid to avoid growth of microorganisms and stored prior to analysis. The samples were analyzed by atomic absorption spectrometry (AAS) for Pb, Zn, Cd and Cu [6]. For the analysis 100 ml was taken from each water sample and 5 ml HNO_3 was added. The mixture was evaporated at 250°C, 5 ml HNO_3 was added again and once more evaporated at 250°C. Then, the samples were cooled at room temperature and diluted with distilled water. For element determination, blank analysis in distilled water has been conducted and working standard solutions were used.

In order to estimate the pollution degree of the region, 194 soil samples were collected from all over the area, including the agriculture areas, hay-fields and woods. The surface soil samples were collected from an area of 15 x 15 cm^2 on 2 different depths, of about 5 cm and 30 cm, respectively in 1 kg of weight. Each sample was carefully grounded and mixed several times in a porcelain mortar with stepwise reduction of the sample by quarting. The soil samples were analyzed by AAS and As, Cd, Cr, Cu, Fe, Ni, Pb, Sb, and Zn elemental concentrations were determined.

Table 1. The production at Copsa Mica smelter complex in the period between 1989 - 2002 [3]

No	*Product*	Production (1000 t/year)													
		1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	Zn metallurgic	29.85	16.5	8.75	13.734	15.628	21.55	29.2	28.35	34.11	30.95	32.6	52.854	53.1	40.658
2	Pb electrolytic	23.52	12.55	10.38	8.6	11.818	15.213	18.023	16.37	16.9	15.5	13.561	20.9	16.077	15.097
3	Zinc powder	2.1	1.225	0.257	0.194	0.13	0.137	0.136	0.15	0.106	-	-	-	-	-
4	Cadmium	0.019	0.007	0.003	0.003	0.008	0.0037	0.0066	0.0014	0.0164	0.0028	0	0.008	0	0
5	Bismuth	0.029	0.015	0.009	0.008	0.002	0.0065	0.0077	-	0.006	0.002	0	0.006	0.0094	0.0067
6	Antimony	0.195	0.057	0.113	0.01	0.105	0.152	0.178	0.186	0.162	0.084	0.121	0.146	0.128	0.007
7	Antimoniate of sodium	0.004	0.001	0.001	-	-	-	-	-	-	-	-	-	-	-
8	Antimony trisulphide	0.006	0.005	0.003	0.00053	0.0015	0.0002	0.0006	-	-	-	-	-	-	-
9	Zinc sulphide	6.08	2.338	1.317	0.104	1.219	1.090	-	-	-	-	-	-	-	-
10	Sulphuric acid	43.49	17.44	1.438	0.366	1.954	-	-	-	-	-	-	-	-	-
11	Refined zinc	18.43	9.75	8	11.61	14.071	18.52	30.16	31.74	32.1	29.93	28.7	51.93	47.2	37.426
Number of employees		3,908	3,498	3,057	2,798	2,665	2,577	2,500	2,400						1,800

4. Univariate statistical analysis. Factor analysis

By univariate statistical analysis of Tarnava Mare River water samples, we determined that Ni, Pb and Zn content exceed more than 10 times the maximum allowed concentration values (Figure 1). In this study it was established that the concentration of all three pollutants decreased significantly over the period the study was conducted. Among them, the Cd concentration had the strongest variation.

The high levels of pollutants in water samples, downstream the Copsa Mica town, are explained by industrial waste discharges in river waters. The area is a hot spot mentioned in international reports as a hazardous industrial site (Figure 2), [8, 9].

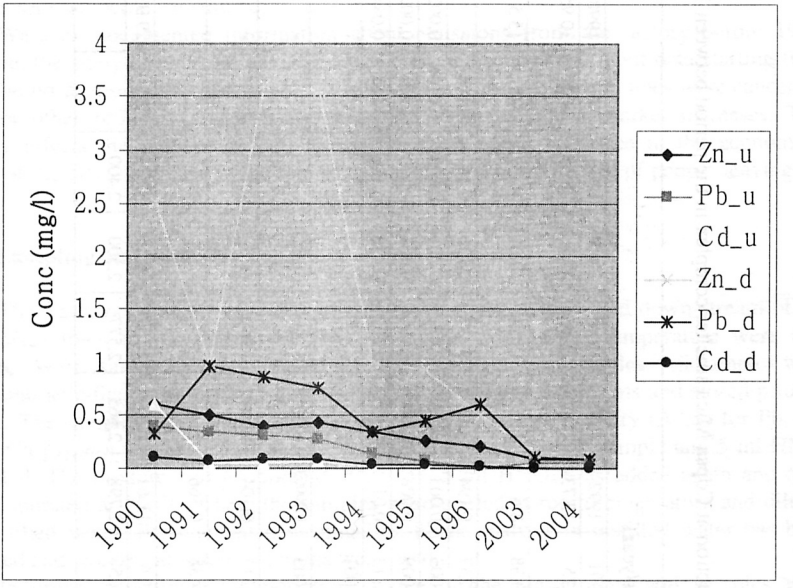

Figure 1. Evolution of heavy metals contamination in Tarnava Mare River – upstream and downstream of Copsa Mica [7]

The R-mode factor analysis was applied to soil data in order to describe the interrelationships among the measured concentrations by means of a few factors. The variance of the three main factors was 75 %. The three factors were characterized as follows:

1. The first factor, which described 25.8 % of the variance, was mostly loaded with Pb (about 41%) and Zn (about 39.5%) and originates in local non-ferrous industry emissions;
2. The second factor, describing 23% of the variance was mostly loaded with As, Cd, Cu, Pb, Sb, and Zn and was characterized as a background pollution factor (due to general and historical pollution);
3. The third factor, accounting for 11% of the variance, was mainly loaded with Fe and Cr. It has a geological nature and was assigned to soil geochemistry.

The pollution consequences in this region are well known and tacitly accepted on a regional and national level. Workers suffer from lead poisoning, respiratory problems and tuberculosis. All drinking water is unfit and alcoholism is way above average. Thus, the retirement age in the region is well below the national limit (45 vs. 62), life expectancy is 10 – 20% lower, premature birth rate is very high, and infant mortality (25 in 1.000) doubles than the average rate in the nearby towns.

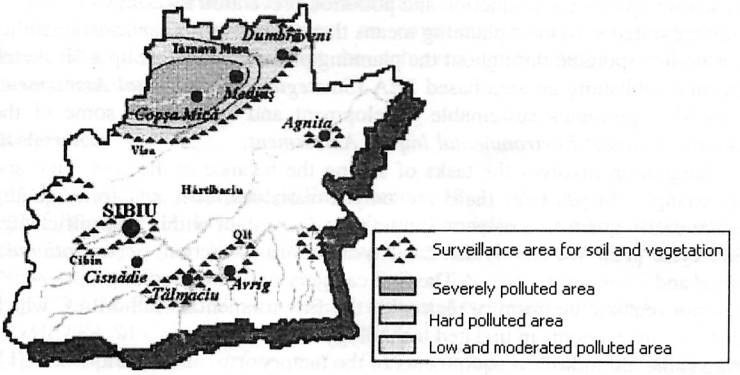

Figure 2 – Mapping of contaminated area in the Copsa-Mica Medias Region [9]

5. Environmental impact generated by the follow-up of the industrial activity

The 3 pillars of sustainable development: economy, social and the environment, pose a fierce struggle on the Copsa Mica – Medias Region. Pollution affects an area inhabited by 150.000 people, among which 70.000 live on a severely polluted territory - 2 towns and 5 villages. Socially, the area is threatened on what concerns a healthy living. SC SOMETRA SA is the only

important employer in the area, so the families in the town rely their living on the low salaries they get from the factory.

The area cannot offer a sustainable development, as the environment will charge back with its supporting capacity no shorter than 50 years. The main responsible for cleaning up and increasing the social conditions, is the company that still operates. Its production does not follow the environmental regulation, or the conditions it has been imposed to when being issued the operation permit. It is estimated that close-up, demolition and land rehabilitation measures rise to approx. 10 mil Euro on behalf of the Greek Holding that manages the Romanian company.

6. Formulating a strategic plan for providing a better perspective for the community

The Copsa Mica area is exposed to 2 categories of risk [10]: *technology risk* - due to the obsolete equipments, and the *marketplace risk* that is strictly connected to the attitudes of the stakeholders - thus against operation of the plant unless setting up cleaner production and pollution prevention measures.

A more integrated system of planning means that environmental and sustainability criteria are incorporated throughout the planning process. We draw up a 3P sketch to help in establishing an area-based SEA (*Strategic Environmental Assessment*) [11], as SEA promotes sustainable development and counteracts some of the limitations of project *Environmental Impact Assessment*.

Integration involves the tasks of setting the balance in the cost, time and quality triangle. In practice, there are only 2 variables: cost and time, quality cannot be easily quantified or varied, thus rests a constant within a specific stage in a life cycle [12]. We distinguish 2 main directions for action: *organizational - sustained* and *community - based*. The first category of actions include:

- develop a realistic conformity plan with the Environmental Authorities, which relates to the investments in updated technology
- closing some old industrial equipments of the factory
- soil rehabilitation and land regeneration through specific programs
- integrating Environmental or Risk Management System [10], with the functional Quality Management Systems
- redesign of some production lines to use scrap materials.

These measures need to be correlated with the community-based actions as:

- access to funding grants for social projects in the area
- greening the image of the town by starting to consider ecological tourism as a mean of job creation in the region
- conservative approach to improving population health in the region
- building a strong ecological culture by raising awareness, providing training and guiding actions from NGOs to the community

We believe that by adopting the framework of measures, sustainable development performance can be achieved in an accounting period of 10 years.

7. Conclusions

This monitoring study performed a realistic estimation of the relative cumulative environmental impact around Copsa Mica town. The specific environmental pollutants emitted by the local industry are characterized by a considerable decrease during the 1989-2002 period.

The extended pollution level of the Copsa Mica-Medias region was reflected by heavy metal content in the two analyzed environmental media.

The biggest overlap values, in the studied region, were observed for cadmium; they are the consequences of the local industry emissions.

Determination of the heavy metal concentrations at different soil layers, show the historical pollution of the investigated area.

In spite of closing some facilities of the smelter complex and of the abatement upgrading that was done at the facilities that are still operational, the Copsa Mica area remains a very polluted area.

There is a severe impact on environment and on community, thus sustainable development cannot be achieved unless strategic environmental assessment would be applied.

References

[1]. J. M. Pacyna, Atmospheric Environment, 18, 1, 1984, 41-50.

[2]. L. Graham, H. Bridgman, *Air pollution modelling in a small industrial city: the case study of Newcastle*, New South Wales, Australia, University of Newcastle, Australia.

[3]. CRAIM Report, *Environmental Impact Assessment and Risk Study for SC SOMETRA SA Copsa Mica*, 2003 – 2004

[4]. C. Oprea, *Multivariate analysis of environmental data by SPSS*, (invited lecture), The International Symposia "*The impact of physical and bio-geo-chemical factors on the sustainable development*", May 15-16, 2004, Environment & Progress – 3/2005, 285-290.

[5]. D. Chicea, H. Barbu, A. Morariu, *On heavy metals pollution in Copsa Mica Area*, Environment & Progress 3, 2005, Cluj-Napoca, 69-74.

[6] Baluta A., *Master Thesis, Pilot study of Impact Pollution in a Medium Industrial City: the case study of Oradea(in Romanian)*, scientific supervisor Dr. C. Oprea.

[7]. C. Baciu, V. Coşara, Al. Ozunu, A. Muică, L. Muntean, R. Mihăiescu, C. Modoi, *Optimizing the water circuit at a smelting facility: S.C. SOMETRA S.A. Copşa Mică (in Romanian)*, Environment & Progress, 4/2005, Cluj Napoca, ISBN 973-8254-77-9, 449-454.

[8]. Report *Environment and Security – transforming risks into cooperation*, p. 22, http://enrin.grida.no/environment-and-security/environment-and-security-english.pdf.
[9]. http://www.ipmsb.ro/surse_poluatoare.htm.
[10]. D. Cadar, D. Candea, Al. Ozunu, *Preliminaries to integrating management systems for S.C. SOMETRA S.A. Copsa Mica*, Environment & Progress, 4/2005, Cluj Napoca, ISBN 973-8254-77-9, 461-466.
[11]. R. Therivel and M. R. Partidario, *The practice of Strategic Environmental Assessment*, Earthscan Publications Ltd., London, 1996, ISBN 1 85383 373 8, 3 – 20.
[12]. W. M. Pryke, P. J. Whiting, S. Pang, R. Kaur, C. Wilmot, *Systems integration throughout the early life cycle*, BT Technology Journal, 1997, 15, 3.