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RESEARCH ON THE IDENTIFICATION OF INACTIVE MINING SITES WITH THE POTENTIAL FOR SOIL CONTAMINATION IN THE JIU VALLEY – CASE STUDY BALOMIR TAILINGS DUMP

Mădălina-Flavia IONIȚĂ[1], *Sorin Mihai RADU*[2*], *Emilia Cornelia DUNCA*[3]

[1]University of Petrosani, Petroșani, Romania, madalina.ionita96@yahoo.com
[2]University of Petrosani, Petroșani, Romania, sorin_mihai_radu@yahoo.com
[3]University of Petrosani, Petroșani, Romania, emydunca@gmail.com

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Abstract: *Jiu Valley is in an extensive transition process from an area rich in coal deposits to an area with 0 Carbon emissions. Coal mining was carried out in 14 mining perimeters arranged along the Jiu Valley. At the same time, the extraction of the useful mineral substance resulted in waste material that was stored in tailings dumps. Out of the total of 49 landfills, 25 have been greened, 15 are inactive and 9 are active. The total area occupied by them is approximately 210 ha, arranged near mining operations, in the valleys of some streams and even in the vicinity of human settlements. The paper aims to identify the potential for soil contamination due to inactive tailings dumps.*
Keywords: *coal, exploitation, tailings dumps, storage, heavy metals, contamination*

1. Introduction

For approximately 200 years of mining activity in the Jiului Valley, there have been serious consequences for the environment and the economy through extensive pollution and the exclusion from the economic circuit of considerable areas of land. Soil pollution with heavy metals as a result of mining operations is a major problem, having devastating effects on the environment and human health. [1]

This paper aims to explore and analyse the research related to the identification of inactive mining sites with the potential for soil contamination in the Jiu Valley region, taking as a case study Balomir tailings dump from Uricani mining perimeter, permanently closed in 2015. This area, due to its rich history of mining activities, is of particular interest in terms of soil contamination.

The purpose of the work is to investigate and highlight the problems related to soil contamination caused by the mining activity carried out in Uricani mining perimeter by Balomir tailings dump. Through a detailed study of Balomir tailings dump, the soil contamination factor will be analysed.

The paper aims to provide a broad perspective on the current situation of Balomir tailings dump and highlight the importance of studies of this kind in the management and protection of the environment in areas affected by mining activities. Also, possible solutions and recommendations will be proposed to remedy and prevent the negative impact of soil contamination in Uricani mining perimeter.

Through this work, it is aimed to contribute to a deeper understanding of the problems related to soil contamination following mining activities and to the development of effective strategies for managing these situations in order to protect the environment and the health of local communities.

2. The current state of the sites in the Jiu Valley

In the Jiu Valley, there were 14 mining perimeters from which coal was extracted underground. Currently, the useful mineral substance is extracted only from four mining operations, respectively: Lupeni, Vulcan, Livezeni, and Lonea mining operations. These aspects are highlighted in Figure 1. Intensive coal

* Corresponding author: Sorin Mihai Radu, prof. Ph.D. eng., University of Petrosani, Petrosani, Romania, Contact details: University of Petrosani, 20 University Street, sorin_mihai_radu@yahoo.com

mining has resulted in 49 tailings dumps, ponds of sterile slurry from coal preparation, as well as ash and slag deposits, covering a total of approximately 250 hectares of land. [2]

These dumps are mainly under the jurisdiction of the local authorities, of which 35 are owned by the town halls, 8 by the mining branches, 4 are managed by the Jiu Valley National Mine Closure Society, one is owned by the County Council, and one belongs to the private sector.

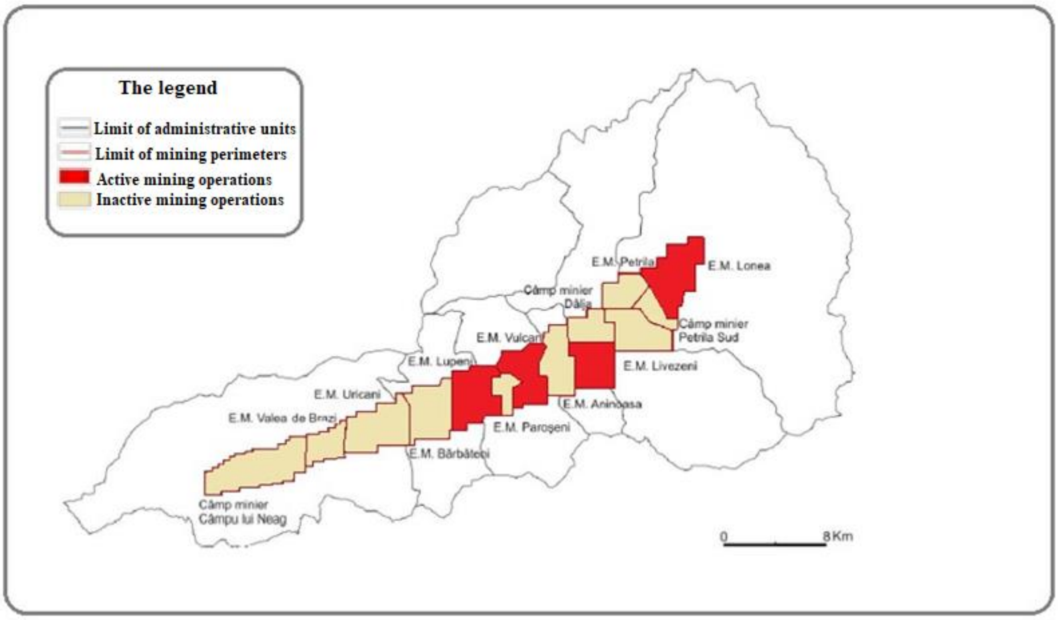

Fig.1. The current situation of the mining perimeters in the Jiu Valley

Over time, work has been carried out to green the tailings dumps, so that 51% of them have been subjected to greening processes. Currently, there are approximately 30.61% of inactive dumps to be used for various energy purposes to obtain green energy and approximately 18.36% of active dumps because tailings from the four active mining operations are still being dumped. The layout of these 3 types of dumps is shown in figure 2.

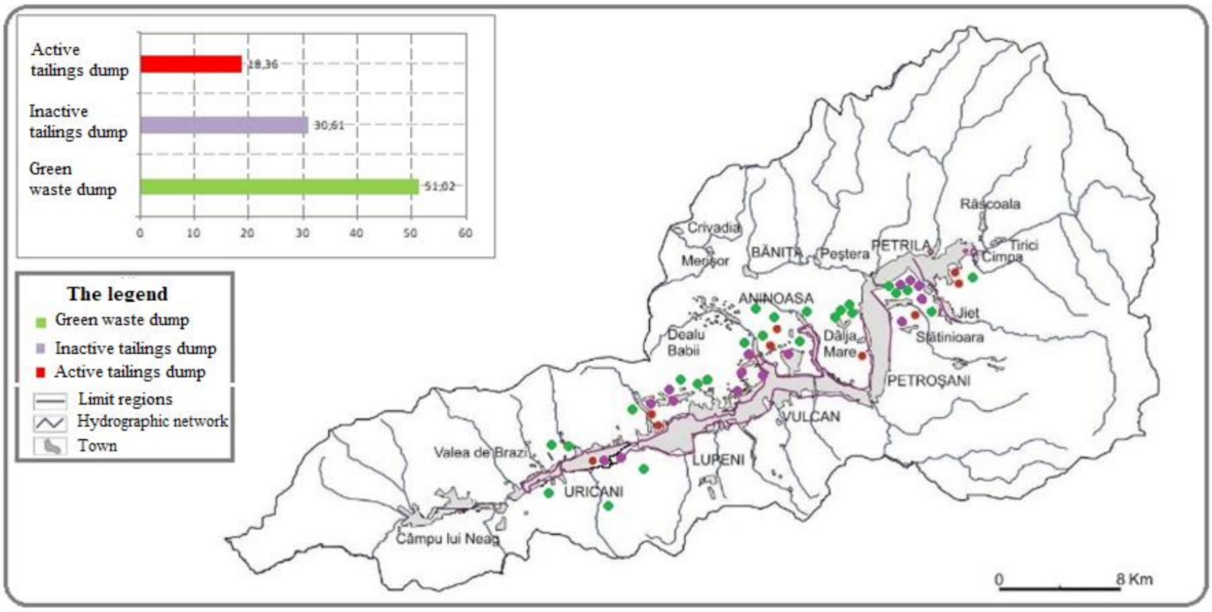

Fig.2 The current situation of the tailings dumps in the Jiu Valley

Analysing the total area occupied by these tailings dumps (approx. 210.78 ha), the largest area of land is attributed to greened tailings dumps, occupying 115.68 ha, which constitutes 55% of the total area; the dumps of inactive tailings extend over an area of 58.55 ha, representing 28% of the entire area; and active tailings dumps occupy 36.54 ha, equivalent to 17% of the total area. Figure 3 shows the distribution of the surfaces occupied by each type of landfill. [3]

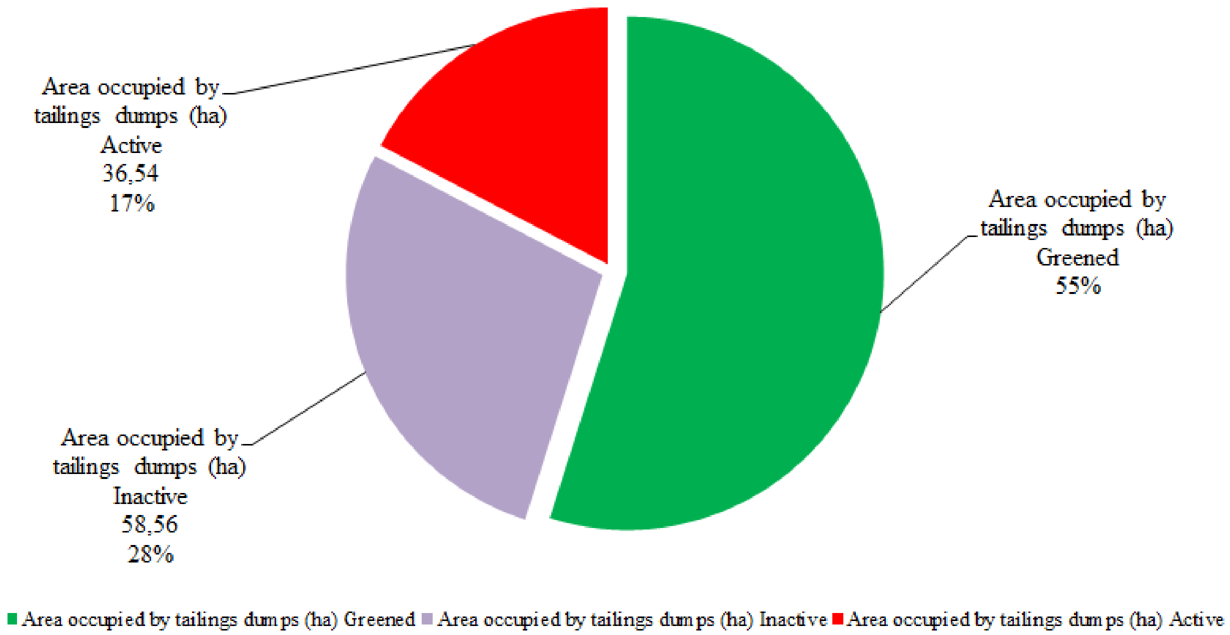

Fig.3. The land area occupied by tailings dumps

3. Identification and analysis of Balomir mining site

Following the exploitation of coal in Uricani mine, part of the resulting tailings was deposited at Balomir dump. This landfill occupies an area of 13 ha and has a volume of 39,000 thousand m^3, and at its base, approximately 100 m away, is Balomir stream. The presence of human settlements can be observed at a distance of 100 m from the base of the dump. Spontaneous vegetation is installed on the surface of the dump, which is partially covered by herbaceous vegetation, and clumps of birches are installed on the slopes. Also, species of shrubs such as blackberry, rose hip, hornbeam, hawthorn, and medicinal plants have been identified: horsetail, horsetail, dandelion, etc.

4. Research methods and techniques for soil contamination

Research on soil contamination with heavy metals due to the disposal of tailings resulting from coal mining activity involves a number of methods and techniques for assessing the level of pollution and environmental impact.

A range of sampling methods and techniques, soil chemical analysis, mapping, and remedial studies will be used to investigate this issue. [4]

Taking soil samples

The soil sampling process was carried out in accordance with the specific methodology, involving the extraction of samples from two different depths. Sampling depths were set uniformly for each sampling point between 0–20 cm and 20–40 cm. A metal soil sampler, polyethylene bags, and labels were used to collect the soil sample. Soil samples were placed in individual 500-gram-capacity polythene bags to be labelled with relevant information, including the exact collection location, depth, and date of collection. This procedure was consistent with the rules and regulations stipulated in the standard STAS 7184/1:1984, regarding soil quality and the collection of samples for pedological and agrochemical investigations. [5]

In order to take soil samples from Balomir tailings dump, we mapped the surface of the dump in units of 1 ha. Each 1 ha unit was associated with an average soil sample, resulting in its composition being between 10 and 20 partial samples.

Following the exploitation of coal in Uricani mine, part of the resulting tailings was deposited in the Balomir dump. After the precise identification of the units of approximately 1 ha, partial samples were collected. The larger the number of subsamples, the more representative the average sample becomes. Figure 4 shows two methods of collecting soil samples: the zigzag method and the diagonal method.

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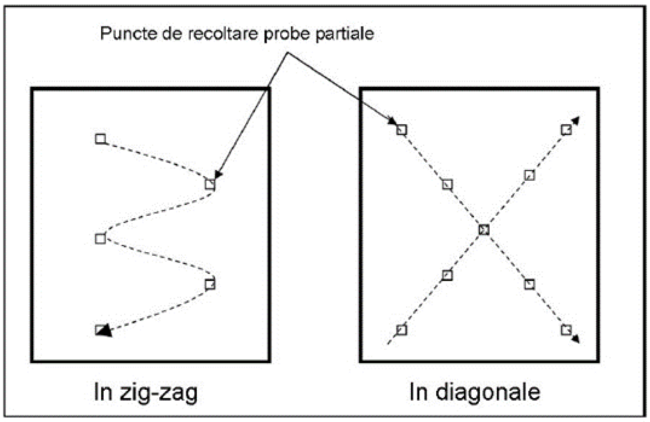

Fig. 4. The method of collecting soil samples

When establishing the sampling points for collecting partial samples from Balomir tailings dump, the configuration of the dump was taken into account. Thus, the collection was carried out using the method of collecting soil samples in zigzag to ensure the uniformity of the sampling. (Figure 5)

In order to assess the content of heavy metals in Balomir tailings dump, detailed mapping was carried out, allowing the location of 17 sampling points. When selecting the locations for these points, the presence of human settlements, watercourses, and various types of ecosystems, as well as the prevailing wind direction, were taken into account.

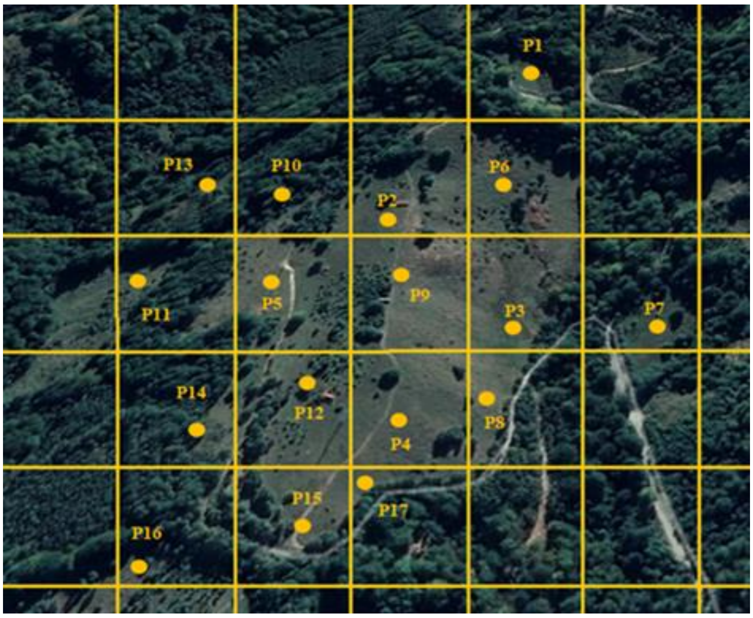

Fig.5. Arrangement of the sampling points on Balomir tailings dump

The soil samples were taken using an aluminium probe. After each step, the probe was cleaned to prevent sample contamination. Before sampling, the soil surface was cleaned to remove organic debris such as plants, roots, and leaves. The container used for collection is 500 g and was filled to its maximum capacity with crushed soil. The soil thus sampled was placed in plastic bags and labelled accordingly.

For the proper interpretation of the results and to facilitate research, each sample was labelled. The information provided by labelling is not only important for identifying each sample but also for formulating fertilization and amendment recommendations based on further analysis. Appropriately labelled samples were transported to the laboratory for analysis. [6]

5. Data analysis and interpretation

Data analysis and interpretation are essential steps in the scientific research process. In order to identify the presence of heavy metals in the soil taken from Balomir tailings dump, the reference values for traces of chemical elements in the soil were used, according to the provisions of Order 756/1997.

The use of a blank sample in soil analysis can be an effective method to confirm and validate the results obtained in the analysis, providing a better understanding of the properties and qualities of the soil in a given area. In this sense, soil samples were taken from agricultural land located in the town of Uricani.

From the analyses carried out on the landfill material and its vicinity, it was found that the normal concentration of heavy metals in the soil for chromium (total) (Cr), copper (Cu), and nickel (Ni) is exceeded. (Table 1) [7]

Table 1. Heavy metal content in soil samples from Balomir tailings dump

Analysed indicator	**U.M.**	**Witness evidence**	**Determined value**	**Normal values in soil**	**Reference values for trace chemical elements in soil**			
					Alert thresholds / types of use		Intervention thresholds / types of use	
					Sensitive	Less sensitive	Sensitive	Less sensitive
Chromium (Cr) total	*mg/kgd.s.*	27.20	34.62	30	100	300	300	600
Copper (Cu)		17.80	58.03	20	100	250	200	500
Nickel (Ni)		19.04	84.72	20	75	200	150	500

Figure 6 shows the variation in the content of heavy metals in the analysed soil samples from Balomir tailings dump. It is found that, for Cr (total), the determined value exceeded 1.15 times compared to its normal value in the soil; the presence of Cu is 2.9 times higher compared to the normal value; and the and the determined value of Ni exceeds 4.23 times its normal value in the soil.

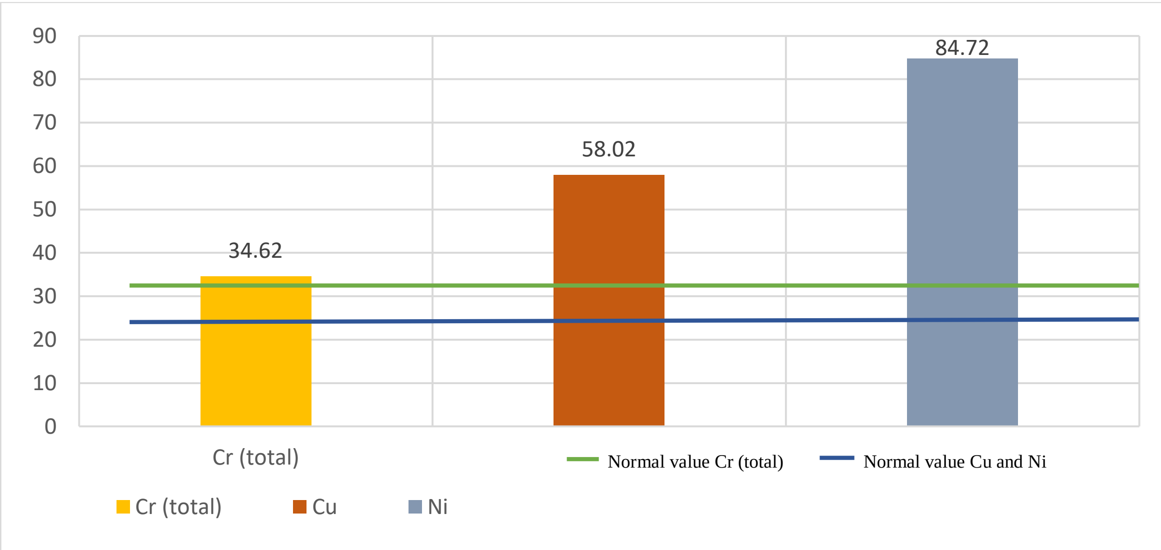

Figure 6. Concentration of heavy metals in Balomir tailings

6. Determination of the heavy metal contamination factor of the soil

In this paper, we aim to investigate the soil contamination factor with heavy metals in Balomir tailings dump by means of the "total contamination factor" (FCT) method.

The method is an effective tool for evaluating and quantifying the level of soil pollution, offering a systematic and objective approach to analysing the risks associated with mining activities. [8]

The evaluation of the contamination factor (FC) of the soil is based on the value of the total contamination factor (FCT). The higher the value of the total contamination factor, the more a higher contamination factor can be indicated. [9]

For the classification of the soil contamination factor, according to the specialized literature, we made a classification with the following intervals, taking into account the reference values from Order 756/1997 (table 4).

By determining the contamination factor, the collected data will be analysed in order to determine the contamination index for heavy metals that exceed the normal values in the soil. Thus, for Balomir tailings dump, the three heavy metals that exceed the normal value in the soil are: Cr (total), Cu, and Ni. Its analysis

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will allow us to assess the impact of mining activities on soil quality and will also provide us with the necessary information for the good management and remediation of the heavy metal contamination produced by inactive Balomir tailings dump. [10]

Table 4. Framing range of the soil contamination factor

The contamination factor	Description
FC < 1	Low contamination factor
1 ≤ FC < 3	Moderate contamination factor
3 ≤ FC < 6	Considerable contamination factor
FC ≥ 6	Very high contamination factor

The determination of the heavy metal contamination index will be carried out using the formula presented below.

$$I_c = \frac{C}{C_{ref}} \quad (1)$$

where:
C – heavy metal concentration in soil, (mg/kg d.s.)
C_{ref} - the normal value for the heavy metal present in the soil, (mg/kg d.s.).

To obtain the total contamination factor (FCT) the contamination index values for each heavy metal were normalized by taking their sum. The total contamination factor (FCT) was calculated using the formula:

$$FCT = \frac{\sum I_{c\,metal}}{n} \quad (2)$$

where:
$\sum I_{c\ metal}$ - the sum of the contamination index values (I_c) for the analyzed heavy metals;
n - the total number of heavy metals assessed.

Table 3 shows the average values of the contamination index determined for Balomir tailings dump. Based on his determinations, we determined the total contamination factor, which has a value of 2.76, which means that the contamination level is moderate. [11]

Table 3. Determination of soil contamination index

	Analysed indicators			Total contamination factor (FCT)
I_c	Cr (total)	Cu	Ni	
	1.15	2.9	4.24	2.76

7. Conclusions

From the field and laboratory analysis in the perimeter of Balomir tailings dump, the following conclusions can be drawn:

- A detailed analysis of the site was required to assess and manage the impact generated by the tailings dump;
- A mapping of the landfill surface was required to take soil samples in order to highlight the presence of heavy metals in the soil;
- According to the regulations in force, 17 sampling points were established from which samples were taken and analysed in the laboratory;
- The presence of heavy metals with excesses of Cr (total) by 1.15 times, Cu by 2.9 times and Ni by 4.23 times, compared to the normal values in the soil, was found.
- For a good presentation of the heavy metal contamination situation, a reference sample was collected from the agricultural lands in Uricani area;
- From the analysis of the contamination factor, it was found that the level of heavy metal pollution of the soil in the perimeter of Balomir dump is medium, which indicates to me that there is a risk to human health that involves the assessment of exposure to chemicals and heavy metals present in the environment and assessment of potential adverse effects on human health.

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It is very important to carry out periodic and continuous assessments of the impact of tailings on the environment and to take measures to protect the environment and properly manage contamination by involving local leadership and the community in the process of monitoring and managing the impact.

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