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ENVIRONMENTAL IMPACT ON SOIL AND WATER BECAUSE OF MINING ACTIVITIES IN THE EASTERN PART OF JIU VALLEY

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Abstract: *Analysing environmental impacts of mining activities involves detailed studies of the interactions between technological activities/operations carried out in a mining operation and environmental components affected by them. In order to carry out a more complex environmental impact assessment caused by mining in the eastern part of Jiu Valley on soil and water 4 mining units have been considered in the study, these being mining unit Lonea, Petrila, and Livezeni with their belonging dumps.*
Main objective of this research is to analyse the impact caused by mining activities in Eastern part of Jiu Valley by the method of impact networks according to the model "causes - pressures, depreciation of the quality of environmental factors – affected parameters - impact". Thus, impacts caused by the mining industry were identified based on the top-down typology, being shaped impact networks for underground coal exploitation and sterile material storage on the surface. The metal content of the dumps was also analysed in order to assess the degree of metals soil enrichment compared to the reference concentration of a blank sample. The analysis of the influence of the local rainfall regime aims to highlight the leaching potential of heavy metals in the body of the dump and the possibility of analysing the scenarios of extension of the pollution phenomenon to the saturated area. The study is addressed to researchers, environmental engineers, hydrogeologists and geologists who want to deepen the study of transfer mechanisms of contaminants from dumps to watercourses receiving areas and their dispersion in unsaturated and saturated areas.
Keywords: *EDXRF, environment, impact assessment, mining, soil*

1. Introduction

The influence of mining activities on environment in the Eastern part of Jiu Valley has a pronounced character because mining is the main economic activity with the largest spatial expansion and with high magnitude and complexity of the generated impacts [1]. Mining activity in the Eastern part of Jiu Valley is based on extraction of coal (pit-coal) from underground and storage of sterile material on the surface in dumps, thus occupying very large areas of productive land. This fact has changed such areas destination for a long time. Environmental hazards associated with dumps include: slope instability, acid drainage and contaminant leaching in groundwater and surface water, dust pollution due to wind erosion and irreversible land degradation.

Impacts of mining activities on water and soil as well as effects caused by mining were analysed by the method of impact networks according to the model "causes - pressures, quality depreciation of environmental factors - affected parameters - impact" to monitor and interpolate variables generated by the complexity of the multiple impacts caused by mining. The presence of major and minor elements in tailings dumps belonging to mining operations causes contaminants transfer to other reservoirs or may directly affect terrestrial or aquatic ecosystems as a result of direct biotope-biocenosis interaction [2], [3], [4]. These possible pollutants transfers were quantified according to the soil enrichment factor in relation to the determined concentrations in an unaffected mining area (blank sample) [5]. The oxidation-reduction capacity of the dumps was evaluated

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according to the morphological configuration of the dump by analysing the pH of dumped tailings at different depths by taking into account components of local rainfall regime [1].

2. Impact analysis of mining industry

Analysing the impact generated by mining operations in the Eastern part of Jiu Valley on the Eastern Jiul River, is implying a preliminary impact analysis because of underground coal extraction activity using impact networks method, in response to the question *"What if?"*, as characterization of the water body in the sampling sections upstream and downstream of each studied mining plant.

In terms of environmental impact generated by mining activities, in the Eastern part of Jiu Valley, primary causes represented by underground coal extraction (Figure 1) and storage of sterile material in dumps (Figure 2).

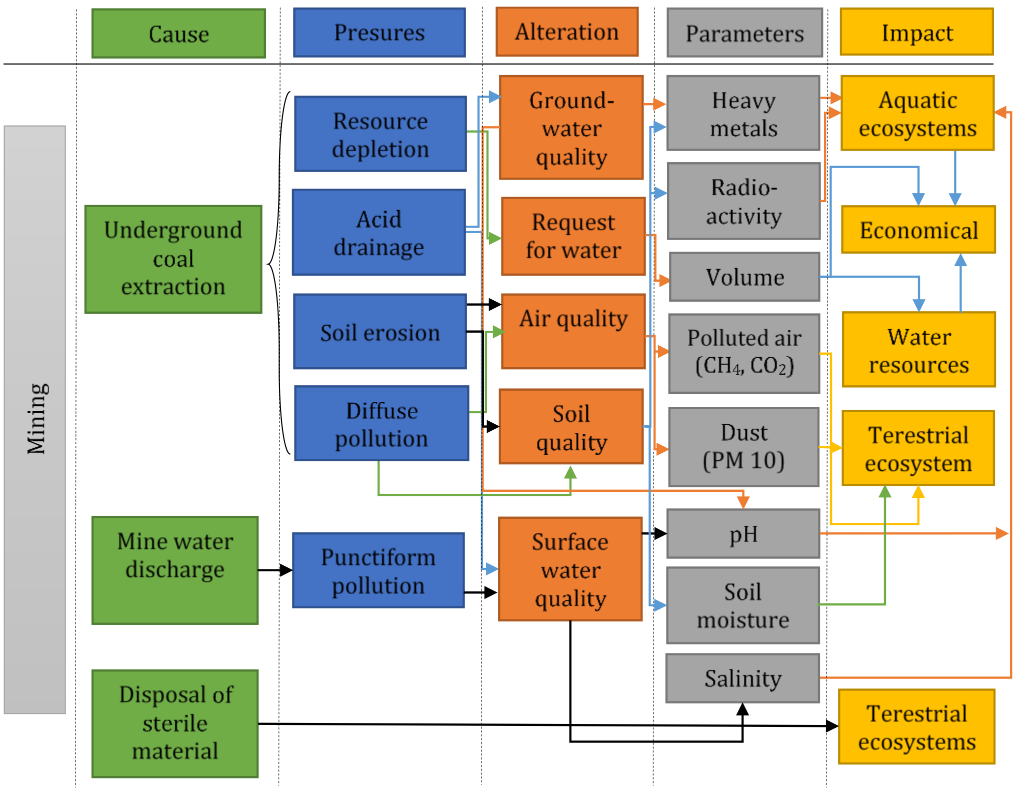

Figure 1 Impact network for underground mining

The exploitation of coal deposits from Eastern part of the Jiu Valley generates a multiple, complex and cumulative impact on environmental single elements (water, air, soil) which manifests on terrestrial and aquatic ecosystems (biodiversity) due to soil degradation, air and groundwater or surface water. As a result of underground mining, subsidence phenomena are facilitated, which are emphasised by rock formations collapse in unsupported underground gaps. Most of the time, subsidence phenomena in Jiu Valley are transmitted to the land surface, affecting micro and macro-relief, as well as the environmental and anthropogenic components like household settlements, natural production complexes and landscape.

The rupture and collapsing of the geological layers also favour the percolation of water from unsaturated zone (aeration) in the lower layers of the lithosphere, resulting in a low hydrostatic level and low humidity of the unsaturated zone. The root system of vegetation developed mainly in the aerated area, and low humidity for a more extended period can cause plants and trees' death. This decrease in humidity is manifested by reduced soil fertility, increased erosion, compaction of the mineral structure at the soil surface, compaction or high degree of water infiltration from atmospheric precipitation. Petrila Mine is the only economic activity that does not carry out any activity at present, being in the post-closure period. After the cessation of underground operations, the hydrostatic level begins to increase continuously exerting a migration of soil pollutants in a vertical concentrations (down ÷ top). Water from coal underground exploitation is discharged into the water bodies, being an advanced treatment to meet the quality criteria (CMA) regulated by NTPA 001/2005 [2], [4].

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From the point of view of the storage of sterile material in dumps/tailings dumps, the overall impact is complex due to the occupation of extensive land areas and the contribution of micro and macro elements from underground (Figure 2).

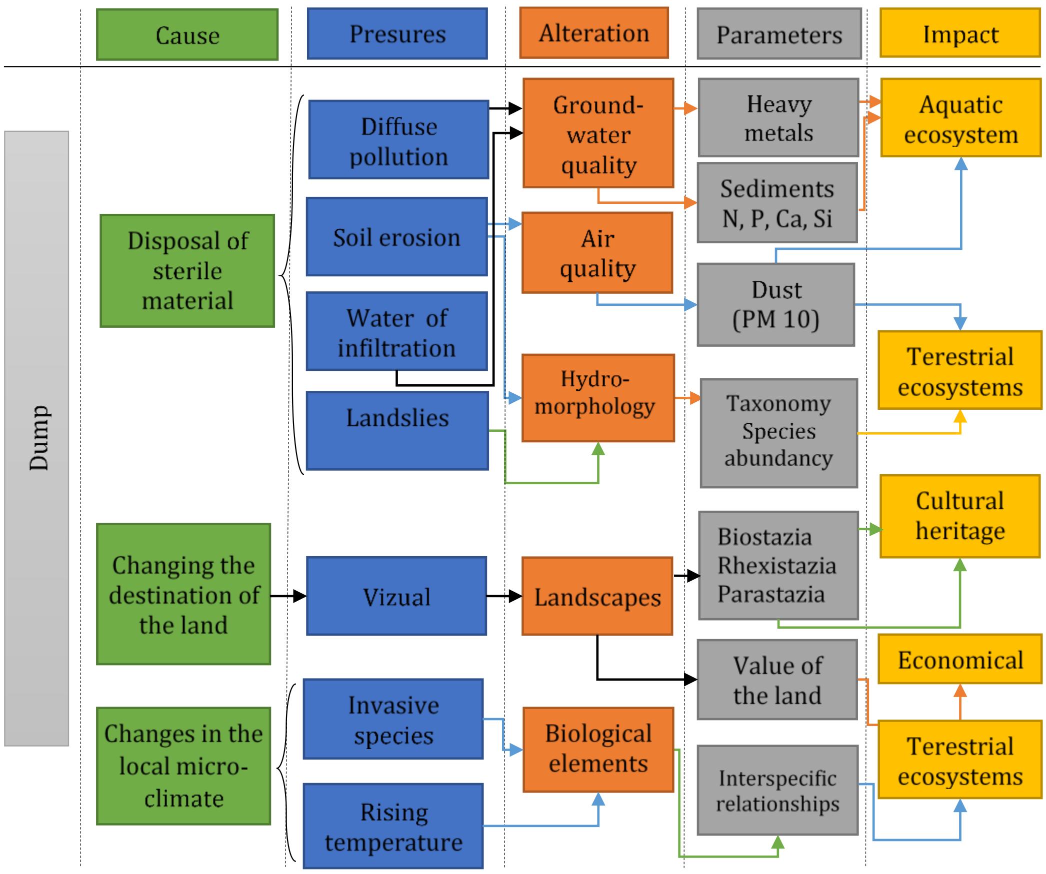

Figure 2 Impact network for sterile material storage

The heavy metals present in the dump body are percolated in the lower horizons as a result of a more significant amount of water infiltrated by precipitation. The infiltration phenomenon is intensified by the dumped material's coarse texture (soil with insufficient water and nutrient retention). The change in the destination of the land on which the dumps in the east of the Jiu Valley are located has caused a negative impact on the local economy, especially as a result of the degradation of the ecosystems and implicitly of the landscape. Substantial amounts of piled material, the appearance of deformed landscapes and distinctive landforms, led to the disappearance of endemic terrestrial ecosystems and the emergence of other invasive allogeneic ecosystems.

Several phisico-chemical parameters were analysed to measure the degree of environmental quality alteration to characterize the impact of dumps on groundwater and surface water quality from the eastern part of Jiu Valley. Thus, soil samples were taken from the four dumps in the eastern part of Jiu Valley, from depths of 5 cm, respectively 30 cm, according to Order No. 184 of September 21, 1997 [2], [4], and an additional sample from a depth of 60 cm was also sampled for a comprehensive analysis of the soil profile.

The soil samples were taken from the dumps belonging to the mining units from the eastern part of the Jiu Valley (the test points are indicated on the maps in figures 3, 7, 11, 15), were dried, crushed and compressed in the form of pellets, then analyzed with a portable X-ray fluorescence spectrometer (EDXRF). Calibration of the measurement instrument was performed according to the standard "SR EN 15309: 2007 Characterization of waste and soil - Determination of the elemental composition by X-ray fluorescence" using certified reference material (NIST SRM 2711a soil Montana II) for the soil matrix [5], [6].

By using collected soil samples arsenic, cadmium, cobalt, chromium, copper, nickel, lead, antimony, thallium, vanadium, manganese, barium, tin, zinc, titanium, calcium, iron concentration in the soil have been concretely measured, got results being compared to the alert and intervention thresholds according to land use categories (table 1) regulated by “ORDER no. 756 of November 3, 1997, for the approval of the Regulation on environmental pollution assessment” [7].

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Table 1 Limit values for heavy metals in soils [7]

Analyzed indicator	Normal values	Alert threshold		Intervention threshold		Terms of reference
		Type of use				
		Sensitive	Less Sensitive	Sensitive	Less Sensitive	
Arsenic	5	15	25	25	50	Order no. 756/1997 (mg / kg dry matter)
Cadmium	1	3	5	5	10	
Cobalt	15	30	100	50	250	
Chromium	30	100	300	300	600	
Copper	20	100	250	200	500	
Nickel	20	75	200	150	500	
Lead	20	50	250	100	1000	
Antimony	5	12,5	20	20	40	
Thallim	0,1	0,5	2	2	5	
Vanadium	50	100	200	200	400	
Manganese	900	1500	2000	2500	4000	
Barium	200	400	1000	625	2000	
Tin	20	35	100	50	300	
Zinc	100	300	700	600	1500	
Titanium	-	-	-	-	-	They are not standardized
Calcium	-	-	-	-	-	
Iron	-	-	-	-	-	

For the studied dumps, the enrichment factor (EF) was calculated based on the average concentration of the elements from the sampling points (PS), compared to the average concentration in the reference sample (RS). The enrichment factor was calculated in order to observe the variation of measured concentrations in a polluted or potentially polluted area depending on the reference sample. The enrichment factor has been calculated by using by equation 1.

$$\text{Enrichment factor} = \frac{PS}{RS} \qquad (1)$$

Elements with an EF up to 10 are considered to be enriched compared to the reference sample which present a low risk in terms of environmental pollution and impact, elements with an EF between 10 and 100 are called moderately enriched elements and present a medium risk, and elements with more than 100 EF are considered to be enriched lands and they are associated with high risks of preading pollutants on other reservoirs.

The acid-base balance of soil was measured by using the pH electrochemical probe by diluting the soil samples in distilled water in a ratio of 1: 3 [8]. The soil reaction has a significant role in the development of vegetation and microorganisms, being defined nine pH ranges for plant species' choice to carry out rehabilitation activities of degraded lands [9].

The purpose of determining pollutants in dumps is to assess the soil's negative variations by enrichment with minor/significant elements and to evaluate the mobility of metals in soils by their affinity for combination with carbonates/bicarbonates soil organic matter [9].

3. Impact of East Jiu Valley sterile rock dumps on soil properties

3.1. Impact of Lonea 1 dump on soil properties

Lonea 1 dump has 59,800 m^2 and is located in the upper part of the eastern part of Jiu river basin [9]. For a homogeneous characterization of the deposited material, a sampling system was build consisted of 5 sampling points on each Lonea 1 dump terrace (Figure 3).

The results obtained from the soil samples taken from the Lonea 1 dump were homogenized for each determined element, depending on the variation range of the concentration (minimum and maximum value) and the average concentration obtained (Figure 4).

In Lonea 1 dump, which belongs to the Lonea mine displacement, arsenic content, copper, and lead exceeds the average value, registering only in specific horizons potentially significant soil pollution. The chromium and nickel contents exceed the alert threshold for the sensitive use category, claiming potentially considerable pollution in the area. Therefore, further monitoring is needed, followed by applying soil

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improvement techniques to reduce pollutant concentrations and reduce the potential impact on the environment. Concentrations of antimony, vanadium, thallium and cadmium exceed the intervention threshold for sensitive and less sensitive uses, and it is necessary to reduce the concentrations of soil pollutants and conduct risk assessment studies.

In the Lonea 1 dump area, a soil sample (blank sample) was also collected and analyzed from a location not affected by the mining activity, considered the reference of the studied area. The quantification was made by comparing the average concentrations of the heavy metals obtained from Lonea 1 dump to the concentrations of heavy metals obtained from the blank sample by support of enrichment factor (Figure 5). From the point of view of soil enrichment factor from extracting the pit coal from underground, the soil on which the dumped material was deposited is not enriched (EF <10) and does not risk groundwater and surface water pollution [9].

In most cases, the soil's pH reaction in the samples collected from Lonea 1 dump indicates a moderately-acidic soil with tendencies towards strongly and very strongly acidic which increase the leaching of heavy metals in the lower horizons of the soil (Figure 6).

Figure 3 Soil collection points from Lonea 1 dump

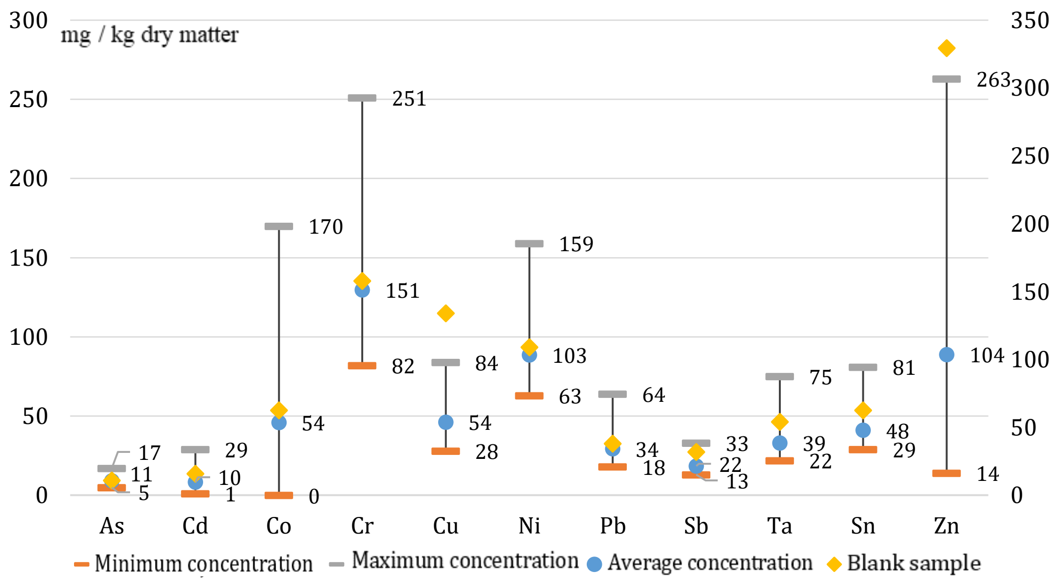

Figure 4 Metal concentrations in Lonea 1 dump

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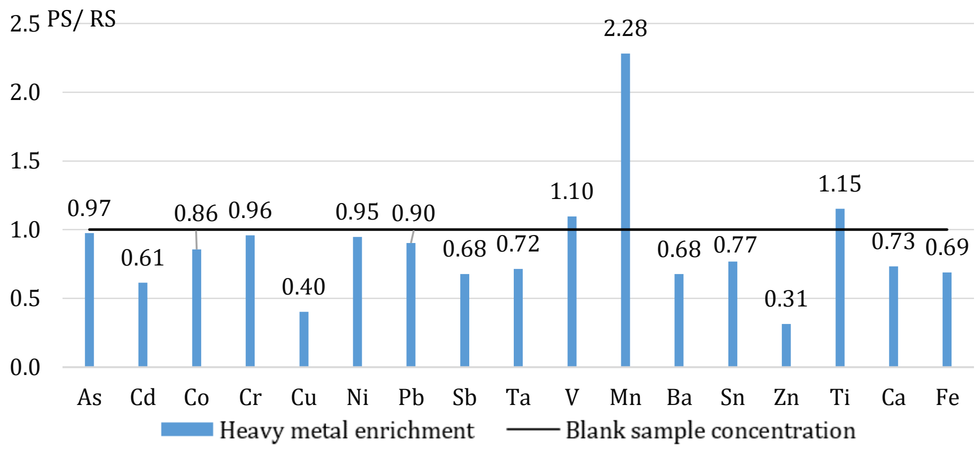

Figure 5 Soil enrichment factor corresponding to Lonea 1 dump

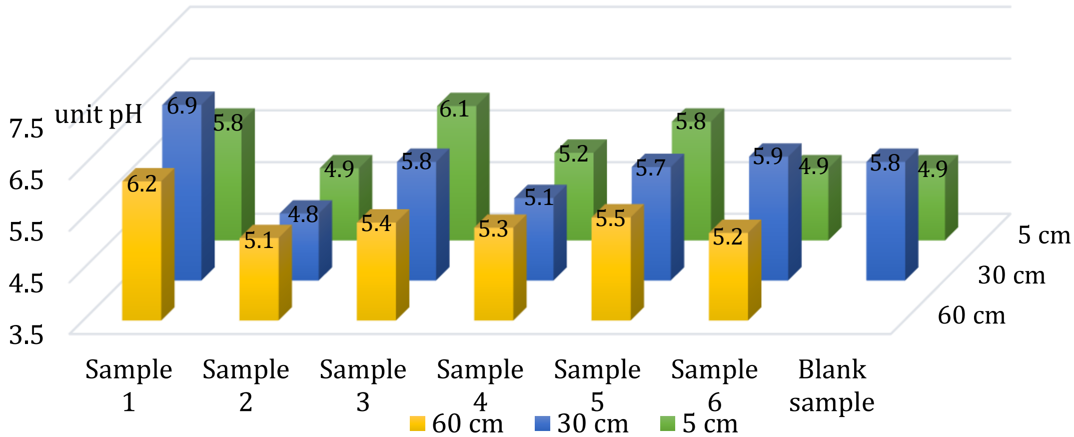

Figure 6 Values of pH for soil samples taken from Lonea 1 dump

The quantitative concentration of heavy metals and the soil's pH, determined from the soil samples taken from Lonea 1 dump, emphasise a low risk of contamination of the Eastern Jiu and the local aquifer.

3.2 Impact of Petrila dump on soil properties

The dump belonging to the Petrila mining site occupies an area of 135 ha, is located in the central part of the eastern part of Jiu river basin. The homogeneous characterization of the material deposited in the dump was performed based on a sampling system consisting of 6 sampling points, located on each branch of the Petrila dump (Figure 7).

Figure 7 Soil collection points from the Petrila dump

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From a hydrological point of view, four lakes' presence is noticeable, whose surface is directly dependent on the season, the zonal rainfall regime and the local seepage. During periods when torrential phenomena occur, the dump is crossed by several streams, affecting the water retention capacity in the dump's body.

The results obtained from the soil samples taken from the dump belonging to the Petrila mining unit were homogenized for each heavy metal determined in the samples, depending on the variation range of concentration (minimum and maximum value) and the average concentration (Figure 8).

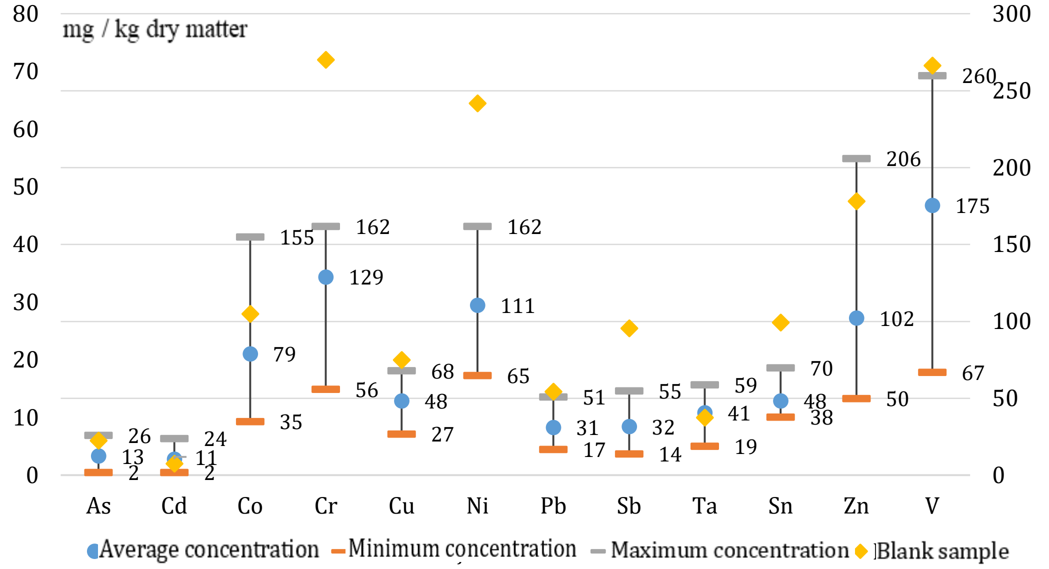

Figure 8 Concentrations determined in samples from Petrila dump

In the dump belonging to the Petrila mining unit, the copper and lead content are slightly increased above the average value (Table 1), with no potentially significant pollution of the area. In most cases, the arsenic, chromium and nickel contents exceed the alert threshold for the sensitive use category, with potentially substantial pollution claimed in the area. Therefore, further monitoring is needed, followed by applying soil improvement techniques to reduce pollutant concentrations and reduce the potential impact on the environment. The concentrations of antimony, vanadium, thallium and cadmium exceed the intervention threshold for sensitive and less sensitive uses, being necessary to reduce the concentrations of pollutants in the soils and to carry out risk assessment studies.

In the adjacent area of the dump, a soil sample (blank sample) was collected and analyzed from a researched area as unaffected by the mining activity, considered the reference concentration of the studied area. The quantification was made by the comparison between the average concentrations of heavy metals obtained from the Petrila dump and the concentrations of heavy metals obtained from the blank sample with the enrichment factor's help (Figure 9). From the point of view of the soil enrichment factor from extracting the useful material from the underground in the Petrila mining region, the soil on which the dumped material was deposited is not enriched (EF <10) is no risk for the waters from the body of the dump.

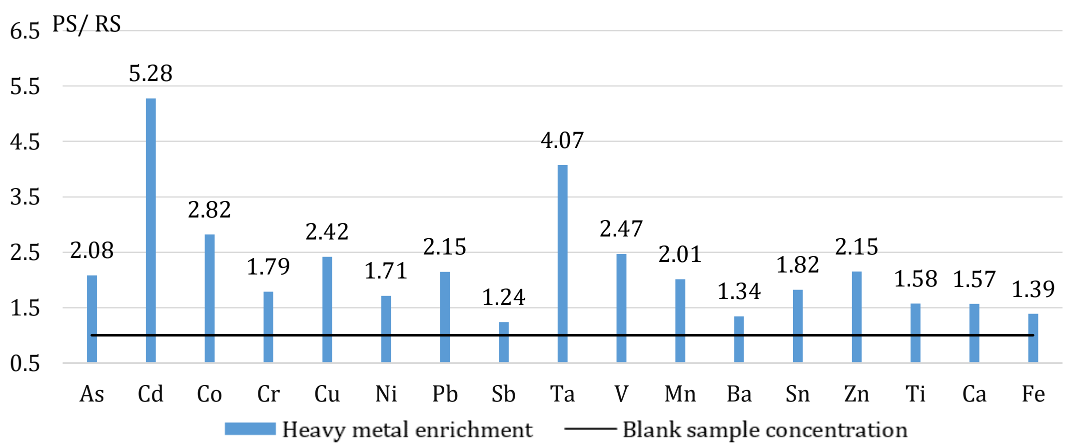

Figure 9 Soil enrichment factor corresponding to Petrila dump

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In most cases, the soil's pH reaction in the samples collected from the Petrila dump (Figure 10), indicates in most cases a moderately acidic soil in the upper horizons of the dump and a strongly and very strongly acidc in the lower horizon of soil, with moderate variations compared to the blank sample that favors the leaching of heavy metals in water bodies located near the Petrila dump.

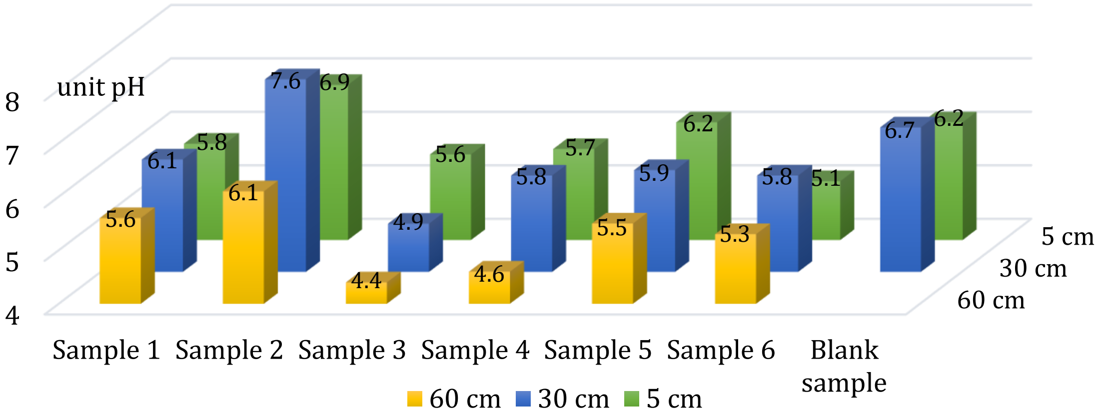

Figure 10 Values of pH for soil samples taken from the Petrila dump

From the point of view of the soil reaction, acidification of the soil in the lower soil horizons is observed, increasing the heavy metal entrainment of dump capacity in the groundwater. Thus, it is necessary to apply the required amendments to improve the soil's buffering capacity in the dump. The quantitative concentration of heavy metals and soil pH, determined from the soil samples taken from the Petrila dump, present a low risk to the environment of contamination of East Jiu river and the local aquifer.

3.3 Impact of Jieț dump on soil properties

The Jieț dump covers 7050 m^2, is located in an urbanized area near the Jieț River. For a homogeneous characterization of the dumped material, a soil sampling system was developed consisting of 4 sampling points located in the dump foot - upper slope system of the Jieț dump (Figure 11).

Figure 11 Soil collection points from the Jieț dump

The results obtained from the soil samples taken from the Jieț dump belonging to the Lonea mining unit were homogenized, and for each element was identified in the sample samples, depending on the variation range of the concentration (minimum and maximum value) and the average concentration obtained (Figure 12).

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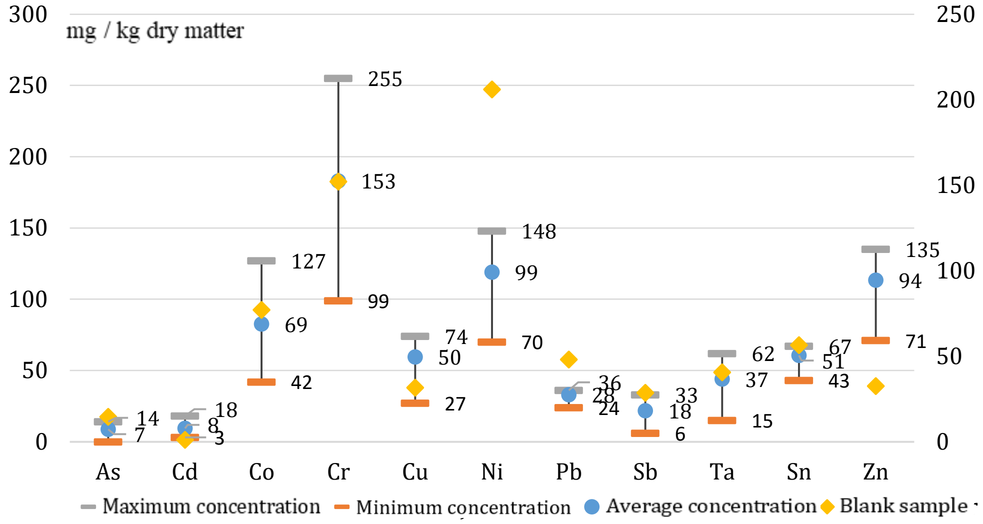

Figure 12 Concentrations determined in the samples from the Jieț dump

In the Jieț dump belonging to the Lonea mining unit, copper and lead's arsenic content is slightly increased above the average value (Table 1), as there is no potentially significant pollution of the area. The chromium and nickel contents exceed the alert threshold for the sensitive use category, claiming potentially considerable pollution in the area. In the case of this dump, additional monitoring is also needed, followed by applying soil improvement techniques to reduce pollutant concentrations and reduce the potential impact on the environment. Concentrations of antimony, vanadium, thallium and cadmium exceed the intervention threshold for sensitive and less sensitive uses, and it is necessary to reduce the concentrations of soil pollutants and develop risk assessment studies.

In the adjacent area of the Jieț dump, a soil sample (blank sample) was collected from an area investigated as not being affected by the mining activity, considered the reference concentration of the studied area. The quantification was made by comparing the average concentrations of heavy metals obtained from the Jieț dump and the concentrations of heavy metals obtained from the blank sample with the enrichment factor's help (Figure 13).

From the point of view of the soil enrichment factor from the activity of extracting useful material from the underground in the Lonea Pilier mining unit, the soil on which the deposited material was deposited is not enriched (EF <10), there being no risks in most cases associated with the pollution of the Jieț River with heavy metals from the dump.

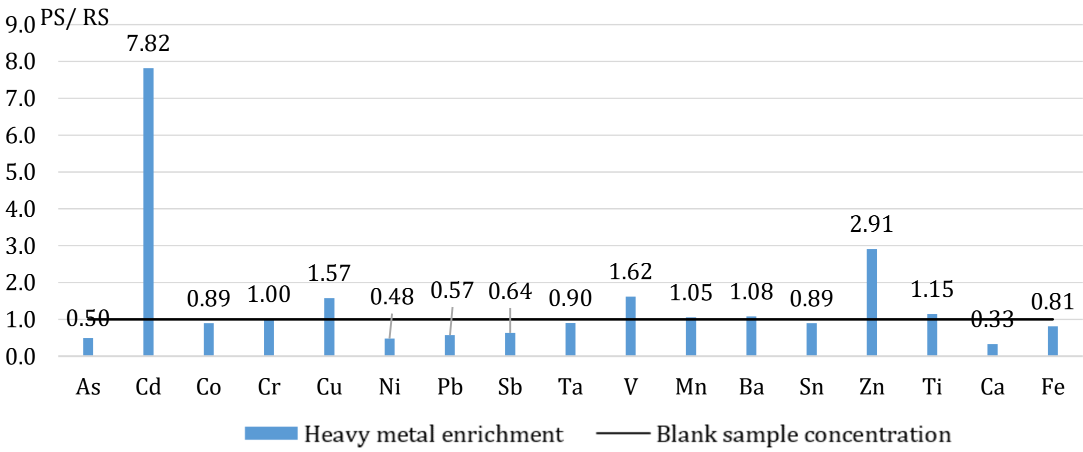

Figure 13 Soil enrichment factor corresponding to Jieț dump

Cadmium requires a significantly supra-unitary presence compared to the region's reference point. However, from the enrichment factor, it does not represent a real danger for local ecological spheres; however, the toxic character and high mobility of the element. The pH of the soil samples taken from the Jieț dump indicates a moderately acidic soil with small variations (Max 1.3 pH unit) compared to the concentration of the blank sample (Figure 14).

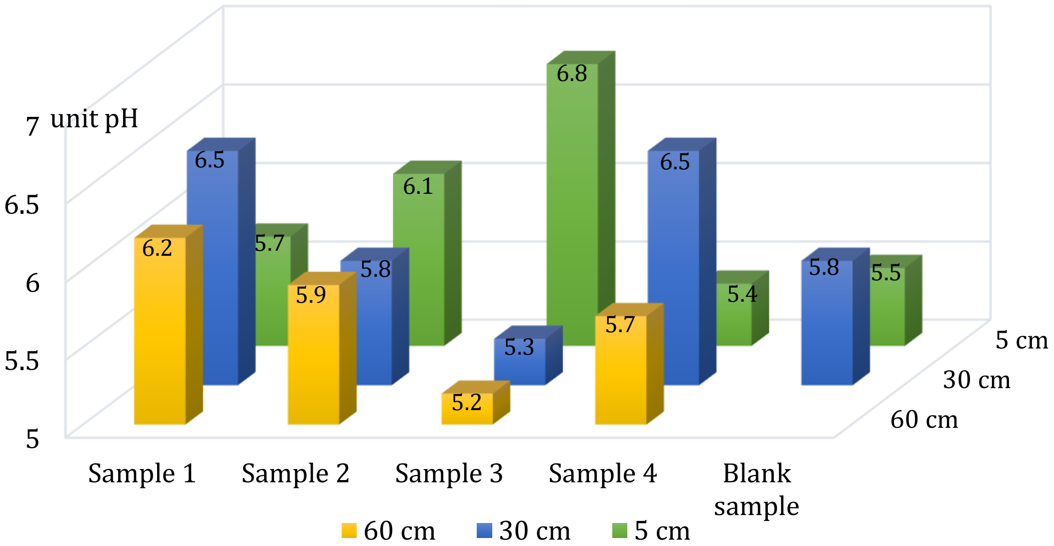

Figure 14 Values of pH for soil samples taken from Jieț dump

The quantitative concentration of heavy metals and soil pH, determined from the soil samples taken from the Jieț dump, present a low risk to the environment of contamination of the Jieț River and local lakes.

3.4 The impact of Livezeni dump on soil properties

The Livezeni dump covers 30,700 m2, located in the lower part of the East Jiul River basin [9]. The barren rocks extracted from the Livezeni mine and the one resulting from the coal sorting are formed from a heterogeneous mixture, both from a petrographic and granulometric point of view [9]. For the most part, it comes from the barren rocks from the productive and basal horizons of the Petroşani coal syncline, being made up of clays, sandstones, marls, sandstones coal shales and coal fragments. For a homogeneous characterization of the dumped material, a soil sampling system was developed consisting of 3 sampling points located in the dump base - upper slope system of the Livezeni dump (Figure 15).

Figure 15 Soil collection points from Livezeni dump

The results obtained from the soil samples taken from the dump belonging to the Livezeni mining unit, were homogenized, for each element determined in the sample, depending on the range of variation of the concentration and the average concentration (Figure 16).

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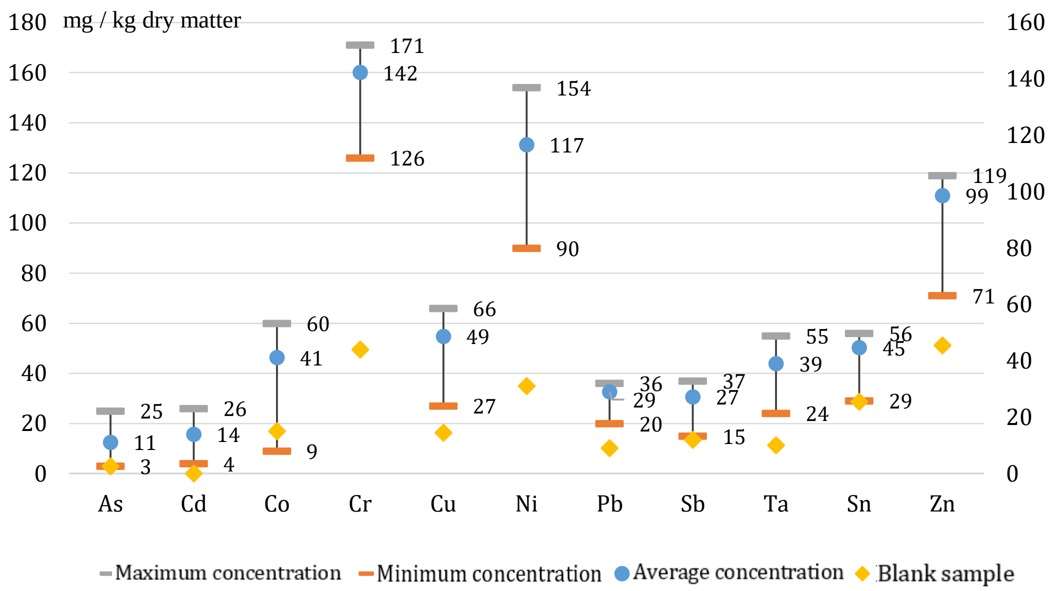


Figure 16 Concentrations determined in samples from Livezeni dump

In the Livezeni dump, the arsenic content, copper and lead is slightly increased above the average value (Table 1), with no potentially significant pollution of the area. The chromium and nickel contents exceed the alert threshold for the sensitive use category, claiming potentially considerable pollution in the area. Therefore, further monitoring is needed, followed by applying soil improvement techniques to reduce pollutant concentrations and reduce the potential impact on the environment. The concentrations of antimony, vanadium, thallium and cadmium exceed the intervention threshold for sensitive and less sensitive uses, being necessary to reduce the concentrations of pollutants in the soils and to carry out risk assessment studies.

In Livezeni dump area, a soil sample (blank sample) was also collected and analyzed from a location not affected by the mining activity, considering the reference of the studied area. The average concentrations of heavy metals obtained from the Livezeni dump and the concentrations of heavy metals obtained from the blank sample was quantified using the enrichment factor (Figure 17). From the soil enrichment factor's point of view because of useful material extraction from the underground, the soil on which the dumped material was deposited is not enriched (EF <10) and does not emphasise surface water groundwater pollution.

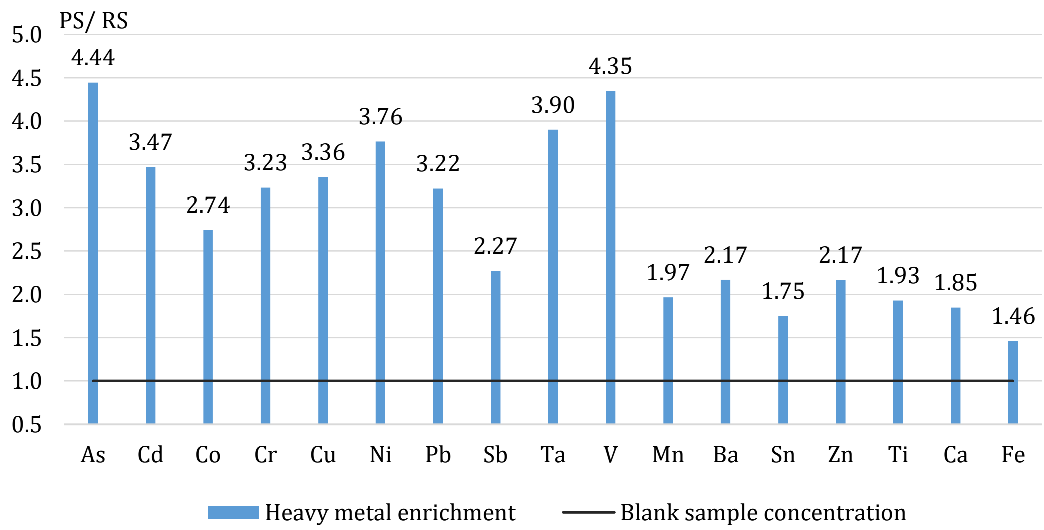


Figure 17 Soil enrichment factor corresponding to Livezeni dump

The abundance of heavy metals in terms of enrichment factor is much higher than in case of other dumps (Lonea, Petrila, Jieţ), what may be a consequence of the more intense carbonization process in the western part of Petroşani basin. The acid-base balance of soil samples collected from the Livezeni dump indicates a slightly and moderately acidic soil with small variations (max 2 ÷ 3 pH units) compared to the blank sample (figure 18).

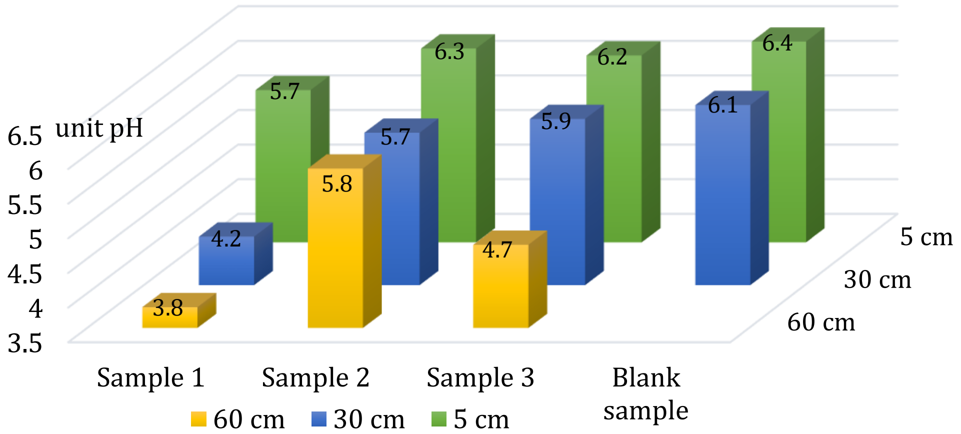


Figure 18 Values for pH of soil samples collected from Livezeni dump

From the point of view of the soil reaction, acidification of the soil is observed in the horizons located at the slope's base, thus increasing the heavy metal entrainment dump capacity in the groundwater. As a result, it is necessary to apply required amendments to improve the landfill's buffer capacity. The concentration of heavy metals and soil pH, determined from the soil samples taken from the Livezeni dump, present a low risk of contamination of Eastern Jiu river and local aquifer.

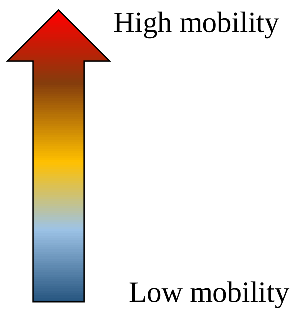
4. The general impact of Eastern Jiu Valley dumps to water quality

The content of heavy metals in the soil comes mainly from the extraction and preparation of coal. Anthropogenic activities such as wood processing, coal burning, road traffic, coal burning and zonal micro-agriculture in human households have a significant influence. Furthermore, uncontrolled vegetation fires contribute to increasing the soils' metal content adjacent to the dump.

Soil enrichment in cadmium is mainly caused by anthropogenic pollution, namely the mining industry (underground coal extraction), the use of fertilizers in zonal micro agriculture, as well as the upward movement of metals in soils due to repeated precipitation and association with organic matter present in organic horizons (top of the ground). The use of fertilizers with a high content of zinc or phosphorus and enriching the soil mobilizes other heavy metals: Ni, Cu, Cd, V, Cr, etc. In the vicinity of dumps in the Eastern part of Jiu Valley, household waste is stored uncontrolled, which can have a negative impact on surface water chemistry, as such deposits generate high temperatures that tend to volatilize cadmium, providing a mechanism for its entry in the hydrological circuit by entraining the particles in the predominant wind direction. Anthropogenic sources of chromium are represented by the burning of upper coals in households and thermal power plants, and the origins of lead represented by the extraction and processing of ores, but also by the combustion of gasoline with Pb additives (lead tetra-methyl $Pb(CH_3)_4$ and tetra-ethyl of lead, $Pb(CH_3CH_2)_4$). As the material stored in the dumps in the Eastern part of Jiu Valley is not considered to be enriched in heavy metals, it is unnecessary to continue researching the degree of mobility of heavy metals in the soil because the phenomena of natural revegetation will surpass the obtaining complex compounds due to the low complexity and magnitude of heavy metal pollution. If it is regarded as a predisposition to enrich the body of water (underground and/or surface) with heavy metals, their degree of mobility can be determined by sequential extraction procedures [9].

Sequential extraction procedures provide an image of the chemical associations of metals with specific sedimentary phases, in which the biological availability, environmental mobility and environmental significance of metals can be estimated [10].

F1 – the metal is mobile (soluble and exchangeable);
F2 – the metal binds to carbonates;
F3 – the metal binds to magnesium oxides;
F4 – the metal binds to organic matter and sulfates;
F5 – the metal binds to amorphous and weakly crystalline iron oxides;
F6 – the metal binds to crystalline iron oxides;
F7 – residual fraction = F8 – (ΣF1 ÷F6);
F8 – the total content by complete digestion with aqua regia;



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The dumps place in the eastern part of Jiu Valley are generally characterized by a low vegetation cover, non-cohesive rocks, considerable slope angles, which favours infiltrations and surface runoff, the effect being amplified by a high rainfall regime and reduced interception due to lack of plant cover. Thus, a significant amount of water flows to infiltrate the dumps ditch where, depending on the oxygen content in the air, pH, complexing agents, the oxidation-reduction potential of the dump, acid drainage is formed which favours metal leaching and salt precipitation with consequences for soil, surface and groundwater contamination (Figure 19).

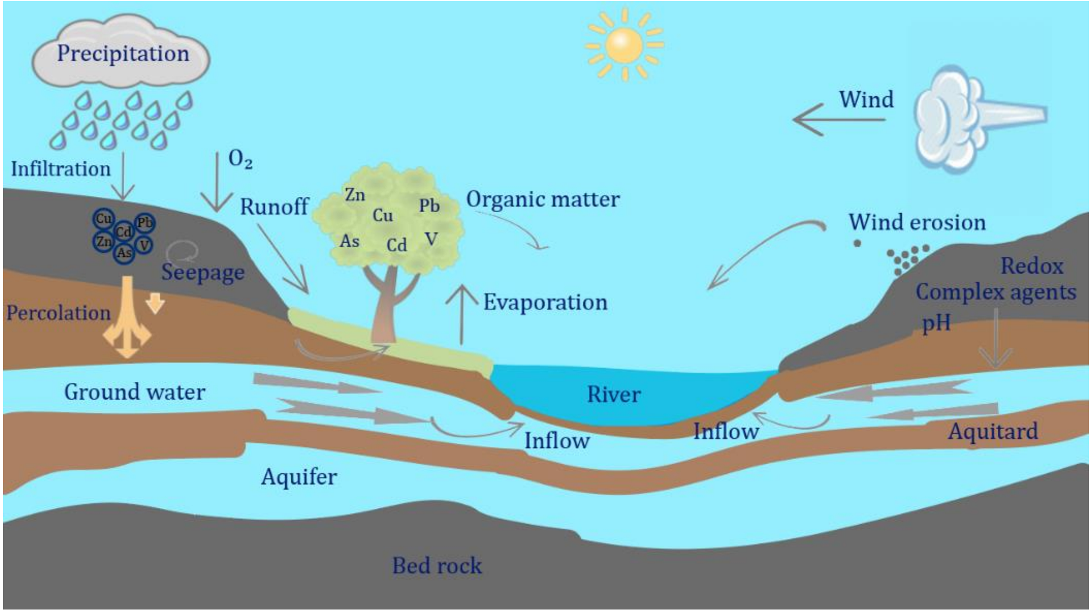

Figure 19 Influence of coal dumps on river basins

Groundwater contamination mainly affects aquatic ecosystems in the east Jiul river basin, which over time can easily bioaccumulate heavy metals from the living environment, as the exposure time for most species is 100%, due to the inability of aquatic ecosystems to change the environment life. From a toxicological perspective, pollution with minor elements exerts effects only at the regional or river basin level. The significant impact on the health of the regional population is produced by the complexity of these effects that are manifested in an aquatic ecosystem according to human needs

The mobility of major and minor elements in the dumps body depends primarily on the effective infiltration of rainwater into the body of dumps, waters that feed the aquifer, implicitly raising the hydrostatic level. Thus, the premises are created to increase the solubility of metals in groundwater.

5. Research on effective infiltration in the Eastern part of Jiu Valley

To determine the effective infiltration into the body of dumps (Table 3) the SINTACS method was used [1], which involves at an early stage the correction of monthly average temperature values according to the monthly amount of precipitation and the calculation of real evapotranspiration (ER), to obtain effective rainfall. The analysis of the infiltration in the regions of the dumps belonging to mining exploitations from the eastern part of the Jiu Valley was used for a very porous land, being used the value of the average precipitations and the infiltration coefficient of the soil depending on the texture [9].

Table 2. Effective infiltration of rainfall

Year	Average rainfall [mm/an]	The type of soil	Infiltration coefficient	ER	*IEa [mm/an]	**IEb [mm/an]
2017	771	Predominant clay sandy	0,25	441,85	82,29	192,75
2018	986			391,33	148,67	246,50

* IEa - Effective infiltration for a low permeability or permeable soil
** IEb - Effective infiltration for a very permeable soil

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In the eastern part of the Jiu Valley, the effective rainfall in dry years represents less than 50% of the total precipitation [9], which means that a large amount of water from rains evaporates before contact with the soil. The accumulation of water in the body of dumps from the eastern part of the Jiu Valley occurs through the effective infiltration of precipitation, the infiltration of runoff water, and underground springs accumulation [9],. The degree of water infiltration in the dumps' body varies depending on the permeability of the rocks, the porosity and the type of porosity, the loosening coefficient of the dumped soil, the intensity and duration of local precipitation.

From the point of view of the predominant type of soil deposited in the dumps (clay-sandy) dumps in the eastern part of the Jiu Valley, the active clay rocks often susceptible to high swellings and contractions, influence on the dumps positive effects due to the reduction of infiltration coefficient, but also adverse effects, which can lead to changes in the consistency and strength characteristics of the dumped material. The water release capacity by saturated clayey-sandy rocks is reduced, but due to the non-uniformity of the dumped material in some regions of the dumps (SSV, SSE and NNV Petrila's dump and NV Lonea's) leaks were observed, indicating in that region a higher permeability of the rocks and a possible transfer of heavy metals from the dumps in the Eastern part of Jiul Valley region.

6. Research on groundwater quality in the Eastern part of Jiu Valley

The unsaturated zone, groundwater and deep water body from the Petroşani Depression is of fissural type, accumulated in conglomerates, sandstones, marls and shale clays, of Burdigalian age composition of the Petroşani sedimentary basin. This basin has a syncline structure in the V-E direction; the axis is located N of the West Jiul (Romanian Jiul) [10]. To the east of Vulcan, the basin has the structure of a syncline. The median anticline (Slătioarei anticline) separates E two synclines of smaller size: at N, the Petrila syncline, and S, the Sălătruc syncline. The basin has been affected by numerous longitudinal faults, developed on its edges and by a series of transversal faults, of which the most important are those in the Petrila area [10].

Burdigalian aquifer deposits are partially uncovered, partially covered by soil or by different genetic types of Quaternary deposits (fluvial, alluvial, eluvial, colluvial, alluvial, etc.) [9]. The degree of groundwater protection is strongly unsatisfactory because the aquifer is not fed enough; Feeding is done mainly through the frame area, from surface waters and rainfall [10]. From a quantitative perspective, the flows of underground springs oscillate depending on the season between 0.14 and 6 l / s and the effective regional infiltration is between 315 and 472.5 mm / year. The aquifer's quality in the eastern part of the Jiu river basin was assessed at four sampling points (Figure 20) following appendix II and V of the Water Framework Directive 2000/60 / EC [11].

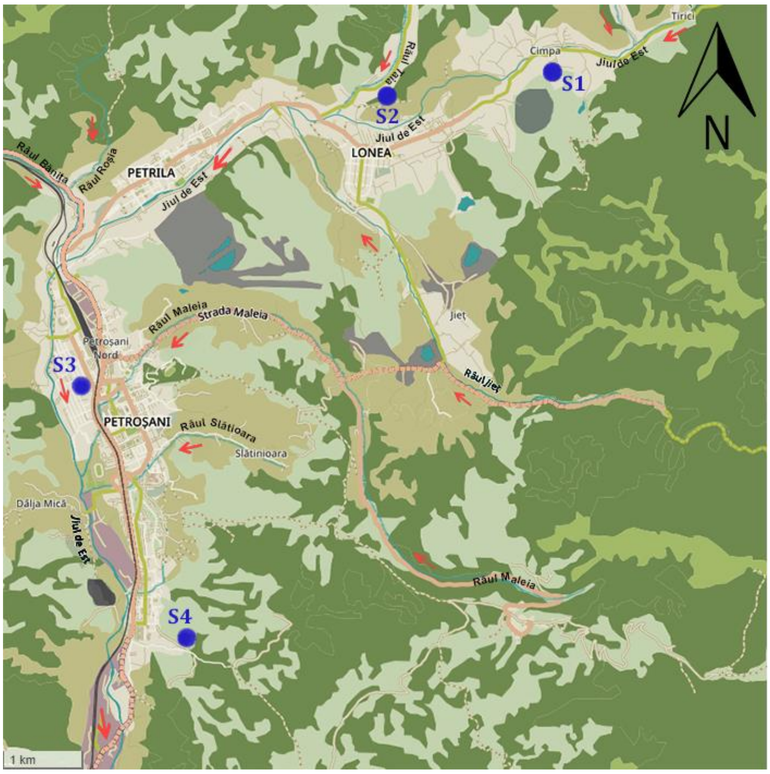

Figure 20 Groundwater sampling points

The sampling points were chosen to evaluate how the groundwater body negatively influences the eastern part of Jiu's quality in the connectivity areas. In the sampling points, quality indicators representative of the local anthropogenic activities were selected (Table 3) [9].

Table 3 Groundwater quality in Eastern Jiu river basin

Sample point	pH [unit pH]	Conductivity [μS/m^2]	Arsenic [μg/l]	Chromium [μg/l]	Copper [μg/l]	Lead [μg/l]	Mercury [μg/l]	Water Quality
S1	6,68	132,9	4	2	1	2	UDL*	Good
S2	6,74	88,9	4	2	3	1	UDL*	Good
S3	6,89	128,6	3	UDL*	1	3	UDL*	Good
S4	7,11	130,5	3	1	UDL*	UDL*	UDL*	Good

UDL* - under detection limit

In the groundwater body, from the point of view of conductivity, no saline or other intrusions from coal mining activity are indicated; The pH level of the water is around the neutral balance of the water and from the point of view of pollutants (heavy metals) they are found in low concentrations, due to the natural geological background. Research conducted by Kovacs, M. et. in 2014 regarding the impact of sedimentable dust concentrations generated by anthropogenic activities in the Jiu Valley on the population, characterizes the studied area as being influenced by mining activities because the results obtained during research exceed in some cases the maximum allowed concentrations of 17 mg dust/month [9]. Wastewater discharges from operating mining units in the eastern part of the Jiu Valley (E.M Lonea and E.M Livezeni) do not exceed the limits for industrial and urban wastewater loading pollutants when discharged into natural receptors regulated by NTPA 001/2005 [11]

7. Conclusion

The significant impact of mining by depositing sterile material on the surface of the land has major environmental impact expecially on water and soil, so in terms of qualitative and qualitative analysis for major and minor elements of dumps belonging to Petrila and Livezeni mining plants. Research activities carried out for all of the studied metals demonstrate a high enrichment factor compared to the blank sample.

In case of Lonea 1 dump, a high enrichment factor for titanium, manganese and vanadium was emphasised, and for Halda Jieț a high enrichment factor was pointed out for copper, vanadium, manganese, barium, zinc, titanium as well as very high exceedance of blank sample in the case of cadmium. The oxidation-reduction capacity of dumps in the Eastern part of Jiu Valley indicates a very acidic until moderate acid pH in the lower horizons of the dumps. In the upper horizons a weakly acidic to moderate acid pH with alkalizing tendencies in some areas was recognized due to migration / accumulation of H^+ and H_3O^+ ions in the lower horizons under the influence of local rainfall regime. Research on shallow groundwater indicates low conductivity, neutral pH, low presence of metals in water, which indicates good water quality. As a conclusion, it can be stated that dumps in Eastern part of Jiu Valley have a high capacity to transfer contaminants in unsaturated area, fact that requires the implementation of ecological rehabilitation measures within available thresholds expecially according to reglementations on national and European level. Therefore, is advisable in this situation that rehabilitation process of dumps should begin as soon as possible because the impact of landscape is quite high and the complexity of other impacts of reservoirs could increase easily. The rehabilitation process could contain earthworks in order to improve the stability factor, pH neutralization by CaO deposition and revegetation with species of economic interest.

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