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ENVIRONMENTAL IMPACT ASSESSMENT RELATED BY ENERGY SECTOR IN ROVINARI MINING AREA

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Abstract: *In this article an impact assessment is carried out, generated by activities in the energy sector related to Rovinari mining area. Energy-related activities in this area are carried out by open pit mining activities in the context of Tismana, Roșia, Pinoasa, Peşteana and Rovinari locations and Rovinari thermal power plant. Some information that has formed the input for the author's approach has been provided by SC. Complexul Energetic Oltenia SA (CEO) and S.C. Institute of Scientific Research, Technological Engineering and Mine Designs on Lignite S.A. Craiova (ICSITPML) which has been processed, analysed and used for the presented environmental impact assessment. Two methods from specialized studies have been used for the impact assessment, namely: the Matrix Method for Rapid Impact Assessment (MERI) and the Method for Integrated Quantitative Impact and Risk Assessment of Environmental Pollution (EIRM). Based on the analysis carried out, it can be concluded that the activity in this sector does not lead to significant negative effects strictly associated with it.*
Keywords: *energy sector, environment, impact assessment, environmental risk*

1. Introduction

The studied area is represented by *Rovinari Basin*, consisting of Tismana, Roșia, Pinoasa, Peșteana and Rovinari open pits and Rovinari thermoelectric power plant (CET), perimeters delimited by the following geological research that has been carried out in the mining areas of this region. It is divided into four distinct areas with following landforms: meadow area of Jiu river, meadow area of Tismana creek, eastern hilly area and western hilly area. The central part is represented by the alluvial plain of river Jiu, with altitudes ranging between + 168m and + 135m to the South [1].

Rovinari basin is represented by flat relief towards the hills, but also hilly parts with strongly fragmented slopes, this being a safe premise for instability of inclined planes and for functioning as important mobile sources. The relief in the studied area is subject to a series of processes such as: drainage, denudation and torrential rain.

The lignite deposit in this basin is close to the surface and thus, there are conditions for its exploitation through open pits.

The coal-bearing floors are Dacian (seams I-VIII) and Romanian (seams IX-XII). The barren rocks that separate the lignite seams are made up of clays, sandy clays, and clayey sands to sands [1].

Rovinari basin falls into the specific climate of hills and plateaus with a temperate continental climate, benefiting from mild winters (average temperature 5^0C) and moderate summers (average temperature 20^0C).

Wind is almost non-existent due to the sheltered climate of this area, the most dominant being from the Northern part. The predominant wind direction is northwest, its average speed being about 3.2m/s [1].

The average monthly and annual rainfall is about 753mm [1].

From the seismic point of view, Rovinari administrative territory falls into the seismicity zone E (a_g=0.12g, T_c=1) with seismic degree 7 [1].

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In the analysed area, the flora and fauna are varied, arranged in floors, in close correlation with the morphological factors.

The mining works carried out in this area led to uncovering of hundreds of hectares, which have had the effect of destroying natural flora, strongly influencing surrounding areas and removing local wildlife.

2. Energy sector in Rovinari basin

This article focuses on the energy sector of Rovinari basin, which consists of E.M.C. Roșia - Rovinari with the open pits Rovinari, Roșia, Peşteana, Tismana and Pinoasa and the CET-Rovinari thermoelectric power plant [2].

2.1. E.M.C. Roșia - Rovinari

Over 75% of the lignite reserves of Oltenia are located on the territory of Gorj County arranged in the three basins belonging to Tg-Jiu Mining Directorate, resources that are used as raw material in the production of electricity in the thermoelectric power plants in Gorj County belonging to Oltenia Energy Complex (CEO). One of the three pit mining operations (EMC) of Tg.Jiu Mining Directorate is E.M.C. Roșia - Rovinari with the following open pits: Rovinari, Roșia de Jiu, Peşteana, Tismana and Pinoasa which fall into the Rovinari mining basin (figure 1) [1].

Fig. 1. Mining basin Rovinari [1]

Rovinari mining basin, formed by the open pits belonging to E.M.C. Roșia - Rovinari, is divided into four distinct areas with the following landforms: meadow area of Jiu River, meadow area of Tismana creek, eastern hilly area and western hilly area. The central part is represented by the alluvial plain of Jiu, with altitudes varying between + 168m and + 135m to the south.

The location of Rovinari basin is in the external areas/ internal areas of Câlnic, Negomir, Fărcășești, Bâlteni, Urdari and Plopșoru villages (Figure 1) [1].

Table 1 gives the extension of the five open pits analysed [1].

Table 1. Area of open pits belonging to EMC Roșia-Rovinari [2].

No.	Mining perimeter/ Open pit	Surface, km^2
1.	Rovinari	6.753
2.	Roșia de Jiu	17.388
3.	Peșteana	18.009
4.	Tismana	17.121
5.	Pinoasa	15.814

2.1.1. Rovinari open pit

The perimeter of Rovinari open pit is located on the territory of Rovinari and Bâlteni villages, in the north-western part of Rovinari mining basin, in the hilly area east of Jiu river and is delimited to the north by the perimeter of former Gârla open pit, to the south by the power lines that connect Rovinari thermoelectric power plant to the national electricity supply system; in the East by Tâlveștilor forest; in the West by the perimeters of former Bâlta Unchiașului, Cicani and Beterega open pits [1].

Rovinari's open pit, having started by 2019, ceased its activity due to the depletion of the deposit.

2.1.2. Roșia de Jiu open pit

Roșia de Jiu open pit is located on the right bank of Jiu River, south of the town of Rovinari. The field of the whole open pit comprises a meadow and a hilly area.

The opening was made through four excavation steps [1]. The exploitation methods applied are: transport of sterile rocks to external dumps; transport of sterile rocks to inner and outer dumps [1].

2.1.3. Peşteana open pit.

The exploitation of lignite reserves in Peșteana perimeter was possible only after the diversion and regularization of Jiu River, which crossed the mining basin from north to south, between the villages of Telești and Plopșoru, on a length of approx. 27 km. Jiu River regularisation canal is located on the eastern boundary of the mining perimeter [1].

The main utilities necessary for the development of the production activity were built for the common use of the two quarries, Peşteana North and Peşteana South.

Peşteana South lignite deposit developed almost entirely within Jiu meadow, while only seams X, XI and XII can be exploited in the open pit.

Peşteana North lignite deposit is located in the central part of Rovinari coal basin, in the hilly area, on the right bank of the Jiu River.

The two perimeters, Peşteana South and Peșteana North, were organized within Peșteana open pit.

2.1.4. Tismana open pit.

The perimeter of Tismana open pit is delimited to the north by the village of Hodoreasca; to the southwest, by the village of Pinoasa; to the south, by Rovinari thermal power plant; to the east, by the village of Șomănești.

The opening of this perimeter was made simultaneously with the execution of diversion works through the northern area of Şomăneşti, of Tismana brook, because it crossed Tismana I and Tismana II exploitation perimeters from west to east existing before the interference that formed a single open pit: Tismana open pit.

2.1.5. Pinoasa open pit

The perimeter of Pinoasa open pit is located on the right slope of Jiu River, in a hilly area, being delimited to the south by Timișeni Valley, to the east by Rovinari thermal power plant, to the north by Tismana quarry, to the west, by the natural gas perimeter area.

The perimeter of the open pit is entirely hilly and was intended, according to some previous provisions, for underground exploitation (Pinoasa mine that was abandoned).

The works for this open pit started with classic equipment in the micro quarry, opening Pinoasa I, II and III and later Pinoasa IV and V. The perimeter of the quarry being near Peşteana North and South quarries, the surface arrangements were provided jointly with these quarries by extending the constructions on the mounting platform, the coal depot and the mine yard.

2.2. CET- Rovinari

Rovinari thermoelectric power plant (figure 2) dates from 1972. It is located about 2 km northwest of the town of Rovinari and about 25 km S-V of the town of Tg-Jiu, in the immediate vicinity of mining operations in Rovinari coal basin: Rovinari, Tismana and Pinoasa open pits.

The precinct of the thermoelectric power plant runs parallel to the regularized bed of Jiu River.

Fig. 2. Overview of CET Rovinari [1]

Rovinari thermoelectric power plant is designed as a basic power plant of the National Energy System - SEN, with an operating regime of 24 hours/day, 7 days/week, 365 days/year.

The activities carried out within Rovinari thermoelectric power plant are carried out in two large combustion plants consisting of 2 energy blocks, each with a thermal power of 878 MWt.

Rovinari thermal power plant uses lignite from the open pits in Rovinari basin as the main fuel. Being located at the "mouth of the mine", which makes it unique in the country, it capitalizes large amounts of lignite through minimal transportation costs. The annual electricity production and energy demand are shown in Table 2.

Table 2. Production and need for energy resources

Electricity produced, MWh/year	**Resources used to ensure production**		
	Lignite, t/year	***) Natural gas, thousand m^3/year**	***) Fuel oil, t/year**
1,802,000	2,269,285.01	6,415.67	434.62

**) Natural gas and fuel oil are fuels used only for starting and stabilizing the flame*

The slag and ash deposits are located 2 ÷ 5 km away from the thermoelectric power plant and occupy an area of 478.9 ha. The ash produced monthly by an energy block is about 64,000 tons (80,000 m^3).

Current situation of deposits [2]:

- ❖ Balta Uncheaşului (34.2 ha) - depleted deposit, covered with earth, grassed.
- ❖ Cicani - Beterega located on the left bank of Jiu River, about 4 km from CET-Rovinari with three compartments.
- ❖ Gârla (160ha), of which active – 113 ha., located at about 4.5km from CET- Rovinari, in the vicinity of Cicani - Beterega deposit, located in elevation from + 180.00mdMN to + 185.00mdMN (Figure 3).

3. The impact of energy activities in Rovinari basin on the environment

The issue of the impact of the energy activities in Rovinari basin on the environment must be approached from two points of view: from the one generated by the lignite exploitation activities in this basin and from the one related to the production of electricity and heat after burning this lignite in the thermoelectric power plant. Thus, this dual approach will outline an overview of assessing the impact generated by energy activities in this area on environmental components.

Fig. 3. Gârla slag and ash deposit [1]

3.1. Pollution generated by the mining activities in Rovinari basin

The entire process of lignite extraction in Oltenia area, in general and Rovinari mining basin, in particular, produces a multitude of negative effects on the environment.

The negative effects of the mining activities on the environment can be summarized as follows:

• Excavation: occupation and degradation of land; destruction of ecosystems; affecting the hydrological and hydrodynamic regime; dust and dust emissions; noise and vibration.

• Transport: fragmentation of the landscape; powder and dust emissions; noise and vibration.

• Landfilling: land occupation and degradation; destruction of ecosystems; powder and dust emissions; noise.

Anthropogenic actions for the exploitation of lignite in open pits, involve destructive - constructive processes that have a high speed of realization and rapid development, influencing the zone relief both directly (by changing the natural balance of the land and modelling processes) and indirectly (by annihilating some components of the geosystem such as: grubbing, modification of flow slopes on the final slopes of the open pits in the hilly area, modification of hydrography networks and outer dumps and changes in soil structure).

3.1.1. Land degradation / Soil pollution

A general feature of quarrying is the removal from the economic circuit of large areas of land necessary for the entire process of extracting the profit (extraction itself, depositing tailings and other waste, arranging and organizing activities related to the extraction of profit, construction of transport routes a.o. for which large areas of land are required which are temporarily removed from the circuit).

Thus, the open pits in Rovinari mining basin will remove from the economic circuit of Gorj County, until the cessation of their activity, an area of approx. 8,277.5 ha of land.

Another characteristic for the open pi in the Rovinari mining basin is the landslide phenomena, which take place at the boundary between the clays, affecting the slopes of the hills and the slopes of the open pits before the start of the works.

The phenomenon of suffosion is not to be neglected either, a phenomenon that appears in the case of slopes made up of sands and clayey sands soaked with water, where the working fronts approach the faults in the deposit. Their exploitation requires special attention in the execution and exploitation processes, but detailed field studies and analysis of data of any kind related to the anthropic activity in the respective area are necessary.

Another problem that can cause great damage to the environment, due to landslides, is the improper location or non-performance of all dump works. It is known that through the mining activity the lithological structure of the land changes, on depths from 2 - 3m and up to over 150 - 200m and at the same time, the stability of the basic land. Moreover, large areas of land are permanently occupied for the deposit of tailings in the outer dumps, which are located outside the exploitation perimeter. The tailings dumps related to the open pits of the Rovinari mining basin occupy an area of 3,892.62ha

The mining mass in the dumps consists of a heterogeneous mixture of rocks from different strengths and origins, with an accentuated non-uniformity of grading and physical-mechanical properties, which makes it impossible to install the flora to restore the dumps in the agricultural or forestry circuit without ecological reconstruction works in advance.

The precipitation that falls on these tailings deposits gives rise to the phenomenon of chemical-bacterial leaching of the metal sulphides they contain. This phenomenon results in solutions that have a smaller or larger amount of copper and other heavy metals. These solutions can reach the groundwater network in the area and/or reach the local and regional hydrography network, due to the fact that these dumps were not built on impermeable surfaces, provided with drainage channels to take over these solutions.

Given that many of the existing dumps in Rovinari basin were built a long time ago, environmental protection measures - in terms of these infiltrations - consist in maintaining the landfill on site, ensuring sewerage and accumulation in tailings ponds. of solutions leaking from precipitation. The fact that most of these tailings dumps are located in isolated, less populated areas has meant that the problem of this pollution is not particularly taken into account.

The impact of mining activities in Rovinari basin on soils is manifested by:

• physical pollution with tailings dust (coal);

• chemical pollution with petroleum products/used oil from some quarry equipment;

• pollution with other waste/residues such as: scrap metal, car batteries, used tires, used tape, aluminium and copper waste, household waste a.o.;

• soil degradation and decrease of fertility class through stripping works for lignite extraction;

• falling of the soil, especially on the surfaces used for utilities that serve the open pit (roads, mine yard, warehouses a.o.) that destroy the structure and implicitly the fertile qualities of the soil;

• the appearance of the erosion phenomenon on the open pit slopes, dumps without vegetation a.o.

In order to assess the quality of the soil in the Rovinari mining basin, it is necessary to quantify the land areas occupied by quarries, dumps, mine yards and mining constructions and land areas diverted from initial uses due to the degradations to which they were subjected.

The categories of land degraded as a result of lignite mining in the Rovinari mining basin are presented in table 3.

Table 3. The categories of land degraded in Rovinari mining basin

No.	The categories of land	Surface, (ha)
1.	Open pits	8,277.50
2.	Dumps	3,892.62
3.	Mine yards/constructions	987.35
4.	Access roads	322.87
5.	Other surfaces	187.22
Total		10,164.56

In order to highlight the possible exceeding of the maximum allowed concentrations of some elements present in the soil and in the tailings dumps, samples were taken according to the methodology provided by the standards in force and subjected to laboratory analyses in the environmental laboratory of the National Agency for Environmental Protection Gorj (ANPMG).

Following the taking of samples from the active dumps and from their direct foundation (vegetal soil) and analyzed in the laboratory, the maximum concentrations of the pollutants included in their composition were determined. The results obtained over a period of 10 years are presented in table 4 and will be the basis for assessing the impact induced by mining activities in the Rovinari basin on land/soil.

Table 4. Concentration of pollutants in dumps and soil

No.	Quality indicators	MU	$C_{det.}$		MAC (normal values) Acc. Order MAPPM no. 756/1997
			Dumps	Vegetable soil	
1.	pH	unit. pH	7.13	7.54	6.5-8.5
2.	As	mg/kg d.s..	4	2	5
3.	Ba		349	311	200
4.	Co		5	6	15
5.	Cr		126	123	30
6.	Cu		2	1	20
7.	Mn		310	301	900
8.	Ni		16	15	20
9.	Pb		21	23	20
10.	V		101	121	50
11.	Zn		47	43	100

The presence of certain elements both in the composition of the soil and in that of the tailings dumps in concentrations close in value, leads to the conclusion that there is no soil contamination caused by the chemical composition of the sterile materials stored in the dumps. The fact that the elements are in close concentrations and in the vegetal soil in the studied areas indicates the fact that there is no migration from the dumped material to the neighbouring areas.

From the analysis of the data presented in table 4 it can be concluded that the values of the concentrations of toxic substances for vegetation are well below the values of the alert thresholds.

3.1.2. Air pollution

The main sources (stationary and mobile) of air pollution generated by the activities in open pits, dumps and related activities in Rovinari basin are:

• the excavation areas of the mining masses, as well as the distribution nodes of the sterile and coal transport strips where, as a result of the coal deposits and the tailings deposits in dumps, dust emissions result;

• the technological and transport equipment used to serve the quarries emit a series of harmful gases and dusts into the atmosphere. They use diesel as fuel, the combustion of which results in: carbon oxides (CO), nitrogen and sulphur oxides (NO_x, SO_x), incompletely burned hydrocarbons (VOCs) and solid particles;

• the slopes and berms of the open pit and the dump, not covered by vegetation, on the surface of which fine sedimentable particles are entrained, by wind;

• access roads from quarries and dumps, which result in significant amounts of suspended dust;

• self-ignition in hot periods, of coal in the warehouse or the layers that emerge through the release of gases or noxious substances in the atmosphere. In addition to the appearance of fire nuclei, gas emissions of methane, ethane, carbon monoxide, sulphur dioxide, nitrogen dioxide, hydrochloric acid and polycyclic aromatic hydrocarbons result. Observations made over time on coal deposits show that the time frame favourable to self-ignition is from 30 days to 90 days from the date of storage, so during this period a number of conditions must be ensured to prevent this phenomenon.

In order to assess *the air quality* in the area related to Rovinari mining basin, the measurements performed by the specialists regarding the concentration of some pollutants in emissions as well as the data provided by ANPM Gorj regarding the air quality in this area were taken into account. The results of the emission measurements in Rovinari mining basin, in the period 2012-2020, are presented in Table 5.

Table 5. Concentration of air pollutants

Quality indicators	**MU**	**C_{det} (range of values accepted for impact assessment)**	**C_{det} (average values accepted for impact assessment)**	**MAC Acc. Law no. 278/2013 and Law 104/2011**
CO	mg/m^3	0.28 – 0.42	0.38	10
NO_x		17.04 – 29.03	26.11	200
SO_2		8.00 – 32.89	29.01	200
PM10		16.71 – 56.12	39.97	20
Pb	µg/m^3	0.0018-0.0056	0.005	0.5
As	ng/m^3	0.0159-2.3048	2.028	6
Cd		0.2627-0.7152	0.669	5
Ni		0.5313-2.4003	2.001	20

Determinations of lead, arsenic, cadmium and nickel were also performed by atomic absorption spectroscopy, from suspended powders of the PM10 fraction collected on filters in automatic air quality monitoring stations. There was no over passing of the limit value (for lead), respectively of the target values (arsenic, cadmium and nickel) provided in Law no. 104/2011.

The annual average values of heavy metals present in suspended powders, PM10 fraction, in relation to the limit values are shown in table 5.

It should be noted that it is practically impossible to make an objective analysis of the contribution to air pollution that can be attributed to mining in the context in which it cannot be separated from other sources of pollution in cities (car traffic, various industrial activities, and individual heating).

Last but not least, we must take into account the proximity of CET Rovinari to the studied area, so we can consider that it can also contribute to air pollution through its emissions.

3.1.3. Water pollution

In Rovinari mining basin, before the start of coal mining, the groundwater from atmospheric precipitation and from surface water through alluvial deposits, had a stable hydrostatic level on the entire surface of the basin. Aquifer formations in the roof and bed of lignite layers have created difficulties in their exploitation, by the danger of flooding of work fronts and mining works, of congestion of equipment in technological flows or by slipping and collapsing work steps and slopes and permanent quarries and thus, it was necessary to dry the present aquifer formations.

The safe exploitation of lignite deposits through quarries, in the meadow area of Rovinari basin, required the lowering of the piezometer level of groundwater by 50-100m, causing the formation of a large depression funnel, which extended far beyond the boundaries of the quarries. As a result, all the wells downstream of the open pits in the meadow area of Rovinari mining basin have completely dried up in a few years. The phenomenon had important negative repercussions on forestry, pastoral and agricultural activities in the entire area located downstream of the quarries.

According to the studied documentation, the drying works carried out in the quarries of Rovinari mining basin lead to the annual evacuation of approx. 90 million m^3 of water, water from drilling rigs and existing pumping stations in up-to-date operations. [3].

In order to assess *the water quality* in the area related to Rovinari mining basin, the measurements provided by Gorj Water Management Service (SGA Gorj) were taken into account. The values of the physic-chemical indicators in the period 2012-2020 are presented in table 6, for surface waters and in table 7 for groundwater.

Table 6. Multiannual average values of surface water quality indicators

No.	**Quality indicators**	**MU**	**$C_{det.}$ (determined average values).**	**MAC Acc. NTPA-001/2002 Modif. 19.03.2007**
1.	pH (TºC=20,3)	unit. pH	7.56	6.5-8.5
2.	Temperature	ºC	13.5ºC	35
3.	Suspensions	mg/dm^3	26	35
4.	BOC_5		2.24	25
5.	COC-Cr		8.22	125
6.	Filterable residue at 105º C		170	10
7.	Chlorides		11.40	500
8.	Sulphates		26.76	600
9.	Ammonium		<0.66	0.32
10.	Petroleum products		<10	10
11.	Calcium		32.67	300
12.	Extractable substances		<20	20

Table 7. Multiannual average values of groundwater quality indicators

No.	**Quality indicators**	**MU**	**$C_{det.}$ (determined average values).**	**MAC Acc. NTPA-001/2002 Modif. 19.03.2007**
1.	pH (TºC=20,3)	unit. pH	6.75	6.5-8.5
2.	BOC_5	mg/dm^3	3.8	25
3.	COC-Cr		11.4	125
4.	Fixed residue		514	2000
5.	Mn		0.053	1
6.	Fe		0.068	5
7.	Sulphates		6.67	600
8.	Ammonium		1.06	0.5
9.	Pb		0.22	0.2
10.	Total Cr		0.22	1
11.	Ca		19.24	300
12.	Mg		11.67	100

3.1.4. Noise pollution.

The main source of noise and vibration is the equipment specific to the lignite extraction activity (excavators, bulldozers, as well as means of loading and transport).

The noise levels resulting from the machinery and means of transport used in the temporary operating perimeter are given in table 8.

Table 8. Noise levels at several analysis points

No.	Point of analysis	Distance from noise source, m	MU	Average calculated values, L_p	Permissible limit (LMA) for industrial areas acc. Standard H.G. no. 493/2006 and SR 10009:2017
1.	Working fronts	5	dB(A)	88	87
2.	Mine yard	50		68	87
3.	Limit of the mine yard	200		56	65
4.	Nearby inhabited area	1500		39	50

Regarding the pollution by electromagnetic radiation and ionizing radiation generated by the machinery and equipment used in technological processes, it is at a low level to have a negative impact on environmental factors in the area.

3.1.5. Impact on biodiversity

The action of anthropogenic processes due to the exploitation of lignite in the quarry, involves destructive-constructive processes that have a high speed of realization and rapid development, influencing the zone relief both directly by changing the natural balance of the land and modelling processes, and indirectly by annihilating components from the geosystem, as:

- grubbing and fruits garden that led to the disappearance of associated fauna and flora;
- the removal of the vegetal soil, which, either was excavated separately and stored, or was excavated together with the tailings with which it mixed inseparably so that, in the tailings dumps, a heterogeneous mixture appears which is accentuated even more on the occasion of their arrangements in agricultural and forestry circuit. Under these conditions, on the tailings dumps, in a period of 3-5 years, no plant life form is installed, after which a series of grassy mesoxerophilic species begin to appear, less demanding to the living conditions offered.

Considering the obligation to return to the agricultural or forestry circuit the lands affected by mining in this area, it is considered that in time the biodiversity here is restored, often more productive.

3.2. Pollution generated by CET-Rovinari

Regarding the activity of the thermoelectric power plant, the pollution generated by this industrial branch has at hand multiple possibilities to minimize the negative impact on the immediate environment, while the exploitation of the deposit raises major problems, both landscape and pollution of all factors, environment, problems that cannot be solved immediately.

Despite this minimization of the direct negative impact at the source, the activity of the thermal power plant, by burning fossil fuels, is the activity with the most significant share of environmental degradation, compared to the activity of depositing, the field of environmental protection.

The main sources of pollution of Rovinari thermal power plant are: chimneys of thermoelectric power plants, wastewater and ash deposits [4].

3.2.1. Land degradation / Soil pollution

The constructions, technological networks, transport routes and free zones that form CET-Rovinari enclosure occupy an area of approx. 82.7ha.

Other pollutants due to energy production and consumption include the resulting waste. The slag and ash resulting from the combustion of the fuel are hydraulically evacuated, by pumping in a single stage, to the plant's depots for final storage. The dense sludge (mixture of slag, ash and gypsum) is currently stored in the only active warehouse of CET Rovinari - Gârla Depot, located 2.5 km away from the plant and which has an area of 150ha, of which 90ha active. The total area of slag and ash deposits, active and inactive, is 478.9ha.

The entire land area that includes the energy activity of the thermoelectric power plant is approx. 561.6ha.

An important contribution to the increase of soil pollution is made by slag and ash deposits/dumps. At Rovinari thermoelectric power plant, lower coals are burned, which makes enormous volumes of ash result from their burning.

In order to evaluate the pollution level, soil samples were taken from the areas with potential pollution risk from the location of the thermal power plant: Outdoor power station; Pool mix; Drinking water station; Chemical station (reagent storage); Boiler operation section, crushing 1 + 2, gate 3; Exploitation section, crushing fuel 3 – band conveyer T32 B.

The samples were taken according to the requirements of OM no. 184/1997, from depths of 5cm and 30cm respectively, with drill-type pedological probe taking into account a series of determining elements: geomorphological complexity, lithological complexity, and predominant wind direction, distance that emissions can reach, etc. The samples with a mass of 75g, taken in plastic bags, were transported and analysed in the laboratory.

Following the laboratory analyses on samples collected in the period 2017-2020, but also corroborated with those performed over time (e.g. 2003, 2009), were selected the multiannual average values of the concentrations of heavy metals in the soil given in the table 9.

Table 9. Multiannual average values of heavy metal concentrations in soil

No.	Quality indicators	MU	$C_{det.}$ Determined values	MAC (Normal values) Acc. Order MAPPM no. 756/1997
1.	pH	unit. pH	7.8	6.5-8.5
2.	As	mg/kg d.s..	3.3	5
3.	Ba		365.8	200
4.	Co		30.2	15
5.	Total Cr		78.6	30
6.	Cu		33.7	20
7.	Mn		719.2	900
8.	Ni		33.9	20
9.	Pb		39.3	20
10.	V		131	50
11.	Cd		1.1	1
12.	Zn		123.3	100

3.2.2. Air pollution

The main fuels currently used at Rovinari thermoelectric power plant are fossil fuels (lignite). In addition, the plant is also supplied with fuel oil (starting fuel) and natural gas (support fuel or auxiliary fuels), which are used to start and / or stabilize the flame when the lignite is of lower quality. The resulting smoke contains both suspensions and gases which in turn contain nitrogen oxides, sulphur dioxide, carbon monoxide, hydrofluoric acid, aldehydes and other hydrocarbons.

Considering the location of the thermoelectric power plant and other related components, the impact of the pollutants discharged into the atmosphere by the combustion plants, takes place over distances from 100m to several tens of kilometres, so in areas relatively close to the thermal power plant. This impact is given by the power of the source and implicitly the amount of pollutants discharged and by the climatic factors in the area.

The main pollutants emitted by combustion sources are: dust (fly ash, coal particles, slag, soot, (a.o.); sulphur oxides (SO_2 and SO_3); nitrogen oxides (NO and NO_2); carbon oxides (CO, CO_2); tars; hydrocarbons; organic acids a.o.

The air pollution is due to the chimneys of the thermoelectric power plant that spreads impressive amounts of unburned coal dust and ash and sulphur compounds (mainly SO_2) in the atmosphere every day, suspensions that the wind carries around the thermal power plant within a radius of 25km.

Heavy metals, halogenated compounds and dioxins, although emitted in smaller quantities, have significant effects on the environment due to their toxicity and persistence.

In order to establish the concentrations of pollutant emissions into the atmosphere, which should be included in the calculation of the impact assessment of the activities within CET Rovinari, the average values of the concentrations of these emissions recorded over several years (2012-2020), from large combustion plants (IMA), specified in the *Annual Environmental Reports*. Thus, it was possible to establish some multiannual average values for the concentrations of SO_2, NO_x and dust, values that we considered significant to be taken into account in the calculation of the impact of CET-Rovinari on the air environment component (table 10).

The results of the emissions measurements for the analysed site indicate that the emission limit values are not exceeded because the desulphurization plant is currently operating and the slag and ash transport and storage facility has been upgraded.

Another type of pollution of the thermal power plant is the local heating of the atmospheric air, due to the evacuation of the flue gases with temperatures around 120^0C or of the technological cooling. The effect of this pollution is not significant, because all energy blocks are equipped with flue gas desulphurization plant, so the pollution can be considered insignificant (the values recorded by the flue gas temperature monitoring system released into the atmosphere are between 61-68^0C).

Table 10. Values of air quality indicators at CET-Rovinari

Quality indicators	**MU**	**$C_{det.}$ Values taken in the impact assessment calculation**	**Allowed Limit Values (ALV))/ Maximum Allowable Concentrations (MAC), Acc. Low no. 278/2013**
SO_2	mg/Nm^3	200	200
NO_x		185	200
Powders		28	20

3.2.3. Water pollution

CET Rovinari uses Jiu River as a source of industrial water supply.

The pollutants and pollution sources for the water environment component at CET Rovinari are:

- cooling waters resulting from the boiler, turbine and generator cooling processes;
- the waters from the hydraulic evacuation of slag and ash resulting from the formation of the slag and ash transport surplus;
- wastewater from the chemical station resulting from the process of demineralization and water softening;
- wastewater from boilers obtained periodically by washing the boiler;
- domestic wastewater from social groups and canteen.

From the multitude of available data, in table 11 are presented the multiannual values of the water quality indicators discharged by the main pollutants from CET Rovinari.

Table 11. Wastewater quality indicators discharged at CET Rovinari

No.	**Quality indicators**	**MU**	**Measured average value/determined C_{det}**	**Allowed Limit Values (ALV/MAC) Acc. H.G. no. 188/2002, amended by H.G. no. 352/2005-NTPA 001**
1.	pH	u.pH/^{0}C	8.45	**6.5-8.5**
2.	Sulphates	mg/dm^3	161.8	**600**
3.	Chlorides		64.8	**500**
4.	Ca		145.8	**300**
5.	Nitrates		3.67	**10**
6.	BOC_5		18	**25**
7.	COC-Cr		50	**125**
8.	Ammoniacal nitrogen		3	**0.72**
9.	Mg		52.54	**100**
10.	Cu		3.24	**0.1**
11.	Se		0.4	**0.1**
12.	As		0.1	**0.1**
13.	Pb		0.015	**0.2**
14.	Hg		0.1	**0.05**
15.	Suspensions		52.24	**60**
16.	**Filterable residue at 105° C**		**555.6**	**2000**

3.2.4. Noise pollution

Noise sources inside the plant are represented by turbo-generators, flue gas fans, air fans, pump stations, steam routes, coal conveyor belts, coal mills, desulphurization plants. These sources produce continuous, high-noise and affect a small area.

At CET-Rovinari the noise is monitored inside, at the boundary of the enclosure and outside it, respecting the provisions of STAS 6161 / 1-79, STAS 6156-86 and STAS 6161 / 3-82, H.G. no. 321/2005 on the assessment and management of environmental noise.

Noise level measurements performed in 2019, according to the Annual Environmental Report, are shown in table 12.

Table 12. Equivalent noise levels at the measurement points

No.	Point of analysis	MU	Average calculated values, L_p	Permissible limit (LMA) for industrial areas, acc. Standard H.G. no. 493/2006 and SR 10009:2017
1.	Precinct	dB(A)	75	**87**
2.	Precinct limit		60	**65**
3.	**Nearby inhabited area**		**60**	**50**

3.2.5. Impact on biodiversity

Regarding the vegetation, flora and fauna in the area related to the Rovinari thermoelectric power plant, it is considered that this impact on biodiversity is not significantly assessed. It seems that plant and animal species have adapted more quickly to the existing environmental conditions, because the slopes and berms of the slag-ash deposits have become grassy, the waters are populated with aquatic fauna, and the large vegetation does not suffer.

4. Assessment of the impact of energy activities in Rovinari basin on the environment

Following the local and regional inventory of the quality of environmental components in relation to the risks to which they are exposed through energy activities in Rovinari mining basin, an assessment was made of the impact generated by the activity of the energy sector on the environment. This assessment is essential for the process of ecological remediation and reconstruction in order to ensure the safety of the population in the area, being an important tool in the decision-making process, the aim being to identify and select activities that must meet all environmental requirements imposed by competent authorities.

In the assessed area, the pollution generated by the activities of the energy sector interacts with other sources present in the area, an interaction that leads to a significant decrease in the quality of environmental components affecting the health of the resident population.

These reasons required a detailed analysis of the current environmental quality situation in the study area. To this end, a systematic study on environmental impact and risk assessment was carried out in relation to the legal framework in force on the maximum permitted concentrations of pollutants identified in the environmental components.

In the evaluation of the impact generated by the energy activity in Rovinari basin, two methods from the specialized literature were used, namely: *the Matrix Method of Rapid Impact Assessment (MERI)* and *the Integrated Quantitative Assessment of the Impact and Risk of Environmental Components Pollution (EIRM)*

4.1. Environmental impact assessment and risk generated by mining activities in Rovinari basin

4.1.1. Evaluation by the rapid impact matrix method (MERI)

Taking into account the analysis carried out in point 3.1 on the impact of mining activities on the environment, the following will affect five environmental components affected, namely: *soil, air, surface water, groundwater and noise.*

Based on the values of the quality indicators of these environmental components (see tables 4-8) and using the theoretical considerations for the MERI method [1, 5], table 13 was prepared for the calculation of the environmental scores and then the impact category was established, which allowed a description to be made of the value of the impact generated by the entire mining activity in Rovinari basin.

Table 13. Impact assessment by the MERI method for mining in Rovinari basin

Environmental component	Evaluation criterion					Environmental score $ES= A_1 \cdot A_2 \cdot (B_1+B_2+B_3)$	Impact category, IC	
	A_1	A_2	B_1	B_2	B_3		Code	Description
Soil	2	-2	2	2	2	-24	-C	Moderate negative impact
Air	2	-1	3	3	3	-18	-B	Negative impact
Surface water	2	-2	3	2	2	-28	-C	Moderate negative impact
Groundwater	2	-2	3	3	2	-32	-C	Moderate negative impact
Noise	2	-1	1	3	2	-12	-B	Negative impact

The impact assessment by this method took into account, in addition to the physic-chemical properties of the quality indicators of the analysed environmental components -reported in the tables mentioned above- the degree of land occupation by mining activities (see table 3) and the negative effects of the drainage works on the groundwater level as sources of drinking water supply of the localities adjacent to the open pits.

Therefore, it is found that *the mining activities in Rovinari basin have a moderate negative impact*, caused in particular by the removal from the economic circuit of significant land areas and drainage works, which influence the groundwater level with repercussions on the supply of drinking water to some localities.

4.1.2. Pollution Impact and Risk Integrated Quantitative Assessment (EIRM)

The same five affected environmental components will be taken into account, as in the case of the MERI method, namely: *soil, air, surface water, groundwater and noise* with the physic-chemical values of their quality indicators, given in tables 4-8.

Based on the theoretical considerations for the EIRM method [1, 5], table 14 for the calculation of units of importance was prepared and then table 15 was drawn up, which showed the values of environmental impacts and risks for the five environmental components studied taking into account and the probabilities (P) of their occurrence.

Table 14. Values of units of importance of the analysed environmental components

Environmental component	**Degree of importance, DI**	**Units of importance $UI = 1000 \cdot DI_i/DI$ (i=1...5)**
Soil	$DI_1 = 1$	233
Air	$DI_2 = 0.8$	186
Surface water	$DI_3 = 0.9$	209
Groundwater	$DI_4 = 1$	233
Noise	$DI_5 = 0.6$	139
Total	DI = 4.3	1000

Table 15. Calculation of environmental impacts (EI) and risks (ER)

Environmental component	**Quality indicator**	**MAC**	**C_{det}**	**Q= MAC/ C_{det}**	**UI**	**EI= $UI \cdot (\Sigma 1/Q_i)/n$**	**P**	**ER= EI·P**
Soil	pH	6.5-8,5	7.13	1.05	233	**270**	0.95	**257**
	As	5	4	1.25				
	Ba	200	349	0.57				
	Co	15	5	3.00				
	Cr-total	30	126	0.24				
	Cu	20	2	10.00				
	Mn	900	310	2.90				
	Ni	20	16	1.25				
	Pb	20	21	0.95				
	V	50	101	0.50				
	Zn	100	47	2.13				
	$(\Sigma 1/Q_i)/n$			**1.16**				
Air	CO	10	0.38	26.31	186	**203**	0.5	**152**
	NO_x	200	26.11	7.66				
	SO_2	200	29.01	6.89				
	PM10	20	39.97	0.50				
	Pb	0.5	0.005	100.00				
	As	6	2.028	2.96				
	Cd	5	0.669	7.43				
	Ni	20	2.001	10,00				
	$(\Sigma 1/Q_i)/n$			**1.09**				
Surface water	pH	6.5-8.5	7.56	1.00	209	**224**	0.80	**179**
	Temperature	35	13,5	2.59				
	Suspensions	35	26	1.35				
	BOC_5	25	2.24	11.16				
	COC-Cr	125	8,22	15.21				
	Filterable residue at 105º C	10	170	0.06				

	Chlorides	500	11.40	43.86				
	Sulphates	600	26.76	22.42				
	Ammonium	0.32	<0,66	0.48				
	Petroleum products	10	<10	1.00				
	Calcium	300	32.67	9.18				
	Extractable substances	20	<20	1,00				
	$(\Sigma 1/Q_i)/n$			**1.07**				
Groundwater	pH	6.5-8.5	6.75	1.11	233	**101**	0.90	**91**
	BOC_5	25	3.8	6.58				
	COC-Cr	125	11.4	10,96				
	Fixed residue	2000	514	3.89				
	Mn	1	0.053	18.87				
	Fe	5	0.068	73,53				
	Sulphates	600	6.67	89.96				
	Ammonium	0.5	1,06	0.47				
	Pb	0.2	0.22	0.91				
	Total Cr	1	0.22	4.55				
	Ca	300	19.24	15.59				
	Mg	100	11.67	8.57				
	$(\Sigma 1/Q_i)/n$			**0.43**				
Noise	Working fronts	87	88	0.99	139	**120**	0.70	**84**
	Mine yard	87	68	1.28				
	Limit of the mine yard	65	56	1.16				
	Nearby inhabited area	50	39	1.28				
	$(\Sigma 1/Q_i)/n$			**0.86**				

Taking into account the proposed classification for impact and risk [5], the analysed area was classified, that is Rovinari mining basin - mining sector, in terms of pollution caused by activities in this area (Table 16).

Table 16. Classification of the environmental impact and risk after its quantification

Environmental component	EI	Description	ER	Description
Soil	270	environment subject to the effects of industrial / human activities within permissible limits	257	average risks at an acceptable level, prevention and monitoring measures
Air	203	environment subject to the effects of industrial / human activities within permissible limits	152	minor risks, must be monitored
Surface water	224	environment subject to the effects of industrial / human activities within permissible limits	179	minor risks, must be monitored
Groundwater	101	environment subject to the effects of industrial / human activities within permissible limits	91	negligible / insignificant risks
Noise	120	environment subject to the effects of industrial / human activities within permissible limits	84	negligible / insignificant risks
Mining in Rovinari basin	**184**	**environment subject to the effects of industrial/human activities within permissible limits**	**153**	**minor risks, must be monitored**

Note: Comparing the quantification of the impact of the activities in Rovinari mining basin, made by the two evaluation methods, there is a certain difference in the classification of the degree of pollution. If by the MERI method the mining activities produce a moderate negative impact, by the EIRM method the environment is affected to an acceptable extent. The explanation is that in the case of the first method, not only the physicochemical characteristics of the quality indicators of the environmental components (process specific to the EIRM method) but also other negative effects of these activities not quantifiable in the EIRM method were taken into account, such as removing from the economic circuit some land surfaces for a long period of time and drying the wells of the inhabitants of the localities adjacent to the quarries caused by the drying of the aquifer formations from the perimeters of the quarries.

4.2. Environmental impact and risk assessment generated by CET-Rovinari

4.2.1. Evaluation by the rapid impact matrix method (MERI)

Taking into account the analysis carried out in point 3.2 on the impact of mining activities on the environment, the following four environmental components will be considered, namely: *soil, air, discharged water and noise.*

Based on the values of the quality indicators of these environmental components (see Tables 9-12) and using the theoretical considerations for the MERI method [1, 5], Table 17 was prepared for the calculation of environmental scores and then the impact category was established, which allowed a description to be made of the value of the impact generated by the entire activity of CET-Rovinari.

The impact assessment by this method took into account, in addition to the physic-chemical properties of the quality indicators of the analysed environmental components, given in the tables mentioned above, and the degree of land occupation by the power plant activities.

Table 17. Impact assessment by the MERI method for CET-Rovinari

Environmental component	Evaluation criterion					Environmental score $ES= A_1 \cdot A_2 \cdot (B_1+B_2+B_3)$	Impact category, IC	
	A_1	A_2	B_1	B_2	B_3		Code	Description
Soil	2	-1	3	3	2	-16	-B	Negative impact
Air	3	-1	2	2	2	-18	-B	Negative impact
Wastewater	2	-1	2	3	2	-14	-B	Negative impact
Noise	2	-1	2	3	2	-14	-B	Negative impact

Therefore, it is found that *the activities of CET-Rovinari have a negative impact*.

4.2.2. Assessment by the integrated quantitative method of pollution impact and risk (EIRM)

The same four affected environmental components will be taken into account, as in the case of the MERI method, namely: soil, air, discharged water, and noise with the physic-chemical values of their quality indicators, given in tables 9-12.

Based on the theoretical considerations for the EIRM method [1, 5], Table 18 was prepared for the calculation of units of importance and then table 19 was prepared, which showed the values of environmental impacts and risks for the four environmental components studied taking into account and the probabilities (P) of their occurrence.

Table 18. Values of units of importance of the analysed environmental components

Environmental component	Degree of importance, DI	Units of importance $UI = 1000 \cdot DI_i/DI$ (i=1...4)
Soil	$DI_1 = 0.8$	228
Air	$DI_2 = 1.0$	287
Wastewater	$DI_3 = 0.9$	257
Noise	$DI_4 = 0.8$	228
Total	DI = 3.5	1000

Table 19. Calculation of environmental impacts (EI) and risks (ER)

Environmental component	Quality indicator	MAC	C_{det}	$Q= MAC/ C_{det}$	UI	$EI= UI \cdot (\Sigma 1/Q_i)/n$	P	ER= EI·P
Soil	pH	6.5-8.5	7.8	0.96	228	347	0.95	329
	As	5	3.3	1.52				
	Ba	200	365.8	0.55				
	Co	15	30.2	0.50				
	Cr-total	30	78.6	0.38				
	Cu	20	33.7	0.53				
	Mn	900	719.2	1.25				
	Ni	20	33.9	0.59				
	Pb	20	39,3	0.51				

	V	50	131	0.38				
	Cd	1	1.1	0.91				
	Zn	100	123.3	0.81				
	(Σ1/Qi)/n			**1.52**				
Air	SO2	200	200	1.00	287	319	0.95	303
	NO	200	185	1.08				
	Powders	20	28	0.71				
	(Σ1/Qi)/n			**1.11**				
Wastewater	pH	6.5-8.5	8.45	0.89	257	853	0.80	683
	Sulphates	600	161.8	3.71				
	Chlorides	500	64.8	7.72				
	Ca	300	145.8	2.06				
	Nitrates	10	3.67	2.72				
	BOC_5	25	18	1.39				
	COC-Cr	125	50	2.50				
	Ammoniacal nitrogen	0.72	3	0.24				
	Mg	100	52.54	1.90				
	Cu	0.1	3.24	0.03				
	Se	0.1	0.4	0.25				
	As	0.1	0.1	1.00				
	Pb	0.2	0.015	13.33				
	Hg	0.05	0.1	0.50				
	Suspensions	60	52,24	1.15				
	Filterable residue at 105º C	2000	555.6	3.60				
	(Σ1/Qi)/n			**3.32**				
Noise	Precinct	87	75	1.16	228	228	0.75	171
	Precinct limit	65	60	1.08				
	Nearby inhabited area	50	60	0.83				
	(Σ1/Qi)/n			**1.00**				

Taking into account the proposed classification for impact and risk [1, 5], the area analysed, CET-Rovinari, was classified in terms of pollution caused by activities in this area (table 20).

Table 20. Classification of the environmental impact and risk after its quantification

Environmental component	EI	Description	ER	Description
Soil	347	environment subject to the effects of industrial / human activities within permissible limits	329	average risks at an acceptable level, prevention and monitoring measures
Air	319	environment subject to the effects of industrial / human activities within permissible limits	303	average risks at an acceptable level, prevention and monitoring measures
Wastewater	853	environment subject to the effects of industrial / human activities causing hazards to life forms	683	medium risks at an unacceptable level, control, prevention measures
Noise	228	environment subject to the effects of industrial / human activities within permissible limits	171	minor risks, must be monitored
CET- Rovinari	**437**	environment subject to the effects of industrial / human activities causing discomfort	**371**	medium risks at an acceptable level, prevention and monitoring measures

Note: Comparing the quantification of the impact of the activities at CET-Rovinari, made by the two evaluation methods, there is some difference in the classification of the degree of pollution. If by the MERI method the activities within the thermal power plant produce a negative impact, by the EIRM method the environment is affected within admissible limits, except for the discharged water. The explanation is that when assessing the impact and risk of the water component, the quality indicators are those measured immediately at the exit from the pollution source. In reality, these waters are more or less treated before they are discharged into the emissary.

5. Conclusions

Based on the analysis made by the two methods presented above the impact of energy sector in Rovinari basin, following conclusions can be revealed:

1. Soil quality is affected to varying degrees by pollution caused by various activities of the energy sector, nevertheless the environment is subject to effects of human activities within admissible limits with minor risks, which must be considered, and monitored. Negative effects appear as a result of land degradation, and as a result of their long-term removal from the agricultural and / or forestry circuit, the main pollutant being mining (see table 3).

2. Air pollution due to energy related activities is quite low due to new technologies and existing installations in CET-Rovinari (e.g. electrostatic dedusting plant, flue gas desulphurisation plant). Environment is affected by energy related activities ≠ within acceptable limits with risks at an acceptable level.

3. Insufficiently treated or untreated wastewater discharge is one of the main causes of pollution and degradation of ***surface water***. It is noted that despite the large amount of wastewater generated by the energy sector, the amount of water that required treatment is very small. Also, the amount of untreated wastewater was very low. At the moment there are major dangers, the environment being subject to the effects of human activities causing dangers to life forms, with medium risks at an unacceptable level (see classification from [1, 5]) Prevention and control measures are needed (increasing the amount of treated water, increasing the efficiency of treatment plants, monitoring the way of discharging domestic water).

4. The natural regime of ***groundwater*** has undergone, over time, a series of quantitative and qualitative changes (see 3.1.3 Water pollution), due both to their use as a source of drinking water and industrial water, by performing hydro-technical and hydro-amelioration works, and the action of pollutants. The environment is subject to the effects of human activities within admissible limits with negligible/ insignificant risks.

5. Noise does not cause human health problems, although main transport lanes and desulphurization facilities near inhabited areas are a nuisance to people.

Therefore, the assessment of the environmental impact generated by the energy related activities in Rovinari area did not lead to the identification of significant negative effects this sector.

6. One of the five main objectives of the European Union's energy policy is *to decarbonize the economy and the transition to a low-carbon economy, in accordance with the Paris Agreement*. That is why the production of electricity on coal (in our case on lignite) is subject to strict environmental rules imposed by the EU. However, Romania cannot do without coal production capacity at this time because they give security to the national energy system and we do not even have a project to replace them and the social factor also intervenes. Achieving environmental protection by applying high-performance less polluting technologies and monitoring the quality of environmental components will be *sine qua non* conditions for the life of this sector based on fossil fuels.

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