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# SOIL POLLUTION IN THE ROVINARI AREA UNDER THE INFLUENCE OF THE COAL-FIRED POWER STATION

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**Keywords**: *pollution, soil, coal-fired power station*

## Abstract

*The coal-fired power stations are particularly complex, important polluting agents. The chimneys for evacuation of burning gases represent the high polluting sources on the environment, while the ash dumps - low sources. The Rovinari coal-fired power stations has an installed power of 1720 MW, including several energetic groups built in 1972-1979 period and it use as a fuel the lignite extracted by surface mining in the respective area.*

*From the geomorphological viewpoint, this area belongs to the Câlnic-Câmpul Mare inter-hilly depression whose altitude, at the Rovinari, is 150 m. The soil forming factors causing the soil evolution have been the rock, parental material and relief, all of them determining the evolution of lithomorphic zonal soils. The soils in the analyzed area represented by the classes: luvisols, hydrisols, cambisols and protisols. The subject of this paper is dealing with the loading degree of soils in the territory affected by the emissions from the Rovinari coal-fired power station. In this, soil samples have been collected from 40 main soil profiles oriented to all the cardinal directions. These soil samples have been analyzed in order to know: pH, base saturation degree, humus, total nitrogen, mobile phosphorus and potassium, heavy metals and sulfur. Within the zone influenced by the Rovinari coal-fired power station, the main pollutants are sulfur dioxide, coal dust and the ash which contains carbon as well as silicon dioxide, aluminium oxides, and alkaline and alkaline earth metals (Ca, Mg, K). Secondary pollutants are heavy metals (Cu, Pb, Zn and Cd), pollution which affects the normal contents of soil, on the one hand, and the concentrations in plants and the human health, on the other hand.*

## INTRODUCTION

In the case of the Rovinari coal-fired power station, 189 ha have been lost from the economic land use until 2004 and other 110 ha land after 2004 being occupied by the ash Cicani and Beterega dumps.

In order to analyze the effects of the emissions from the Rovinari coal-fired power station, as well as of the blowing of the ash dumps, soil samples have been collected from sites located on eight radial directions starting from the power station to the exterior.

Along each direction, the sampling sites are located at every 1.5 km distance in between, the last sites being at 7.5 km far from the power station. This spatial distribution of sites permitted to analyze the dispersion of pollutants coming both from the emission of chimneys and the ash dumps, as well as their contents in the sterile dumps.

The dusts and sulfur oxides are emitted by chimney at variable quantities depending on number of groups in operation. In the last time, the maximum effective concentration of settling dusts varied between 16.35 and 190.64 g/m$^2$, annual mean being 12.29-106.32 g/m$^2$, and the frequency of exceeding the maximum allowable concentration was of 67.82%

Generally, the contents of heavy metals in the Rovinari zone are at a normal-low loading, excepting some sites where the determined maximum values are ranked at the higher classes. The higher values are generally due to some particularly characterized soils met along the eight directions of site locations; but, also, in some site close to power station or located on Spolic Entianthrosols formed as a result of surface mining.

Finally, the burning gases fall on the soil and vegetation, as aerosols or acid rains. Until now, the field research carried out within the area of the main power stations did not find important modifications of soil reaction caused by the emissions from the coal-fired power stations. This fact is due to the high height of the chimneys for evacuation of burned gases that permits the dispersion of gas pollutants on large land surface areas. Secondary, many soils developed in the zone influenced by emissions are buffered, the calcium carbonates buffering the leaching and debasification processes.

## MATERIAL AND METHODS

The carrying out of this work needed field studies to do soil sampling and observations on materials representing slopelands and terraces around the Rovinari fired-coal power station. Soil samples have been collected for 0-20 cm and 20-40 cm depths. The places of soil samples have been located on the map. The 40 collected soil samples have been collected along the cardinal directions, and the soil samples were analyzed for: pH, base saturation degree, humus, total nitrogen, mobile phosphorus and potassium, heavy metals and sulfur (as $SO_4^{2-}$).

In order to facilitate the interpretation of loading degree of potential pollutants and make a comparison between the contamination intensities of each pollutant element, an excessive coefficient of maximum normal content (Cn), proposed by Lăcătuşu, 1995 and Florea, 2003, has been calculated for each individual element. This Cn coefficient is defined as the ratio between the respective element content and the maximum normal content of that element. As concerns the potential polluting substances, the reference contents established by the Ministry of Waters, Forests and Environmental Protection (Order No. 756/1997) have been applied.

The value 1 of this coefficient means the lack of a contamination, according to the official rules. Sub-unitary values mean a low geological background for the respective element, while the over-unitary values may mean a contamination with the respective element due to the pollution source, so much the higher as the value of this coefficient is higher.

To be able to evaluate the pollution degree, similarly, the coefficients corresponding to the thresholds of "warning" and "triggering", briefly called warning coefficient (Ca) and triggering coefficient (Ci) for each potential pollutant, dividing the value corresponding to warning level and triggering level by the maximum normal content of the respective pollutant.

As the exceeding coefficient of normal content (Cn) of each element is coming nearer to the warning coefficient (Ca) or the triggering coefficient (CI), so the contamination or the pollution of the respective site is more intensive, of course, depending on these values, the adequate measures are taken, consequently.

These relative values for the above mentioned coefficients permit a light comparison of pollution intensities of different chemical elements.

## RESULTS AND DISCUSSION

The study of pollution of soils in zone of the Rovinari coal-fired power station necessitated an ample analysis of soil properties because these form a complex mantle determined by the diversity of relief, groundwater, rock and parent material conditions.

Soils in the analyzed area represent the classes: Luvisols (Typic and Stagnic Preluvosols, Typic and Stagnic Luvosols), Hydric Sols (Typic Stagnolosols) and Protisols (Typic Regosols, Eutric and Entic Alluviosols, Spolic Entianthrosols).

The analyzed data emphasize that, generally, the heavy metals in the Rovinari zone present normal or slight loading, excepting some site where the determined values show high contaminations. The higher values are, generally, due to some particular characteristics of soils met along the eight directions for location of sites, but also due to the reducing of the distance to the power station or due to the location on the Spolic Entianthrosols resulted by the surface mining.

Each pollutant will be individually analyzed further on.

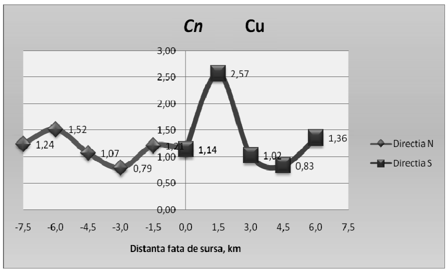


**Fig. 1. Variation of coefficients exceeding the maximum normal values of copper on the N-S directions**

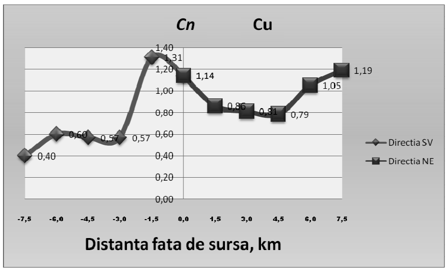


**Fig. 2. Variation of coefficients exceeding the maximum normal values of copper on the W-E directions**

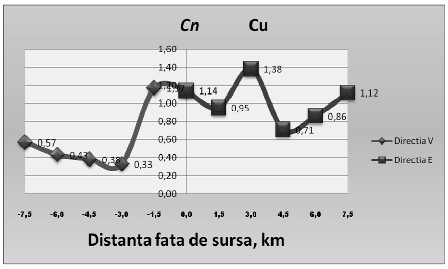


**Fig. 3. Variation of coefficients exceeding the maximum normal values of copper on the NE-SW directions**

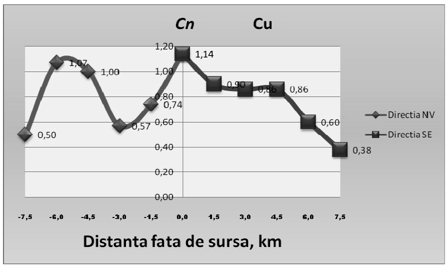


**Fig. 4. Variation of coefficients exceeding the maximum normal values of copper on the NW-SE directions**

The N-S direction is very expressive where the two maximum values (1.5 and 6 km) are evident on the both directions. As concerns W-E direction, the variation of values to W is less evident than to E.

Variations along the other directions are less prominent but evident, getting lower to the S-E direction. No value exceeds the alert coefficient, the power station influence being reduced.

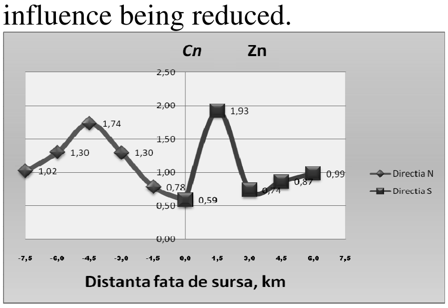


**Fig. 5. Variation of coefficients exceeding the maximum normal va lues of zinc on the N-S directions**

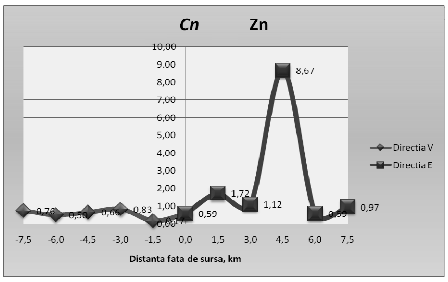


**Fig. 6. Variation of coefficients exceeding the maximum normal values of zinc on the W-E directions**

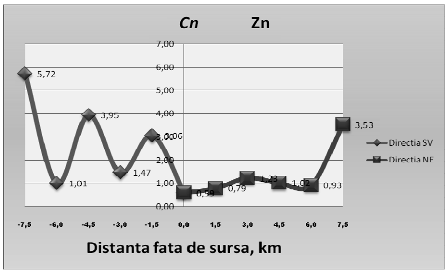


**Fig. 7. Variation of coefficients exceeding the maximum normal values of zinc on the NE–SW directions**

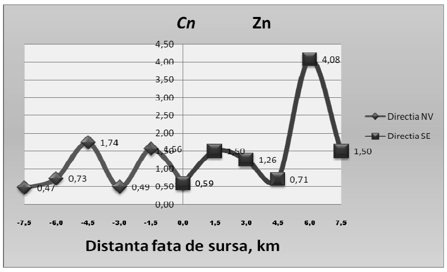


**Fig. 8. Variation of coefficients exceeding the maximum normal values of zinc on the NW-SE directions**

Along the W, N, S-W, N-W and S-E directions, the values of coefficient exceeding maximum normal content remain reduced near the power station. Along the other directions; along the other directions the increases occur even from a distance of 1.5 km. High increases beyond the alert coefficient (2.97) occur on the S-E, E, N-E, S-W directions. The value corresponding to the trigger coefficient is reached only on the E direction at a distance of 4.5 km.

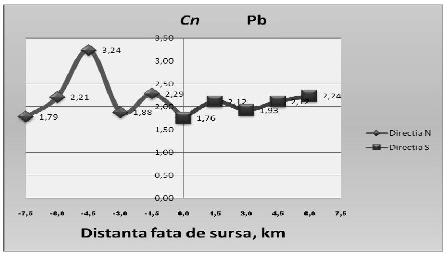


**Fig. 9. Variation of coefficients exceeding the maximum normal values of lead on the N-S directions**

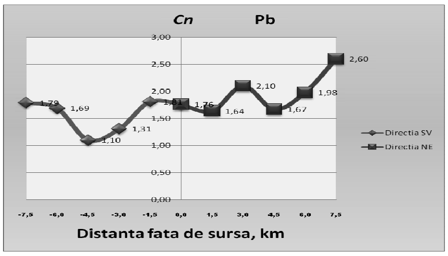


**Fig. 11. Variation of coefficients exceeding the maximum normal values of lead on the NE–SW directions**

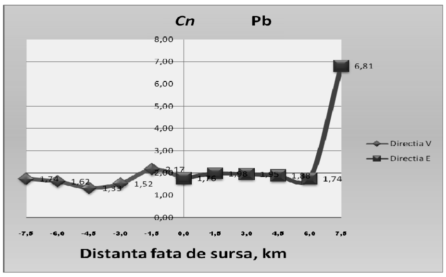


**Fig. 10. Variation of coefficients exceeding the maximum normal values of lead on the W-E directions**

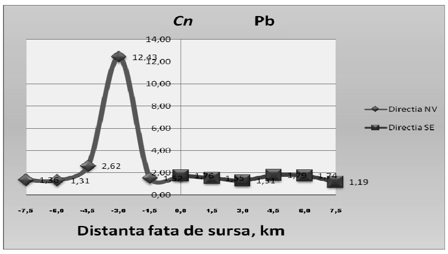


**Fig. 12. Variation of coefficients exceeding the maximum normal values of lead on the NW-SE directions**

Mean values determined at different distances present levels that reveal a certain loading with lead as compared to the coefficient exceeding the normal content; mean values determined at the distance of 3 km exceed the alert coefficient (2.97).

Along the different directions, increases over the coefficient exceeding the normal content are observed, such as: on the N direction at 4.5 km, on the E direction at 7.5 km, on the N/E direction at 7.5 km, and on the N/W direction at 3 km, where the highest value within the studied territory was more than two time higher than the triggering coefficient (12.43), this increase being due to other causes.

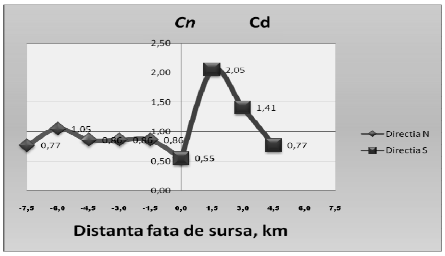


**Fig. 13. Variation of coefficients exceeding the maximum normal values of cadmium on the N-S directions**

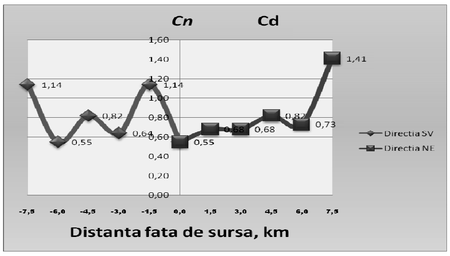


**Fig. 15. Variation of coefficients exceeding the maximum normal values of cadmium on the NE–SW directions**

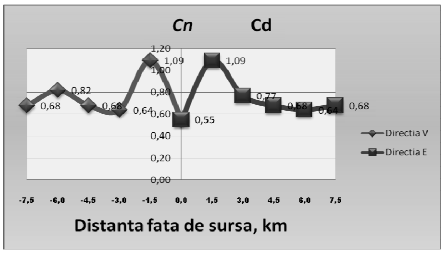


**Fig. 14. Variation of coefficients exceeding the maximum normal values of cadmium on the W-E directions**

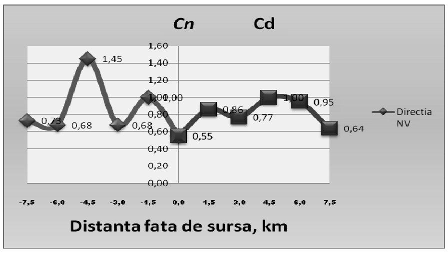


**Fig. 16. Variation of coefficients exceeding the maximum normal values of cadmium on the NW-SE directions**

The highest loading is on the S direction. Along the other directions, particular loadings do not occur, except site 38, where measured value (1.45) is higher than the coefficient exceeding the normal content. The alert coefficient is not exceeded.

## CONCLUSIONS

1. In the area influenced by the Rovinari coal-fired power station, some more important aspects have been emphasized.
2. The Rovinari coal-fired power station, characterized by installed capacity of 1720 MW, represents a major source of soil pollution, by its sterile dumps provided by surface mining and ash dumps, as well as the gas emissions from the Rovinari coal-fired power station chimneys, especially, heavy metals (Cu, Zn, Pb, Cd).
3. The analyzes show that, according to the coefficients exceeding the normal maximum content, only the zinc, lead and nickel are the metals which

exceed the alert coefficient. With the lead, along the north-western direction, at 3 km far, there is the highest value in the whole the analyzed territory (12.43), values which exceeds two times the triggering coefficient, an increase due, probably, to other causes.

4. As regarding the most intensively loaded direction, this is the southern direction, the values due to the wind coming from the northern part, which has a frequency two times higher as compared to the other directions.
5. As concerns the pollution of soils caused by the Rovinari coal-fired power station, the following affirmations can be stated:

- the impact on the soil properties is usually produced in immediate neighborhood of the Rovinari coal-fired power stations;
- the level of heavy metal accumulation and the area of pollution phenomenon extending depend on the age of the coal-fired power stations, installed capacity, technical performances of installation for scrubbing the burning gases, and, finally, the managerial influence;
- the high capacity coal-fired power stations, like Rovinari, have a great impact on quality of soils, distribution zone of heavy metals exceeding 10 km far from the source.

6. From the viewpoint of the impact of the coal-fired power stations on soils, the following statements should be pointed out:

- The energetic sector in Romania is preponderantly ensured by the coal-fired power stations (85%) and less by the primary energy such as hydraulic and nuclear energy. The fuels used indigene coals that have a high content of sulfur, plus some liquid fuels, and gas. Relatively low performance of the energetic sector is caused by the inadequate repairs and maintenances as a result of financing shortage. This sector is one of the branches of the industrial activity potentially generating pollutants.
- While the pollution decreases in the last time, especially as a result of the generally decrease of economic activity, the energetic sector, still, remains one of the main source of environmental pollution (and implicitly of soil) with $SO_2$, $NO_x$, dust and $CO_2$.
- Besides the economic activity level, the proportion of pollution depends on both the fuel used for producing the electrical and thermic energy and the burning process technology. From this view point, the highly efficient eco-technological systems for burning have a particular importance and can lead to decreasing of the environmental pollution by reducing with about 30% the emissions gases ($CO$; $CO_2$; $NO_x$; $SO_X$).
- The best measure is to prevent the pollution or its decrease. Therefore, it is further necessary to improve, as much as possible, the fuel quality,

combustion procedures, sulfur removal technologies, the systems of retaining the dust and noxious substances, to improve the ash transport and deposition. Periodically, an analysis on the coal introduced in the technological process should be made to know the composition and to avoid the maximum potential risk and the element nature.

7. Also, in this context, the following recommendation could be made:

- Further monitoring within the area under the influence of coal-fire power station and establishing some sensitive site "sensor sites" to depict in real time the eventual negative evolutions;
- Further execution of works and studies for development of finished dumps, especially, by their use for forestry or edilitary purposes (recreational parks, lots for parking vehicles, etc.), but also for reclaiming the affected lands and increasing the soil fertility aiming at their as high efficient valuation as possible.
- In the case of using the dumps for agricultural production, it should be avoided their use for orchards, vegetables and forage plants; under such uses, the soil reaction should be maintained by liming to reduce the solubility of heavy metals, and if the irrigation is applied, the sprinkler irrigation is recommended (to wash the leaves).

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