SOIL QUALITY EVALUATION IN THE AREA OF ROVINARI POWER PLANT

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ABSTRACT: Energy activities conducted in thermo electrical plants are polluting the soil directly and continuously with combustion products released through the chimneys, ash, combustion gases and polycyclic aromatic hydrocarbons. Chemical pollution of the soil that is produced by the complex character of the emissions generated by the activity of thermo electrical plants manifests itself mainly by loading the soil with heavy metals and making it more acid. In the following document, a study about the influence of Rovinari power plant over the quality of the soil will be presented, through the evaluation of the pH indicators, chlorides and heavy metals.

KEY WORDS: soil, quality, power plant, indicators

1. INTRODUCTION

Soil pollution produced by the plants can be classified by the way the pollutant agents influence the quality of the soil in physical, chemical, biological and radio-active pollution. As a stationary pollution source, the power plant is polluting directly and continuously the soil with combustion products released through the chimneys (tall pollution source), ash (in the plants that work on solid fuels), combustion gases (sulfur oxides, nitrogen, carbon) and polycyclic aromatic hydrocarbons. The ash dump or the coal storage together with the dissipations resulting due to winds, as well as accidents or incidents that happened while the normal functioning of the power plant are additional soil pollution sources, named short pollution sources [1-3]. As a symptom of the chemical soil pollution that a plant can produce, we must mention: the loading of the soil with heavy metals, loading of the soil with sulfur (SO_4^{2-}), loading of the soil with polycyclic aromatic hydrocarbons, acidification of the soil. Chemical pollution of the soil is caused both by tall sources, as well as short ones (ash dumps). Tall sources release in the atmosphere huge quantities of gas pollutants and solid particles, which are dispersed on large distances, depending on the height of the chimneys, the speed of the gasses at the exit of the chimney, the direction and intensity of the air currents. During the turbulent diffusion in the atmosphere, in the presence of humidity, the sedimentary processes will overlap with the reaction ones [4,5]. At the ground level, the effects of this type of pollution are not instant, because this component of the environment has the capacity to store diverse pollutants and to counteract their action. The source of heavy metals present in combustion gases is the burned coal. The concentration of heavy metals in the ash evacuated through the plant's chimneys is influenced by the coal's initial content of

heavy metals and by the enrichment coefficient. The heavy metals present in combustion gases are the result of one of the following processes: vaporization, followed by inhomogeneous condensation and smoke coagulation or inhomogeneous condensation and development of the ash; reactions with diverse oxidants, in order to create chlorides, sulphides or oxides, even if they are steams or solids (the steams will eventually condense, resulting in smoke or ash); development of fly ash [6,7]. The quantitative presence of heavy metals in the gas flow removed through the chimney and also in the ash and slag from the burner is depending on the concentration of the diverse heavy metals in the burned coal. The splitting in ash, slag, fly ash and volatile emissions depends on the volatilization temperature of the metals or on the absence of chlorite in the combustion system, also on the partial pressure of the oxygen in the system. In the coal extracted from the earth diverse species of heavy metals can be identified, found in different quantities, depending on the type of coal and it's origin [8,9].

2. THE CHARACTERIZATION OF SOIL IN THE AREA OF ROVINARI POWER PLANT

The main purpose of this study is monitoring the contribution of Rovinari power plant to the soil's pollution in the source's placement area, in order to obtain soil samples, at first, sampling points were established. So, in order to be able to distinguish the level of heavy metals accumulation, reference profiles were established, considered as witness profiles. The placement of these profiles was made on the basis of geological characteristics, the area of the profiles being protected against pollutants. The evidence sampling was made on standard depths according to the regulations in (Order no. 184/1997). Highlighting the emissions influence degree on the soil's proprieties in coal consuming plants required a collection of soil samples from two depths. This way of sampling is imposed by the current standards for polluted terrains.

The first sampling depth is 0-10 cm, and in needs to reveal the direct impact on the soil surface. The second depth, 10-20 cm, can establish the degree of pollutants accumulation on the plowing layer, which is the area of agricultural plant's roots maximum concentration and it can correspond to the soil materials that were unaffected by mechanical interventions, considering the medium depth of autumn plowings. In Rovinari area, 60 soil samples were collected out of 30 soil profiles, on the following cardinal directions: N, W, S, SW and SE. The distances towards the source, from which soil samples were collected depending on local conditions, varied between 300 and 2000 meters. Soil samples were collected with a pedological probe drill. The samples of about 75g soil were harvested in plastic bags and transported to the lab where they were dried up in the air and prepared for the next set of analysis: pH, chlorides, heavy metals: Cu, Zn, Pb, Cd. The heavy metals were dosed as total forms through spectrophotometry method with atomic absorption, total forms dosed in hydrochloric solution obtained after disaggregation with hard acids (HNO_3, H_2SO_4, $HClO_4$).

Table 1 presents the values for pH and chlorides indicators determined in the years of 2014 and 2015. The values determined for heavy metal contents in the soil in 2014 and 2015 are presented in tables 2 and 3.

In order to determine the soil's pollution level depending on each monitored pollutant and to appreciate it's pollutant loading level, the monitoring results in 2014-2015 period were compared with the normal chemical element

concentration from the soil. The common heavy metal concentration from the soil is set according to the medium values of content in the Romanian soils, but also on the regulations from other countries, especially from Holland. Unlike the dutch soils, Romanian soils are distinguished by a large diversity, both in their genesis and evolution, as well as their geochemical characteristics. So, the loading of heavy metals (pedogeochemic fond) is different from an area to another and from a material type to another.

Table 1. Measurements of pH and chlorides indicators in Rovinari area (2014 – 2015).

Area	Sampling point	Depth profile (cm)	Measured values in 2014		Measured values in 2015	
			pH (pH units)	Chlorides (mg Cl^- /100g soil)	pH (pH units)	Chlorides (mg Cl^- /100g soil)
Rovinari	Vart (2000 m N Termo)	0-10	7,16	78,81	6,98	71,00
		10-20	6,82	71,00	7,02	67,45
	Rogojelu II (300 m W Termo)	0-10	6,74	67,45	6,84	78,10
		10-20	6,59	63,90	6,95	74,50
	Conveyor belts (1000 m SW Termo)	0-10	6,44	71,00	6,74	71,00
		10-20	6,27	60,35	6,90	71,00
	Drilling vicinity (1500 m S Termo)	0-10	6,72	67,45	6,72	60,35
		10-20	6,86	74,55	6,63	63,90
	Moi bridge (800 m SE Termo)	0-10	6,48	71,00	6,88	67,45
		10-20	6,51	71,00	6,72	71,00

Table 2. Measurements of heavy metals in Rovinari area during 2014.

Sampling point	Depth profile (cm)	Measured indicators in 2014											
		Cu			Pb			Zn			Cd		
		Normal value	Alert limit	Measured value	Normal value	Alert limit	Measured value	Normal value	Alert limit	Measured value	Normal value	Alert limit	Measured value
Vart (2000 m N Termo)	0-10	20	100	58,2	20	50	5,8	100	300	74,4	1	3	0,2
	10-20	20	100	57,4	20	50	6,2	100	300	77,6	1	3	0,2
Rogojelu II (300 m W Termo)	0-10	20	100	44,2	20	50	3,4	100	300	102,0	1	3	0,6
	10-20	20	100	43,8	20	50	4,4	100	300	98,8	1	3	0,4
Conveyor belts (1000 m SW Termo)	0-10	20	100	70,4	20	50	3,8	100	300	122,4	1	3	0,6
	10-20	20	100	68,2	20	50	2,4	100	300	118,2	1	3	0,6
Drilling vicinity (1500 m S Termo)	0-10	20	100	31,8	20	50	6,2	100	300	47,6	1	3	0
	10-20	20	100	26,2	20	50	7,8	100	300	52,2	1	3	0,2
Moi bridge (800m SE Termo)	0-10	20	100	35,4	20	50	2,8	100	300	40,8	1	3	0
	10-20	20	100	32,4	20	50	4,4	100	300	45,8	1	3	0

Table 3. Measurements of heavy metals in Rovinari area during 2015.

Sampling point	Depth profi-le (cm)	Measured indicators in 2015											
		Cu			Pb			Zn			Cd		
		Normal value	Alert limit	Measured value	Normal value	Alert limit	Measured value	Normal value	Alert limit	Measured value	Normal value	Alert limit	Measured value
Vart (2000 m N Termo)	0-10	20	100	54,8	20	50	7,4	100	300	72,2	1	3	0,2
	10-20	20	100	58,4	20	50	8,1	100	300	78,8	1	3	0,2
Rogojelu II (300m V Termo)	0-10	20	100	49,4	20	50	6,9	100	300	96,4	1	3	0,4
	10-20	20	100	45,0	20	50	5,3	100	300	95,8	1	3	0,2
Conveyor belts (1000 m SV Termo)	0-10	20	100	65,8	20	50	4,8	100	300	104,8	1	3	0,6
	10-20	20	100	69,6	20	50	4,2	100	300	112,2	1	3	0,6
Drilling vicinity (1500 m S Termo)	0-10	20	100	41,8	20	50	3,3	100	300	58,4	1	3	0,2
	10-20	20	100	42,8	20	50	2,9	100	300	54,6	1	3	0,2
Moi bridge (800m SE Termo)	0-10	20	100	45,6	20	50	4,2	100	300	60,8	1	3	0,2
	10-20	20	100	46,2	20	50	5,4	100	300	59,6	1	3	0,4

That's why, in order to have a more objective approach of the heavy metals content from the soils around plants that consume coal, the content values of the witness profiles will be taken in consideration. In fig. 1 and 2 are represented the variations of pH from the soil in the bordering area of Rovinari power plant, during 2014 and 2015. All the above show that the pH values during 2014 varies between 6.44 and 7.16 pH units for the profiles located at 0-10 cm, respectively 6.27 and 6.86 pH units for the profiles from 10 to 20 cm. During year 2015, a pH variation from 6.72 to 6.98 units can be noticed for the 0-10 cm profile, as well as 6.63 to 7.02 pH units for the 10-20 cm profile. The changes in chlorides concentrations concerning Rovinari area during 2014 and 2015 are presented in figures 3 and 4.

It's noticeable that the values measured in year 2014 are around 67.45 to 78.82 for the 0-10 cm profiles and 60.35 to 74.55 for the 10-20 cm ones.

In year 2014 a change in the chlorides content can be noticed, starting from between 60.35 to 78.10 mg Cl^-/100g soil for the 0-10 cm profile and 63.9 to 71 mg Cl^-/100g soil for the 10-20 cm one.

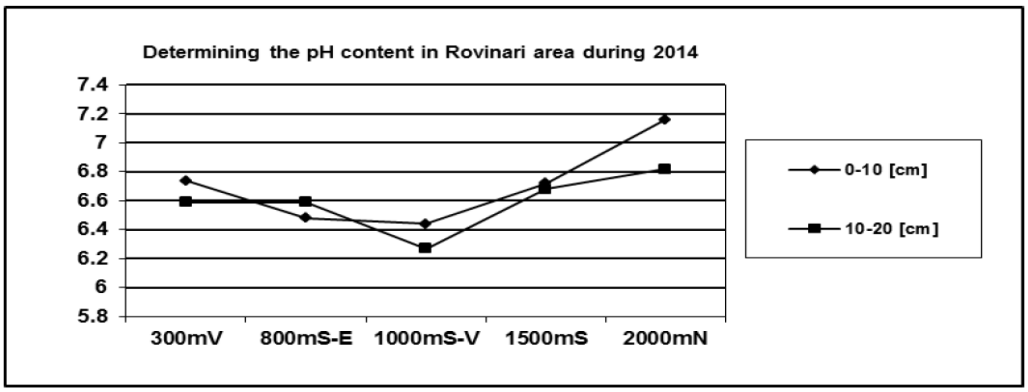

Fig.1. pH variation in the soil during 2014

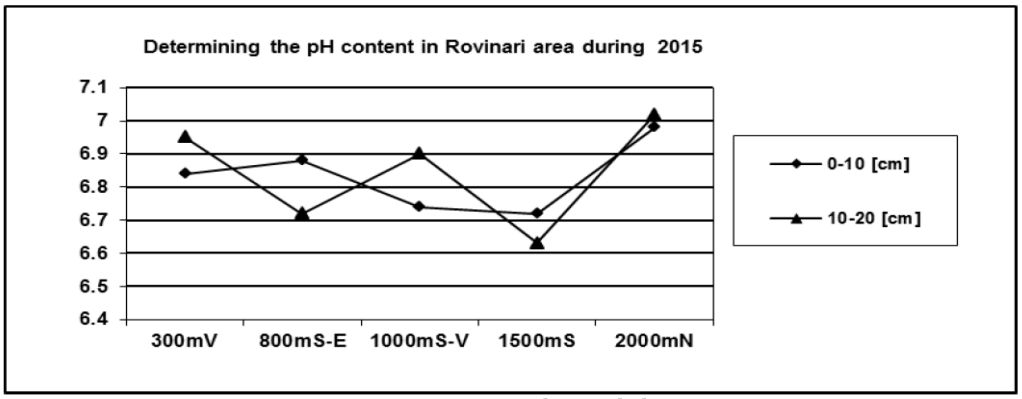

Fig. 2. pH variation in the soil during 2015

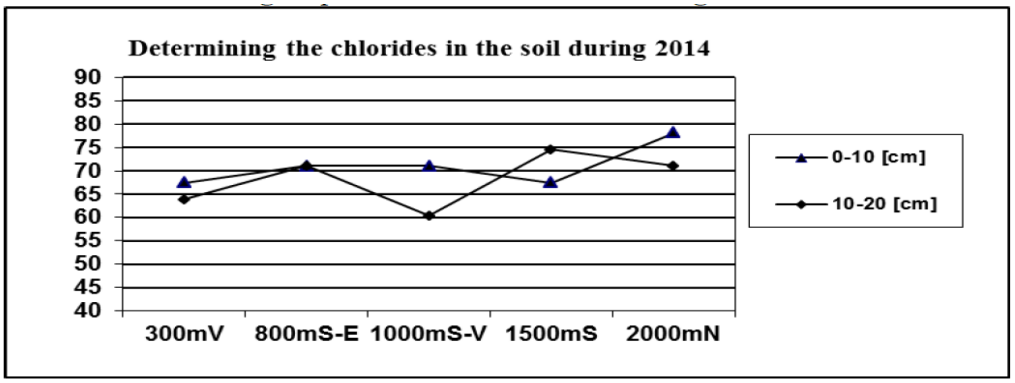

Fig. 3. Variation in the soil's chlorides content in year 2014

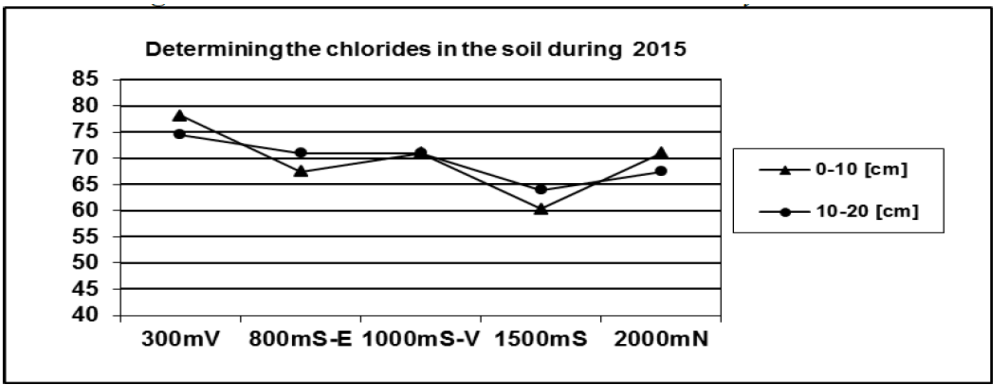

Fig. 4. Variation in the soil's chlorides content in year 2015

Regarding the assessment of soil's heavy metal content, the results recorded for copper, in the points distributed on the 5 cardinal directions, during years 2014 and 2015 are shown in figures 5 and 6. Values measured in year 2014 are around 26.2 and 70.4 mg/Kg and the maximum recorded value is three times bigger than the normal value, in the sampling point found 1000 m away from Rovinari power plant. It's noticeable that normal values were exceeded in all measurements.

In fig. 6 it's noticeable that the maximum recorded value (69,6 mg/Kg) is three times bigger that the normal value. Also, the normal values were exceeded in all measurements. Exceedings of the normal values were recorded even in the case of zinc. Figures 7 and 8 provide the graphics for the zinc values analyzed during 2014 and 2015, in the influence area of Rovinari power plant. It's noticeable the values measured for zinc during 2014 area around 40.8 and 122.4 mg/Kg.

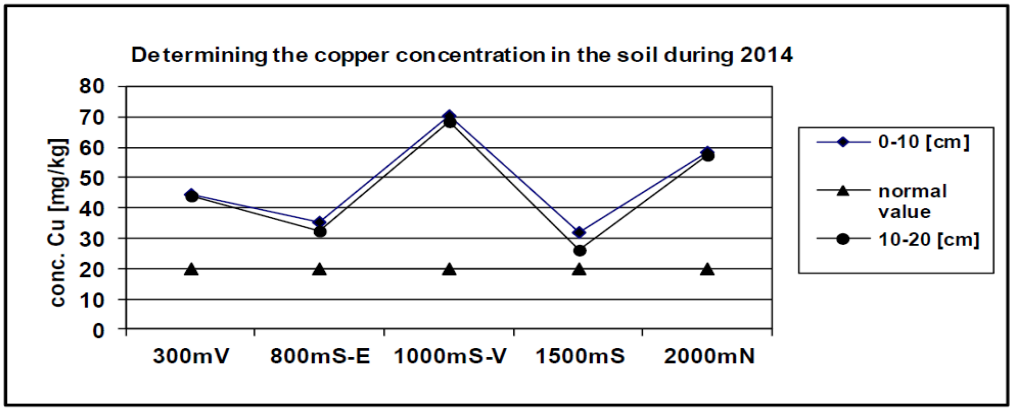

Fig. 5. Variation in soil's copper content during 2014

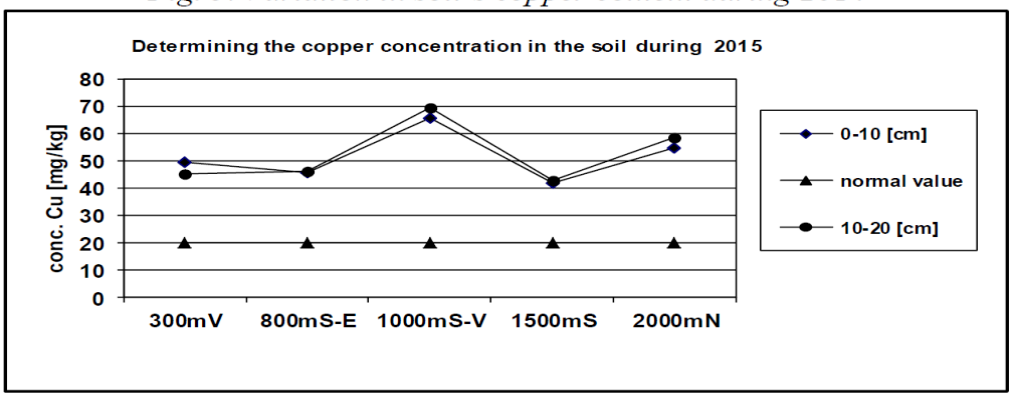

Fig. 6. Variation in soil's copper content during year 2015

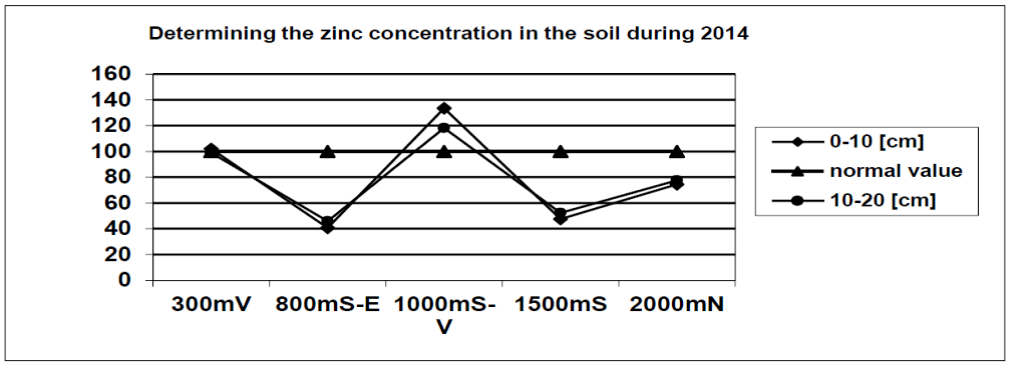

Fig. 7. Variation in soil's zinc content during 2014

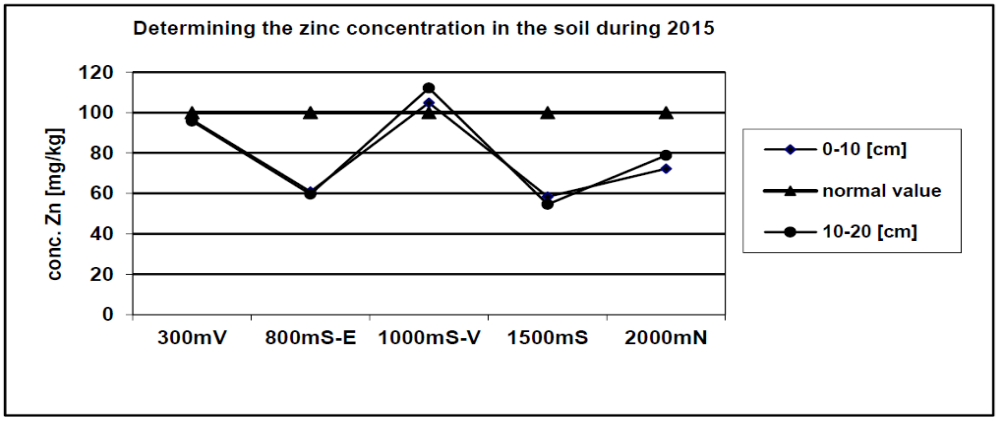

Fig. 8. Variation in soil's zinc content during 2015

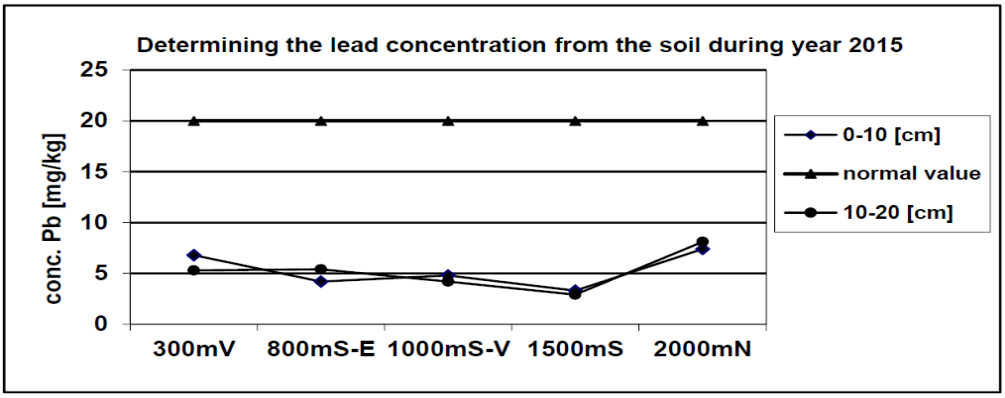

Fig. 9. Variation in lead content during 2015

Regarding the sampling point located at 1000 m S-V, an exceeding with 22.4% of the normal value can be observed. From all ten conducted measurements, two exceeded the normal value (100 ppm).

The zinc concentration values from the soil in Rovinari area during 2015 varies between 54.6 and 11.2 mg/Kg, two of ten determinations exceeded the normal value.

Figure 9 provide the lead concentrations recorded during 2015 in the Rovinari plant's bordering area for the five cardinal points that were analyzed.

The measured values are around 2,9 and 8,1 mg/Kg and there was no exceeding of the normal value in neither of the conducted measurements. Similarly, it has been found that the values recorded for cadmium samples during year 2015 in Rovinari area did not exceed the normal values.

3. CONCLUSIONS

Power plants generate a direct and continuous pollution to the soil through the ash which results after the combustion of solid fuels, through combustion gases (NOx, SO_2, CO_2), and also through polycyclic aromatic hydrocarbons. The tall pollution sources (chimneys) as well as short ones (ash dumps) are causing the soil's chemical pollution. Tall sources are releasing in the atmosphere huge quantities of gaseous pollutants and solid particles, which spread on large distances. The soil's chemical pollution can result in modifications in the substrate's reaction, modifications in organic matter content, in microelements, salts and so on. In this study the soil's quality evaluation has

been conducted in the bordering area of Rovinari power plant through sampling evidences from it's influence area, followed by measurements of pH and chlorides indicators, as well as the content of heavy metals (Cu, Zn, Pd and Cd) in the soil, on five cardinal directions: N, W, S, SW, SE. The distances towards the power plant from which soil samples were taken varied between 200-2000 m. In order to establish the degree of soil's pollutants content, the results of monitoring during 2014 and 2015 period were compared with the usual concentration of chemical elements in the soil. So, regarding the determined heavy metal content, after the result's interpretation by comparison with normal concentration, it has been discovered that there were concentrations of cooper and zinc above the normal value. Lead and cadmium concentrations measured in 2014 and 2015 fit in the normal values.

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