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LONG TERM HEAVY METALS SOIL POLLUTION CAUSED BY EMISSIONS FROM THERMAL POWER PLANT DOICEŞTI

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Abstract

Some of the most complex polluters of the environment are Thermal Power Plants that are using coal as energy source. There are two types of environmental pollution sources: the main are baskets exhaust gases of coal combustion, so called high sources, and the secondary sources that are ash dumps resulted from the coal combustion activities, so called low sources. Thermal Power Plant Doicesti, located in the area of Sub-Carpathian hills, on Ialomiţa Valley, is a major source of environment pollution with sulfur, since 1952 when was built. By geographically point of view, the studied territory can be included into Sub-Carpathians' Curvature, more specify in the Prahova's Sub-Carpathian subunit. Pedogenesis factors: rock, topography and parent material, have led the evolution of isolated, lythomorphic soils. In the investigated territory four soil classes: Luvisols, Cambisols, Vertisols and Protisols were identified, each of them with types and subtypes mentioned in the paper. The subject of this paper is to analyze the loading degree of sulphur of the soils affected by emissions from Thermal Power Plants Doiceşti. Soil samples collected from 23 soil profiles distributed in all cardinal directions, were analyzed for total, organic and mobile sulphur contents. In the investigated area, sulphur pollution of soils, caused by sulphur emissions from Thermal Power Plant Doiceşti, were recorded. The sulphur pollution phenomenon gathering way by changing the normal content of soil, plant, and consequently, could affecting the health of the inhabitants of this territory.

Key words: *heavy metals pollution, soil, Thermal Power Plant (TPP).*

INTRODUCTION

Thermal Power Plant Doiceşti is the oldest power plants in Romania, dating since 1952. Those 57 years of its operation left their mark on the characteristics of soils developed in the area of influence of emissions.

Sulfur from the burning gases reach the final on soils and vegetation in the form of aerosols or acid rain. Up to date, expeditionary field researches, performed in the areas of the main power stations could not show significant changes in soil reaction caused by emissions from coal thermal power plants. This fact is due to large height of exhaust baskets of burned gasses, which allows distribution of gaseous pollutants in large territory. Secondly, many of the soils developed in the influence area of emissions are buffered by carbonates which prevent leaching and depletion of bases processes.

Fig. 1. Dâmboviţa County

Generally, the sulfur content in the form of SO_4^{-2} is less than 450 $mg \cdot kg^{-1}$ in unpolluted soils. Determination of sulfur loading degree is very difficult, because each soil is a separate entity characterized by specific chemical properties. However, large quantities of sulfur present in burned coal is often found in the A horizon of soils located in the area of influence of power plants emissions. The thermal power plant Doicesti is located in the Carpathian hills, on Ialomita Valley. South of town Pucioasa valley enlarges its width exceeding 2 km in Doicesti area. Doiceşti, Cornetu and Brăneşti Hills have different sizes and orientations, their height varying between 375-518 m. Most of the ridges have heights lower than those of Thermal Power Plant basket exhaust gases, its superior part can be seen from the side Forest Balteanu located on the second line of hills behind the Doiceşti Hill [1].

MATERIAL AND METHOD

Development of the present study needed field investigations field to collect soil samples and observations on materials constituting slopelands and terraces surrounding the Doiceşti and Rovinari thermo-electric power stations. Sampling was made on the 0-20 cm and 20-40 cm depth. Soil sampling points were located on the map. 24 soil samples have taken, from Doiceşti and 40 soil samples from Rovinari they being subject to the following set of analyses: pH and copper [1].

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 [4].

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 DISCUSSIONS

The study of pollution of soils in the Doiceşti thermoelectric power station area required further larger analysis of soil properties because the soils form a complex mantle caused by the diversity of relief, groundwater, rock and parent material conditions.

Within the area influenced by the Doiceşti thermoelectric power station, soil samples were taken from 24 profiles, mostly located on both sides of the Ialomiţa river, between the Pucioasa and Târgovişte municipalities and to the west of the Dâmboviţa river between the Izvoare and Drăgăeşti-Ungureni localities.

Location of soil profiles from the Doiceşti thermoelectric power station is as follows: on the Ialomiţa valley at 0.8 to 9.5 km N, 0.8 to 6.7 km E, 1.7 to 6.3 km S-SSE , on the left of Dambovita to the Târgovişte 1.6 to 9 km S-SW-V, and 6.9 to 9.1 km, respectively.

About 50% of the soil profiles are on meadow, Alluviosols (AS) (Aseu mostly and the remaining - Entic, Prundic, Gleyic Alluviosols). The rest of soils are Cambisols - 17.65% (Typical, Lithic and Spolic Eutricambisols), Luvisols - 17.65% (Typical and Reddish Preluvisols, and Typical and Stagnic Luvisols); Regosols - 8.82%;

Chernisols I - 2.94% (Cambic Rendzins) and Pelisols - 2.94% (Eroded Typical Vertosols) [4].

Further each pollutant will be separately examined.

A characteristic of soils in the Doiceşti thermoelectric power station area is the low-moderate supply with humus, but the coal dust, very rich in organic carbon, has a direct influence on its content in soils in the area affected by emissions. Although, the humus content is generally used to characterize the state of soil supply with organic matter as, in this particular case, I found impossible to use this parameter as a means of comparison.

This feature is determined by the processes of bioaccumulation which, for various reasons, did not allow accumulation of large amounts of humus. Climatic conditions and natural vegetation do not favor the accumulation of large amounts of plant residues on the soil surface and in the soil profile. Many of the soils in the studied territory are affected by erosion processes that have as effect the soil material transport from the upper part of soil profile. All these soils, under natural conditions, may have no more than 1.8 to 3.0% humus. The organic carbon content varied widely in the investigated profiles, from 0.89 to 4.78%.

The behavior of any chemical element is influenced by soil reaction. There is a relationship of proportionality between the level of soil acidity and the sulfur mobility. In the investigated area, the analyses revealed a variation of pH values from 6.09 to 8.17, i.e. a variation from slightly acid to slightly alkaline soil.

The subject of this paper is, however, the assessment of the soil load degree with heavy metals from the Doiceşti thermoelectric power station. Soil samples have been collected from 24 soil profiles in all the cardinal directions. These soil samples have been analyzed for copper, zinc, lead and cadmium.

As concerns the copper content, it exceeds the normal content within the whole territory in the Ialomiţa floodplain - between the south alignment Teiş-Anina, Brăneşti in the north part and Lăculeţe valley in east part. Maximum values can exceed the normal content of 10 to 20 mg·kg-1 content (20 $mg \cdot kg^{-1}$), but well below the alert threshold, so there is threshold, that is there is a slight contamination (loading). In a single site (13 km NNW from the Doiceşti thermo-electric power station), in the 20-40 cm layer, the copper content reached 141 $mg \cdot kg^{-1}$, that is, exceeded the alert threshold, probably as the result of the plant protection treatments applied in grapevine, or a local geochemical anomaly (site ignored in the data interpretations).

Coefficient values exceeding the maximum normal content vary between 0.6 and maximum 2.4, being no pollution with copper. The coefficient corresponding to the alert threshold (4.76) is not exceeded.

As regards the territorial distribution (Fig. 2), a coefficient exceeding two times the normal maximum content of more than 2 is observed on a reduced area to east of the Doiceşti thermoelectric power station and on an area located along the Ialomiţa valley with this coefficient of 1.25 to 2 which extends to north up to 5 km, and to the south in the dominant wind direction up to 7.5 km.

The exceeding coefficient between 1 to 1.25 times occurs in the whole south region up to beyond the Târgovişte at Dragomireşti, and to the north along the river up to beyond Pucioasa, more than 3.5 km, In the rest of the territory contamination does not occur, the coefficients being sub unitary. Due to the high relief, in the west and east of the Ialomiţa valley, the contamination in the respective regions is not observed.

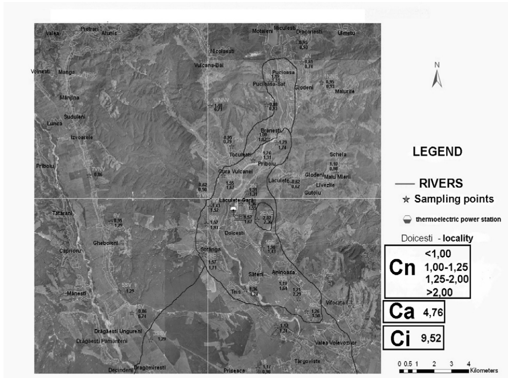

Fig. 2. Distribution of exceeding coefficients of the normal maxim content of copper in the area influenced by the Doiceşti thermoelectric power station

As concerns the zinc, a behavior similar with that of copper is observed, the areas with some loading following the river and Lăculeţe Valley. Maximum value of 160 mg·kg1 is also recorded in 13 NNW site, exceeding by 60% the normal of content 100 $mg·kg^{-1}$, but well below the alert threshold, this value being accidental.

In case of the 3 SSV site with 160 $mg·kg^{-1}$, the possible source of pollution is COS Târgovişte, because higher contents are observed in the north of the city of Târgovişte (south-east 4 and 5 sites).

Excepting the values of coefficients that seem abnormal of 1.59 near Drăgăeşti and 1.65 near Vulcan, the rest of values shows no exceed of the normal content, this ratio being much subunitary, excepting the site 1SE south of Doiceşti. The very close variation with the distance of the coefficient values for zinc (Fig. 3) highlights, actually, the absence of contamination with zinc.

For the most part of the region exceeding the normal maximum content coefficient is predominantly less than 0.6, but along the Ialomiţa valley higher values of normal content exceeding coefficient between 0.6 to 1 occur, which could be attributed to the influence of the Doiceşti thermoelectric power station emissions. The extending area of this element is also far to the south (approximately 5.5 km) as compared to the north part (about 3.5 km).

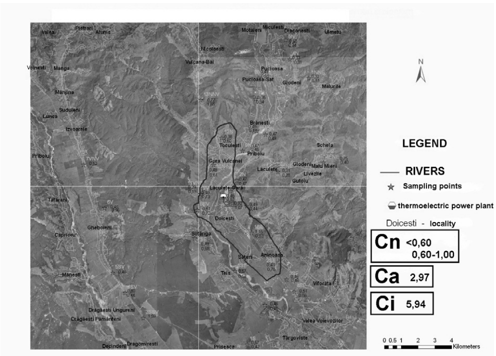

Fig. 3. Distribution of exceeding coefficients of the normal maxim content of zinc in the area influenced by the Doiceşti thermoelectric power station

Generally, the lead presents normal to *slight-moderate* pollution content (loading), maximum value being recorded at the1N (0-20 cm layer) site with 55 $mg·kg^{-1}$ and the 1E (20-40 cm layer) site with 75 $mg·kg^{-1}$, respectively.

As concerns the influence of the Doiceşti thermoelectric power station due to the contamination with lead, this is more difficult to specify as distribution due to the interference with the lead pollution caused by vehicles.

Coefficient values exceeding the normal content exceed all over the values 1 that shows a lead contamination throughout the land area; a decrease of value is observed as the distance from the source increases. Values exceeding the alert coefficient occur only in a reduced area located mainly in the south, west and east of the Doiceşti thermoelectric power station (Fig. 4). Values exceeding the intervention coefficient did not occur. Coefficient values exceeding the normal content between 1.7 and 2.4, that is, to a certain extent to alert coefficient (Fig. 3) are observed along the Ialomiţa valley.

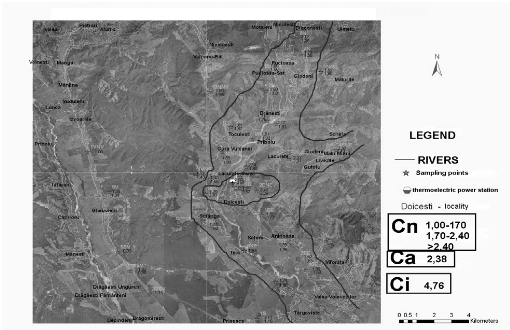

Fig. 4. Distribution of exceeding coefficients of the normal maxim content of lead in the area influenced by the Doiceşti thermoelectric power station

The cadmium has concentrations included in the normal-slight loading range in 1E and 8V, respectively, sites, and the values in other sites are approximately equal to the normal value. Values of exceeding coefficient of normal maximum content that decrease with distance exceed the value 1 only along the Ialomiţa valley to the north and south of the the Doiceşti thermoelectric power station, extending 5 km to the north and 9 km to the south. These values are between 1 and 1.7, much lower than the alert coefficient (2.73).

In the rest of area, values remain subunitary not being influenced by emissions, except for a small area at Pucioasa that could likely have a local cause (Fig. 5).

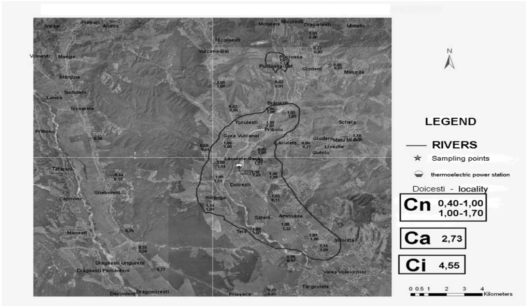

Fig. 5. Distribution of exceeding coefficients of the normal maxim content of cadmium in the area influenced by the Doiceşti thermoelectric power station

CONCLUSIONS

The area affected by the Doiceşti thermoelectric power station is located in the Prahova Subcarpations, in the Ialomiţa floodplain wide of 2 km in south part and 1 km north part, respectively.

Pedogenetic factors determined the occurrence of various soils, the most common being Fluvisols, followed by the Eutric Cambisols and Luvisols.

Most soils have a neutral-slightly alkaline reaction, being resistant to pollution with acid contaminants. The soils in the central-eastern area evolved on more acid materials (e.g. the Typical Luvisol site - 5 SE).

• General formation conditions determined an evident accumulation of small quantities of humus, receiving to some extent organic carbon derived from coal dust, fact illustrated by the C/N ratio, slightly higher than that of normal conditions.

• The Doiceşti thermoelectric power station polluted area which extends along the Ialomiţa river south-north direction having as as boundaries Teiş-Săteni, Aninoasa in south; and Brăneşti in north and Glodeni in East. Within the above mentioned territory, soils that are sightly polluted with Zn and Cu, and moderately-strongly polluted with coal dust and ash, which changed the humus content and texture.

• The area of maximum influence of these particulates is located around the Doiceşti thermoelectric power station where the soil particle size distribution are drastically changed on the soil profile. In the area, south and west of Târgovişte the zinc pollution is observed due to other sources.

• Self-purification processes are insufficient to ensure the environmental protection. In order to reduce the atmosphere pollution degree, the following recommendations are given:

- to improve the combustion;
- to reduce the sulfur content of fuels and increase the degree of retention of emitted sulfur;
- to increase height of chimneys and improvement of emission conditions;
- to improve capture of pollutants emitted in the form of dust and gas;
- to establish the special protection areas and warning areas.

These measures lead to the reduction or soil mantle contamination or pollution control.

• Technologically depleted dumps should be reclaimed especially for forestry, as a measure for the protection of environment and people health.

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