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THE IMPACT OF THE THERMAL POWER PLANT IN GACKO ON LAND DEGRADATION

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Abstract

In the process of a thermal power plant operation (Gacko, East Herzegovina) there is a huge amount of ashes which is mostly deposited near it. In the process of coal exploitation and thermal power operation, a soil damage occurs by means of surface mines, material disposal as well as by sedimentation of aeroprecipitates created at the operation of the thermal power plant.

This paper presents the results of detailed field and laboratory research of morphological, physical and chemical properties, 2 deposol profile and 4 profile natural autochthonous soil near to the dump with the aim to characterize the soil damage. In relation to the autochthonous soil, deposols are characterized by a greater depth of solum, heavier mechanical composition, increased alkalinity and carbonate status and lower contents of humus and overall nitrogen. The total contents of Cd, Pb, Cu on an autochthonous soil and deposols is below the MAC. The value of contents of total Zn in deposols is below the MAC, while in the natural autochthonous soil is above the MAC (339.03 ppm) and it indicates a contamination which can be of geochemical origin.

Key words: *kalkocambisol, deposol, heavy metals*

Introduction

In the process of thermal power plant Gacko leads to disruption soil and to its destruction. With these processes have already been affected area of 752 ha. In the process of the plant's operation creates an enormous amount of ash that is usually deposited in the vicinity. These dumps usually occupy considerable areas of cultivated land, thereby disconnecting the of primary production. The subject of the research is “Dražljevo” locality where the ashes from the first day of operation of the mine and thermal power plant in Gacko have been stored. At the beginning of the Nineties, a recultivation of the ash dump Dražljevo was performed, and the thickness of the added layer of humus was about 45 cm. 20 years later, there has been noticed a spontaneous self-healing by means of vegetation. A significant erosion has been noticed, especially at the south side of the dump where even spontaneous vegetation has not appeared.

Some soils are directly exposed to the influence of waste technogenic materials, which are excreted into the environment during the industrial process, and have a harmful effect to the soil. As an example, numerous dumps can be mentioned which are mostly in close proximity to factories, farms, mines, oil-gas exploration drill holes and other objects. In practice up to now, the ways of waste materials disposal lead to significant changes in the entire ecosystem of the endangered area (Nešić et al. 2006).

Đokić and Obradović (2006) are of the opinion that at the location of a mine, during the performing of exploitation operation, a permanent degradation of the entire space occurs, changes in local topography occur, and temporary dumps of waste material are formed, consisting mostly of waste rock (pedological layer and a small amount of raw minerals) grabbed at the mechanical removal of waste rock. Šubranović et al, (2011) stated that the coal

exploitation in Gatačko polje created: areas degraded by surface mines (at the areas which had already been degraded, internal landfills of tailings and dump of ashes and slag were formed), areas degraded by external landfills of waste rock and tailings, surfaces occupies by objects of the surface mine and thermal power station, the industrial circle and sanitary protection zone around the surface mine and landfill.
The aim of this paper is to determine the characteristics of recultivated dumps and autochthonous soil spreading around the dump, through a pedological research, and thus get an objective insight into the type, degree, and range of the soil damage.

Material and methods

The pedological research consisted of field and laboratory work. The six pedological profiles were opened, i.e. 2 at the dump and 4 on the autochthonous soil next to the dump. After the profiles were opened, the internal and external morphology of the soil was examined in detail and soil samples were taken for the laboratory testing.
Laboratory testing of physical and chemical properties of the soil were performed at the laboratory of the Faculties of Agriculture in East Sarajevo and Zemun, pursuant to generally accepted methods (JDPZ, 1966, 1971 and 1997) for this type of research. The extraction of heavy metal traces on the atomic absorption spectrometer by means of graphite and flame furnace was performed in the laboratory of Federal Agro-Mediterranean Institute in Mostar.

Results and discussion

On the basis of field and laboratory research it has been determined that on the examined area the following systematic units of soil have been present: recultivated dumps of ashes (profiles 1 and 2) and calcomelanosol (profile 3, 4, 5, 6) as autochthonous soil.

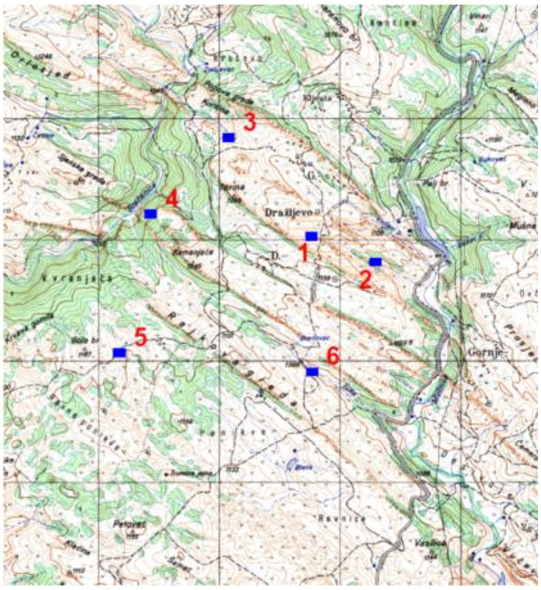

Figure 1. Position of tested soil is shown on the map R=1:50000

Calcomelanosol pursuant to the classification of soil of Yugoslavia (Škorić et al. 1985) and Resulović et al. (2008), belongs to the section of automorphic soils, class of humus-accumulative, subtype of organomineral black soil, variety: cliff, with A-C profile build, with molic horizon. According to WRB classification (FAO, 2006) is Molic Leptosol.

Surface layers of created technogenic soils in the previous period have been determined and classified in different ways. Under deposol (Resulović, 1979) considered to be those lands that have started to create the dumps, landfills, material excavated during surface mine operations.

Internal morphology of profile

I (0-10 cm) - brown horizon (10 YR 3/4), dark brown in dry and humid state (10 YR 3/2). Pursuant to texture, it is clay loam with powdery structure, carbonaceous, strongly permeated with tendrils of grass vegetation.
II (10-33 cm) - brown horizon (10 YR 4/4), dark brown in dry and humid state (10 YR 3/4). Pursuant to texture, it is powdery clay loam with crumbly structure, carbonaceous.
III (33-42 cm) - brown horizon (10 YR 4/3), dark brown in dry and humid state (10 YR 3/3). Pursuant to texture, it is powdery clay loam with prismatic structure, carbonaceous.
IV (42-63 cm) - yellow-brown horizon (10 YR 5/4), brown in dry and humid state (10 YR 4/4). Pursuant to texture, it is sandy loam with prismatic structure, carbonaceous.

Figure 2. Profile 2

Pursuant to Rasulović et al. (2008), the newly created soils belong to the section of automorphic-terrestrial soils, class of technogenic soils – technosols, with six subclasses. Deposols and recultisols on the altered natural substrate belong to the first subclass. With the profile build: Y1-Y2-Y3… soil (deposols) and jY-Y1-Y2 (recultisols). According to the classification of soils of Yugoslavia (Škorić et al. 1985), deposols belong to the section of automorphic soils, class of technogenic soils. On the basis of subtype, they are divided pursuant to the type of material (soil, ores, slag), with profile built: I, II, III… and according to the WRB classification (FAO, 2006) the new soil creations belong to the class Technosols, Spolic Anthrosols.

According to the the concept of FAO (WRB, 1998) Anthropomorphic soil materials - the consolidated mineral or organic matter, ie. Anthrosols (AT) anthropogenic-technogenic soil Anthrosols (AT) and Technosols (TE) make the group of “soils with strung human influence”, according to WRB (2006), although there is a minor conflict between AT and TE. Anthrosols have been formed by long-term human activities. Technosols are soils with fresh sediments of artificial origin or soil which carries the products of foreign origin.

Amo (0-9cm) - brown horizon (10YR 3/2) in dry and humid state dark brown (10 YR 3/1). Pursuant to texture, it is powdery clay loam with powdery structure, carbonaceous, strongly permeated with tendrils of grass vegetation.

Figure 3. Profile 3

The main purpose of the WRB classification is to build an unique worldwide basis to the land as a common "scientific language", by which he will be able to correlate national classifications Stjepan et al. (2009).

Mechanical composition and physical properties of deposols and black soil on firm limestone are presented in Table 1.

Deposols are heterogeneous at a small distance because the mass of deposols has been obtained by imperfect mixing and is characterized by insufficient homogeneousness. Deposols are characterized by physical properties which are mostly much worse in relation to the properties of autochthonous soils on which the dumps have been formed.

Table 1. Mechanical composition of deposols and black soil on firm limestone

Profile No.	Horizon	Depth in cm	Coarse sand 2.00-0.2 %	Fine sand 0.2-0.05 %	Dust 0.05-0.002 %	Clay < 0.002 %	Skeleton (%)	Texture class
1	I	0-9	18.80	17.50	46.58	17.12	3.48	Loam
	II	9-22	6.80	11.90	53.42	27.88	0.00	Powdery clay loam
2	I	0-10	8.40	13.40	47.64	30.56	0.33	Clay loam
	II	10-30	3.70	5.80	50.58	39.92	0.00	Powdery clay loam
	III	30-42	4.20	8.60	53.32	33.88	0.00	Powdery clay loam
	IV	42-60	46.70	24.20	24.46	4.64	27.67	Sandy loam
3	Amo	0-8	20.30	10.80	44.02	24.88	64.48	Loam
4	Amo	0-9	9.00	4.40	53.08	33.52	7.17	Powdery clay loam
5	Amo	0-14	25.10	11.30	45.48	18.12	0.65	Loam
6	Amo	0-11	15.10	7.30	45.84	31.76	27.79	Clay loam

Black soil to sail limestone characterized by a higher content of the skeleton in the surface horizon (0.65-64.48%).

Table 2. Basic chemical properties of deposol and black soil on firm limestone

Profile No.	Horizon	Depth in cm	pH		$CaCO_3$ %	Humus %	N %	mg/100 g of soil	
			1M KCl	H_2O				P_2O_5	K_2O
1	I	0-9	7.48	8.17	5.72	11.31	0.23	19.20	9.99
	II	9-22	7.13	8.04	4.14	4.70	-	7.07	21.70
2	I	0-10	7.14	8.20	2.70	3.99	0.22	11.90	17.07
	II	10-30	7.05	8.05	2.41	3.08	-	6.94	22.73
	III	30-42	7.07	8.25	3.55	3.21	-	3.30	23.08
	IV	42-60	7.67	7.94	16.20	4.80	-	14.18	6.88
3	Amo	0-8	6.37	7.29	0.59	8.50	0.62	9.78	26.89
4	Amo	0-9	6.75	7.76	0.48	8.48	1.07	10.08	34.99
5	Amo	0-14	6.31	7.29	0.48	9.17	0.61	4.10	39.21
6	Amo	0-11	5.80	6.82	0.00	7.75	0.39	2.62	>40

Autochthonous soil, calcomelanosol, is characterized by (Table 2) a weakly acid to neutral reaction (5.80-6.75%). Profiles 3, 4 and 5 are carbonates, while the profile 6 is noncarbonates in the humus accumulative horizon (Table 2). Surface horizons of soil profiles is 7.75 to 9.17% with humus. The contents of total nitrogen is in accordance with the humus contents. The contents of easily accessible phosphor in the surface horizon is low (2.62-10.08mg/100g), while the contents of easily accessible potassium is in the class of highly supplied soils (26.89-40 mg/100g).

Chemical properties of deposols are characterized by neutral to weak alkaline reaction in surface horizon. They are carbonaceous from the surface, well supplied with humus and total nitrogen. The contents of easily accessible potassium and phosphor is within the limits of medium supply.

On the basis of the aforementioned, it can be concluded that deposols are characterized by beneficial physical and basic chemical properties.

Heavy metals are also present in traces in non-polluted soils, as a result of geochemical origin. The concentrations in which the metals occur depend on the sources of pollution and features of the system they are in, where the values may vary from the level of traces to extremely high concentrations which can be extremely toxic for an ecosystem, pursuant to Belanović et al. (2003), Sehgal et al. (2012) Kostić et al. (2012).

Table 3. Minimum, maximum and mean values of heavy metals calkomelanosol

	Depth in cm	Cadmium (Cd)	Lead (Pb)	Copper (Cu)	Zinc (Zn)	Nickel (Ni)
Min.	10	1.34	35.70	38.60	333.50	65.50
Max	10	1.61	42.90	19.30	348.00	186.70
Average	10	1.50	39.73	29.70	339.03	143.90

To estimate the soil contamination by heavy metals (Table 3), i.e. by dangerous and harmful materials, the Maximum Allowable Concentration (MAC) criteria (for agricultural soils) have been used, threshold value on which soil quality and remediation value are sustainable (for non-agricultural soil) (Official Gazette of the Republic of Serbia 1994 and the Decree of the Official Gazette of the Republic of Serbia 2010).

The total contents of Cd, Pb, Cu on an autochthonous soil and deposols is below the MAC. The value of contents of total Zn in deposols is below the MAC, while in the natural autochthonous soil is above the MAC (339.03 ppm) and it indicates a contamination which can be of geochemical origin.

The contents of total Ni in all tested samples is above the MAC, as well as above the threshold value on which the soil quality is sustainable. Talking about the criterion for non-agricultural soils, which is a bit milder than the MAC, the total contents of all the tested elements is below the remediation values, i.e. the value which indicates that the basic soil functions have been endangered or severely damages and require remediation, repairing and other measures (Off. Gazette of the RS 88/2010).

Results of the research (Report on the state of soil in Serbia, 2009) showed that the average content of cadmium in soils Serbia 0.81 mg/kg, lead 40 mg/kg, copper content was on average 27 mg/kg, the average content of zinc is 48 mg/kg, an average of nickel content of 58 mg/kg.

The total content of Cd, Zn and Ni on autochthonous soil is above the adjusted threshold value where the sustainable soil quality, and Pb and Cu below the adjusted threshold value. The total content of Cd, Cu and Ni in deposols are above the adjusted threshold value where the sustainable soil quality, and Pb and Zn below the adjusted threshold value for deposol.

Table 4. Minimum, maximum and mean values of heavy metals of recultivated landfill

	Depth in cm	Cadmium (Cd)	Lead (Pb)	Copper (Cu)	Zinc (Zn)	Nickel (Ni)
Min.	10	0.38	59.50	26.92	35.01	128.08
Max	10	1.72	67.63	58.60	135.12	184.70
Average	10	1.14	63.06	47.07	100.41	159.35
Min.	20	1.01	41.10	27.00	30.10	134.00
Max	20	2.41	58.26	54.99	150.40	174.90
Average	20	1.78	51.91	42.26	100.23	149.98

Conclusion

On the basis of the performed research, it has been determined that deposols are characterized by beneficial physical and basic chemical properties.
The presence of carbonate in the black soil on limestone sail can be explained by the scattering of the landfill where ash spreads easily with weaker winds and falling on surrounding land.

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