Characterisation of soil degradation and the ecopedological impact phenomena in the Zlatna area, Romania

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Abstract

As a result of industrial activity (a non-ferrous metal processing factory) in Zlatna the affected area is about 10 km upstream and 30 km downstream around the Zlatna town. The heavy metals are accumulated and concentrated in the soil, water and vegetation and acid rains with sulfur dioxide affected the vegetation leading to the appearance on the large surfaces of the erosion phenomenon. In our research, we have followed to determine the total content of heavy metals (Pb, Cu, Zn and Cd) and their effect on the soils properties. We have found out that the fertility state of the soils is affected, the morphological, physical and chemical modifications of the soil's profiles, lying on different pollution levels (heavy metals accumulations) are different compare to unpolluted area and are characterized by acidification, the depletion of bases, the content of organic matter is, generally low, the surface layer is at the most moderated structured, granular, angular and subangular blocky structure, with small- medium seized peds, high accumulation of heavy metals, at the level of superior layer and especially of lead, followed by copper, cadmium and zinc.

Key words: acidification, degradation of soil fertility, heavy metals pollution

Introduction.

Even after the complete shut down of the smelter two years ago, the level of accumulations are still high in the soils, because these elements are not leaching out from the soil profiles and are accumulated and bound to the soil compounds. Knowing the modifications induced by pollutants allow us to make an appreciation of soils evolution and to applied appropriate measures of depollution and remake of the soils.

Material and methods

For tackling the proposed targets, there have been analyzed nine types of soils from different locations of the researched area on its entire soil profile, by studying the soil's morphological, physical and chemical parameters. The interpretation of the analytical data has been done according to the „The elaboration methodology of soil-cultivating studies" ICPA, Bucharest, 1987 [3].

The analyses methods used for determining the soils' physical and chemical properties were those adopted in the present, in the offices' practice of the soil-cultivating and agrochemical studies in the county; ICPA, 1981- „The soil's chemical and physical analysis"; ICPA, 1986 „Methods of soil's chemical analysis"; ICPA, 1987 – „The elaboration methodology of soil-cultivating studies", part I, II and III; The determination of the heavy metal content (Pb, Cu, Zn, Cd total and mobile forms), whose extract has been obtained through the wet disintegration in a mixture of strong acids (nitric, perchloric and sulfuric acid 2:1:0,2) and solution extract Na_2EDTA.

Results and discussion

The characterization of the soils' degradation and of the impact eco-pedological phenomena under the pollution's impact with heavy metals and sulfur compounds:

The soils' reaction (pH H_2O) joins the high acid class through the acid hydrolysis caused by the SO_2 and the sulfides.
The depletion of bases pursues loyally the soil's acidification according to its profile.
The soils' content of organic matter is, generally, low, with the exception of some shallow horizons, where there is being produced a moder accumulation under the pollution impact.
The extremely low content of total nitrogen and phosphorus and also low potassium reflects the soil's poor supply with macro elements.
The horizon A is at the most moderated structured, granular, angular and subangular blocky structure, with small- medium seized peds.
High accumulation of heavy metals, at the level of superior layer and especially of lead, followed by copper, cadmium and zinc.
Soil reaction: The accumulation of sulfur, oxides, heavy metals and H_2SO_4 leads to the soil's acidification, especially of those, which are natively acid[4],[5]. This acidification process can be satisfyingly explained through a general reaction, possible at the adsorption complex level and of the soil's solution: $2H^+ + SO_4^{2-} \rightarrow H_2SO_4$
The protons and the sulfate ions determine besides the soil's acidification also a depletion of bases of the colloidal complex with permanent character.
In the research area, the acid soils, generally, become more acid with 0.5 – 2 pH units in time, so that one cam remarks a high increase of the acidity, especially at the level of superior layers (table 1).
The areal soils reaction (pHH_2O) is very powerfull acid, with some exception as in the case of more buffering soils as eutricambisols and aluviosols, which are neutral to low alkaline.

Table 1. Soil reaction (pH H_2O) in the surface layers

Soils	pH	
	min	max
1. Haplic Luvisol	4,4	5,5
2. Luvisol	3,4	6,1
3. Rhodic luvisol	3,4	5,7
4. Albic luvisol	3,8	5,6
5. Eutric cambisol	3,3	6,3
6. Aluviosol entic	5,5	6,4
7. Aluviosol	5,2	6,8
8. Cambisol – eroded phase	4,5	5,9
9. DystricRegosol	4,5	5,9

Humus content: the evolution of humus content lies on the outlook, that the modification of the humus content in the superior layer, as a consequence of the mineralizing and synthesis processes, equals the resultant of the algebraic additions of these processes' effects [1].
The degradation of the compounds of the adsorption complex is a significant process in the area and it determines an important reduction of its physical and chemical qualities. In the case of acidified and strongly polluted soils, the content of humificated organic matter diminishes itself. The diminishing of the humus content is obvious due to the pollution (acidification, depletion of bases and accumulation of heavy metals).
The humus of the polluted soils undergoes, besides this phenomenon with a quantitative character, also a qualitative disturb, because of the content's increase of the fulvic acids, reflected by low contents of total nitrogen.
This phenomenon of quantitative and qualitative reduction of organic matter is obvious to all types of soils, except some surface layers where we have a moder accumulation under the pollution impact. Also, the organic matter has a partial effect of buffering of the soil reaction and complexation of heavy metals, reducing their availability for plants [6].

Clay content: the quantity of soil's clay has got direct effects upon the retention of heavy metals. Once being absorbed by the fine fraction, they can be stocked for a certain period of time or can be released slowly. The soil's high clay content has got direct effects upon the retention of heavy metals. Once absorbed by the fine fraction, they can be stocked for a certain period of time or can be released slowly. The soils with a high quantity of clay exert a depolluting role upon the environment, through their retention in the soil and the avoidance of their passage to the vegetation level [2].

The soils' particles-size composition in the ploughed area shows a significant increase of sand and dust fractions, together with the compounds' degradation and that of the mineral binding material of the adsorption complex. The excessive decrease of the calcium quantity in the soil, associated with the low clay content, as well as the reduction of the organic compound, directly affects the soil's buffering capacity and their structure.

Clay minerals: the type of clay was determined by pH, in the acid reaction conditions was formed illite, chlorite and kaolinite, which influence the soil structure, knowing the fact that in general these types of clay minerals have a more reduce specific surface and a low power of hydration and swelling then montmorillonite, that lead to forming of an inferior structure, less porous and instable to water.

Soil structure In most of the cases, the horizon A is at the most moderated structured, granular, angular and subangular blocky structure, with small- medium seized peds.

Heavy metals content: the retention of heavy metals at the soil's fine fraction level depends on the cationic adsorption capacity of the minerals, thus acting as a depollution factor upon the environment, through the avoidance of the translocation of heavy metals at the level of superior plants. At the same time, the soil's loading degree with these elements increases, through accumulations of high quantities, which sometimes can reach critical levels [3].

The main pollutants in the area are heavy metals (Pb, Cu, Zn şi Cd) and sulphur compounds, the most aggressive for vegetation and soil. Thus, heavy metals are concentrated at the level of adsorbtive complex and soil solution, especially at the surface layers, at values that often over pass the tolerated maximum limits, mostly for lead and cooper.

In Zlatna area the heavy metals accumulation over pass the maximum tolerated limits, especially for lead which is primary pollutants in the area, but also cooper, zinc and cadmium (table 2). On the soil profile the heavy metals accumulation decrease with depth, the values are lower under 20 cm depth, except for zinc which has a tendency to migrate in depth because low bounding with organic matter and clay.

Table 2.The heavy metals content of soils in superior layers (0-20 cm) (mg/kg)

Soils	Pb		Cu		Zn		Cd	
	min	max	min	max	min	max	min	max
1. Haplic Luvisol	40	984	7,5	165	55	141	0,4	0,8
2. Luvisol	159	611	27,5	203	92	155	0,8	1,4
3. Rhodic luvisol	349	3125	170	677	51	770	2,7	4,4
4. Albic luvisol	226	243	73	99	40,5	385	0,9	2,2
5. Eutric cambisol	145	241	133	612	48	502		2,0
6. Aluviosol entic	130		36		44		0,45	
7. Aluviosol	246	601	144	387	88	819	0,7	3,2
8. Cambisol – eroded phase	178		151		259		1,5	
9. DystricRegosol	755		410		897		2,2	
Maximum tolerated limits (Romania)	100		100		600		3	
Normal content	20		20		100		1	

The retain of the level of surface layers of high quantities of heavy metals its due to organic matter, mineralogical composition of soil fine fraction and the effect of acidification of the emissions.

Erosion: as a result of degradation of organic matter and mineral components, the soils fertility in the area have been reduced significantly, and erosion processes, very active through lack of vegetation degraded essentially the ecosystem.

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