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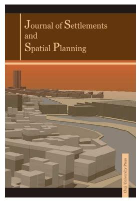

Landscape Transformations in the Rural Areas of the East Upper Thracian Plain (Southeast Bulgaria)

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A B S T R A C T

There are different approaches to evaluate the human impact over landscapes. One of them is the geochemical research which focuses on finding and differentiation of the pollutants in the contemporary landscapes. Both slightly transformed landscapes (background landscapes) and heavily transformed landscapes are surveyed. Among the prioritized pollutants are the heavy metals (Pb, Cu, Zn, Mn, Ni, Co, Cr, Cd). Detecting and monitoring of the concentration of some chemical elements and their compounds in the landscape components are parts of the environmental monitoring and protection. The main research goals are based on the idea of applying landscape-geochemical methods in the terms of relatively short-term and representative survey of the heavy metals' concentration in the region. A set of soil samples is collected from different locations considering the stage of human impact in order to provide a meaningful geochemical 'picture' of the researched area. The investigated territory is the catchment of Sazliyka River (a left tributary of Evros River (Maritsa)), which mostly incorporates a big portion of the East Upper Thracian Plain. Higher density of settlement network is typical here as well as high rural population density rate. The catchment includes landscapes on the transition between lowland and mountainous topography in the conditions of intensive agriculture, industry, and transport infrastructure. One of the biggest industrial clusters in Bulgaria is located in the territory. Almost the entire catchment includes landscapes significantly transformed by human activities.

1. INTRODUCTION

In the last decades significant attention has been paid to the status of agricultural landscapes from different perspectives. The environmental aspect is one of them. The level of pollution caused by different pollutants in the soils of those landscapes is specifically researched. Agricultural land takes around 10-12% of our planet's land surface. Less than 1/3 of it is occupied with meadows and pastures. In Europe, agricultural landscapes take over 32% and their level of manmade transformation is significantly high. The modern research approaches of the geochemistry of landscapes are diverse. The soil, as a peculiar 'centre' of the natural complex, accumulates a lot of substances created by the *technogenic* impact. The heavy metals are some of the most dangerous pollutants. They are prioritized substances in the environmental research approaches. They need to be researched and identified in the landscapes transformed at different levels as well as in the pristine landscapes. All agricultural landscapes are an important and inseparable part of such a research because they reflect the harvesting and gathering of food production in every country.

2. THEORY AND METHODOLOGY

In accordance to the level, to the intensity, and other specifics of the impact, two major types and several subtypes of *agro-technogenesis* (agricultural impact over the landscape status and condition) could be outlined. The first one is related to the direct geochemical influence of the agro-technogenesis over the landscape's nature. The direct use of chemicals and land cultivation are examples of it. The second type is the indirect geochemical influence caused by hydro-ameliorative projects (irrigation), soil erosion, deforestation, desertification, and many other similar processes of landscape degradation. These two types determine the sheet (use of chemicals) and the linear-sheet (irrigation) spreading of pollutants in the landscapes [12], [6].

The consequences of the use of chemicals in agriculture are related to the change and redistribution of chemical elements and substances in the soil of agricultural landscapes. The use of chemicals affects the biological circle and the equilibrium of elements in the soil-plant system; it pollutes the soil, the underground water, the plants, the animals, and, indirectly, it affects humans. Elements as N and P, heavy metals, pesticides, etc. cause such an impact. The level of accumulation and content of substances is different in any particular regions of the world. That is why agricultural landscapes should be geochemically researched at different scale – local, regional, and global.

Fertilizers could contain not only the major biophilic elements like N, P, K, but also diverse concentration of the following microelements: Cu, Zn, Pb, Mn, Ni, Co, Cr, Cd, As, Ng, etc. along with the aggregates of Mo, Se, B, etc. The major source of pollution are the non-standardized fertilizers which are usually used locally. In case that industrial and urban waste waters are used for irrigation, the variety of pollutants is great [1], [4]. A long-lasting period of irrigation with polluted water causes the accumulation of many dangerous pollutants on the so called *geochemical barriers*. There they are a risk for the agricultures for a relatively long period of time. For instance, the cereal crops are endangered by higher concentration of Zn, Cu, Ni, and Cd. Almost everywhere the bottom sediments of polluted waters contain Sn and Ag. In soils and plants irrigated with waste waters the coefficients of concentration of heavy metals towards the average clarkes of the same elements in background, unaffected soils and plants, make diverse rows of pollution: in soils - Cu>Cd>Zn>Hg>Pb>Ni; in plants - Hg>Cd>Pb>Ni>Cu>Zn [14]. This confirms the idea of selective concentration of some important pollutants which in background conditions are hardly accessible for plants.

3. RESULTS AND DISCUSSION

The presented research is a scientific attempt of surveying the contemporary stage of agriculture landscapes in one of the most intensively used regions of Bulgaria, in terms of agriculture – the Upper Thracian Plain. The research area covers the parts of Sazliyka River catchment located in the Stara Zagora Plain – the eastern part of the Upper Thracian Plain. A number of 4 cities and more than 50 villages are located on this territory. The industrial specialization is diverse. The biggest industrial objects are those incorporated in the Maritsa Iztok Power Generating Complex and those that are located in the City of Stara Zagora.

Table 1. Concentration of heavy metals (mg/kg) in lithosphere, world soils, Europe soils, Bulgaria soils, Bulgaria background soils, and soils of the East Upper Thracian Plain, agricultural landscapes in the East Upper Thracian Plain, and non-agricultural landscapes East Upper Thracian Plain.

Chemical element	Cu	Zn	Pb	Mn	Ni	Co	Cr
Lithosphere[1]	47.00	83.00	16.00	1000.00	58.00	18.00	83.00
World soils[2]	20.00	50.00	10.00	850.00	40.00	8.00	100.00
Europe soils[3]	17.30	68.10	32.60	810.00	37.30	10.40	94.80
Bulgaria soils[4]	30.00	75.00	35.00	1000.00	36.00	20.00	70.00
Bulgaria background soils[5]	24.00	67.00	25.00	695.00	32.00	16.00	60.00
East Upper Thracian Plain (EUTP) soils	31.47	100.97	32.62	565.79	38.13	21.18	38.48
Soils in agriculture landscapes of EUTP	28.99	103.84	27.80	584.61	40.41	20.51	37.92
Soils in non-agriculture landscapes of EUTP	36.12	95.57	41.67	530.50	33.86	22.42	39.52

1) Vinogradov, 1962; 2) Vinogradov, 1956; Kirkham, 2008; 3) Salminen, 2005; 4) Mirčev, 1971; 5) Penin, 2003.

For achieving the research goals a fieldtrip observation has been done in the rural areas and representative soil samples have been collected. These places have had well developed land use since ancient times. The land use has been quite intensive for the last century. The content of prioritized in environmental research microelements has been investigated: Cu, Zn, Pb, Mn, Ni, Co, Cr. The absolute content and concentration have been measured for the different soil types that are specific for the plain: Vertisols, Fluvisols, and Solonetz. The analyses were made in the Geochemistry Laboratory of the Faculty of Geology and Geography, Sofia University 'St. Kliment Ohridski', Bulgaria.

The analyzed results for absolute content and concentration of heavy metals in the soils of the researched area, of Bulgaria, of Europe, and of the world are displayed in Table 1.

In the applied geochemistry of landscapes there is a system of coefficients that present the ratio between the average content of chemical elements of comparable objects. As a result of migration the chemical elements can either be concentrated or dispersed. The study of these two opposite sides of migration appears as one of the most important specifics of the geochemistry methodology. In these terms, several coefficients are usually used for the characterization of migration. The most important of them are the clarke of concentration and the clarke of dispersion. The clarke of concentration (KK) is the ratio of the element's content in a particular natural object (soil, sediment, rock, etc.) towards its clarke in the lithosphere. If the clarke of concentration coefficient is lower than 1 it is necessary to calculate a reverse quantity for emphasizing the result – the clarke of dispersion (KP). It shows the ratio of the element's clarke in the lithosphere against its content in a particular natural object [12].

The geochemical landscape research often demands a comparison between different systems with specific distribution of many component chemical elements. In those cases it is appropriate to visualize the obtained data drawing of the so called *geochemical spectrums*. They enable to perceive the results of elements' concentration or dispersion in particular objects. A main consequence of the human impact over nature is the formation of anomalous elements and substances' concentration as a result of pollution in particular landscape components. The discovering of this technogenic anomalous concentrations is one of the main goals of the geochemistry of landscapes. Several geochemical spectrums have been drawn as part of the survey that we carried out in the East Upper Thracian Plain.

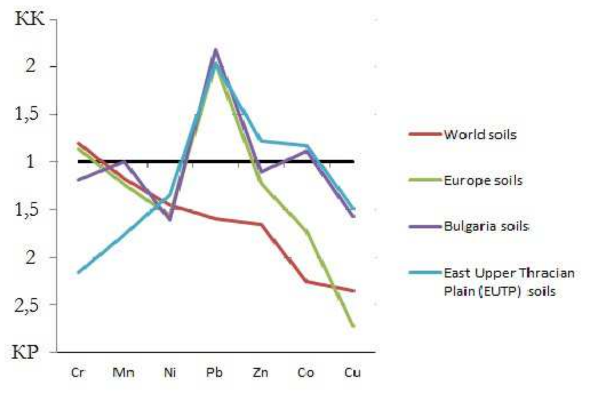

Fig. 1. The geochemical spectrum of the heavy metals in the world soils, Europe soils, Bulgaria soils, and Soils in the East Upper Thracian Plain (KK – clarke of concentration, KP – clarke of dispersion).

The local litho-geochemical specifics of the region have been considered in the spectrum analyze. It is necessary to be mentioned that this research is a part of a developing scientific project dedicated to the exploring the landscape-geochemical status of the natural and the agricultural landscapes in the catchment of Sazliyka River – the biggest tributary of Maritsa (Evros) River in Bulgaria [11].

On Figure 1 it is displayed a graphic model of the geochemical spectrum of heavy metals in the world soils, Europe soils, Bulgaria soils, and soils in the East Upper Thracian Plain. Its analyze shows that Europe and Bulgaria soils have higher concentration of Pb (KK>2) in comparison with the world soils. The soils in Bulgaria have higher concentration of Zn and Cu in comparison with the continent's soils and the soils of the researched area. Similar increased content of Pb, Zn, and Cu in the soils of Bulgaria have been recorded by many authors [7], [10]. As compared to the world soils and those in Europe, the soils in Bulgaria and the researched region have lower concentration of Cr. The soils in the researched region are with the lowest concentration of Mn (KP around 1.8) while the concentration of this element for the entire Bulgaria are almost same like the clarke of lithosphere.

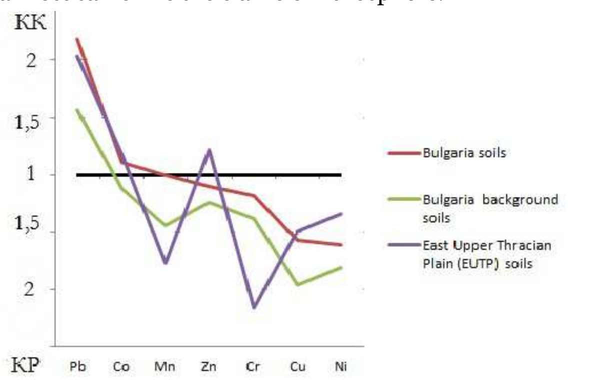

Fig. 2. The geochemical spectrum of heavy metals in the soils of Bulgaria, the background soils of Bulgaria, and the East Upper Thracian Plain soils (KK – clarke of concentration, and KP – clarke of dispersion).

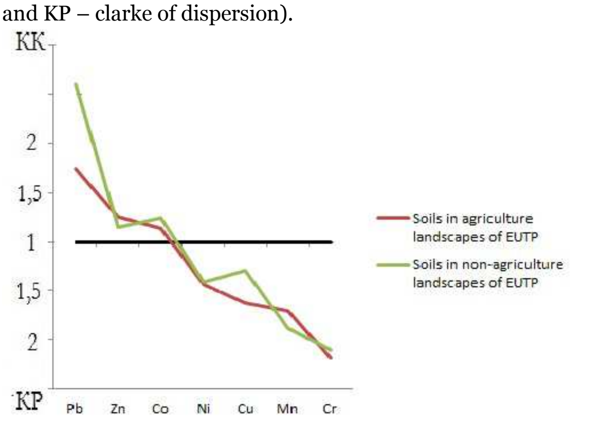

Fig. 3. The geochemical spectrum of heavy metals in the soils of agriculture and non-agriculture landscapes in the East Upper Thracian Plain (KK – clarke of concentration, and KP – clarke of dispersion).

Figure 2 displays the relation between the concentration of heavy metals in the soils of Bulgaria, in the soils of background regions, and the soils of the researched area. The spectrum analyze shows that elements Cr and Mn have the lowest concentrations (Cr has KP = 2.2, and Mn has KP = 1.7). The elements Zn and Ni have higher concentration as compared to the soils in Bulgaria and the background soils. The Pb concentration exceeds the background values (KK = 1.6) and it reaches KK = 2 while the value for the whole country is KK = 2.2. These results indicate that the researched region is relatively clean and unaffected by intensive activity soils, regarding most of the microelements. This is a positive outcome considering the production of crops in unpolluted by heavy metals areas. Locally, it is important to separate the agricultural landscapes and the non-agricultural landscapes. The heavy metals' content is displayed on the geochemical spectrum of Figure 3. For this comparative graphic we used and calculated a large number of average values for the heavy metals' content in the East Upper Thracian Plain. The spectrum results show that Cr content is decreased in the both types of land the same values of concentration being registered in case of Co and Mn. Increased concentration of Pb, Ni, and Cu was indicated in the agricultural landscapes. Zn also registered relatively high concentration.

The research activities show that soils in vineyards have increased concentration of Cu which is directly related to the use of plant protective substances containing Cu. In the vineyards of our research area the average content of Cu surpasses 85 mg/kg, which is almost twice than the Cu concentration in soils of other crops' lands. Pollution with Cu in vineyards has been indicated in Bulgaria and Moldova [9]. The soil erosion which is relatively intensive in the hilly parts of the region also affects the migration of microelements and their redistribution mostly on the slopes with higher inclination. Similar research data from Great Britain shows that landscapes in the foothills have Cr, Cu, Pb, and Ni from 4 to 13.5 times more than the landscapes with eroded soils on the top of the hills. The lateral migration on the slope is connected mostly to the illuvium fraction and the dust particles in moveable organic-mineral aggregates and in substances of dissolved forms [13]. Similar type of redistribution of microelements has been observed in the research region as well as neighbouring regions in the foothills of near surrounding mountains and inner lowland hills.

4. CONCLUSION

In conclusion, it should be marked that a relatively insignificant pollution with heavy metals has been found in the agricultural landscapes in the researched area. Increased concentrations of the elements Ni, Cu, Zn were indicated. The survey shows that this territory can be considered as relatively clean and unpolluted with heavy metals. This is a factor for the developing of modern bio-farming and sustainable agriculture. Here some of the largest horticulture, arboriculture, and viticulture plantations in Bulgaria are located. It is necessary to maintain a periodic shift of monitoring of heavy metals' concentration in the soils of the area in order to guarantee the quality of the agricultural production. The current survey is part of landscape-geochemical research of the human impact in the Sazliyka River's catchment in South East Bulgaria.

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