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Geochemical Peculiarities Of Element Accumulation In Soils Of Mountain Landscapes In The West Caucasus.

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ABSTRACT

In the present research the peculiarities of chemical elements accumulation in the soils of mountain landscapes were analysed. It was revealed that the concentration of many chemical elements, zink in particular, is substantially lower than on average in the region, and it varies only slightly with the type of the landscape. Acid sodium bycarbonate or calcium-sodium hydrocarbonate type of water migration was formed due to the influence of the chemical activity of precipitation and the peculiarities of the biological cycle. The research showed that the concentration and the level of soil saturation with chemical elements increase with the higher altitude of the slope in the areas under investigation. It can be explained by the unidirectional matter flow from the higher altitudinal belts (which are more autonomous) in the cascade landscape geochemical system.

Keywords. Landscape, soil, geochemical peculiarities, chemical element concentration, altitudinal belt.

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INTRODUCTION

Mountain landscapes are gradually transformed both naturally due to geological, orographic, climate and hydrological peculiarities of the region and the time factor, and as a result of large-scale anthropogenic activities. The latter lead to the decrease in the size of natural landscapes and the increase in the size of transformed ones, which causes disruption of the natural circulation of elements, degradation of natural landscapes and their weaker sustainability [1], [2], [3]. In addition, high- and mid-altitude landscapes have a relatively low degree of self-organization and, as a consequence, they are more exposed to changes. For instance, mountain-meadow landscapes are similar to steppe in biomass and annual production, but they are closer to tundra in the speed of plant remains decomposition, lack of heat which limits biological circulation of elements, and acidic reaction. Such systems are quite sensitive to any changes. In contrast to flatland geological systems, mountain landscapes are characterized by high intensity of geochemical elements connection as plants are the only component maintaining their sustainability. Thus, the analysis of geochemical peculiarities of elements accumulation in the components of the landscapes at different levels of structural organization is the imperative of our time.

SUBJECTS AND METHODS OF THE RESEARCH

The research into the geochemical peculiarities of elements accumulation in soils of mountain landscapes was conducted on the territory of Karachai and Cherkess Republic. The key areas were situated within the Lateral Range and at random within the Main Caucasus Range.

Unlike the Main Caucasus Range, the Lateral Range is not a continuous mountain chain; it is divided into autonomous mountain groups by transverse faults. It has an east-west trending from Fisht – Oshten to Kazbek, so climate differences contributed to the formation of longitudinal differences in climate conditions and to the appearance of physiographic districts – Labino-Teberdinskiy district of dark coniferous forests and subalpine meadows, Teberdino-Elbrusskiy district of pine- and fir-tree forests and alpine meadows and Kubano-Terskiy district of pine-tree forests and alpine meadows (pic. 1).

Pic. 1. The scheme of location study landscapes

1 – Sophia high- and mid-altitudinal; Gondaray mid-altitudinal and Aksko-Dzhalpakkol high-altitudinal

The study of geochemical peculiarities was undertaken within the systems of testing sites in different geobotanical belts. The laboratory analyses were carried out in the laboratory of soil science and landscape geochemistry of North-Caucasus Federal University. The concentrations of lead, cadmium, zinc and copper were chosen as informative indicators.

Soil samples were selected on the testing sites of 10×10 m size from 5 chip samples of a five-point pattern. The sample selection was done in accordance with the requirements for soil selection articulated in Federal Standards (GOST) 17.4.3.01–83, 28.16.8–89, and in "Guideline…" (1981, 1982). Individual samples were selected up to 5-10 cm deep. Soil samples were thoroughly stirred and quartered.

The laboratory analysis of soil, plant and insect samples was done with "Polarograph ABC-1.1" according to "The methodology of copper, lead, cadmium and zinc mass fraction measurement in soil samples, benthal deposits, plants and food". The methodology was developed by "Volta" research and technical company, specified in the document № 11-03 of Measurement Procedure (St. Petersburg), certified according to the Federal Standard P 8.563–96 after the metrological evaluation of materials on Measurement Procedure development. The method is based on the bringing of the selected soil samples to the air-dry fine condition, their processing with acids (chlorhydric and fluohydric acids), and decomposition of interfering organic compounds and further identification of elements (copper, lead, cadmium and zinc) in acid digest through stripping voltammetry method.

RESEARCH RESULTS AND THEIR DISCUSSION

The research covered four landscapes – Sophia high- and mid-altitudinal, Gondaray mid-altitudinal and Aksko-Dzhalpakkol high-altitudinal; more than 100 soil samples were selected. The main soil characteristics of the landscape were received.

General geochemical peculiarities of West Caucasus landscapes were first described by V.V. Dyachenko (2004). He states that the concentration of many chemical elements, zinc in particular, in high-altitudinal landscape soils is substantially lower than on average in the region and varies insignificantly with the landscapes, which is due to the relative likelihood of environmental conditions of these landscapes (coarseness, a great amount of precipitation, low water mineralization, weak acid reaction of soils).

The type of water migration is acid sodium bycarbonate or calcium-sodium hydrocarbonate, which is due to the influence of the chemical activity of precipitation and the peculiarities of the biological cycle. Under such conditions, ash content and plant saturation with bases is lower, biogeochemical concentration process is weaker, acid desalinization leading to the washover of elements develops quickly. A number of soil-building compounds become significantly depleted of some elements.

The distribution of chemical elements is affected by the natural and anthropogenic factors, the most important of which in high-altitudinal belts are excessive humidity and acid desalinization.

The study of geochemical peculiarities of Sofia mid-altitudinal and Sofia high-altitudinal landscapes was undertaken on the territory of Karachai-Cherkess republic within the Lateral Range boundaries in Sofia river valley.

A system of testing sites which cover all high-altitudinal geobotanical belts within altitude of 1700-2800 m above the sea level was created to receive the data.

The alpine belt vegetation includes short grasses represented mainly by gramineal and mixed herbs meadows, with coarse mountain-meadow soils. Earlier, cattle was grazed in high-altitudinal meadow belts, but this practice has been ceased in recent years. The subalpine geobotanical belt is represented by typical gramineal and mixed herbs.

In circus ecotone of the forest upper boundary, the vegetation is represented by birch crooked forests and subalpine meadows and includes a great number of anthropophytes.

The geobotanical belt of conifer forests is widespread on the slopes of Sofia mountain valley. Under conditions of current heat-and-moisture exchange, western slopes are covered by pine- and fur-tree forests while fur-tree forests are typical for the eastern slopes. The landscape includes coarse mountain and forest brown soils.

The geobotanical belt of Sofia river valley ecotone is of the anthropogenic origin. Earlier, pine-tree forests grew in the valley; later they were cut clear. Low diversity of herbs is typical for the geobotanical belt of the valley ecotone; gramineals and anthropophytes prevail. The landscapes are represented by mountain and meadow soils. Currently, the territory is used as a pasture field.

According to V.V. Dyachenko's data [1], Sofia landscapes can be classified as biogenic with hydrocarbonate sodium-calcium type of water migration. On the alkali-acid criteria they can be classified as weak acid. Geochemical analysis was conducted according to the methodology described before. Among the most important factors affecting the current conditions of water migration are humus content and the degree of soil acidity.

All facies of Sofia landscapes are characterized by acid soils (table 1).

Table 1: Soil acidity and humus content in geobotanical belts of Sofia landscapes

Testing site №	Geobotanical belt	Altitude above the sea level, m	pH	Humus, %
1	Alpine meadows	2800	4,11	7,9
2	Subalpine meadows	2430	4,73	4,6
3	Circus ecotone of the forest upper boundary	2350	5,11	3,9
4		2200	5,42	8,1
5		2000	5,37	7,6
6	Coniferous forests	1770	5,67	6,9
7		1750	5,08	4,3
9		1800	5,82	8,7
8	Valley ecotone of anthropogenic disturbance	1700	5,39	8,3

Soil acidity and humus content in geobotanical belts of Sofia landscapes

Low pH of soils can be explained by the fact that the formation of the acidity pattern is affected by a number of factors, such as bedrock characteristics (granitoids produce soils with acid reaction), underground water and climate conditions. Soil pH in geobotanical belts tends to demonstrate lower acidity down the slope from the alpine meadow belt to the dominant belt of coniferous forests (pic. 2).

Due to its molecular structure, humus strongly influences the accumulation and migration of the chemical elements in soil and plays an important role in the regulation of migration flows. In the alpine belt the percentage of humus content is relatively high – 7,9 % . The peculiarity of humus of alpine belt is its "coarse" nature, i.e. it contains only partially humified plant remains. Then, humus content in the upper soil horizon decreases twice towards the subalpine belt. The highest percentage of humus content in soils can be found in valley ecotone of anthropogenic disturbance.

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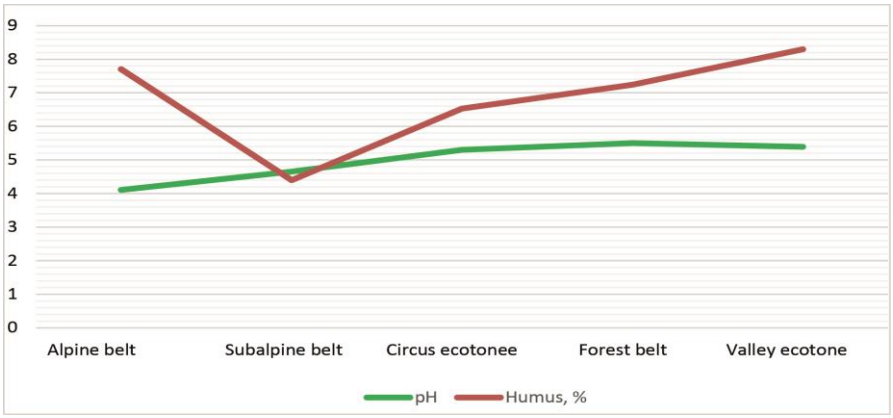
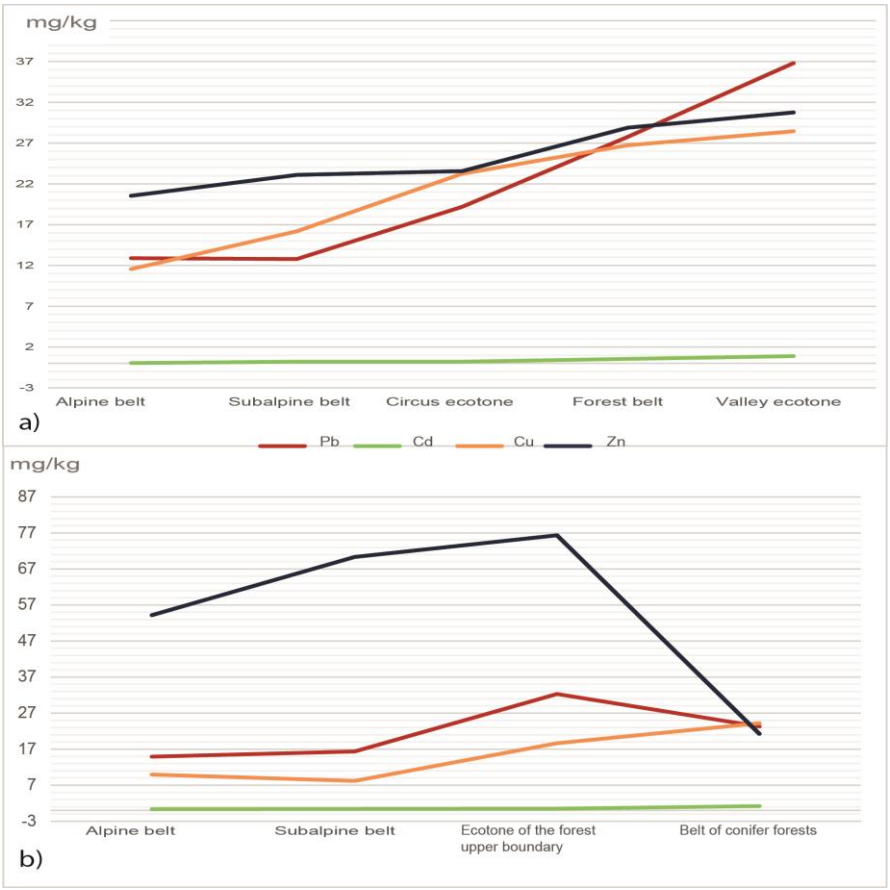


Pic. 2. Acidity and humus content distribution of upper soil horizon among geobotanical belts

The concentration of chemical elements gradually reduces with the lower altitude above the sea level and with the change of alpine belt into valley ecotone of Sofia river. The lowest concentartions of all elements in question are typical for soils of the alpine meadow belt.

In addition, there is a common tendency towards higher concentrations with the growth of the anthropogenic load in Sofia river valley. For example, the concentration of copper, lead and zinc in valley ecotone soil is three times higher than in the alpine belt, while the concentration of cadmium is 22 times higher (its concentration in soils of alpine belt tends towards zero – 0,04).

CONCLUSION



Pic. 3. Lateral distribution of elements in soils of different landscapes: a) Sofia; b) Aksk-Dzhalpakkol and Gondaray

The levels of concentration and the degree of soil saturation with elements in different landscapes increase in facias down the slope, which is determined by the key role of matter flow in the cascade landscape – geochemical system.

On the whole, the results of the geochemical analyses of facias components in the number of high-altitudinal geobotanical belts showed similar characteristics in all important regions of West and Central Caucasus, which proves common conditions of element migration in mountain landscapes.

The study of the redistribution of elements in different geobotanical belts of landscapes revealed the prevailing role of soils among the analysed components in the accumulation of the elements (pic. 3).

The levels of concentration and the degree of soil saturation with elements in different landscapes increase in facias down the slope. It can be explained by the unidirectional matter flow from the higher altitudinal belts (which are more autonomous) in the cascade landscape geochemical system. As a result of percipitation, the elements are washed over from the soils of high-altitudinal facias and the elements are accumulated in soils of lower-altitudinal facias due to the matter flow.

This leads to the highest concentrations of elements in soils of lower parts of slopes and of river valleys, so Cd > Pb > Cu > Zn row is formed according to the degree of elements mobility. The results fit B.B. Polynov's conception [4] on the key role of matter flows in landscapes and V.V. Dyachenko's conclusions about the mobility of various elements [5].

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