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PAPER

MICROELEMENTS OF MEADOW-OASIS SOILS OF WESTERN FERGANA

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Abstract

Data on the main properties and characteristics of meadow-oasis saline and non-saline soils of Western Fergana are presented, and their microelement composition is characterized. Microelement contents are compared with their average contents in the lithosphere and soil, and their accumulation and dispersion are assessed. The distribution of microelements of manganese, zinc, strontium, chromium, nickel, cobalt, tin, and molybdenum in the soil profile is shown. Series of accumulating and dissipating chemical elements are identified based on concentration and dispersion clarkes.

Key words: meadow-oasis soil, microelements, concentration clarke, dispersion clarke

Introduction

Emissions and waste from highly developed industries, particularly the chemical, energy, and automotive industries, as well as the use of mineral and organic fertilizers, pesticides, herbicides, and many other toxic chemicals in agriculture, contribute to soil contamination with toxic chemicals, particularly heavy metals and so-called microelements. These substances enter the soil solution, where they are absorbed by plant roots and accumulate in various organs. Further, directly or indirectly entering the human body, they can contribute to the development of various diseases and complications.

The biological availability of soil micronutrients is the primary factor determining the quality of plant products. The transfer of elements from the soil to plants is determined by the pH of the environment and the oxidation-reduction potential, the particle size distribution and mineral composition, the quantitative and qualitative composition of organic matter, and the soil temperature and water regime [4].

Microelement biogeochemistry emerged and developed thanks to the work of F.W. Clark, V.I. Vernadsky, A.E. Fersman, A.I. Perelman, B.B. Polynov, V.M. Goldshmidt, G.S. Washington,

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A. Kabat-Pendias, H.Pendias, and many other geochemists. In Uzbekistan, particularly in the Fergana Valley, biogeochemical research was conducted by Ya.K. Kruglova, M. Aliyeva, G.Yuldashev, H.Kh. Tursunov, M. Isagaliev, A. Turdaliev, and others.

Despite numerous comprehensive studies in the field of biogeochemistry, many problems still remain, such as those noted by A. Kabata-Pendias [4], the balance and cycles of trace elements and radionuclides under specific biogeochemical conditions, the distribution of elements in soils, soil solution and other environments, the transfer of trace elements from soil to plants, the risk to human health caused by trace element imbalance in the environment, etc. A favorable human habitat is closely related to the chemical properties of soils and, in particular, to an adequate and safe content of trace elements. The state of the environment and human health depend on the mobility and bioavailability of many trace elements. Consequently, the behavior of trace elements in ecosystems is a priority issue in modern biogeochemical research [4,5].

Research Object and Methods

The study was conducted on farmland in the western Fergana Region. The subjects of the study were meadow-oasis soils with a saz regime. Field and laboratory studies utilized V.V. Dokuchaev's morphogenetic method, physicochemical and neutron activation methods, and generally accepted standard agrochemical methods widely used in soil science. The elemental composition of the soil and plants was determined using the neutron activation method in the Laboratory of Ecology and Biotechnology of the Institute of Nuclear Physics of the Academy of Sciences of the Republic of Uzbekistan. Samples irradiated in a nuclear reactor were $5 \cdot 10^{13}$ neutrons/cm^2 · s. The quantities of chemical elements were determined based on their half-lives.

Research Results and Discussion

In Western Fergana, which is characterized by a desert climate, meadow-oasis soils have formed due to centuries of irrigated agriculture and unique hydrogeological conditions. These soils are common in the middle and lower parts of alluvial fans with an irrigation-saz groundwater regime. Their properties and characteristics have been significantly altered by long-term intensive irrigated agriculture—microclimate, abundant and regulated moisture, mechanical cultivation, systematic fertilization, land reclamation, etc [7,9,11].

The main characteristic of meadow-oasis soils is the agro-irrigation horizon, which owes its origin to the introduction and deposition of silt and other suspended particles by the turbid waters of the Sokh and Isfara rivers. It has a thickness of 60-80 cm. The color is monotonously gray, the mechanical composition is predominantly medium loamy, with a fine-grained structure.

Below lies the parent rock, a loamy composition, yellowish-gray in color with a brownish-greenish tint at the top, becoming mottled toward the bottom, with greenish tones dominating. Small gypsum crystals are found.

The lower part of the soil profile is gleyed, heavy, and unevenly colored. The upper half of the layer is dominated by reddish-brown tones with dark spots. Further down, greenish, bluish, and darker tones predominate, creating a distinctive mosaic of colors. The layer's texture is curdy. The humus content within the agro-irrigation horizon of meadow-oasis saz soils ranges from 1.5 to 2.1%. Humus in meadow-oasis soils is relatively rich in nitrogen. The C:N ratio typically ranges from 7 to 9.

The studied soils were enriched with total phosphorus throughout the entire thickness of the agro-irrigation horizon, especially in the arable horizon – 0.398%. The parent material had the lowest content – up to 0.10

The main factor determining the total phosphorus content in irrigated soils is the amount of phosphorus fertilizer applied. In meadow soils, fertilizer phosphorus is extremely quickly bound into poorly soluble compounds—calcium, iron, and aluminum phosphates. These compounds constitute the main source of phosphorus, accounting for up to 60-80% of the total phosphorus content in soils.

High variability in available P_2O_5 in the arable horizon (up to 54.9 mg/kg) is associated with varying rates of applied phosphorus fertilizers. High levels of available phosphorus are due to the systematic application of high doses of phosphorus

fertilizers, and the soils are classified as moderately and highly phosphorus-rich.

The total potassium content in meadow-oasis soils reaches 0.93%. In terms of available potassium, they are classified as moderately rich. The K_2O content in the arable horizon exceeds 400 mg/kg of soil.

The processes of migration and accumulation of chemical elements in soils and plants are closely interrelated. The content of elements in soils is primarily related to their content in the parent rock. It should also be noted that irrigation, hydrogen, and biogenic factors play a particularly important role in the migration, accumulation, and redistribution of chemical elements in the arid conditions of the study area. Plants selectively absorb elements from the soil, but the content of a chemical element in the soil plays a crucial role in this complex physiological process. The plant's need for a particular chemical element depends on its content in the soil.

The elemental composition of newly irrigated saline meadow saz soils differs significantly in content and distribution within the profile from that of meadow-oasis saz soils (Table 1). Chemical elements, except for Ni, are present in higher concentrations in the surface horizon of newly irrigated saline soils than in meadow-oasis soils. The average Ni and Mo contents are nearly identical across the soil profiles of both saline and non-saline soils. The amounts of Mn, Sr, Zn, Cr, Co, and Sn are higher in saline irrigated soils than in non-saline meadow-oasis soils. Mn and Sr are the predominant elements. However, their contents are below their clarke values. The amounts of Zn and Mo exceed their lithospheric and soil clarke values. Sr content in meadow-oasis soils is below the clarke value, while it is higher in newly irrigated saline soils. The upper horizon of the transition layer contains a small maximum of Cr, Ni, Sc, and Co. A second maximum of these elements is found in certain horizons in the lower part of the profile.

The values of concentration and dispersion clarkes of microelements, given in Table 2, characterize the concentration or dispersion of chemical elements in the studied soil and rock relative to the earth's crust (lithosphere). Concentration clarkes and dispersion clarkes, proposed by V.I. Vernadsky in 1937, show the relative abundance of chemical elements in nature

Table 1

Trace element content in meadow-oasis soils

Depth, cm	Mn	Sr	Zn	Cr	Ni	Co	Sc	Mo
Newly cultivated moderately saline meadow saz soil								
0-30	745	351	108	63	25	12	9,8	3,7
30-48	590	346	132	60	20	10,8	9,8	3,7
48-74	640	291	130	74	25	12,7	10,7	2,9
74-100	590	340	129	62	22	11,7	9,9	2,6
100-121	530	359	126	50	20	10,8	10,5	2,7
121-154	590	300	130	46	25	10,5	10,6	2,6
Meadow-oasis soil								
0-21	530	310	99	39	29	8,5	7,2	3,3
21-46	610	240	87	42	21	10	9,0	3,6
46-68	490	270	93	44	23	9,5	8,3	3,4
68-115	520	360	88	51	26	12	9,1	2,7
132-160	570	240	69	47	20	9,4	8,8	4,1
160-190	620	190	89	49	22	9,7	7,4	2,7
Lithospheric Clarke n 10^{-3}[1]	100	34	8,3	8,3	5,8	1,8	1,0	0,20
Soil Clark n 10^{-3} [1]	85	30	5	20	4	0,8	0,7	0, 1

[2, 10]. If a chemical element accumulates in soil or another natural object, then the value of its concentration clarke will be higher than one - Kk> 1. Thus, the value of the concentration clarke of zinc and molybdenum in meadow-oasis saz soils of the Sokh alluvial fan along the entire profile fluctuates within the range from 0.83 to 1.19 and from 1.35 to 2.05, and in newly developed saline meadow soils from 1.30 to 1.59 and from 1.30 to 1.85, respectively. Moreover, higher values are characteristic of the upper part of the soil profile—the agro-irrigation layer. The transitional part of the profile from soil to rock is characterized by lower clarke concentration values, with rock occupying an intermediate position.

Consequently, Zn and Mo accumulate relatively more intensively in soil horizons. This is apparently facilitated by the turbidity of irrigation water and the application of soil and mineral fertilizers.

Table 2.

Values of concentration and dispersion of microelements

Depth, cm	Mo	Zn	Sr	Sc	Cr	Mn	Co	Ni
	Clarks concentration			Clarke scattering				
Newly cultivated moderately saline meadow saz soil								
0-30	1,85	1,30	1,03	1,02	1,32	1,34	1,50	2,32
30-48	1,85	1,59	1,02	1,02	1,38	1,69	1,66	2,90
48-74	1,45	1,56	0,86	0,93	1,12	1,56	1,42	2,32
74-100	1,30	1,55	1,00	1,01	1,33	1,69	1,54	2,63
100-121	1,35	1,51	1,05	0,95	1,66	1,88	1,66	2,90
121-154	1,30	1,56	0,89	0,94	1,80	1,69	1,71	2,32
Meadow-oasis soil								
0-21	1,65	1,19	0,91	1,38	2,12	1,88	2,11	2,00
21-46	1,80	1,05	0,71	1,11	1,97	1,63	1,80	2,76
46-68	1,70	1,12	0,79	1,20	1,88	2,04	1,89	2,52
68-115	1,35	1,06	1,06	1,09	1,62	1,92	1,50	2,23
132-160	2,05	0,83	0,71	1,13	1,72	1,75	1,91	2,90
160-190	1,35	1,07	0,56	1,35	1,69	1,61	1,85	2,63

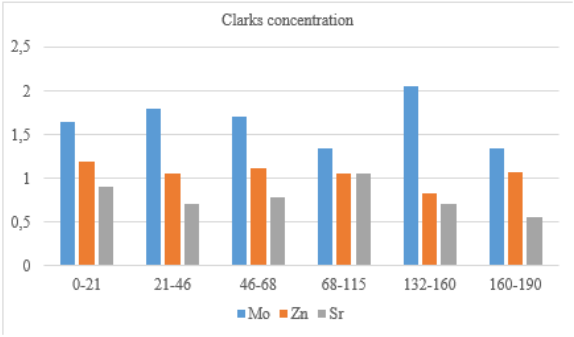


Figure 1. Clarks concentration of microelements

The content of Sc, Cr, Mn, Co and Ni in the studied soils is much lower than their average content in the earth's crust, i.e., the clarke - Kc < 1. These elements do not accumulate in soils, but dissipate. According to the clarkes of concentration and dissipation, series of accumulating and dissipating chemical elements are distinguished. The series of accumulating elements in meadow-oasis soils include molybdenum, zinc and strontium: Mo(1.65) – Zn(1.19) – Sr(0.91), and in newly irrigated saline soils: Mo(1.85) – Zn(1.30) – Sr(1.03)

The scattered chemical elements are represented by the following rows:

For meadow-oasis soils — Sc(1.38) – Mn(1.88) – Ni(2.0) – Co(2.11) – Cr(2.12);

For newly irrigated saline soils — Sc(1.02) – Cr(1.32) – Mn(1.34) – Co(1.50) – Ni(2.32)

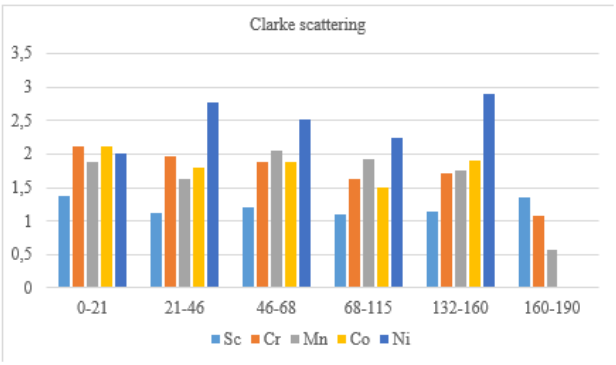


Figure 2. Clarke scattering of microelements

Thus, the chemical element content in newly irrigated saline meadow saz soils of Western Fergana, especially in the surface horizons, is higher than in meadow-oasis soils. Meadow-oasis soils, both saline and non-saline, are characterized by low contents of Sc, Cr, Mn, Co, and Ni, and are classified as dispersing microelements. Mo, Zn, and Sr are accumulating elements, as their content exceeds the average levels in the lithosphere and soil.

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