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Biogeochemistry of Fallow (Virgin) Lands and Irrigated Soils in the Mirzachul Oasis

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Abstract This article presents data on the biogeochemical properties of fallow (virgin) lands and irrigated soils in the Mirzachul oasis, as well as the biological absorption coefficients of biomicronutrients. The study includes an analysis of the biological absorption coefficients of natural plant species commonly found on fallow (virgin) lands — *Karelinia caspia* Pall. Less., *Zygophyllum oxianum* Boriss., *Halimocnemis villosa* Kar. & Kir., *Tamarix* — and cultivated crops grown on irrigated soils such as cotton (*Gossypium hirsutum* L.), melon (*Melo bilobola* L.), and wheat (*Triticum durum* Desf.).

Keywords Mirzachul oasis, Fallow lands, Irrigated serozem-meadow soils, Meadow-serozem soils and meadow soils, Natural plants, Cultivated agricultural crops, Biogeochemical province

1. Introduction

The Mirzachul oasis, located in the Syrdarya region of the Republic of Uzbekistan, is characterized by a wide distribution of virgin (uncultivated) lands and irrigated soils. These soils are subject to various natural and anthropogenic influences that affect their chemical composition, fertility, and ecological condition. Understanding the biogeochemical characteristics of these soils is essential for assessing their agricultural potential and ecological sustainability.

As the global economy continues to expand at a rapid pace, societies are facing new challenges in managing their natural resources. Soil, as a fundamental natural resource, plays a crucial role in ensuring sustainable economic growth and human well-being across all regions of the world. In order to improve environmental quality and achieve balanced growth in line with a sustainable economy, it is essential to gain a deep understanding of soils, including their properties, functions, ecological roles, and management strategies [15].

Analysis of Scientific Sources. Geochemistry, which today studies the history and circulation chains of elements in the Earth or in soil, continues to regard the investigation of element dynamics within the parent “rock-soil-plant” chain of both virgin and irrigated soils as a significant task. Regardless of whether the land is virgin, irrigated, rain-fed, pasture, or belongs to another category, it generally contains most of the elements found in D.I. Mendeleev's periodic table, excluding artificially synthesized ones. This is due to the fact that current analytical methods, based on available technical and technological capabilities, are not et able to detect all natural elements present in the soil [9].

A.I. Perelman, N.S. Kasimov, M.A. Glazovskaya, B. B., Dobrovolsky, B. A., and Kovda, V. A. conducted pioneering and comprehensive research in the fields of soil chemistry, geochemistry, and soil biogeochemistry, achieving advancements through various research methodologies [11,4,3,8].

Biogeochemistry encompasses both biotic and abiotic reactions, incorporating organic and inorganic species. This discipline integrates marine, aquatic, terrestrial, and atmospheric sciences, ensuring continuous processes over various temporal scales [5,2].

Quantitative analysis of macro- and microelements in plants is a crucial step in determining the presence of toxic and hazardous concentrations of heavy metals that may pose a threat to living organisms. Furthermore, research on hyperaccumulator plants and their specific organs is of significant importance [9].

Relevance of the Topic. Based on the doctrine that "soil is a natural-historical body and is divided into various soil zones across the world," Dokuchaev, V. V. scientifically substantiated the genetic interconnection among different components of nature — such as vegetation and wildlife, soil, rock formations, surface and groundwater, relief, and others. In doing so, he developed the scientific principles and methodologies for studying the pedosphere — the soil — which he considered the "mirror of the landscape Subsequently, his student Vernadsky, V. I. [18] defined soil as a "biocosmic natural body" and emphasized the importance of studying it through synthetic sciences such as geochemistry, biogeochemistry, and soil biogeochemistry.

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In this regard, he laid the foundation for the doctrine of the ubiquity of elements in the biosphere based on the principles of geochemistry and the hypothesis that "all elements are present everywhere", thereby contributing significantly to our understanding of the history and distribution of elements within the biosphere.

In recent ears, numerous researchers across various regions of the world have conducted scientific and applied studies aimed at reducing the toxicity and negative effects of heavy metals found not only in natural vegetation but also in agricultural crop species.

According to G. Yuldashev and A. Turdaliyev [16], conducting biogeochemical research is particularly important for analyzing the quantity and quality of elements when studying the correlation between plants and the soil-climatic conditions in which they grow.

Thus, determining the concentration of microelements not only in natural vegetation but also in agricultural crops is of significant importance. In particular, it is essential to analyze their distribution across specific vegetative and generative organs — including roots, stems, leaves, buds, flowers, fruits, and seeds — as this represents one of the key research objectives.

Based on the above, we conducted a biogeochemical study of the soils of Uzbekistan's gray soil zone, specifically focusing on fallow lands and irrigated soils within the Mirzachul oasis.

2. Research Object and Methods

During the research conducted between 2023 and 2025, investigations were carried out in the territories of Khavast and Akoltin districts of the Sirdarya region, focusing on the widespread gray soils and irrigated lands. The studies examined soil salinization processes, their direction and intensity, as well as the qualitative composition of salt components, their accumulation and transformation within the soils.

In addition, the geochemistry and biogeochemistry of elements were analyzed in both natural vegetation — such as *Karelinia caspia*, *Tamarix*, *Zygophyllum oxianum*, and *Halimocnemis villosa* — and cultivated crops, including cotton (*Gossypium hirsutum* L.), wheat (*Triticum durum* Desf.), and melon (*Melo bilobola* L.).

Field and soil investigations were conducted using the morphogenetic and comparative-geographical approaches developed by B.B. Dokuchaev, as well as the systematic pedogeochemical methods proposed by A.I. Perelman [11], G.V. Dobrovolsky [3], Glazovskaya [4], and Alina Kabata-Pendias [7].

Chemical analyses were carried out in accordance with the widely accepted methodological guidelines: *"Manual for Conducting Chemical and Agrophysical Soil Analyses for Land Monitoring"* [13] and *"Guidelines for the Management of Saline Soils"* [14]. The chemical analysis of soil and plant organs (root, stem, leaf, flower, and fruit) was performed using mass spectrometry at Uzbekgeologiqidiruv JSC. Analytical calculations and interpretations were based on A.P. Vinogradov's Clarke values.

3. Research Results and Discussion

Soils widely distributed in the newly developed area of the Mirzachul oasis, which belongs to the fallow (virgin) land region, were studied. In particular, fallow lands (section 8), irrigated meadow- soils (section 1), irrigated meadow-serozem soils (section 9), and irrigated meadow soils (section 14) were investigated. A comparative analysis of the quantitative content of elements was conducted based on their natural occurrence, including in soil and groundwater.

The classification system proposed by V.I. Vernadsky was used as the basis for these studies. According to the analyses, the content of Ca in fallow lands and irrigated soils of the Mirzachul oasis and their parent rocks ranges from 10,200 to 99,780 mg/kg; Al ranges from 44,790 to 74,470 mg/kg; Fe from 25,760 to 39,550 mg/kg; Mg from 12,360 to 25,980 mg/kg; K from 13,300 to 20,790 mg/kg; and Na from 8,798 to 12,010 mg/kg. The analyses also revealed that due to the periodicity of irrigation, calcium is leached by 1 to 1.5 times, while magnesium and sodium are leached by 1.5 to 2 times. Within this context, calcium and iron were found to be predominant.

We studied the geochemical characteristics of macro- and microelements and their migration in soils formed under automorphic, semi-hydromorphic, and hydromorphic conditions based on the geochemical research methods recommended by A.I. Perelman [11]. The study was conducted using concentration clarkes (Cc) and clarke distributions (Cd). The Cc and Cd values of fallow lands and irrigated soils were developed by comparing them with soil and lithosphere clarkes established by A.P. Vinogradov.

According to the Kk analysis of the studied soils, in the plow layer (0–30 cm), the following cyclic elements showed elevated concentrations (Kk > 1) relative to the lithosphere clarke: In fallow (virgin) lands: As, Mo, Ca, Pb, B, and Ba; In irrigated meadow-serozem soils; As, Mo, B, Sr, Mg, Ba, Zn, Pb, and P; In irrigated serozem-meadow soils: As, Mo, Ca, Ba, Pb, B, Zn, and Sr; In irrigated meadow soils: As, B, Ca, Mo, and Pb.

The sequence of the concentration Clarke of the studied chemical elements in the plow layer (0-30 cm) is as follows:

Section No. 8 – **fallow land**, 0-30 cm:

Cyclic elements:

$$\frac{As}{20{,}59} > \frac{Mo}{3{,}07} > \frac{Ca}{2{,}02} > \frac{Pb}{1{,}34} > \frac{B}{1{,}33} > \frac{Ba}{1{,}26} > \frac{Sr}{0{,}96} > \frac{Zn}{0{,}96} > \frac{P}{0{,}96} > \frac{Mg}{0{,}94} > \frac{Cu}{0{,}77} > \frac{Fe}{0{,}71} > \frac{Al}{0{,}71} > \frac{K}{0{,}70} > \frac{Ni}{0{,}66} > \frac{Mn}{0{,}59} > \frac{Co}{0{,}59} > \frac{Na}{0{,}38};$$

Section No. 1 – **irrigated meadow-serozem soils**, 0-35 cm:

Cyclic elements: $\frac{As}{24,29} > \frac{Mo}{3,45} > \frac{Ca}{2,89} > \frac{B}{2,44} > \frac{Sr}{2,44} > \frac{Mg}{1,39} > \frac{Ba}{1,13} > \frac{Zn}{1,10} > \frac{Pb}{1,07} > \frac{P}{1,06} >$
$\frac{Cu}{0,95} > \frac{Al}{0,87} > \frac{Fe}{0,85} > \frac{K}{0,83} > \frac{Ni}{0,73} > \frac{Co}{0,70} > \frac{Mn}{0,66} > \frac{Na}{0,48}$;

Section No. 9 – **irrigated serozem-meadow soils,** 0-30 cm:

Cyclic elements: $\frac{As}{21,76} > \frac{Mo}{3,00} > \frac{Ca}{2,07} > \frac{Ba}{1,32} > \frac{Pb}{1,29} > \frac{B}{1,26} > \frac{Zn}{1,01} > \frac{Sr}{1,01} > \frac{Mg}{0,83} > \frac{Al}{0,82} > \frac{P}{0,82} > \frac{K}{0,79} > \frac{Cu}{0,77} > \frac{Fe}{0,76} > \frac{Co}{0,67} > \frac{Mn}{0,63} > \frac{Na}{0,42}$;

Section No. 14 – **irrigated meadow soils,** 0-28 cm:

Cyclic elements: $\frac{As}{17,24} > \frac{B}{3,02} > \frac{Ca}{2,13} > \frac{Mo}{2,09} > \frac{Pb}{1,01} > \frac{Ba}{0,98} > \frac{Zn}{0,86} > \frac{Sr}{0,76} > \frac{Mg}{0,73} > \frac{Al}{0,73} > \frac{K}{0,64} > \frac{Fe}{0,63} > \frac{Cu}{0,63} > \frac{P}{0,56} > \frac{Ni}{0,56} > \frac{Co}{0,52} > \frac{Mn}{0,47} > \frac{Na}{0,38}$;

Among the cyclic elements, the concentration clarke of calcium (Ca), an alkaline earth element, in the studied soils and their parent rocks indicates geochemical provinciality. It was found that Ca concentrations decreased by approximately 1 to 1.5 times in the following order: fallow (virgin) lands (0.34–3.37), meadow-serozem soils (0.35–2.89) > irrigated serozem-meadow soils (2.07–2.19) > meadow soils (2.13–2.79). This trend is attributed to the leaching of calcium, an alkaline earth element, from the soil and groundwater systems.

Among the cyclic elements, the concentration clarke of sodium (Na), an alkali element, in the studied soils and their parent rocks indicates geochemical provinciality. It was observed that Na concentrations decreased in the following order: fallow (virgin) lands (0.38–0.45) > meadow-serozem soils (0.36–0.48) > serozem-meadow soils (0.39–0.42) > meadow soils (0.35–0.40).

The concentration clarke of arsenic (As) in the studied soils and their parent rocks ranges from 17.06 to 83.53, indicating that, in virgin soils, the content exceeds the soil clarke by 10 to 49 times — a clear sign of geochemical provinciality. It is particularly important to note that the Kk values of arsenic were recorded within the following ranges: in fallow (virgin) lands: 20.59–83.53, in meadow-serozem soils: 20.71–24.41, in serozem-meadow soils: 18.47–30.41, in meadow soils: 17.06–28.53.

Among the dispersed elements, particularly the light metals, the concentration clarke of gallium (Ga) in the studied soils and their parent rocks ranges from 1.79 to 42.2. The Cc values of gallium were recorded as follows: in fallow (virgin) lands: 31.2–42.2, in meadow-serozem soils: 2.19–2.64, in serozem-meadow soils: 2.09–2.44, in meadow soils: 1.79–1.99. This indicates a nearly 17-fold decrease in concentration from fallow (virgin) lands to irrigated soils. According to scientific sources [20], the chemical properties of gallium are similar to those of aluminum. However, due to its lower chemical reactivity, reactions involving metallic gallium tend to occur much more slowly.

In the studied soil types, the concentrations of As, Mo, Ca, Pb, B, and Ba were found to be higher than their respective soil clarke values. The maximum concentration clarke (Cc) values for these elements were recorded within the following ranges, respectively: As – 17.06–83.53, Mo – 2.09–6.31, Ca – 1.85–3.37, Pb – 1.01–1.34, B – 1.22–3.84, Ba – 1.03–1.42.

In the plow layer of fallow (virgin) lands and irrigated soils in the Mirzachul oasis, the clarke distribution (Cd) of cyclic elements varies as follows. The clarke distribution (Cd) sequence of the studied chemical elements in the plow layer (0–30 cm) is as follows:

Section No. 8 – **fallow land**, 0-30 cm:

Cyclic elements: $\frac{Na}{2,66} > \frac{Mn}{1,71} > \frac{Co}{1,68} > \frac{Ni}{1,52} > \frac{K}{1,43} > \frac{Fe, Al}{1,41} > \frac{Cu}{1,31} > \frac{Mg}{1,06} > \frac{P}{1,04} > \frac{Sr}{1,04} > \frac{Zn}{1,04} > \frac{Ba}{0,80} > \frac{B, Pb}{0,75} > \frac{Ca}{0,49} > \frac{Mo}{0,33} > \frac{As}{0,05}$;

Section No. 1 – **irrigated meadow-serozem soils**, 0-35 cm:

Cyclic elements: $\frac{Na}{2,08} > \frac{Mn}{1,52} > \frac{Co}{1,43} > \frac{Ni}{1,36} > \frac{K}{1,20} > \frac{Fe}{1,18} > \frac{Al}{1,15} > \frac{Cu}{1,05} > \frac{P, Pb}{0,94} > \frac{Zn}{0,91} > \frac{Ba}{0,88} > \frac{Mg}{0,72} > \frac{Sr, B}{0,41} > \frac{Ca}{0,35} > \frac{Mo}{0,29} > \frac{As}{0,04}$;

Section No. 9 – **irrigated serozem-meadow soils,** 0-30 cm:

Cyclic elements: $\frac{Na}{2,40} > \frac{Mn}{1,58} > \frac{Co}{1,49} > \frac{Ni}{1,43} > \frac{Fe}{1,32} > \frac{Cu}{1,30} > \frac{K}{1,27} > \frac{Al}{1,22} > \frac{P}{1,21} > \frac{Mg}{1,20} > \frac{Zn, Sr}{0,99} > \frac{B}{0,79} > \frac{Pb}{0,77} > \frac{Ba}{0,76} > \frac{Ca}{0,48} > \frac{Mo}{0,33} > \frac{As}{0,05}$;

Section No. 14 – **irrigated meadow soils,** 0-28 cm:

Cyclic elements: $\frac{Na}{2,64} > \frac{Mn}{2,15} > \frac{Co}{1,91} > \frac{Ni}{1,80} > \frac{P}{1,79} > \frac{Cu}{1,59} > \frac{Fe}{1,58} > \frac{K}{1,56} > \frac{Mg, Al}{1,37} > \frac{Sr}{1,31} > \frac{Zn}{1,16} > \frac{Ba}{1,02} > \frac{Pb}{0,99} > \frac{Mo}{0,48} > \frac{Ca}{0,47} > \frac{B}{0,33} > \frac{As}{0,06}$;

The final outcome of the migration process of elements in soil is their distribution and accumulation [1]. Radial migration, i.e., eluviation–accumulation coefficients, represents a soil indicator that characterizes the migration of chemical elements within the soil profile. These coefficients describe the accumulation or movement of elements in specific soil-genetic horizons compared to the initial parent materials.

Radial differentiation provides a clearer understanding of how biomicronutrients are redistributed within the soil profile and, more broadly, across the landscape [19,6].

The radial differentiation coefficient (Rd) in the A and B1 horizons of virgin soils ranges between 1.08 and 1.53. The accumulation sequence based on Rd values was observed as follows: In fallow (virgin) lands: B > Ba > Pb > Mn, Zn > K > Ni > Fe > Mg > Al > Cu > Co; In irrigated meadow-serozem soils: B > Mg > P > Ca > Na > Cu > K > Al > As > Mn > Fe >

Ni > Zn > Co; In serozem-meadow soils: Ba > P > Pb > Zn, Ni > K > Mn > Fe, Na > Co; In meadow soils: B > Al > Zn > Mg > K > Na, Ba > Pb > Fe.

It is important to emphasize that, due to hydromorphism processes, the radial differentiation coefficient (Rd) was found to be lower in serozem-meadow and meadow soils. In these soils, most cyclic elements were observed to have higher concentrations in the upper soil layers. This phenomenon is explained by the association of elements with organic matter, the metabolism of plant and animal life, and the low mobility of elements in the studied soils under weakly alkaline conditions.

It is known that an element considered a microelement for one plant species can exhibit the ability to accumulate in large amounts in another species or its organs. Similarly, many chemical elements that occur in macro quantities in the soil and are classified as macroelements from a geological perspective may appear as microelements within the plant body.

In our research, the elemental chemical composition of natural plants and agricultural crops was also analyzed based on groups of cyclic and dispersed elements. The elemental composition of natural and cultivated plants was studied in relation to the composition of the soils in which they grow and are cultivated [10].

In soil profiles taken from the studied fallow (virgin) lands, irrigated irrigated meadow-serozem solils, serozem-meadow soils, and meadow soils (sections No. 1, 8, 9, and 14), the concentrations of arsenic (As), molybdenum (Mo), calcium (Ca), lead (Pb), boron (B), barium (Ba), strontium (Sr), magnesium (Mg), zinc (Zn), and phosphorus (P) were found to be higher compared to the soil clarke values across all layers. Conversely, the content of heavy metals such as iron (Fe), manganese (Mn), and cobalt (Co) was observed to be deficient in these soil layers.

The biological absorption coefficients of heavy metals in natural plant species of virgin soils decrease in the following order: In Karelinia caspia (Pall.) Less., the sequence is Zn > Cu > Ni > Pb > Co > As > Fe; in Zygophyllum oxianum Boriss, Cu > Zn > Ni > Pb > Fe > Co > As; and in Halimocnemis villosa Kar. & Kir. and Tamarix the pattern is Zn > Cu > Ni > Pb > Co > Fe > As. According to the biological absorption coefficients of microelements by the studied natural plants (Karelinia caspia, Zygophyllum oxianum, Halimocnemis villosa, and Tamarix) as well as agricultural crops (cotton, wheat, and melon), it was determined that, for phosphorus (P), the organs of cotton (Gossypium hirsutum L.) and melon (Cucumis melo L.) belong to the “strongly accumulating” group (5–10) based on their biological absorption ranking. Among the agricultural crops, wheat (Triticum durum Desf.) organs fall into the “weakly accumulating” group (1–5) according to the biological absorption classification.

The biogeochemical activity of natural plant species in relation to cyclic and dispersed elements (Fe, Ca, Na, K, Mo, Mn, Ba, Sr, Zn, Ni, Co, Mg, Al, B, P, Cu, Pb, As, Rb, Cs, Ga, Li) was measured as follows: Tamarix showed 6.55 (0.30%), Karelinia caspia (Pall.) Less. – 9.67 (0.44%), Zygophyllum oxianum Boriss – 10.73 (0.49%), and Halimocnemis villosa Kar. & Kir. – 14.41 (0.66%), with an average of 10.34 (0.47%).

In wheat (Triticum durum Desf.) grown under irrigated meadow-virgin soil conditions, the values were: stem – 4.11 (0.19%), leaf – 4.17 (0.19%), ear – 5.83 (0.27%), and root – 7.10 (0.32%), with an average of 5.30 (0.24%).

In melon (Cucumis melo L.) grown under irrigated serozem-meadow soil conditions, the biogeochemical activity values were as follows: fruit – 5.96 (0.27%), leaf – 16.45 (0.75%), root – 16.66 (0.76%), stem – 19.06 (0.87%), flower – 20.46 (0.93%), with an average of 15.72 (0.72%). In cotton (Gossypium hirsutum L.) grown under irrigated meadow soil conditions, the values were: root – 9.16 (0.42%), stem – 11.11 (0.51%), boll – 14.11 (0.64%), flower – 21.03 (0.96%), leaf – 23.28 (1.06%), with an average of 15.74 (0.72%). Thus, the biological activity index of natural plants growing in fallow lands was: Tamarix – 0.30%, Karelinia caspia – 0.44%, Zygophyllum oxianum – 0.49%, and Halimocnemis villosa – an average of 0.66%. The biological activity index of agricultural crops was found to be 0.24% for wheat and 0.72% for melon and cotton.

Based on the biological absorption coefficient data obtained for natural plants (Karelinia caspia, Zygophyllum oxianum, Halimocnemis villosa, Tamarix) and cultivated crops (cotton, wheat, and melon), the intensity of biological absorption was assessed by grouping the elements into the following series:

To assess the ability of living organisms to absorb and accumulate elements, the intensity of chemical element absorption (Ax) was proposed as a biogeochemical indicator by B. B. Polinov [12]. Academician A.I. Perelman later introduced this indicator to science under the name of the biological absorption coefficient.

According to the methodology proposed by A.I. Perelman, if the absorption intensity (Ax) of elements is less than 1, it is considered that the elements are being retained rather than accumulated by plants. The most important generalized indicator of the biogenic migration intensity of an element is its biofilicity (B). This is determined by the ratio of the element's clark in a living organism to its clark in the lithosphere or soil [11]. In general, it is important to remember the relative nature of these indicators.

The elemental composition of natural and cultivated plants was analyzed in relation to the composition of the soils where they naturally occur and are cultivated.

In natural plant species found in gray soils, the biological absorption coefficients of heavy metals are arranged in the following decreasing order: in Karelinia caspia (Pall.) Less., Zn > Cu > Ni > Pb > Co > As > Fe; in Zygophyllum oxianum Boriss, Cu > Zn > Ni > Pb > Fe > Co > As; and in Halimocnemis villosa Kar. & Kir. and Tamarix, Zn > Cu > Ni > Pb > Co > Fe > As.

The control of chemical element content in soils, particularly the reduction of contamination levels by heavy metals and natural radionuclides, can utilize the geochemical properties of studied native plants and agricultural crops (cotton, wheat, and melon). This approach enables the development and implementation of agromeliorative, namely phytomeliorative, measures and the proper placement of plants.

In wheat (Triticum durum Desf.) grown under irrigated meadow-serozem soils, phosphorus (P) was recorded; in melon (Melo bilobola L.) grown under serozem-meadow soils, potassium (K) and strontium (Sr) were noted; and in cotton (Gossipium hirsutum L.) grown under meadow soils, potassium (K), molybdenum (Mo), and strontium (Sr) were observed. These elements belong to the biologically accumulating group (Ax > 1) categorized as "weakly accumulating" (1-5) elements, while phosphorus (P) under serozem-meadow and meadow soil conditions falls into the "strongly accumulating" (5-10) group (Figures 1, 2, 3).

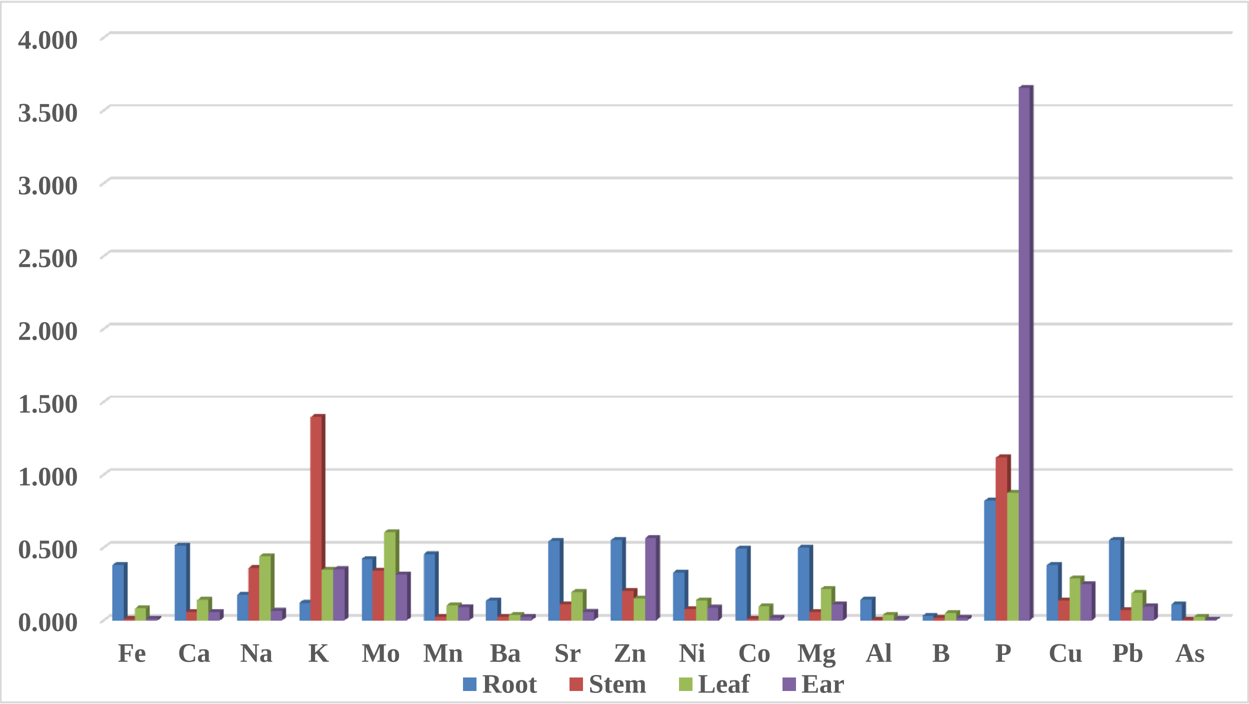

Figure 1. Biological absorption coefficients of trace elements (in mg/kg) in the organs of wheat (Triticum durum Desf.) plants

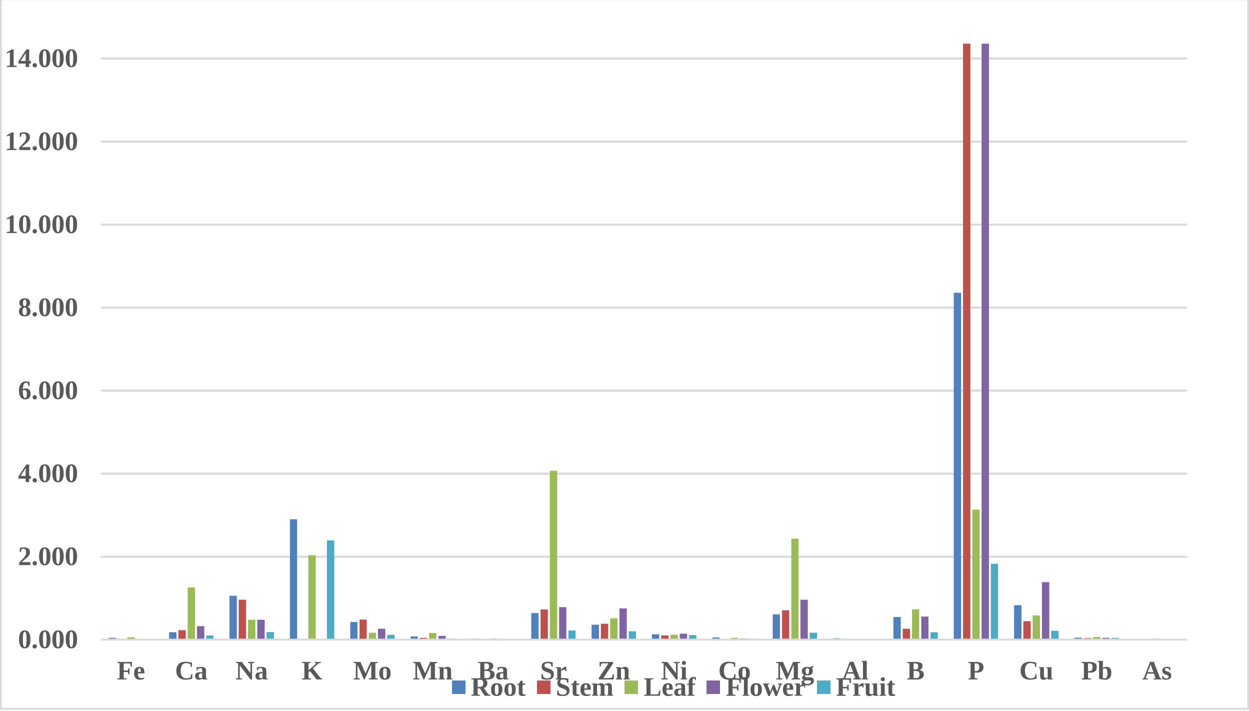

Figure 2. Biological absorption coefficients of trace elements (in mg/kg) in the organs of melon (Melo bilobola L.) plants

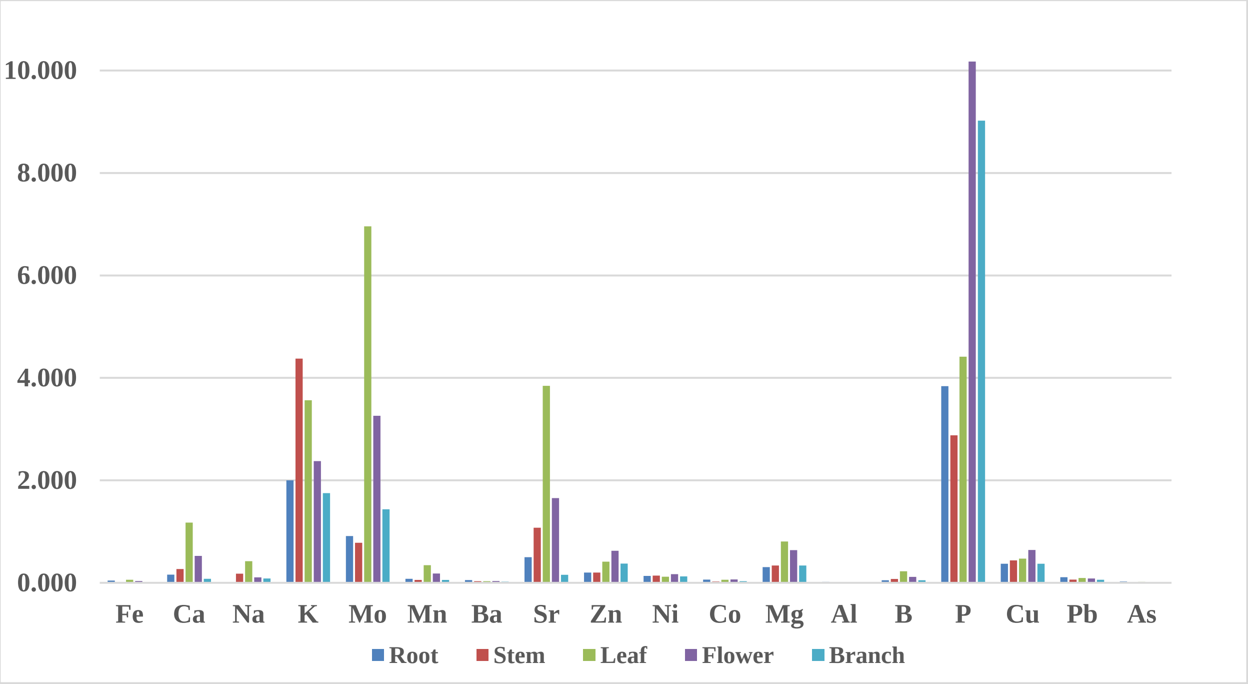

Figure 3. Biological absorption coefficients of trace elements (in mg/kg) in the organs of cotton (Gossypium hirsutum L.) plants

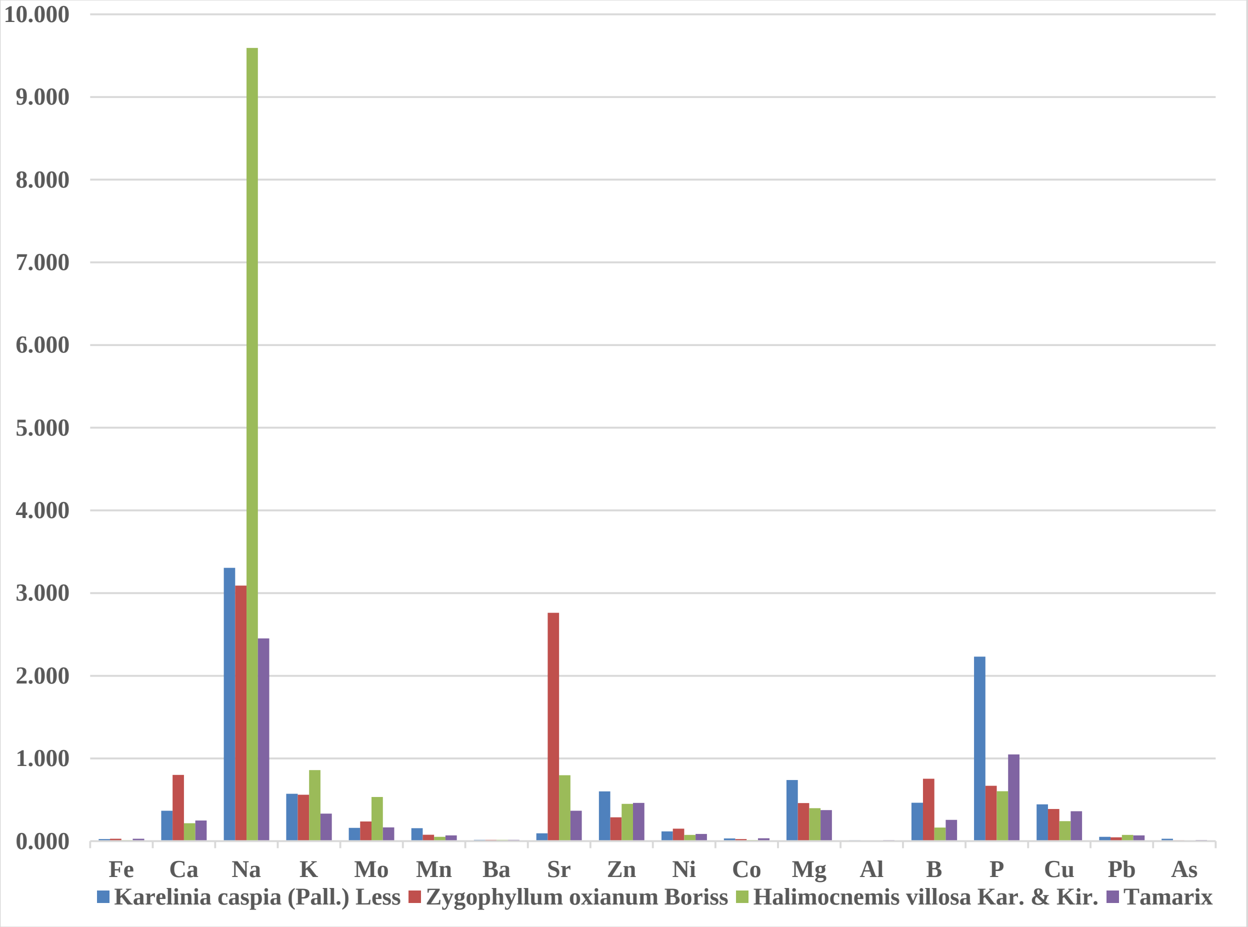

Figure 4. Biological absorption coefficients of trace elements (in mg/kg) in the above-ground organs of Karelinia caspia (Pall.) Less., Zygophyllum oxianum Boriss, Halimocnemis villosa Kar. & Kir., and Tamarix plants

4. Conclusions, Suggestions, and Recommendations

1. According to the biological absorption coefficient of biomicronutrients, fallow lands and irrigated soils fall into the categories of weak accumulators (Ax > 1), as well as very weak (Ax < 0.1), weak (Ax = 0.01–0.1), and moderate (Ax = 0.1–1) retainers. The biogeochemical activity index (BGAI) of natural plants growing under gray soil conditions was found to be 6.55 in *Tamarix*, 9.67 in *Karelinia caspia (Pall.) Less*, 10.73 in *Zygophyllum oxianum Boriss*, and on average 14.41 in *Halimocnemis villosa Kar. & Kir*. Among agricultural crops, this indicator was 5.30 mg/kg in wheat, 15.72 mg/kg in melon, and 15.74 mg/kg in cotton.
2. The radial differentiation coefficient (Rd) of cyclic and dispersed elements in the A and B1 soil horizons was observed to range between 1.08 - 1.53. The order of element accumulation according to Rd values was as follows: In fallow (virgin): B > Ba > Pb > Mn, Zn > K > Ni > Fe > Mg > Al > Cu > Co; in irrigated meadow-serozem soils: B > Mg > P > Ca > Na > Cu > K > Al > As > Mn > Fe > Ni > Zn > Co; in serozem-meadow soils: Ba > P > Pb > Zn, Ni > K > Mn > Fe, Na > Co; in meadow soils: B > Al > Zn > Mg > K > Na, Ba > Pb > Fe. This pattern of element accumulation is attributed to hydromorphic processes, and it has been confirmed that the radial differentiation coefficient (Kr < 1) is lower in meadow-gray and meadow soils, indicating weaker radial differentiation in these soil types.
3. Under the conditions of the Mirzachul oasis, in the "soil – natural and cultivated plants" system, the background levels of cyclic elements such as Fe, Ca, Na, K, Mo, Mn, Ba, Sr, Zn, Ni, Co, Mg, Al, B, P, Cu, Pb, and As, as well as dispersed elements including Rb, Cs, Ga, and Li, play a fundamental role. These background concentrations serve as a basis for the geochemical and biogeochemical characterization of fallow lands and irrigated soils, soil geochemical and ecological monitoring, the selection and optimal placement of high-yield agricultural crops, and the production of environmentally friendly (ecologically clean) agricultural products.

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