Int.J.Curr.Microbiol.App.Sci (2025) *14*(03): 1-5

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 14 Number 3 (2025)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2025.1403.001

Biogeochemistry of Microelements (Mn, Zn, Mo) in Typical Gray Soils in Uzbekistan

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Keywords

Medicinal plant, arable layer, microelement, typical gray, anzur onion

Article Info

Received:
12 January 2025
Accepted:
22 February 2025
Available Online:
10 March 2025

A B S T R A C T

In this study, the amount of Mn, Zn, Mo, and biogeochemical properties and biological absorption coefficients were determined in the topsoil layer of typical irrigated gray soils formed in the territory of the Tashkent Botanical Garden named after F.N.Rusanov under the Institute of Botany of the Academy of Sciences of the Republic of Uzbekistan and in the composition of the organs of the Anzur onion (*Allium suworowii* Regel.) plants were calculated and analyzed. This served as the basis for ensuring normal plant growth.

Introduction

Currently, extensive measures are being taken to study and cultivate medicinal plants to protect and prevent the health of the population of the Republic of Uzbekistan. In addition, modernization of agriculture, efficient use of land resources, irrigated soil cover, improvement of ecological and reclamation conditions, preservation, restoration, and increase in fertility, as well as cultivation and cultivation of highly medicinal plants of various families remain an important task in our country. This is why the great ancient scholar Abu Ali Ibn Sina, who said that soil is the basis of life and death of living beings, especially emphasized in his works. These views are also being proven in current scientific research and have not lost their relevance.

It is well known that studying the amounts of essential nutrients found in the soil formed under different climatic conditions and increasing their fertility levels is one of the most important and urgent issues. Several scientific studies have been conducted in this regard. However, their study required clear procedures and research (Isomiddinov Jaloldinovich *et al.,* 2024; Yahaya *et al.,*

2010). According to their region of distribution in nature, they are the most essential microelements found in various types of soil and plants.

Numerous scientific studies have been conducted on the importance and distribution patterns of microelements in the soil and plants.

In addition, the specific characteristics of the chemical element composition of podzolic and alluvial soils formed on Sakhalin Island were determined. Podzolic soils were relatively low in Mn, Ni, Cu, and Zn, whereas alluvial soils were significantly higher in Na, K, Mg, and Zn (Vodyanitskii *et al.,* 2015). Separate scientific data are provided on the importance of Mn, Zn, Cu, Co, Ni, Cr, Pb, Cd, and Fe found in soil and plant composition (Sosorova *et al.,* 2012).

Additionally, the lack of minerals and vitamins necessary for the human body can lead to the development of various diseases. Therefore, it has been established that the presence of sufficient amounts of Co, Cr, Cu, Fe, Mo and Zn microelements in the soil directly affects the quality of plant yields and is necessary for the human body (Krasilnikov *et al.,* 2021). At the same time, quantitative differences in the microelements (Mn, Zn, Cu, Co, Ni, Cr, Pb, and Cd) and Fe present in the soil and plants of the Kotokel Lake basin were studied (Sosorova *et al.,* 2012). The microelement composition of mountain brown soils in the Chornohir and Marmaro reserve massifs has been studied for Pb, V, Cr, Zn, Mn, and Cu (Vodyanitskii *et al.,* 2015).

In particular, although the trace elements detected in the vegetative and generative organs of the medicinal onion Anzur grown in irrigated typical gray soils are small in quantity, their detection and analysis, determination of the fertility of typical gray soils, their connection with nutrients, and determination of the direction of chemical processes are of theoretical and practical importance. Therefore, the study of the distribution, migration, and biogeochemical properties of trace elements present in the soil-plant composition and considered necessary is an urgent problem.

Materials and Methods

Typical irrigated gray soils and anzur onion (*Allium suworowii* Regel.) plants formed under climatic conditions in the territory of the Tashkent Botanical Garden, named after F.N. Rusanov under the Institute of Botany of the Academy of Sciences of the Republic of Uzbekistan, were selected as the object of research.

As the main method of research, the microelement composition of soil and anzur onion was analyzed by the neutron-activation method. During the activation analysis at the Ecology and Biotechnology Laboratory of the Institute of Nuclear Physics of the Republic of Uzbekistan, samples were irradiated in a nuclear reactor with a neutron flux of 5×10^{13} neutrons/cm^2 s, and their amounts were determined based on the half-lives of the chemical elements.

Results and Discussion

The morphological cross-section of typical irrigated gray soils distributed in the Tashkent Botanical Garden, named after F.N.Rusanov under the Institute of Botany of the Academy of Sciences of the Republic of Uzbekistan, is unique, with a sod layer, light gray, moist, weakly compacted, granular, and crumbly structure. Various plant root and earthworm extracts were abundant. The soil is heavily worked on by soil animals and has a two-layer structure. Its thickness, depending on the length of the irrigation period, was 0-25 cm. The subsoil layer is light gray, moist, medium, and heavy, with a fine-grained structure, rich in roots, and many worm tracks. Small stone fragments of various sizes were also observed.

The relative distributions of Mn, Zn, and Mo trace elements in the plow layer of the soil cross section were observed.

Typical irrigated gray soils are characterized by varying degrees of variation in the amount of trace elements in the surface layer and in the organs of the Anzur onion (*Allium suworowii* Regel) plant.

The studied microelements Mn, Zn, Mo were found to be present in the surface layer of the soil in the amounts of manganese (Mn) 680 mg/kg, zinc (Zn) 9 mg/kg, molybdenum (Mo) 0,23 mg/kg. In addition, according to Vinogradov, each of the studied microelements was observed to be less than that of the soil clarke.

It was found that the microelement composition of the organs of the medicinal onion (*Allium suworowii* Regel.) Plant changes depend on the amount of microelements in the soil (Table1, Figure1). In particular, it was found that manganese (Mn) is distributed in the organs of the medicinal onion (*Allium suworowii* Regel.) plant in the

amounts of 10.9 mg/kg in the ripe onion head, 5,25 mg/kg in the stalk, 82,6 mg/kg in the leaf, and 42,2 mg/kg in the seed. The element zinc (Zn) was found to be present in the ripe onion head at 19,7 mg/kg, in the stalk at 9,92 mg/kg, in the leaves at 19,4 mg/kg, and in the seeds at 73,8 mg/kg, while molybdenum (Mo) was found to be present in the ripe onion head at 0,51 mg/kg, in the stalk at 0,96 mg/kg, in the leaves at 8,27 mg/kg, and in the seeds at 0,37 mg/kg.

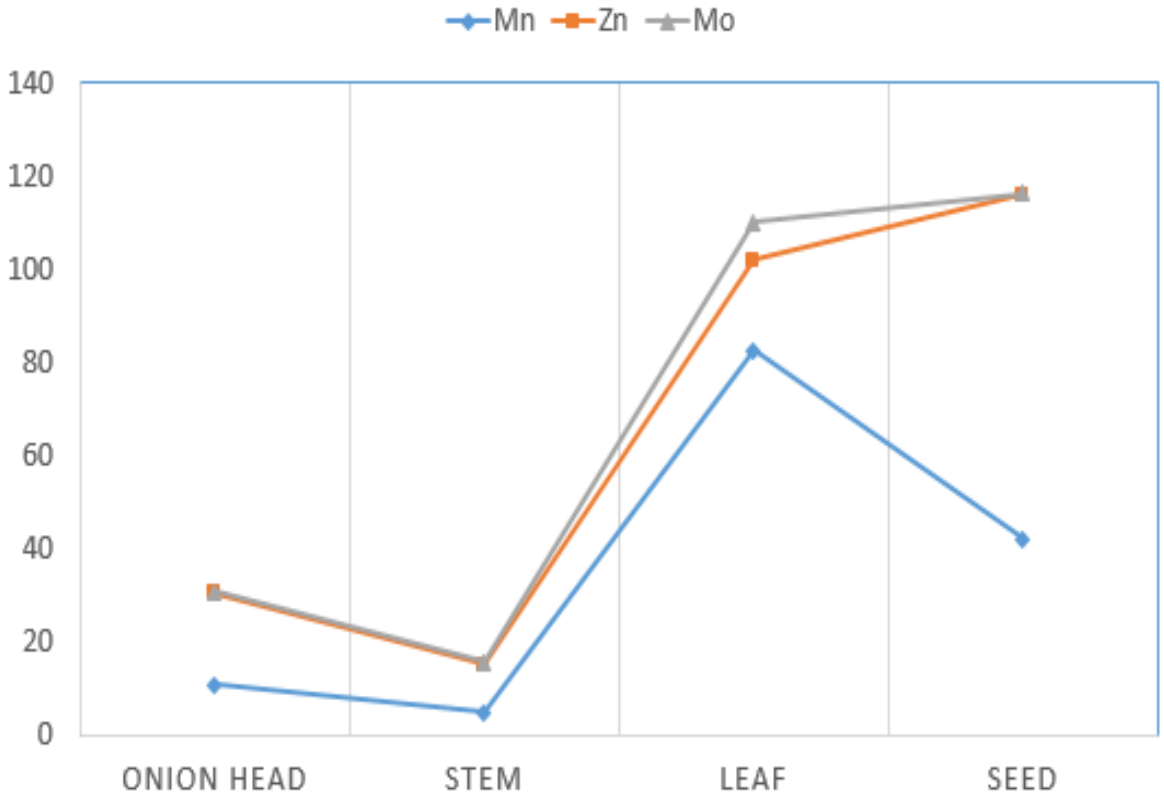
The biological absorption coefficient characterizes the biogenic migration processes. Biogenic migration is involved in the absorption of mobile elements, and the turnover of small biological substances is observed. Plants absorb chemical elements from the soil in different phases and organs.

According to the biological absorption coefficient, the trace elements detected in the composition of typical gray soils were observed in the organs of the medicinal onion (*Allium suworowii* Regel.), with the largest amount of molybdenum (Mo) varying from 1,60 to 35,9 mg/kg, and the smallest amount of manganese (Mn) varying from 0,007 to 0,12 mg/kg.

Table.1 Micronutrient content of typical gray soils and Anzur onion (Allium suworowii Regel) plants, mg/kg (n=5)

Element	Soil 0-25 cm	Allium suworowii Regel				Bioavailability coefficient			
		Onion head	Stem	Leaf	Seed	Onion head	Stem	Leaf	Seed
Mn	680	10,9	5,25	82,6	42,2	0,01	0,007	0,12	0,06
Zn	9,0	19,7	9,92	19,4	73,8	2,2	1,10	2,15	9,2
Mo	0,23	0,51	0,96	8,27	0,37	2,2	4,2	35,9	1,60

Figure.1 Changes in the content of microelements in the composition of the Anzur onion (*Allium suworowii* Regel) plant



Typical gray soil and medicinal onions (*Allium suworowii* Regel.) plants absorbed more microelements found in the roots, stems, and seeds than in the bulb. The absorption of manganese (Mn), which has the highest value in the soil, by the onion organs was higher than that of other elements in the soil environment.

All microelements contained in the soil changed in the body of the onion plant. However, there are certain patterns of their accumulation in the vegetative organs of plants. The highest levels of elements were detected in the leaves and roots of onion plants, and the leaves occupied an intermediate norm. The onion seeds were characterized by the highest storage of the elements.

The chemical elements are the main source of nutrients for the onion (*Allium suworowii* Regel) plant, which ensure that all the elements present in it are sufficient and in moderation, allowing the plant to grow normally and produce high-quality crops. In cases where the amount of elements in the soil is insufficient, microelements can also be supplied to the plant as nutrients in solution by spraying them on the leaves or by applying them to the soil.

There is an integral biogeochemical relationship between typical irrigated gray soils and the elemental composition of Anzur onions. All the microelements present in the soil were found in the studied onions, although in different quantities. The decrease in the amount of microelements in the surface layer of irrigated typical gray soils followed the order Mn>Zn>Mo. In the organs of the Anzur onion plant, it was determined that the following order is observed: in the onion head, Zn>Mn>Mo, in the stem, Zn>Mn>Mo, in the leaves, Mn>Zn>Mo, and in the seeds, Zn>Mn>Mo. This change is consistent with the law of selective absorption of the microelements from the soil.

Author Contributions

ZI and MI, MU contributed to the design and implementation of the research; AM analyzed the results and wrote the manuscript.

Data Availability

Not applicable.

Funding Statement

The authors did not receive any funding for this study.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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How to cite this article:

Zokirjon Isomiddinov Jaloldinovich, Murodjon Isagaliev Tuychiboevich, Usmonova Mukhayyoxon Sobirjonovna and Abdupattoeva Mubinabonu Sobitali Qizi. 2025. Biogeochemistry of Microelements (Mn, Zn, Mo) in Typical Gray Soils in Uzbekistan. *Int.J.Curr.Microbiol.App.Sci.* 14(03): 1-5.
doi: https://doi.org/10.20546/ijcmas.2025.1403.001