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The Microelement Composition of Typical Grey Soils in the Kashkadarya Basin

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Abstract This paper discusses the microelement composition of the soils in the typical grey soil region of the Kashkadarya Basin, including virgin typical grey, rainfed typical grey, and irrigated typical grey soils. The reduction in mobile microelement concentrations follows the sequence **Mn > Zn > B > Cu**, which is directly associated with irrigation processes.

Keywords Microelements, Grey soils, Biogeochemical, Morphogenetic, Lithosphere, Clark, Mechanical composition, Plants, Soil

1. Introduction

Soil serves as the primary reservoir of chemical elements necessary for all living organisms. Despite their minimal quantities in soils, microelements perform vital biochemical roles. An imbalance in their levels, either excessive or deficient, can disrupt intermediate metabolism in plants or animals, leading to diseases. The study of microelement composition and migration in geographical landscapes is crucial due to the significant variability in concentrations driven by environmental conditions (Dobrovolskiy, 1999) [1].

The concentration of essential elements in soils is an important indicator of the region's biochemical status. Furthermore, understanding the microelement composition of soils is necessary for:

Assessing plant nutrient requirements.

Addressing soil pollution issues.

Supporting sustainable agricultural practices (Aleksandrova, 2015) [2].

2. Findings

1. **Microelement Distribution Sequence:**
   - Across all three soil types (virgin, rainfed, and irrigated), the sequence of microelements based on mobility is **Mn > Zn > B > Cu**.
2. **Irrigation Impact:**
   - The variations in microelement mobility are strongly linked to irrigation practices, indicating the need for targeted soil management strategies.
3. **Importance of Microelements:**
   - These elements, despite being present in trace amounts, significantly affect soil fertility and plant productivity. Their availability is influenced by soil type, genesis, and irrigation practices.
4. **Recommendations for Fertilization:**
   - The study recommends applying microelement-enriched fertilizers tailored to the specific deficiencies in rainfed and irrigated soils to optimize crop yields.

3. Material and Methods

In our study, the microelement composition of virgin, rainfed, and irrigated typical grey soils in the Kashkadarya basin was investigated.

The research was conducted under field, laboratory, and analytical conditions, following standard methods commonly accepted in soil science. The methodologies included morphogenetic, biogeochemical, chemical-analytical, and profile approaches.

Chemical analyses were carried out in accordance with E. Arinushkina's manual, "Rukovodstvo po khimicheskomu analizu pochv" (Guide to Chemical Analysis of Soils).

This systematic approach ensured precise and reliable results regarding the distribution and mobility of microelements in the studied soils.

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4. Results and Discussion

Microelements play a critical role in the growth, development, and productivity of agricultural crops, as well as in improving soil fertility. Elements such as **Boron (B), Copper (Cu), Zinc (Zn), Manganese (Mn), Molybdenum (Mo), and Chromium (Cr)** are classified as **biomicroelements** due to their physiological significance, contribution to soil fertility, and enhancement of crop yield [3.27; 46-b.] [4].

The focus on these elements is heightened in irrigated agricultural systems, where their properties and behavior are relatively well studied. However, from a **biogeochemical perspective**, research on these elements remains limited (Turdaliyev A.T., et al., 2017; 100-103-b.) [5].

Microelements and Agricultural Productivity

Numerous researchers have established correlations between the availability of mobile microelements and the productivity of agricultural crops. According to Yu.A. Azarenko [2.4; 87-b.] [6], the distribution of microelements depends on **bio-climatic**, **geo-morphological**, and **hydrogeological** factors.

M.T. Isagaliyev's studies in the **Fergana Valley** revealed notable differences in the migration and accumulation of biomicroelements in irrigated soils. For instance, manganese predominates in the plow layer of dark, typical, and light grey soils, but its share decreases in deeper layers, where zinc becomes dominant [7].

Deficiency of Key Microelements

A lack of microelements such as **Cu, Zn, Mn, and B** in soils negatively impacts crop productivity. The availability of these microelements in soil is influenced by:

- The **parent material** of the soil.
- The degree of **soil cultivation** and cultural practices.
- The specific **soil type** and **subtype**.

Findings on Microelement Distribution

In this study, the total and mobile concentrations of Cu, Zn, Mn, and B in irrigated grey soils were found to differ significantly depending on soil layers. This differentiation is directly related to the **mechanical composition** of the soils:

- **Cu, Zn, Mn, and B concentrations** are most pronounced not only in the plow and sub-plow layers but also throughout the agro-irrigation layer.
- The mechanical composition of the soil influences the differentiation of these elements.

This indicates the importance of understanding the role, distribution, and reserves of microelements during the formation of grey soils.

Threshold Concentrations for Optimal Plant Nutrition

Based on microelement grading established by E.K. Kruglova et al. [2.54; 252-b.] [8]:

- Mobile **Cu**: 0.4–0.8 mg/kg.
- Mobile **Zn**: 1.5–2.5 mg/kg.
- Mobile **Mn**: 80–100 mg/kg.
- Mobile **B**: 0.8–1.2 mg/kg.

These concentrations are sufficient for optimal nutrition of cotton and other crops.

Research by J.M. Qo'ziev [2.63; 25-b., 3.27; 46-b.] emphasizes that the distribution of microelements in grey soils of the Kashkadarya basin is influenced by:

1. Soil genesis.
2. Mechanical composition.
3. Intensive agricultural practices.
4. Irrigation systems.

Soil Mechanical Composition and Microelement Mobility

- **Light-textured soils**: Microelements tend to leach into deeper layers.
- **Heavy-textured soils**: Microelements accumulate more in the surface layers.
- **Medium-textured soils**: Microelements are distributed more uniformly across soil layers.

This detailed understanding of microelement behavior provides a foundation for designing targeted agricultural practices to enhance soil fertility and crop productivity.

Copper (Cu) in Irrigated Typical Grey Soils

- The total copper content in the layers of irrigated typical grey soils ranged between **25.0–45.0 mg/kg**, while the subsoil layers contained **18.0–35.0 mg/kg**.
- The copper distribution showed a gradual decrease from the surface to the lower layers.
- Copper tends to accumulate in **oxidation** and **evaporation barriers**:
  - **Evaporation barriers** corresponded to the plow layers.
  - **Oxidation barriers** were observed approximately below 50 cm.
- Mobile copper content:
  - **Plow and sub-plow layers**: 0.35–0.77 mg/kg.
  - **Transitional layers (42–105 cm)**: 0.35–0.49 mg/kg.
  - These levels fell within the "acceptable" range (0.40–0.80 mg/kg), except for lower layers (<50 cm), where copper content increased to 0.89–0.95 mg/kg, indicating a **highly enriched group**.

Zinc (Zn) and Its Correlation with Copper

Copper and zinc often migrate and accumulate together due to their classification as **chalcophile elements** and **paragenetic partners**. Thus, zinc is commonly found where copper is present.

- Total zinc content:
  - **Plow and sub-plow layers**: 45–98 mg/kg.
  - **Lower layers**: 28–65 mg/kg.

Manganese (Mn) and Boron (B) in Soil Profiles

- **Manganese (Mn):**
  - Total manganese in soil profiles ranged from **864–1000 mg/kg**.
  - Mobile manganese content was higher in the lower layers (**105.17–126.04 mg/kg**) than in the plow and sub-plow layers. This is attributed to the **leaching effect**

of irrigation, which washes away manganese more than other elements or removes it through crop harvests.

- **Boron (B):**
  o Mobile boron content:
  - **Virgin and rainfed soils**: 0.69–1.29 mg/kg in plow and sub-plow layers.
  - **Irrigated soils**: 1.22–1.52 mg/kg in transitional and lower layers, surpassing the "acceptable" range (0.80–1.20 mg/kg).

General Trends in Microelement Distribution

The study revealed consistent patterns in the behavior of mobile microelements across different soil types in the Kashkadarya Basin:

- **Virgin typical grey soils**: Mn > B > Zn > Cu.
- **Rainfed typical grey soils**: Mn > Zn > B > Cu.
- **Irrigated typical grey soils**: Mn > Zn > B > Cu.

This sequence reflects a decrease in the mobility of microelements, primarily influenced by irrigation processes.

5. Conclusions

1. **Copper** accumulates in oxidation and evaporation barriers, while its mobility decreases in deeper layers.
2. **Zinc** shows similar migration patterns due to its paragenetic relationship with copper.
3. **Manganese** content is highest in lower layers due to leaching caused by irrigation.
4. **Boron** levels are relatively higher in irrigated soils, particularly in deeper layers.

The sequence **Mn > Zn > B > Cu** for microelement mobility emphasizes the direct impact of irrigation on soil composition, necessitating targeted soil management and fertilization strategies to ensure crop productivity.

Conclusion

1. Microelement Mobility Trends

In the soils of the typical grey soil region of the Kashkadarya basin—specifically virgin, rainfed, and irrigated typical grey soils—the order of decreasing mobility of microelements follows the sequence **Mn > Zn > B > Cu**. This pattern is directly associated with the irrigation process.

2. Microelement Availability in Soil Types

The microelement content varies significantly across virgin, rainfed, and irrigated soils. For optimal agricultural practices, especially in rainfed and irrigated soils, it is recommended to apply microelement-enriched fertilizers (Mn, Zn, B, Cu) based on the level of microelement availability and crop requirements.

3. Deficiency of Manganese in Rainfed and Irrigated Soils

In rainfed and irrigated typical grey soils, manganese deficiency was observed in the plow and sub-plow layers, with mobile manganese levels classified as "insufficient" (<80 mg/kg).

This deficiency increases the susceptibility of crops grown in these soils to **chlorosis**, a condition that impairs plant health.

To address this, it is essential to apply manganese-containing microelement fertilizers promptly, following established agricultural protocols.

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