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Article

# General Physical Properties of Rainfed Soils in the Northern Part of the Turkistan Range

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**Abstract:** This article examines the general physical properties of rainfed (boghar) soils in the northern part of the Turkestan mountain range. It has been established that over the past period, the general physical properties of these soils have undergone certain changes. The main reasons for this include climate change and the impact of anthropogenic factors, namely the implementation of agrotechnical measures, continuous grazing of large and small ruminants on virgin lands, as well as the use of heavy agricultural machinery, which has negatively affected soil bulk density and total porosity.

**Keywords:** Rainfed Soil, General Physical Properties of Soil, Particle Density, Bulk Density, Total Porosity.

## Introduction

Soil density and the structural condition of the arable layer are among the leading factors determining soil fertility. The density of soil layers influences the formation of structure by defining the size and proportion of aggregates, the air–water ratio, as well as heat exchange processes in the soil and their interrelation. The density of a soil layer depends on its composition, the ratio of aggregates of different sizes, and its particle-size (granulometric) composition. Monitoring the density of soil layers and maintaining them in an optimal condition is of great importance for obtaining high yields from agricultural crops [1].

The physical properties of soil make it possible to characterize the most important processes occurring in typical rainfed serozem soils and play a significant role in determining their fertility. The deterioration of the soil's physical properties complicates the supply of water, nutrients, and air to plants, as well as makes soil cultivation processes more difficult. The particle density of soil, also known as specific gravity, is the ratio of the density of soil solid particles to the density of water. In simple terms, it shows how many times soil particles are heavier than water. It is expressed in g/cm$^3$. Specific gravity is a relatively stable property and does not change significantly over time [2].

In his studies conducted between 1938 and 1942, B.V. Gorbunov provided the first comprehensive description of the chemical and physical properties of serozem soils in the rainfed agricultural zones of the foothill regions of the Turkestan mountain range. His work was based on soilgeomorphological regionalization of these areas and represents an important early contribution to the scientific understanding of soil characteristics in this region. At the same time, he conducted his research in identifying and comparing changes in the soil fertility of serozem soils under conditions uncultivated land and cultivated lands were close to each other. In his research, the author extensively described the genetic characteristics, morphology, chemical composition, water-physical properties, humus and nutrient content, moisture regime, changes in loess during the formation of gray soils, and the causes of compaction in the middle part of the soil cross-section of light, typical, dark, and alkalized (leached) serozem and brown soils [3]. Many scientists have noted in their studies that bulk density and specific gravity, which are among the physical properties of soil, change as a result of erosion and soil cultivation. According to the data obtained, the bulk density in the surface layers of soil is on average 1.31-1.42 g/cm3 on eroded slopes, and 1.30-1.34 g/cm3 on uneroded areas

Soil density varies depending on its mineralogical and granulometric composition, structural state and organic matter, and farming culture. Humus-rich, structured, and mature soils have low density, while humus-poor, structureless soils have high density [4].

## Materials and Methods

The study was conducted on rainfed serozem soils using a field–laboratory approach to evaluate the physical properties of soil, including bulk density, particle density (specific gravity), and total porosity. Eight soil profiles (cross-sections) representing light, typical, and dark serozem soils under both cultivated and uncultivated conditions were selected.

Soil samples were collected from different genetic horizons, including the upper sod layer, sub-sod layer, plough layer, and sub-plough layer. Standard soil sampling procedures were applied to ensure representativeness of the data.

Bulk density was determined using the core method (undisturbed soil samples), while particle density (specific gravity) was measured using the pycnometer method. Total porosity was calculated based on the relationship between bulk density and particle density using standard agrochemical formulas.

The obtained data were statistically analyzed and compared across different soil types, land-use conditions (cultivated and uncultivated), and soil depths to assess variability in soil physical properties.

## Results

The particle density of light serozem soils ranged from 2.70 to 2.75 g/cm$^3$ in the upper layers and from 2.72 to 2.75 g/cm$^3$ in deeper layers. In typical serozem soils, values varied between 2.70–2.75 g/cm$^3$, while in dark serozem soils, the range was 2.72–2.76 g/cm$^3$ across different profiles [5].

Overall, particle density showed minimal variation between soil types and depths, indicating its relative stability as a soil physical parameter.

### Bulk density

Bulk density demonstrated more pronounced variability compared to particle density.

- Light serozem soils: 1.32–1.47 g/cm$^3$
- Typical serozem soils: 1.25–1.39 g/cm$^3$
- Dark serozem soils: 1.22–1.40 g/cm$^3$

Higher bulk density values were observed in uncultivated and eroded soils, while lower values were recorded in cultivated soils with better structure and organic matter content

### Total porosity

Total porosity ranged as follows:

- Light serozem soils: 46–51%
- Typical serozem soils: 49–54%
- Dark serozem soils: 49–56%

Higher porosity was recorded in cultivated soils compared to uncultivated ones, indicating improved soil structure under agricultural management practices [6].

In our studies, the content of the upper sod layer and the sub-sod layer of the light serozem soil was 2.74-2.75 g/cm3, and in the lower layers it was 2.72-2.73 g/cm3, while the second section of the light serozem soil was 2.70-2.71 g/cm3 in the plough layer and sub-plough layer, and in the lower layers it was 2.73-2.75 g/cm3 (Diagram 1). The specific gravity of the 3th cross-section of the typical serozem soil rainfed in the plough layer and sub-plough layer was 2.70-2.71 g/cm3, and in the lower layers it was 2.73-2.75 g/cm3, while the 4th cross-section of the typical serozem soil in the upper sod layer and the sub-sod layer was 2.73-2.74 g/cm3, and in the lower layers it was 2.72-2.73 g/cm3 (Diagram 1) [7]. The specific gravity of the 5th section of the rainfed dark serozem soil in the plough layer and sub-plough layer was 2.72-2.75 g/cm3, and in the lower layers it was 2.74-2.76 g/cm3, while the specific gravity of the 6th cross-section of the protected dark serozem soil in the upper sod layer and the sub-sod layer was 2.72-2.76 g/cm3, and in the lower layers it was 2.73-2.75 g/cm3 (Diagram 1 ). The specific gravity of the 7th cross-section of the heavily uncultivated land de-alkalined dark serozem soil in the upper sod and the sub-sod layer was 2.72-2.74 g/cm3, and in the lower layers it was 2.75-2.76 g/cm3, while the specific gravity of the 8th cross-section of the heavily de-alkalined dark serozem soil in the plough layer and sub-plough layer was 2.74-2.75 g/cm3, and in the lower layers it was 2.72-2.76 g/cm3 (Diagram 1).From the results of these studies, we can see that there was not a huge difference in specific gravity, because specific gravity is not a very rapidly changing indicator [8].

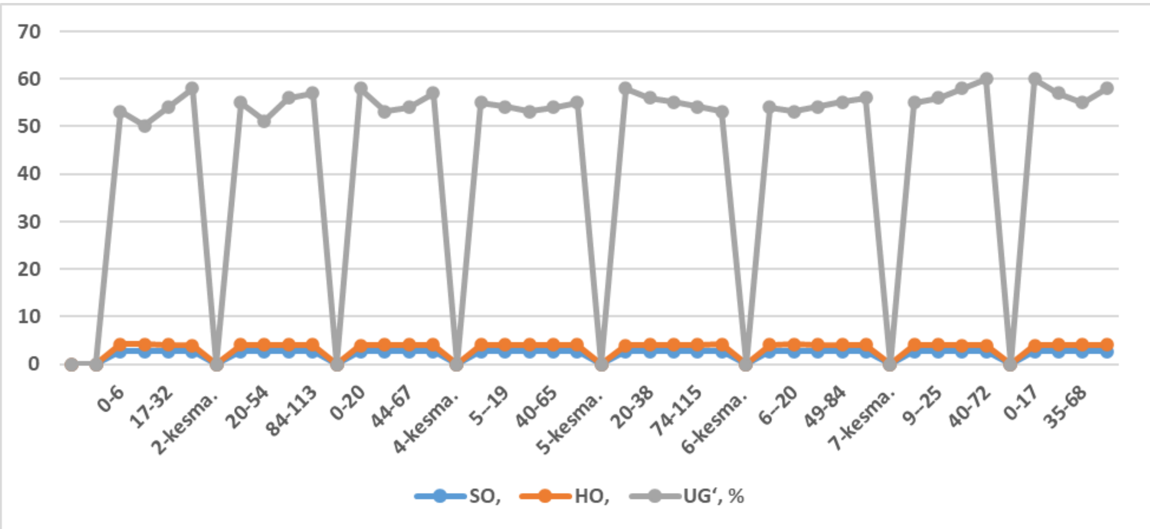


**Figure 1.** General physical properties of rainfed soils (data by D.J. Mamaraimov, 2022-2024).

**General trend.**

The results (Diagram 1) show that soil physical properties vary significantly depending on land use, soil type, and depth. Bulk density and porosity demonstrated stronger sensitivity to management practices, while particle density remained relatively stable [9].

**Discussion**

The obtained results clearly demonstrate that soil physical properties are strongly influenced by agricultural practices and land-use intensity. The relatively stable nature of particle density confirms that this parameter is primarily determined by mineral composition rather than management practices [10-12].

In contrast, bulk density and total porosity showed significant variability, indicating their sensitivity to external factors such as tillage, erosion, organic matter content, and machinery use.

Similar patterns have been reported in previous studies, where soil compaction was associated with increased bulk density and reduced porosity [13].

Lower bulk density and higher porosity in cultivated soils can be explained by improved soil aeration, organic matter accumulation, and regular agrotechnical interventions. Meanwhile, higher compaction in uncultivated or heavily used soils may result from the absence of soil loosening and continuous pressure from natural or anthropogenic factors [14].

The results also confirm that erosion processes contribute to soil degradation by increasing bulk density and reducing pore space, which negatively affects water infiltration, root development, and microbial activity.

From an agronomic perspective, these changes directly influence soil fertility. Increased bulk density reduces oxygen availability for plant roots and limits nutrient uptake, while reduced porosity negatively affects water–air balance in the soil system.

Therefore, maintaining optimal soil structure through appropriate agricultural practices is essential for sustainable soil fertility management in rainfed serozem regions [15].

## Conclusion

The present study analyzed the physical properties of rainfed serozem soils, with particular emphasis on bulk density, particle density (specific gravity), and total porosity across different soil types and land-use conditions. The results demonstrate that particle density remains a relatively stable soil parameter, showing only minor variation across soil profiles and depths, as it is mainly determined by mineral composition.

In contrast, bulk density and total porosity exhibited more pronounced variability depending on soil type, depth, and agricultural management practices. Cultivated soils generally showed lower bulk density and higher porosity compared to uncultivated soils, indicating improved soil structure and better conditions for water–air exchange and root development.

The study confirms that soil physical properties are significantly influenced by agrotechnical measures, organic matter content, and land-use intensity. In particular, long-term cultivation and proper soil management contribute to the improvement of soil structure, while erosion and insufficient management lead to soil compaction and reduced porosity. Overall, maintaining optimal soil physical conditions is essential for sustaining soil fertility and ensuring stable agricultural productivity in rainfed serozem regions. The findings highlight the importance of implementing effective soil conservation and management strategies to prevent soil degradation and enhance long-term agricultural sustainability.

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