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"ECOLOGO-GENETIC FORMATION AND DISTRIBUTION PATTERNS OF MOUNTAIN BROWN SOILS IN THE TURKESTAN RANGE"

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Abstract:

This study investigates the ecologo-genetic formation processes and natural distribution patterns of mountain brown soils developed in the mid-altitude zones of the Turkestan mountain range. Field observations, morphological analyses, and ecological comparison methods were applied. The results indicate that the formation of mountain brown soils occurs under the combined influence of relief, climate, vegetation cover, moisture regime, and parent material. With increasing altitude, climatic conditions become cooler, precipitation increases, and vegetation composition changes, leading to a transformation in the physicochemical properties of the soils. Based on morphological and genetic features, three main subtypes of mountain brown soils were identified: calcareous, typical, and slightly de-alkalized. These findings provide a scientific basis for understanding the ecologo-genetic development patterns of soils in mountainous regions and serve as a foundation for their sustainable use and conservation.

Keywords: Turkestan mountain range, mountain brown soils, ecologo-genetic formation, vertical zonality, relief, climate, vegetation cover, distribution patterns, mountain ecosystems.

INTRODUCTION: Soil resources today have global strategic importance, forming a key component of food security, climate change mitigation, and sustainable development policies. According to the FAO's Global Soil Partnership (GSP) initiative, nearly one-third of the world's soils are affected by degradation, which has a serious impact on ecological balance and the sustainable use of natural resources. Therefore, mountain soils, particularly mountain brown soils that develop under natural ecologo-genetic conditions, are considered one of the most important natural systems requiring global scientific attention and monitoring.

According to the classical theory of soil science, soil formation processes occur under the complex interaction of interrelated natural factors. This principle was first proposed by the Russian scientist V.V. Dokuchaev (1883) and later developed into a scientific model by H. Jenny (1941). Jenny's model emphasized that soil formation depends on the interaction of climate, organisms, relief, parent material, and time. This ecologo-genetic framework is now recognized by the Food and Agriculture Organization of the United Nations (FAO) as a universal model for understanding soil formation processes.

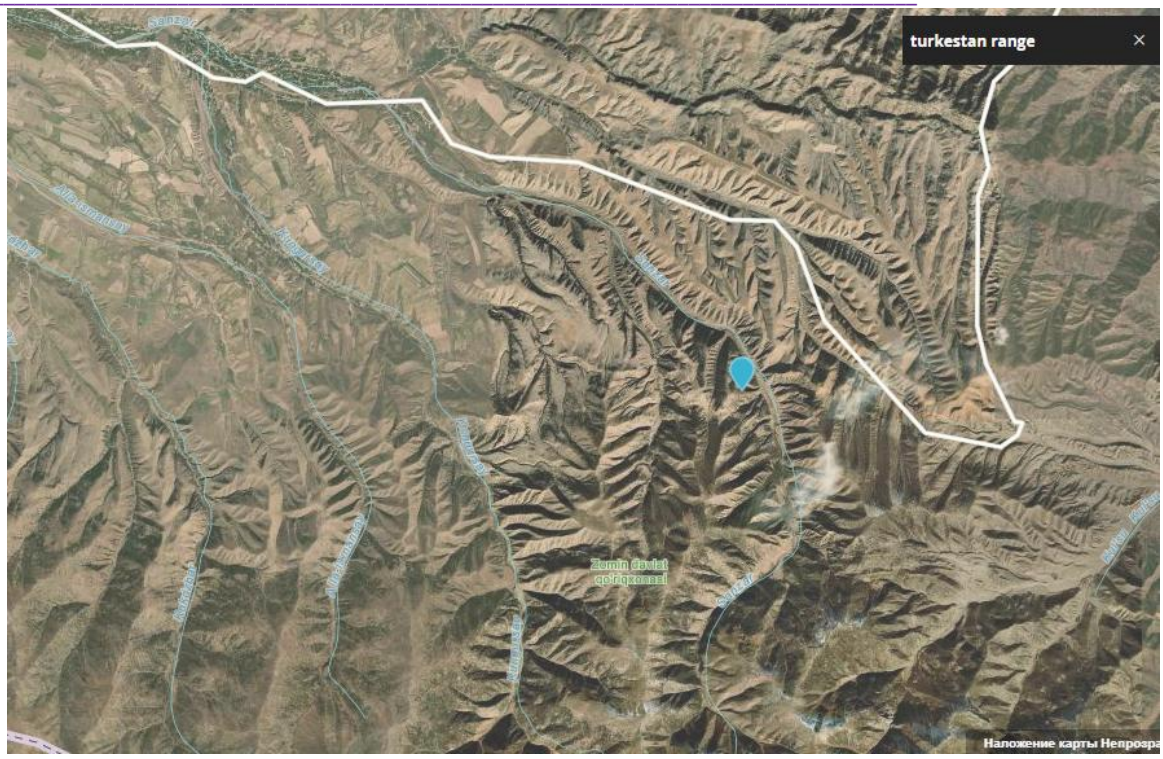
In the Turkestan mountain region, these factors interact harmoniously: with increasing altitude, the climate becomes cooler, precipitation increases, vegetation composition changes, and as a result, soil properties also transform accordingly. In the lower zones, calcareous brown soils prevail; in the mid-altitude belts, typical brown soils dominate; and in the upper zones, slightly de-alkalized brown soils develop. This sequence reflects the fundamental ecologo-genetic mechanism governing the formation and distribution of soils in mountainous environments.

The purpose of this research is to scientifically determine the ecologo-genetic formation processes and natural distribution patterns of mountain brown soils in the Turkestan mountain range. The findings of the study have both theoretical and practical significance for soil science and the management of mountain ecosystems.

THE DEGREE OF STUDY OF THE PROBLEM

Research on the natural–geographical conditions, vegetation cover, and soil formation patterns of the Turkestan mountain range has been conducted systematically since the mid-20th century.

Gorbunov B.V. and Kimberg N.V. (1949) developed a general soil–climatic zonation scheme for Uzbekistan, in which the mountainous regions of the country were classified as areas dominated by brown and dark brown soils. Later, Gorbunov B.V. (1972) provided a comparative analysis of soils in the northern and southern parts of Uzbekistan, scientifically substantiating their genetic differentiation, physicochemical properties, and fertility levels.



Grabovskaya O.A. (1958) studied the morphology, mechanical composition, and moisture regime of the soil cover in the central part of the Turkestan range, identifying the zonal differentiation of soils depending on relief and vegetation variation.

Demurina E.M. (1975) investigated the vegetation cover of the western part of the range and determined its ecological role in soil formation processes, providing an important theoretical basis for the study of soil–vegetation interrelations.

Fakhriddinova M.F. (1998) examined the brown soils of the northern Turkestan range within the Zomin National Nature Park, describing their morphological structure, genetic horizons, and physicochemical composition.

Abdurakhmanov N.Yu. (2004), in his dissertation titled "Soils of Rainfed Lands and Evaluation of Their Fertility (On the Example of the Foothills and Piedmont Plains of the Turkestan Range, Jizzakh Region)", analyzed the morphological and agrobiological features of soils in the foothill and piedmont zones, providing a scientific foundation for fertility assessment.

Kuziev R.Q. and Sektemenko V.E. (2009), in their monograph "Soils of Uzbekistan", comprehensively described the types of mountain soils, their distribution patterns, and ecological characteristics. In addition, Kuziev R.Q., Sektemenko V.E., and Ismonov A.J. (2010) presented in the "Atlas of the Soil Cover of the Republic of Uzbekistan" detailed maps and morphological descriptions of brown soils in the Turkestan range.

Shadieva N. (2017) investigated the humus status and physicochemical properties of humic acids in mountain soils of the Turkestan range, identifying the stable forms of organic matter in their composition.

Ergasheva O.Kh. (2018) studied the pedofauna, biological activity, and biodiagnostics of eroded soils in the northern Turkestan range, demonstrating that soil fauna serves as an important ecological indicator of soil fertility.

At the global level, the FAO (2015) report "Understanding Mountain Soils" emphasized that mountain soils are an essential component of global ecosystem services, playing a vital role in ensuring food security and nutrition for more than 900 million people worldwide..

MATERIALS AND METHODS

The research was carried out on the mid-altitude slopes of the Turkestan mountain range, at elevations between 800 and 2000 meters above sea level. The relief of the study area is characterized by a complex folded structure, formed mainly on eluvial–deluvial and partly proluvial deposits. The average annual precipitation is around 500–600 mm, which has a significant influence on the processes of soil formation.

The main objective of the study was to investigate the ecologo-genetic formation patterns of mountain brown soils. To achieve this, field observations, morphological analyses, and ecological comparison methods were applied. Soil profiles were excavated on the northern slopes of the Turkestan range, within the Bakhmal district of the Jizzakh region. For each profile, the color variations, thickness of the humus horizon, mechanical composition, presence of carbonates, parent material characteristics, and slope exposure were examined.

Based on the collected field data, it was determined that the formation of mountain brown soils under altitudinal zonation conditions occurs through the combined influence of relief, moisture, and vegetation cover. The obtained results provide a scientific basis for understanding the ecologo-genetic development patterns of soils in the mountainous regions of the Turkestan range.

Figure 1. *Study area map of the Turkestan mountain range showing the main research site in the Bakhmal District, Jizzakh Region (800–2000 m a.s.l.).(Source: compiled by author based on Google Earth imagery)*

RESULTS AND DISCUSSION

The results of the study show that the formation and spatial distribution of mountain brown soils in the Turkestan mountain range are determined by the complex interaction of relief, climate, vegetation cover, parent material, and anthropogenic factors. These soils occur above dark gray soils, mainly on moderately folded mid-altitude slopes and on deluvial–eluvial deposits, at elevations between 800 and 2000 meters above sea level. Their formation is strongly influenced by the amount of annual precipitation (500–600 mm), the decrease in temperature with altitude, and the exposure of the slopes to solar radiation.

Soil Subtypes and Morphological Characteristics

The mountain brown soils are divided into three main subtypes: calcareous, typical, and slightly de-alkalized mountain brown soils. These subtypes are closely interrelated and form a continuous vertical zonality system, reflecting gradual transitions along the altitudinal gradient.

Calcareous mountain brown soils are distributed in the lower altitudinal zones (800–1300 m) and are bordered by dark gray soils below. These soils are characterized by the accumulation of carbonates in the lower horizons, weak leaching processes, and a loamy or sandy-loam texture.

Typical mountain brown soils occur between 1300 and 1600 m, where the parent rocks are mainly loess, limestone, sandstone, and shale. In this zone, the average annual precipitation is about 500–600 mm, and the vegetation consists mainly of mixed shrubs and ephemeral grasses.

Slightly de-alkalized mountain brown soils are found at elevations of 1700–2000 m, predominantly on northern and northeastern slopes with relatively gentle gradients. Their formation is strongly influenced by high moisture content, increased precipitation, and reduced solar radiation.

Geological and Lithological Conditions

The parent materials of these soils consist mainly of Paleozoic formations, including sandstone, shale, limestone, diorite, and granite, as well as Quaternary loess and proluvial–deluvial deposits. The lithological composition defines the mechanical texture, water regime, and the depth of carbonate accumulation. The folded and erosional-denudational relief structure significantly affects soil thickness, drainage, and profile stability, shaping the genetic diversity of the soil cover across the mountain range.

Impact of Vegetation and Biological Factors

The vegetation cover in the Turkestan mountain range changes with elevation, following a clear pattern of vertical zonation. In the altitudinal range of 1200–2000 meters, the dominant vegetation consists of juniper forests (Juniperus seravschanica, J. semiglobosa, J. turkestanica), as well as shrub and meadow-steppe communities. Juniper roots form a dense sod layer that prevents erosion and promotes humus accumulation. Vegetation diversity and density enhance organic matter input and improve soil aggregation and water infiltration.

As elevation increases, plant species composition shifts toward mesophytic and alpine grassland species, resulting in increased humus content and more active soil-forming processes. Thus, vegetation plays a crucial role in stabilizing soil structure and regulating nutrient cycling in mountain ecosystems.

Human Impact and Anthropogenic Processes

In recent decades, the Bakhmal district of the Turkestan mountain system has experienced increasing anthropogenic pressure due to agricultural expansion, livestock grazing, and deforestation. Continuous use of sloping lands for rainfed agriculture has led to a decline in natural fertility, reduction of humus reserves, increased soil compaction, and enhanced water and wind erosion.

Anthropogenic activities have altered the natural balance of soil processes, reducing biological activity and the soil's capacity for self-restoration. Overgrazing, excessive tillage, and unsustainable irrigation practices disrupt the ecological equilibrium and accelerate degradation. Therefore, sustainable land management, afforestation, and erosion control measures are vital to preserve the ecological and productive stability of mountain brown soils.

CONCLUSION

The ecologo-genetic formation of mountain brown soils in the Turkestan mountain range is a result of the combined influence of climatic, geomorphological, lithological, biological, and anthropogenic factors. With increasing altitude, changes in temperature, precipitation, and vegetation composition lead to a stepwise differentiation of soil properties. Consequently, mountain brown soils serve as a sensitive indicator of the natural and ecological conditions of the Turkestan mountain ecosystems.

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