Volume 3, Issue 11, November - 2025
ISSN (E): 2938-3781

Web of Agriculture: Journal of Agriculture and Biological Sciences
webofjournals.com/index.php/8

EFFECTS OF SLOPE EXPOSURE ON CARBONATE ACCUMULATION AND THE DEVELOPMENT OF ALKALINITY CONDITIONS IN DESALINATED MOUNTAIN BROWN SOILS

Baxtiyor Ergashev,
Junior Researcher Institute of Soil Science and Agrochemical Research
E-mail: ebaxtiyor300@gmail.com

Giyos Abduvoxidov
(PhD) in Agricultural Sciences, Senior Scientific Researcher
The Scientific Research Institute for Cotton Breeding,
Seed Production and Cultivation Agrotechnologies
E-mail: giyos981589@mail.ru

Abstract
This study examines the effect of slope exposure on the vertical distribution of carbonates and the development of alkalinity conditions in desalinated mountain brown soils of the Turkistan range. Soil samples collected from watershed, south-facing, and north-facing slopes were analyzed for carbonate (CO_2%) and pH values. The findings indicate that slope exposure significantly influences soil heat–moisture conditions, thereby affecting carbonate migration and alkalinity formation within the soil profile.

Keywords: Slope exposure, carbonates, alkalinity, pH, desalinated mountain brown soils, Turkistan Mountains.

Introduction

The complex relief of the Turkistan mountain system, together with variations in altitudinal zones and climatic conditions, determines the diversity of soils formed across the region. Among these, desalinated mountain brown soils are widespread in the dry mountainous steppe zone and typically occur at middle and upper elevations. Their development is shaped not only by lithological composition and moisture–temperature regimes, but also significantly by the aspect of the slope on which they form.

Slope orientation plays a decisive role in modifying the thermal and moisture conditions that govern pedogenesis. South-facing slopes receive greater solar radiation, resulting in intensified evaporation and rapid moisture loss, whereas north-facing slopes maintain a cooler microclimate that promotes higher moisture retention. As a result, even at the same elevation, soils on different slope aspects exhibit noticeable differences in the vertical distribution of carbonates, the depth of their migration, and the overall alkalinity regime. In desalinated mountain brown soils, where leaching processes are generally weak, carbonate movement and pH formation are especially

Volume 3, Issue 11, November - 2025
ISSN (E): 2938-3781

Web of Agriculture: Journal of Agriculture and Biological Sciences
webofjournals.com/index.php/8

sensitive to these microclimatic contrasts.

Previous studies have shown that the vertical distribution of carbonates in mountain brown soils is strongly influenced by slope exposure. Kuziev et al. (2010) reported that on south-facing slopes, stronger solar radiation and evaporation keep carbonates concentrated in the upper horizons, while on north-facing slopes, greater moisture availability leads to their accumulation in deeper layers. Research conducted in the Chatkal mountain system (Aliboeva et al., 2023) also confirmed that slope exposure directly affects the distribution of organic matter, NPK elements, and carbonates through differences in heat–moisture conditions. Similarly, Raupova et al. (2022) found that the migration of carbonates and the formation of pH regimes in mountain soils depend on infiltration intensity and the moisture regime of the slope.

These findings demonstrate that slope exposure is one of the key environmental factors regulating carbonate migration and alkalinity development in desalinated mountain brown soils. However, despite its importance, pedochemical contrasts among soils formed on watershed, south-facing, and north-facing slopes in the Turkistan range have not been sufficiently investigated. Therefore, identifying the influence of slope exposure on carbonate accumulation and alkalinity formation constitutes an important scientific task. This study aims to address this gap by providing a comprehensive analysis of the chemical properties of soils developed on contrasting slope aspects of the Turkistan mountain system and by elucidating the geomorphological factors that determine their variability.

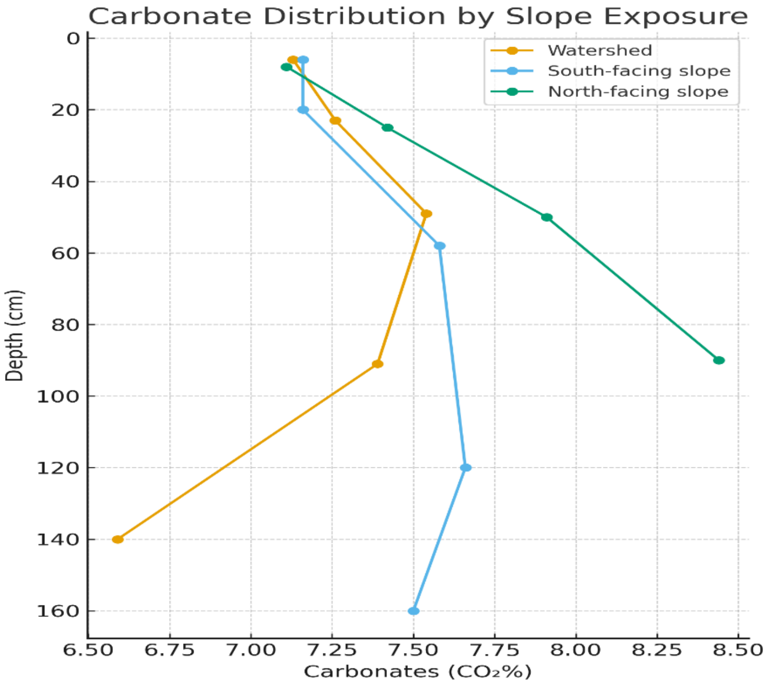
Materials and Methods

The study was conducted on three representative soil profiles located on watershed, south-facing, and north-facing slope exposures. Each profile was fully excavated, and the genetic horizons were identified based on their morphological characteristics. Composite samples were collected from each horizon following standard field sampling procedures.

In the laboratory, carbonate content (CO_2%) was determined using the classical calcimetric method, while soil pH was measured potentiometrically in a 1:2.5 soil–water suspension. The obtained data were analyzed by comparing variations across depths and between the profiles. Calculations and data processing were performed in Excel, and the results were summarized based on mean values and observed trends.

Results and Discussion

The results of the study showed that the vertical distribution of carbonates varied considerably across the three soil profiles. In the watershed profile, carbonate content ranged from 6.59% to 7.54%, gradually increasing with depth. This pattern reflects the weak leaching conditions characteristic of these soils and indicates slow downward migration of carbonate-bearing solutions into the lower horizons.



In contrast, the south-facing slope exhibited remarkably stable and uniformly high carbonate concentrations (7.16–7.66%) throughout the profile. This pattern is attributable to the strong solar radiation load and intensified evaporation characteristic of south-facing aspects, which restrict downward percolation and promote the retention of carbonates in upper and middle horizons. The relative uniformity of carbonate distribution indicates a pedogenic environment dominated by evaporation-driven upward capillary movement.

The north-facing slope displayed the deepest and most pronounced carbonate enrichment, with values peaking at 8.44% in the 50–90 cm horizon. The cooler and more humid microclimate of this exposure enhances infiltration and delays evaporation, allowing carbonate-rich solutions to migrate downward and precipitate at greater depths. This forms a distinct illuvial carbonate zone—a hallmark of pedogenesis under more favorable moisture conditions.

Thus, the aspect-controlled contrast is evident:

South-facing slopes concentrate carbonates near the surface.

North-facing slopes accumulate carbonates in deeper horizons.

Watershed positions represent an intermediate state.

These trends confirm that slope exposure governs the balance between evaporation and percolation, which is the principal mechanism driving carbonate redistribution in these soils.

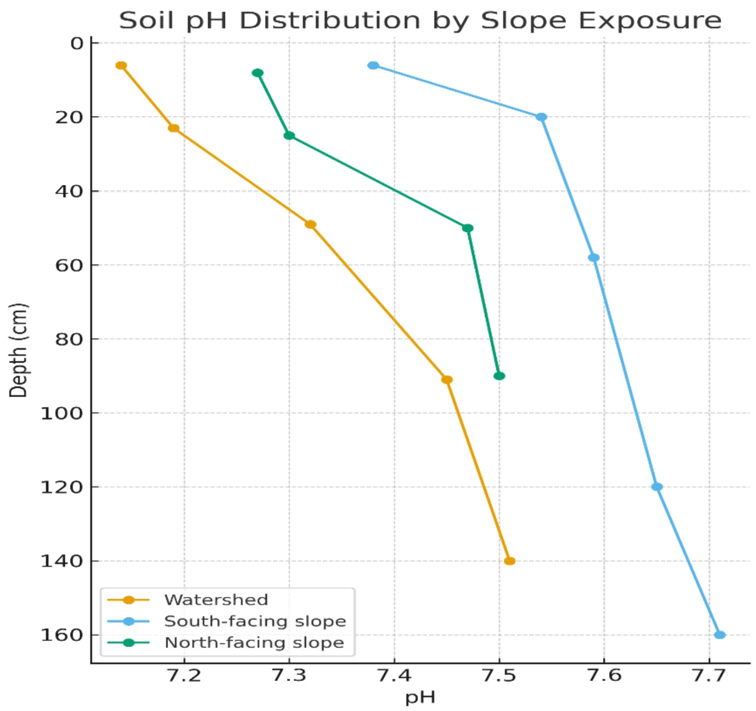
Alkalinity (pH) dynamics and microclimatic gradients

Soil pH values ranged from 7.14 to 7.71, indicating a consistently alkaline environment across all exposures. The watershed profile showed moderate fluctuations (7.14–7.51), demonstrating balanced thermal and moisture regimes without strong dominance of either leaching or evaporative concentration.

The south-facing slope registered the highest alkalinity levels (7.38–7.71). This elevation in pH is directly linked to intense evaporation, which favors the concentration of soluble carbonate forms

Web of Agriculture: Journal of Agriculture and Biological Sciences
webofjournals.com/index.php/8

and reinforces alkaline conditions in upper horizons. The strong correlation between elevated pH and stable carbonate levels in this profile underscores the evaporative nature of south-facing Ped environments.



Conversely, the north-facing slope exhibited slightly lower but still alkaline pH values (7.27–7.50). The cooler, moister conditions on this exposure promote mild leaching and reduce carbonate accumulation near the surface, resulting in comparatively lower pH values. These pH dynamics align with the deeper carbonate maxima found in the profile, confirming a more pronounced downward migration of carbonate solutions.

Overall, the pH regime demonstrates that alkalinity formation is tightly coupled with slope-induced microclimatic contrasts, where temperature and moisture availability shape the intensity of pedochemical transformations.

Integrated pedogenic interpretation

A synthesis of carbonate and pH data highlights several key soil-forming mechanisms:

South-facing slope: High solar load → strong evaporation → carbonate retention in upper horizons → elevated pH.

North-facing slope: Cooler, moister microclimate → greater infiltration → carbonate accumulation at depth → moderately lower surface alkalinity.

Watershed conditions: Balanced heat and moisture → intermediate pedogenic behavior.

Slope exposure as the controlling factor: Aspect dictates the ratio of evaporation to leaching, which in turn determines the direction and magnitude of carbonate migration and alkalinity formation.

These mechanisms collectively demonstrate that aspect is not merely a supporting geomorphic factor, but a primary regulator of pedogenesis in mountain brown soils.

Scientific implications

The pronounced exposure-dependent differences identified in this study have important implications for:

- the assessment of soil fertility and nutrient dynamics,
- predicting erosion and degradation risks on contrasting slopes,
- optimizing land-use planning in mountainous dry-steppe environments,

Conclusion

The findings demonstrate that slope exposure functions as an independent pedogenetic mechanism governing the chemical balance of desalinated mountain brown soils. The study reveals that the vertical positioning of carbonates and the stabilization of alkalinity do not follow a uniform pattern across the landscape, but instead reflect exposure-specific pedochemical dynamics unique to each slope orientation. This approach shows that these soils can be differentiated not only by their morphological features but also by the exposure-driven chemical processes that shape their internal development.

The results indicate that slope exposure can serve as a distinct diagnostic criterion in the pedogenetic interpretation of desalinated mountain brown soils, offering a new scientific perspective for their classification, evolutionary assessment, and agroecological evaluation.

References

1. Kuziev, R. Q., Sektemenko, V. E., & Ismonov, A. J. (2010). Atlas of the Soil Cover of the Republic of Uzbekistan. Tashkent: Academy of Sciences of Uzbekistan.
2. Aliboeva, M., Jabbarov, Z., Fakhrutdinova, M., & Pulatov, B. (2023). Soil organic carbon, NPK and carbonates as affected by topographic aspect at Chatkal State Biosphere Reserve mountains, Uzbekistan. AIP Conference Proceedings, 2612(1), 030025. https://doi.org/10.1063/5.0116225
3. Raupova, N. B., Gulamova, Z. S., & Boboev, F. F. (2022). Change of morphogenetic, chemical and physical properties of soils of vertical zonality of Western Tian Shan under influence of erosion. Galaxy International Interdisciplinary Research Journal, 10(12), 1595–1600.