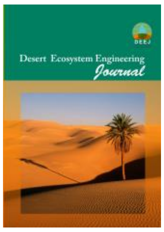
DEEJ (2025) 14 (3) 1-2

University of Kashan

Desert Ecosystem Engineering Journal

Journal homepage: http://deej.kashanu.ac.ir



Assessing Soil Organic Matter Composition and Key Influencing Factors in a Reclaimed Rangeland, Ghahavand Plain

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Received: 11/05/2025 Accepted: 10/11/2025

Extended Abstract

Introduction: Increasing the soil organic carbon (SOC) stock is critically important for mitigating climate change. Soil carbon sequestration is governed by complex interactions between the atmosphere, soil properties, tree species, the chemical composition of litter, and environmental management. Management practices, particularly grazing and enclosure, can significantly alter the chemical composition of SOC. For instance, grazing pressure has been shown to increase the proportion of more readily degradable carbon compounds, such as cellulose. Despite the recognized significance of carbon sequestration in rangeland ecosystems, the chemical composition of soil organic matter (SOM) and its relationship with soil physicochemical properties remain poorly studied.

The rangelands in the Qahavand Plain have experienced severe degradation due to unsustainable exploitation and overgrazing. Compounding this issue, recurrent droughts have accelerated soil erosion and desertification in the region. In response, restoration initiatives were implemented in degraded rangelands using the species *Atriplex canenses* and *Nitraria schoberi*, followed by enclosure management.

Materials and Methods: This study was conducted to investigate changes in organic carbon storage and its relationship with soil organic matter components—specifically cellulose, hemicellulose, and lignin—in the surface and subsurface soils of the restored rangelands in the Qahavand Plain. Sampling was carried out in 2016. A total of 60 soil samples were collected systematically and randomly from two depth intervals: 0-10 cm (surface soil) and 10-30 cm (sub-soil). Various physicochemical properties of these samples were measured.

Prior to statistical analysis, the data were tested for normality using the Kolmogorov-Smirnov test. Variables that violated the assumption of normality were normalized using appropriate transformations: inversion for cellulose, cosine for clay and lignin, and square root for silt and hemicellulose percentages.

Subsequently, a t-test (Proc ttest procedure in SAS v.9.4) was employed to identify significant differences in organic carbon content and other soil properties between the surface and sub-soil layers. Finally, correlation analysis and Principal Component Analysis (PCA) were performed using R and Brodgar software to examine the relationships between organic matter compounds and stored organic carbon.

Results and Discussion: The results demonstrated that soil depth had a significant effect on all measured physical and chemical parameters. Notably, the concentrations of organic matter, cellulose, and lignin were significantly higher in the subsurface soil (10-30 cm) compared to the surface layer (0-10 cm), with increases of 34.75%, 79.12%, and 67.57%, respectively.

Several parameters, including pH, electrical conductivity (EC), bulk density, cellulose, hemicellulose, and lignin, were strongly correlated with soil organic matter (SOM) across both depths. Among these, lignin

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DOI: 10.22052/deej.2025.256798.1105

exhibited the strongest positive correlation (r = 0.84), followed by pH (r = 0.78), hemicellulose (r = 0.72), and cellulose (r = 0.71).

The 34.75% increase in the average SOM content in the subsurface soil represents a significant change, underscoring the positive impact of vegetation restoration. This accumulation is likely driven by increased aerial biomass and litter input from the established *Atriplex canenses* and *Nitraria schoberi*, a finding that supports our initial hypothesis.

The significant relationships observed between SOM and the physicochemical parameters reinforce the central role of organic matter in soil ecosystems. SOM serves as the primary source of carbon and energy for decomposer and heterotrophic microorganisms. Consequently, any reduction in organic matter input can disrupt microbial activity and impede the decomposition process, creating a feedback loop that further limits soil organic carbon sequestration.

Conclusions: In conclusion, this study demonstrates that rangeland rehabilitation in the Qahavand Plain plays a crucial role in enhancing soil organic carbon (SOC) stability and mitigating desertification. The observed relationships between organic matter composition and soil properties, particularly the significant accumulation of the more recalcitrant lignin fraction in the subsurface soil, support this finding. The decomposition process of plant litter typically occurs in two stages: an initial, rapid phase where soluble compounds like cellulose and hemicellulose are broken down, followed by a slower phase governed by the decay of lignin and nitrogen mineralization. Our results, showing a strong correlation between lignin and stable SOC, align with this model and confirm the success of the restoration efforts in building a more stable carbon pool.

Given the context of ongoing climate change, it is recommended that the effects of vegetation restoration on SOC storage be further investigated across other rangeland and forest ecosystems. Furthermore, to enhance carbon sequestration potential and ecosystem resilience in degraded areas like the Qahavand Plain, future restoration programs should consider incorporating alternative native species alongside *Atriplex*.

Keywords: Soil Organic Matter, Carbon Sequestration, SOC Stability, Soil Quality, Desertification.