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INFLUÊNCIA DA MATÉRIA ORGÂNICA NOS ATRIBUTOS MORFOLÓGICOS DE LUVISSOLOS EM ÁREA DESERTIFICADA

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RESUMO: A degradação do solo pode alcançar níveis extremos, culminando na desertificação. No Brasil, cerca de 16% do território é classificado como Área Suscetível à Desertificação (ASD), caracterizada por um índice de aridez entre 0,05 e 0,65. Este estudo foi conduzido em uma ASD localizada na Comunidade Riacho do Brum, Médio Jaguaribe, Ceará. Foram selecionados Luvissolos sob diferentes coberturas vegetais: Área mantida em pousio (AP) desde 2020; Área com práticas conservacionistas (AC) realizadas desde 2014; Área com alto grau de degradação (AD) e horizonte A erodido; e Área com vegetação preservada (AM) e espontânea mais densa, sem práticas agrícolas. Em cada tratamento, foram abertas seis minitrincheiras e foram coletadas amostras dos dois horizontes mais superficiais de cada ponto. As análises morfológicas foram realizadas em campo e o Carbono Orgânico Total (COT) foi quantificado via seca, com analisador elementar. Os resultados indicaram que a quantidade de COT esteve fortemente associada aos aspectos morfológicos de cor (valor e croma), de consistência (seca e úmida) e de plasticidade, reforçando o papel da matéria orgânica como indicadora da qualidade do solo em áreas degradadas.

Palavras-chaves: desertificação, semiárido, aspectos morfológicos

INFLUENCE OF ORGANIC MATTER ON THE MORPHOLOGICAL ATTRIBUTES OF LUVISOLS IN A DESERTIFIED AREA

ABSTRACT: Soil degradation can reach extreme levels, culminating in desertification. In Brazil, approximately 16% of the territory is classified as an area susceptible to desertification (ASD), characterized by an aridity index between 0.05 and 0.65. This study was conducted in an ASD located in the Riacho do Brum Community, Médio Jaguaribe, Ceará. Luvisols under different vegetation covers were selected: areas maintained fallow (AP) since 2020; areas with conservation practices (AC) carried out since 2014; areas with a high degree of degradation (AD) and eroded A horizons; and areas with preserved vegetation (AM) and denser spontaneous vegetation without agricultural practices. In each treatment, six mini-trenches were opened, and samples were collected from the two most superficial horizons of each point. Morphological analyses were performed in the field, and total organic carbon (TOC) was quantified via dry matter analysis using an elemental analyzer. The results indicated that the amount of TOC was strongly associated with the morphological aspects of color (value and chroma), consistency (dry and wet), and plasticity, reinforcing the role of organic matter as an indicator of soil quality in degraded areas.

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Keywords: desertification, semi-arid, morphological aspects

1 INTRODUCTION

Approximately 40% of the planet's land is estimated to have experienced some degree of degradation, meaning that soil degradation directly or indirectly affects approximately 3.2 billion people worldwide. This process is associated with a significant decrease in biodiversity and a loss of agricultural and environmental productivity, resulting in significant socioeconomic impacts estimated at trillions of dollars annually (*Sutton et al.*, 2016). When this degradation reaches more extreme and persistent levels, it can culminate in desertification.

Desertification is defined as soil degradation in arid, semiarid, and dry subhumid regions, resulting from the interaction of natural factors, such as climate variability, and inadequate human activities, including deforestation, overgrazing, unsustainable agricultural management, and intensive use of natural resources (UNCCD, 1994). It is a multifactorial and complex process that affects the physical and chemical integrity of the soil and the consequent maintenance of its ecosystem functions.

This phenomenon is particularly frequent in semiarid regions, which cover approximately 41% of the Earth's surface and are home to more than 250 million people worldwide (Huang *et al.,* 2020). The ecosystem services of these areas, which include climate regulation, nutrient cycling, food production, and biodiversity conservation, increase their socioenvironmental importance (WU *et al.,* 2021). However, its sensitivity to the effects of climate change, combined with anthropogenic pressures, potentiates the occurrence and intensification of the desertification process (Burrell; Evans; Kauwe*,* 2020).

In the semiarid region of Brazil, approximately 16% of the land is considered susceptible to desertification (ASD); these areas encompass areas where the aridity index is between 0.05 and 0.65, and this index is calculated as the ratio between the average annual precipitation and the average annual reference evapotranspiration (Ceará, 2010; Brazil, 2007).

Thus, there is an urgent need to control desertification worldwide because of its negative influence on the achievement of the Sustainable Development Goals, especially the Eradication of Poverty (SDG 1), Zero Hunger and Sustainable Agriculture (SDG 2), and Life on Land (SDG 15), which seek to achieve a balance between socioeconomic development and environmental preservation (Smith *et al.,* 2020).

Given this scenario and the need to understand the interactions between soil attributes and management practices that can favor recovery, the objective of this study was to evaluate the influence of organic matter on the morphological attributes of the most superficial horizons of soils in a degraded area undergoing recovery under different vegetation cover conditions resulting from management.

2 MATERIALS AND METHODS

The study was conducted in the Riacho do Brum Community, which is located in the middle Jaguaribe region of the state of Ceará, Brazil, approximately 238 km from Fortaleza. This region is environmentally and socioeconomically significant because of its location within the semiarid context of Brazil, which is characterized by high climatic variability and soil susceptibility to degradation.

The municipality of Jaguaribe, where the community is located, has an average annual temperature ranging between 26°C and 28°C (Funceme, 2009) and an average annual rainfall of 676.9 mm, with a rainy season from January to April. The predominant climate is classified as hot semiarid tropical and mild hot semiarid tropical according to the Institute of Economic Research and Strategy of Ceará (IPECE, 2017). The estimated potential evaporation is 1,080 mm $year^{-1}$ (Braga; Varejão-Silva, 1990). The irregularity of the rainfall regime and the negative water balances throughout the year, associated with the deciduous vegetation typical of the region,

cause clear differences in the landscape throughout the year.

Since 2012, the Riacho do Brum region has been the target of technical interventions by the Ceará Foundation for Meteorology and Water Resources (Funceme) through the Project for the Recovery of Degraded Areas of the Riacho do Brum Hydrographic Subbasin—Jaguaribe/CE.

For the execution of the work, profiles of Luvissols exposed to four contrasting conditions of land use and vegetation cover were selected: Fallow area (AP) – maintained without agricultural use since 2020, with controlled entry of goats, favoring the partial regeneration of vegetation; Area with conservation practices (AC) – where technical interventions have been carried out by Funceme professionals since 2014; Area with a high degree of degradation (AD) – characterized by having an eroded A horizon, low vegetation cover and no conservation practices; and Area with preserved vegetation (AM) – with denser spontaneous vegetation and no agricultural practices, in a better state of conservation due to the absence of a recent history of agricultural use.

Mini-trenches were opened in each treatment, prioritizing points with greater representation of vegetation development conditions, and materials were collected from the two most superficial horizons of each point.

Morphological analyses included descriptions of horizon thickness and depth, color under dry and wet conditions, texture, consistency (dry, moist, and wet), and structure (degree of development, shape, and size). These analyses were performed in the field, following the Manual for Soil Description and Collection in the Field (Santos *et al.,* 2013) and using the Munsell Color Chart.

Total organic carbon (TOC) quantification was performed by dry combustion in the laboratory using a high-precision elemental analyzer, according to the methodology described by Nelson and Sommers (1996). For statistical analysis, quantitative values were assigned to the hue, structure, and consistency characteristics, which allowed the application of quantitative methods and the performance of correlations between the TOC content and morphological attributes (Silva Júnior, 2025).

The normality of the data was verified using the Shapiro–Wilk test ($p < 0.05$), and in the absence of a normal distribution, Spearman's correlation analysis was performed. All the statistical analyses were performed using statistical software. Analysis Systems – SAS (SAS, 1989).

3 RESULTS AND DISCUSSION

On the basis of Spearman's correlation analysis between total organic carbon (TOC) and the morphological attributes of Luvissols (Table 1), a significant and positive association was observed between some variables and TOC levels, whereas others did not. In particular, dry ($r = 0.40132$; $p = 0.0047$) and wet ($r = 0.36158$; $p = 0.0116$) consistencies were significantly correlated (Table 1), indicating that soils with higher organic matter contents tend to also exhibit greater cohesion and resistance under dry and wet conditions, highlighting their influence on aggregate stability even under unfavorable climatic conditions.

Table 1. Spearman correlation analysis between the TOC content and morphological attributes of Luvisols in a desertified area under different management practices.

Variable	r	p	Association
Thickness	-0.18641	0.2046	Not significant
Hue (dry color)	-0.14697	0.3188	Not significant
Value (dry color)	**-0.42153**	**0.0028**	Significant and negative
Chroma (dry color)	-0.27154	0.0619	Not significant
Hue (wet color)	0.01579	0.9152	Not significant
Value (wet color)	**-0.50697**	**0.0002**	Significant and negative
Chroma (wet color)	**-0.37359**	**0.0089**	Significant and negative
Form (structure)	0.06577	0.6569	Not significant
Size (structure)	-0.04596	0.7564	Not significant
Degree (structure)	**0.27450**	**0.0590**	Positive borderline
Dry consistency	**0.40132**	**0.0047**	Significant and positive
Moist consistency	**0.36158**	**0.0116**	Significant and positive
Plasticity	**0.48740**	**0.0004**	Significant and positive
Stickiness	0.12031	0.4154	Not significant

r: correlation coefficient; p: statistical significance
Source: The authors (2025)

There was a positive correlation with the degree of development of the structure (r = 0.27450; p = 0.0590); the influence of organic matter on water retention capacity and soil fertility through the improvement of soil structure was also noted by Oliveira, Souza & Nascimento (2020), Silva *et al.* (2021) and Silva *et al.* (2023). This result is associated with the ability of organic matter to contribute to the formation and maintenance of a more developed structure, even though the maintenance of the soil organic layer is hampered by the climatic conditions of this region, with rainfall concentrated only within a few months of the year.

Plasticity was positively and significantly correlated with TOC (r = 0.48740; p = 0.0004), reinforcing the idea that organic matter can directly influence the ability of soil to deform plastically without rupture, as observed by Keller and Dexter (2012), who, when the correlation between plasticity and texture and between plasticity and soil organic matter was studied and when soils of similar texture and with different percentages of organic matter were analyzed, revealed a strong correlation between SOM and plasticity, highlighting that soils with a higher organic matter content tend to exhibit greater plasticity because of increased cohesion and water retention in the aggregates.

With respect to horizon color, some variables did not significantly correlate with the TOC content, including dry hue (r = -0.14697; p = 0.3188), wet hue (r = 0.01579; p = 0.9152), and dry chroma (r = -0.27154; p = 0.0619). On the other hand, the dry value (r = -0.42153; p = 0.0028) and wet value (r = -0.50697; p = 0.0002), as well as wet chroma (r = -0.37359; p = 0.0089), were significantly correlated with the TOC content, which can be explained by the darkening of the studied horizons caused by the increase in organic matter content. This effect occurs because of the pedogenetic process of melanization, in which organic matter corroborates the intensification of the dark color in the soil. Similar findings were reported by Silva *et al.* (2024), who studied the carbon stock in the surface horizons of Luvissols, Cambisols and Argisols, and by Barbosa (2024), who analyzed the quality of Luvissols in Ceará.

The other variables evaluated did not significantly correlate with the TOC content, including horizon thickness (r = -0.18641; p = 0.2046), structural shape (r = 0.06577; p = 0.6569), structural size (r = -0.04596; p = 0.7564) and stickiness (r = 0.12031; p = 0.4154), indicating that these morphological attributes tend to be less influenced by organic matter content or that their expression depends

on other factors, such as texture, management and history of land use.

4 CONCLUSIONS

Spearman's correlation analysis revealed a strong correlation between the amount of total organic carbon and color (especially value and chroma) resulting from the melanization process and between the TOC content and the dry and wet consistency and plasticity of the soils. These results confirm the influence of organic matter on the morphological attributes of degraded and recovering Luvisols, reinforcing its role as an indicator of soil quality in degraded areas.

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