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# Vegetation Cover Effects on Soil Organic Carbon Stocks in Arid Steppe Soils of Zmalet El Emir Abdelkader (Tiaret, Algeria)

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***Abstract***
*Steppe soils in the arid Algerian High Plateaus constitute a fragile and understudied edaphic resource whose organic carbon dynamics remain poorly documented at the local scale. This study assessed the physicochemical properties and organic carbon (OC) stock of topsoil (0-30 cm) in the commune of Zmalet El Emir Abdelkader (Tiaret province, Algeria) under three dominant steppe formations: Artemisia herba alba, Stipa tenacissima, and Peganum harmala. Fifteen composite samples (five per plant cover) were collected using a stratified random design and analysed for particle-size distribution, bulk density, pH (water and KCl), electrical conductivity, total and active calcium carbonate, and organic carbon/matter (Walkley–Black method). The soils were predominantly sandy-loam to loamy-sand in texture, loosely structured (bulk density 1.0-1.3 g cm* $^{-3}$*), strongly calcareous, alkaline (pH 8.2-9.4), and virtually non-saline; none of these properties differed significantly among vegetation covers (one-way ANOVA, p > 0.1). Organic carbon stocks over 0–30 cm averaged only 18.96 ± 11.01 t C ha* $^{-1}$ *under Stipa tenacissima and 24.05 ± 10.67 t C ha* $^{-1}$ *under Peganum harmala, both at or below the ~20–25 t C ha* $^{-1}$ *reference range typically reported for Mediterranean arid soils, while Artemisia herba alba held a significantly higher stock of 46.36 ± 6.39 t C ha* $^{-1}$ *(one-way ANOVA, F(2,12) = 11.55, p = 0.0016; confirmed by Kruskal-Wallis, p = 0.0068; Tukey HSD, p < 0.01 vs. both other covers). Total* $CaCO_3$*, organic matter and organic carbon concentrations followed the same significant pattern, whereas S. tenacissima and P. harmala were not statistically distinguishable from one another for any parameter. These results identify vegetation cover - and Artemisia herba alba in particular - as the principal driver of surface organic carbon storage in these arid steppe soils, with direct implications for rangeland carbon management and restoration priorities.*

***Keywords:*** *soil organic carbon stock; steppe soils; vegetation cover; arid land; calcareous soils; Tiaret; Algeria.*

## 1. INTRODUCTION

Soil is far more than an inert physical support for vegetation and human activity: it is a living system whose mineral matrix, water, air and organic fraction jointly determine its functioning and productivity [1]. Within this system, soil organic matter (SOM) plays a central role in fertility, physical structure and water retention capacity [2], and soil organic carbon (SOC) - its main constituent — is widely regarded as an integrative indicator of pedological health, reflecting both fertility status and the resilience of terrestrial ecosystems [3]. Globally, soils store an estimated 1,500–2,400 Pg of carbon, exceeding the combined atmospheric and vegetation pools [4], which gives SOC a strategic role in climate change mitigation [5].

In arid and semi-arid regions, and particularly in the Algerian steppe of the High Plateaus, this issue is especially acute. These rangelands, dominated by xerophytic species such as *Stipa tenacissima*, *Artemisia herba alba* and *Peganum harmala*, protect soils from erosion and regulate biogeochemical cycles [6,7]. However, low rainfall, high temperatures and intense evapotranspiration restrict organic inputs and accelerate mineralisation, structurally limiting SOC accumulation [8]. Compounding this climatic constraint, overgrazing, inappropriate tillage and land clearing progressively degrade these soils, undermining their ecological and productive functions [9]. Reference values place SOC stocks of Mediterranean arid soils below 20–25 t C $ha^{-1}$ in the top 30 cm under natural conditions [10], yet local, quantitative data for the Tiaret steppe remain fragmentary, limiting evidence-based land management.

Against this backdrop, the present study addresses the following research question: to what extent are SOC stocks in the steppe soils of the Zmalet El Emir Abdelkader commune (Tiaret province) shaped by vegetation cover and by intrinsic soil physicochemical properties? Specifically, we (i) quantify SOC stocks and physicochemical properties under three representative steppe formations, (ii) statistically evaluate the influence of dominant vegetation on their distribution, and (iii) examine the relationships between texture, pH, carbonate content and organic carbon storage in this arid pedoclimatic context.

## 2. MATERIALS AND METHODS

### 2.1. Study area

The study was conducted in the commune of Zmalet El Emir Abdelkader, Daïra of Ksar Chellala, Tiaret province, Algeria, located approximately 158 km south-east of Tiaret city (UTM coordinates: X 413,657 - 469,966 m; Y 3,849,539 - 3,897,326 m), covering 120,558 ha of the Algerian High Plateaus. The landscape is dominated by low relief interspersed with the Rechaïga, Nador, Zerga, Metales and Ksar Chellala djebels, with alluvial glacis plains drained by the Oued Smir toward the Oued Touil. Land use combines extensive pastoral rangeland (alfa and *Artemisia* formations, ~27,072 ha) with irrigated and rainfed agriculture along the Oued Touil valley. Soils belong to the Sierozem group, poorly developed, skeletal, and dominated by calcareous parent material, subdivided into modal, calcareous-nodular, and calcareous-crusted subgroups.

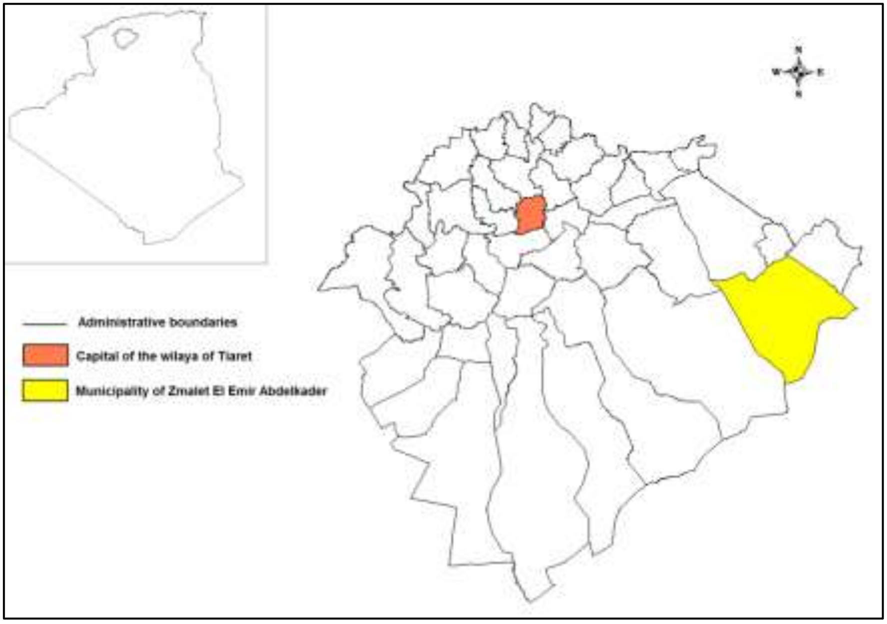

**Figure 1:** Geographical location map of the study area

Climatically, based on the Ksar Chellala meteorological station (2002-2018), mean annual rainfall was 230.04 mm, ranging from 119 mm (2017, driest year) to 404.6 mm (2018, wettest year), with a seasonal regime of autumn > spring > summer > winter (62.5, 60.7, 58.7 and 48.2 mm, respectively). Mean annual temperature was 18.96 °C, with a minimum of 3.11 °C in January and a maximum of 37.95 °C in July. The Bagnouls-Gaussen ombrothermic diagram indicated a dry season extending over almost the entire year, and the Emberger pluviothermic quotient ($Q2 = 22.64$) placed the area in the arid bioclimatic stage with a mild winter.

### 2.2. Soil sampling

A stratified random sampling design was adopted to capture the spatial heterogeneity associated with vegetation type and edaphic conditions while limiting SOC-estimation bias [11]. Three plots were delimited according to their dominant vegetation cover - *Stipa tenacissima*, *Artemisia herba alba*, and *Peganum harmala* - and five topsoil samples (0-30 cm) were collected per plot (n = 15 total) using a hand pedological auger. Samples were geo-referenced, sealed in labelled plastic bags, and transported to the laboratory. After air-drying for two days, samples were gently crushed and sieved to 2 mm; coarse elements were discarded and the fine fraction retained for analysis.

### 2.3. Laboratory analyses

Bulk density was determined by the calibrated cylinder method (205.04 $cm^3$) on the 0-30 cm surface layer. Particle-size distribution (clay < 2 µm, fine silt 2–20 µm, coarse silt 20-50 µm, fine sand 50–200 µm, coarse sand 200–2000 µm) followed the AFNOR NF X 31-107 pipette method [12]. Soil pH was measured potentiometrically in a 1:5 (w/v) suspension in distilled water and in 1 mol $L^{-1}$ KCl, following NF ISO 10390 [13]. Electrical conductivity was measured on the same 1:5 aqueous extract and expressed in mS $cm^{-1}$. Total $CaCO_3$ was determined volumetrically using the Bernard calcimeter [14]; active $CaCO_3$ was determined by ammonium oxalate complexation followed by permanganometric titration of the excess oxalate [15]. Organic carbon was determined by the Walkley-Black wet oxidation method [16,17], and organic matter content was derived using the conventional conversion factor of 1.72.

### 2.4. Soil organic carbon stock calculation

Soil organic carbon stocks (t C $ha^{-1}$) were calculated for the 0-30 cm layer using the standard fixed-depth equation [10]:

$$SOC\ stock\ (t\ C\ ha^{-1}) = OC\ (\%) \times BD\ (g\ cm^{-3}) \times d\ (cm)$$

Where OC is the organic carbon content determined by the Walkley-Black method, BD is the bulk density of the corresponding sample, and d is the sampling depth (30 cm). No correction for coarse fragments (> 2 mm) was applied, as these were removed by sieving prior to analysis and represented a minor fraction of the sampled volume. This fixed-depth approach, while standard practice and directly comparable with most published regional SOC stock data, can introduce a modest bias relative to equivalent-soil-mass approaches when bulk density varies markedly between samples [10]; given the narrow range of bulk density values observed in this study (0.91-1.26 g $cm^{-3}$), this bias is expected to be minor.

### 2.5. Statistical analysis

One-way ANOVA was used to test the effect of vegetation cover on each soil parameter, followed by Tukey's HSD post-hoc test where the ANOVA was significant ($p < 0.05$). Normality (Shapiro-Wilk) and homogeneity of variances (Levene's test) were checked prior to each ANOVA. For electrical conductivity, which violated the normality assumption under *A. herba alba* (Shapiro-Wilk $p = 0.012$, driven by a single high value), the non-parametric Kruskal-Wallis test was used instead, followed by pairwise Mann-Whitney U tests with Holm correction. All analyses were performed in Python (SciPy 1.17).

## 3. RESULTS

### 3.1. Particle-size distribution and texture

Across the 15 samples, sand was the dominant fraction (mean 53.82%; range 16.10-90.65%), followed by silt (mean 36.67%; range 4.50-75.90%) and clay (mean 9.51%; range 0.40-32.75%), placing the soils in the sandy-loam to loamy-sand USDA textural classes. Clay content averaged 5.89 ± 5.14% under *S. tenacissima*, 14.46 ± 14.07% under *A. herba alba*, and 8.18 ± 2.84% under *P. harmala*; however, one-way ANOVA showed no significant effect of vegetation cover on clay ($F(2,12) = 1.27$, $p = 0.316$), silt ($F(2,12) = 0.16$, $p = 0.851$), or sand content ($F(2,12) = 0.001$, $p = 0.999$). The high within-group variance observed under *A. herba alba* (driven chiefly by one sample reaching 32.75% clay) explains the absence of a statistically detectable effect despite the twofold difference in group means.

### 3.2. Bulk density

Bulk density values were uniformly low: 86.67% of samples fell in the “low” class (1.0-1.3 g $cm^{-3}$) and 13.33% in the “very low” class (< 1.0 g $cm^{-3}$); no sample exceeded 1.3 g $cm^{-3}$. Mean values were closely comparable among covers (Table 1), and one-way ANOVA confirmed the absence of a significant cover effect (F(2,12) = 0.52, p = 0.606), indicating that bulk density in this environment is governed primarily by parent material and geomorphology rather than by vegetation type.

### 3.3. Soil reaction (pH)

All samples were alkaline in water: 60% “basic” (pH 7.5-8.5) and 40% “very basic” (pH > 8.5); the difference among covers was not significant (F(2,12) = 0.68, p = 0.525). pH in KCl was systematically higher than in water (80% “alkaline”, 8.1-9.0; 20% “strongly alkaline”, > 9.0), again without a significant cover effect (F(2,12) = 2.07, p = 0.169).

### 3.4. Electrical conductivity

Salinity was negligible overall: 93.33% of samples were “non-saline” (EC < 0.6 mS $cm^{-1}$) and only 6.67% “slightly saline” (0.6-1.2 mS $cm^{-1}$). Mean EC was highest, and markedly more variable, under *A. herba alba* (0.156 ± 0.113 mS $cm^{-1}$) than under *P. harmala* (0.090 ± 0.016) or *S. tenacissima* (0.070 ± 0.007). Because the *A. herba alba* group departed significantly from normality (Shapiro-Wilk, p = 0.012) as a result of one high value (0.35 mS $cm^{-1}$), a Kruskal-Wallis test was used in place of ANOVA and indicated a significant overall effect of vegetation cover (H = 8.42, p = 0.015). Pairwise Mann-Whitney U tests with Holm correction showed that *A. herba alba* differed significantly from *S. tenacissima* (p = 0.031), while neither differed significantly from *P. harmala* (p = 0.103 and p = 0.332, respectively). This result should be interpreted cautiously given its dependence on a single elevated value.

### 3.5. Calcium carbonate content

Total $CaCO_3$ was systematically high, with 73.33% of samples in the “medium” class (10-25%) and 26.67% in the “high” class (25-55%); no sample fell below 10%. Vegetation cover had a significant effect on total $CaCO_3$ (F(2,12) = 13.71, p < 0.001). Tukey's HSD test showed that *A. herba alba* (32.15 ± 7.32%) differed significantly from both *S. tenacissima* (17.72 ± 3.62%; p = 0.0012) and *P. harmala* (19.41 ± 1.21%; p = 0.0031), whereas *S. tenacissima* and *P. harmala* did not differ from each other (p = 0.842). Active $CaCO_3$ was more homogeneous among covers (24.30-27.90%) and showed no significant cover effect (F(2,12) = 0.40, p = 0.681).

### 3.6. Organic matter and organic carbon

Organic matter content was low overall: 20% of samples were “very poor” (< 1%), 46.67% “poor” (1-2%), and 33.33% “medium” (2-4%); no sample reached the “rich” class (> 4%). Organic carbon followed the same pattern, with 33.33% of samples “extremely low” (< 0.7%), 20% “very low” (0.7-1%), and 46.67% “low” (1-1.7%); no sample exceeded 1.7% OC.

Vegetation cover had a highly significant effect on both organic matter (F(2,12) = 10.84, p = 0.0020) and organic carbon (F(2,12) = 11.81, p = 0.0015). Tukey's HSD test showed that *A. herba alba* (OM = 2.538 ± 0.303%; OC = 1.476 ± 0.176%) differed significantly from *S. tenacissima* (OM = 1.022 ± 0.674%, p = 0.0019; OC = 0.595 ± 0.392%, p = 0.0019) and from *P. harmala* (OM = 1.448 ± 0.548%, p = 0.0179; OC = 0.726 ± 0.320%, p = 0.0062). By contrast, *S. tenacissima* and *P. harmala* were not significantly different from each other for either OM (p = 0.438) or OC (p = 0.784), indicating that, statistically, the vegetation covers form two homogeneous groups rather than a three-level gradient.

### 3.7. Soil organic carbon stocks

Expressing organic carbon on an areal basis (0-30 cm) reveals the ecological significance of the vegetation-cover effect more clearly than concentration data alone. Mean SOC stocks reached 46.36 ± 6.39 t C $ha^{-1}$ under *A. herba alba*, compared with 24.05 ± 10.67 t C $ha^{-1}$ under *P. harmala* and 18.96 ± 11.01 t C $ha^{-1}$ under *S. tenacissima* - a 2.4-fold difference between the highest- and lowest-storing covers. Vegetation cover had the strongest effect of all variables tested on SOC stock (one-way ANOVA, F(2,12) = 11.55, p = 0.0016), corroborated by a Kruskal-Wallis test (H = 9.98, p = 0.0068) given a marginal departure from normality under *A. herba alba* (Shapiro-Wilk, p = 0.019). Tukey's HSD confirmed that *A. herba alba* differed significantly from both *S. tenacissima* (p = 0.0019) and *P. harmala* (p = 0.0082), while the latter two did not differ significantly from each other (p = 0.688).

Benchmarked against the ~20-25 t C $ha^{-1}$ commonly reported as a natural reference range for Mediterranean arid soils in the top 30 cm [10], the stocks measured under *S. tenacissima* and *P. harmala* sit at or below this range, consistent with an advanced state of carbon depletion, whereas *A. herba alba* stands well above it. Within-cover variability was also substantial (coefficient of variation: 58.0% under *S. tenacissima*, 44.4% under *P. harmala*, 13.8% under *A. herba alba*), reflecting the fine-scale spatial heterogeneity of carbon storage typical of degraded steppe rangeland, and indicating that *A. herba alba* plots were also the most internally homogeneous in their carbon-storage function.

**Table 1. Mean ± SD physicochemical properties of topsoil (0–30 cm) under three steppe vegetation covers, Zmalet El Emir Abdelkader (n = 5 per cover), with one-way ANOVA/Kruskal-Wallis results.**

| Parameter | *S. tenacissima* | *A. herba alba* | *P. harmala* | Test statistic | p |
|---|---|---|---|---|---|
| Clay (%) | 5.89 ± 5.14 | 14.46 ± 14.07 | 8.18 ± 2.84 | F = 1.27 | 0.316 |
| Silt (%) | 39.90 ± 22.25 | 31.66 ± 20.32 | 38.45 ± 29.35 | F = 0.16 | 0.851 |
| Sand (%) | 54.21 ± 26.11 | 53.88 ± 16.71 | 53.37 ± 28.82 | F = 0.001 | 0.999 |
| Bulk density (g $cm^{-3}$) | 1.112 ± 0.119 | 1.050 ± 0.129 | 1.104 ± 0.046 | F = 0.52 | 0.606 |
| pH ($H_2O$) | 8.488 ± 0.117 | 8.366 ± 0.308 | 8.496 ± 0.091 | F = 0.68 | 0.525 |
| pH (KCl) | 9.056 ± 0.268 | 8.790 ± 0.160 | 8.910 ± 0.177 | F = 2.07 | 0.169 |
| EC (mS $cm^{-1}$) | 0.070 ± 0.007 a | 0.156 ± 0.113 b | 0.090 ± 0.016 ab | H = 8.42 | 0.015 * |
| Total $CaCO_3$ (%) | 17.72 ± 3.62 a | 32.15 ± 7.32 b | 19.41 ± 1.21 a | F = 13.71 | <0.001 * |
| Active $CaCO_3$ (%) | 26.80 ± 7.86 | 27.90 ± 8.03 | 24.30 ± 1.48 | F = 0.40 | 0.681 |
| Organic matter (%) | 1.022 ± 0.674 a | 2.538 ± 0.303 b | 1.448 ± 0.548 a | F = 10.84 | 0.0020 * |
| Organic carbon (%) | 0.595 ± 0.392 a | 1.476 ± 0.176 b | 0.726 ± 0.320 a | F = 11.81 | 0.0015 * |
| SOC stock (t C $ha^{-1}$) | 18.96 ± 11.01 a | 46.36 ± 6.39 b | 24.05 ± 10.67 a | F = 11.55 | 0.0016 * |

*Different superscript letters within a row indicate significant differences (Tukey HSD or Mann-Whitney/Holm, $p < 0.05$). * $p < 0.05$.*

## 4. DISCUSSION

The physical properties of the studied soils - dominant coarse fractions and loose, uncompacted structure - are consistent with earlier characterisations of Algerian *Stipa tenacissima* formations, attributed to selective aeolian erosion depleting fine particles from surface horizons [18]. The absence of a statistically significant cover effect on clay, silt, sand and bulk density corroborates the view that structural soil properties in steppe environments are governed more by parent material and geomorphology than by plant cover [19], as also reported for the wider Algerian High Plateaus [20]. The numerically higher, but non-significant, clay content under *A. herba alba* nonetheless echoes findings from western Algerian *Artemisia* steppes, where dense tussocks are thought to attenuate aeolian erosion and favour fine-particle retention [21]; the high within-group variance observed here suggests this effect, if real, is highly localised rather than uniform across the plot, and a larger sample size would be needed to confirm it statistically.

The generalised alkalinity of these soils (pH 8.2-9.4, not significantly different among covers) is typical of Mediterranean calcimagnesic soils where high $CaCO_3$ content exerts strong buffering [22], and is quantitatively comparable to values reported for *Artemisia herba alba* steppes elsewhere in western Algeria (pH 8.72–8.78; [21]) and for *Stipa tenacissima* rangelands in the Saïda region [23]. The systematically higher pH in KCl than in water - also documented in strongly calcareous soils of the

Algerian High Plateaus [24] - reflects the dominant buffering effect of carbonates on the adsorbing complex [22]. The near-absence of salinity is consistent with the distinction, established for Algerian steppe soils, between non-saline alfa/*Artemisia* rangelands and the halomorphic soils of endorheic depressions [24,25]. The higher and more variable EC under *A. herba alba* - statistically significant only under a rank-based test, and driven by a single elevated value - is compatible with localised evapotranspirative ion concentration between tussocks [26], but given its sensitivity to one data point, we treat it as a tentative rather than a robust finding; targeted resampling around individual *A. herba alba* tussocks would be needed to confirm whether this reflects a genuine ecohydrological process or measurement noise.

The overall deficiency in organic matter and organic carbon corroborates long-standing descriptions of Algerian and North African arid steppe soils, where low biomass inputs combine with rapid summer mineralisation to produce a structural organic deficit [8,24]. Comparable Walkley–Black-derived OC values have recently been reported for pastoral soils in the arid Ghardaïa region of Algeria [27], and low SOC storage under low and erratic rainfall has similarly been confirmed across North African arid/semi-arid rangelands [28]. The central finding of this study - the statistically significant superiority of *A. herba alba* over both other covers in OM, OC, total $CaCO_3$, and SOC stock - mirrors results from western Algerian *Artemisia* steppes, where OM contents of 1.67-2.34% were attributed to sustained soil moisture beneath tussocks, enhanced microbial activity, and slowed decomposition of aromatic litter [21]. Perennial vegetation producing litter rich in secondary compounds is known to slow microbial mineralisation and partially stabilise soil carbon [29], which plausibly explains the significantly elevated OC and SOC stock observed here under *A. herba alba*, whose terpenic compounds may exert an additional allelopathic constraint on decomposer activity [30]. Notably, *S. tenacissima* and *P. harmala* did not differ significantly from one another for any organic parameter, indicating that the often-described "intermediate" status of *P. harmala* is not statistically distinguishable from the degraded alfa condition in this dataset; both should therefore be considered a single, organically depleted group relative to *A. herba alba*, consistent with the pioneer, disturbance-associated status documented for *P. harmala* on degraded soils [31] and with reports of strongly organic-depleted horizons in degraded alfa steppes of south-western Algeria linked to overgrazing and surface warming [32].

Expressed as areal stocks, *S. tenacissima* (18.96 t C $ha^{-1}$) and, to a lesser extent, *P. harmala* (24.05 t C $ha^{-1}$) fall at or below the ~20-25 t C $ha^{-1}$ range commonly cited as representative of Mediterranean arid soils [10], whereas *A. herba alba* (46.36 t C $ha^{-1}$) stands well above it, indicating a comparatively better-preserved carbon-storage function under this cover. The markedly lower coefficient of variation under *A. herba alba* (13.8% vs. 44-58% elsewhere) further suggests that, beyond storing more carbon on average, this cover also stabilises its spatial distribution - plausibly through more homogeneous canopy and litter deposition - whereas the high variability under *S. tenacissima* and *P. harmala* is consistent with the patchy, disturbance-driven degradation typically described for these formations [31,32].

These organic patterns must be interpreted jointly with the pedochemical context: the significantly higher total $CaCO_3$ under *A. herba alba* (32.15% vs. 17.72-19.41% elsewhere) parallels its elevated OM/OC, consistent with reports that this species preferentially colonises more calcareous substrates [7]. More broadly, the strongly alkaline pH and high $CaCO_3$ content across all covers likely constrain decomposer microflora activity and limit humification [22], while the generally low clay content restricts the formation of stabilising clay–humus complexes, leaving organic carbon vulnerable to mineralisation and erosion regardless of cover type [33]. Together, these constraints confirm the structural fragility of organic carbon stocks in these steppe soils in the face of ongoing degradation and climate pressure [24].

## 5. CONCLUSION

This study characterised the physicochemical properties and soil organic carbon stock of steppe topsoils under three representative vegetation covers in Zmalet El Emir Abdelkader (Tiaret province, Algeria). The soils are sandy-loam to loamy-sand in texture, loosely structured, strongly calcareous, alkaline, and virtually non-saline, with none of these properties differing significantly among vegetation covers. Vegetation cover had a statistically significant effect on total $CaCO_3$, organic matter, organic carbon and SOC stocks (one-way ANOVA, $p \leq 0.002$ in all cases), with *Artemisia herba alba* holding significantly higher values than both *Stipa tenacissima* and *Peganum harmala* (Tukey HSD, $p < 0.05$). Expressed as carbon stocks over the 0-30 cm layer, this translated into a significant, 2.4-fold difference between covers - 46.4 t C $ha^{-1}$ under *Artemisia herba alba* against 19.0 and 24.1 t C $ha^{-1}$ under *Stipa tenacissima* and *Peganum harmala* respectively, the latter two sitting at or below reference levels for Mediterranean arid soils. By contrast, *S. tenacissima* and *P. harmala* were not statistically distinguishable from one another for any organic or carbonate parameter. These statistically robust results reinforce, rather than merely echo, earlier qualitative observations: vegetation cover - specifically *Artemisia herba alba* - is a genuine, quantifiable driver of surface carbon storage in this arid steppe system. These findings support prioritising *A. herba alba*-based vegetation in steppe restoration programmes, alongside stricter grazing regulation, to help stabilise the fragile carbon stocks of these arid ecosystems. Future work should extend sampling to full soil profiles with seasonal replication, incorporate biological indicators of soil quality, and increase sample size to confirm the electrical conductivity pattern identified here.

## Conflict of interest

The authors declare no conflict of interest.

## Data availability

Data supporting the findings of this study are available from the corresponding author upon reasonable request.

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