QUANTITATIVE ANALYSIS OF THE COMMUNITY STRUCTURE AND SOIL SUPPORTING *HELICHRYSUM CONGLOBATUM* AND ITS MICRO-MORPHOLOGICAL FEATURES

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Abstract. The woolly perennial herb *Helichrysum conglobatum* (family**:** Asteraceae) is important for medicine and trade. The current study examined the physicochemical properties of the soil supports the plant, the macro- and micro-morphological features of its stem and leaf, and its vegetation composition. Both physical and chemical soil analyses were performed using a sieve, a flame photometer, and titration methods. The stem and leaf sections were examined using safranin staining and a Zeiss light microscope. Using the "list-count quadrat" method in the growth habitat, the quantitative estimation of community composition and structure was made, revealing that the plant community was dominated by *Helichrysum conglobatum* throughout four seasons, from autumn 2023 to summer 2024. All species in every quadrat were recognized and counted. The results showed that the soil supporting *Helichrysum conglobatum* was salty and consisted of sandy gravel. Moreover, the plant had terminal corymbose inflorescences and sessile leaves with a clasping base. Stem and leaf anatomy in summer was the same as in winter, except that the outline in cross-section of the stem was terete with few ridges, and the leaf diagram was more duplicated with several repeated vascular bundles in summer. The obtained data are beneficial for the documentation, biodiversity, and sustainability of *Helichrysum conglobatum*.
Keywords: *stem anatomy, leaf anatomy, ecological studies*, *physical soil analysis, chemical soil analysis, vegetation analysis*

Introduction

Helichrysum (Asteraceae) is a genus of evergreen shrubs that grow naturally in various regions around the Mediterranean Sea and include more than 600 species (Nardella et al., 2004; Zengin et al., 2020). Flowers, leaves, and fruits of *Helichrysum* have been used since ancient times in folk medicine, food, and cosmetic preparations due to their antiseptic and aromatic properties (Hennia et al., 2019). It has also been considered a holy plant in Mediterranean cultures (Edmondson et al., 1993; Nardella et al., 2004). In ancient Egypt, especially during the Greek and Roman periods, floral components of *Helichrysum* had a symbolic and religious importance and were used as ornaments on mummies (Nardella et al., 2004).

Genus *Helichrysum* has been represented in the Egyptian flora by three wild species: *Helichrysum conglobatum*, *Helichrysum orientale*, and *Helichrysum glumaceum* DC (Boulos, 2002; El-Ghazooly et al., 2003; El-Moaty et al., 2023). *Helichrysum*

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conglobatum (Viv.) Steud., known for its medicinal and fragrant properties, is found along the Mediterranean coast from the border with Libya near El Sallum to Port Said (Boulos, 2002; El-Moaty et al., 2023). It is found particularly in Agiba, Marsa Matrouh region, which has an arid Mediterranean climate with substantial coastal influences. This unique climate creates various ecological stresses that form the native vegetation (El-Zeiny et al., 2023).

A comprehensive micro-morphological investigation of *Helichrysum conglobatum* is important to understand its morphological adaptations to the coastal environment, whereas the micro-anatomical data are crucial for accurate taxonomic classification and for elucidating the plant's ecological performance under environmental stress (Kamatchi et al., 2024). Furthermore, analyzing the vegetation composition and community dynamics in the area of Marsa Matrouh is critical for understanding the ecological settings in which *Helichrysum conglobatum* is grown. Analyzing the plant species' community composition, structural features, and dynamics can help analyze interspecific connections as well as the possible effects of climate change, edaphic factors, and human activities on these ecosystems. Integrating micro-morphological data with vegetation analysis provides a complete picture of the plant's adaptation strategies. Hence, we hypothesize that *Helichrysum conglobatum* grows under specific soil conditions and exhibits special adaptive morphological and anatomical features across seasons, which contribute to its ecological dominance and plausibility for medicinal and commercial applications. Accordingly, this study aims to investigate the soil properties, anatomical features in dry and wet seasons, and vegetation dominance of *Helichrysum conglobatum*. It attempts to understand the plant's ecological adaptability and support its sustainable use in medicine and biodiversity conservation. To the best of our knowledge, it is the first time to investigate the micro-morphological characters of *Helichrysum conglobatum* stem and leaf, soil characteristics, and its vegetation analysis.

Materials and methods

Plant materials

The fresh plant materials of *Helichrysum conglobatum* (Viv.) Steud. (Sys. *Gnaphalium conglobatum* Viv., *Helichrysum siculum* Boiss.) were collected seasonally from Agiba, 20 km west of Marsa Matrouh (N 31º 16' 55", E 027º 05' 11", Elevation 2M), during the period of investigation from autumn (2023) to summer (2024).

Soil materials

During the period of investigation (from autumn 2023 to summer 2024), the soil samples that support *Helichrysum conglobatum* were collected from two depths in the studied area: the surface layer (0–20 cm) and the bottom layer (21–40 cm).

Macro- and micro-morphological studies

Fresh plant materials were collected from the natural habitat at Agiba, Marsa Matrouh. The macro-morphological and floral characters were studied from fresh plant materials. For micro-morphological investigations, fresh materials were fixed in FAA (40% formalin-glacial acetic acid-70% alcohol) in ratios of 5:5:90 v/v/v. Stem samples were taken from the 6^{th} internode below the apex and sectioned at 20–30 μm, whereas leaf blade samples were taken from mature leaves (at the 6^{th} node) and were sectioned at

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10-20 µm. Sections were stained in safranin (1% solution in 50% ethanol) and light green (1% solution in 96% ethanol) according to Dilcher (1974). The permanent three microscopic slides of stem and leaf anatomy in summer and winter seasons were photographed using a Zeiss Research microscope. Regarding leaf anatomy, the terminology concerning the mesophyll type was given according to Metcalfe and Chalk (1979) and Fahn (1974).

Ecological studies

Climatic factors

The mean values of climatic factors of Agiba, Marsa Matrouh, were obtained from the Meteorological Department of Egypt during the period of investigation from autumn 2023 to summer 2024.

Edaphic factor (soil analysis)

Soil samples that support *Helichrysum conglobatum* were collected for physicochemical analysis from the two depths (0–20 and 21–40 cm) during the period of investigation from autumn 2023 to summer 2024.

Soil physical properties

Soil texture (granulometric analysis)

Soil texture was determined through mechanical analysis. Ten samples from each of the two depths, surface layer (0-20) and bottom layer (21-40), were collected. Samples collected from each layer were transferred into a clean plastic bucket for thorough mixing before further analysis. Accordingly, combined samples from each layer were achieved by the sieve method using a standard, rot-top electric sieve shaker (Jackson, 1973; Jones, 2018).

Soil moisture content

The soil moisture content was determined at the two depths (0–20 and 21–40 cm), according to the method described by Rowell (2014).

Soil chemical properties

For chemical analysis, soil:water extract (1:5 w/v) was prepared as follows: 250 mL of distilled water were added to 50 g of air-dried soil and shaken for one hour. The soil particles were allowed to settle down, and the supernatant was subsequently decanted. After repeated filtrations, a clear solution was obtained (Jones, 2018). Organic carbon content was determined using the titration method (Jones, 2018), where 0.5 g of soil was taken and transferred into a 500 mL conical flask. Then, 10 mL of 1 N potassium dichromate ($K_2Cr_2O_7$) followed by 20 mL of concentrated sulfuric acid (conc. H_2SO_4) were added and shaken for one min. After shaking, it was left to stand on a piece of asbestos for about 30 min. About 200 mL of water, 10 mL of phosphoric acid (H_3PO_4), and 1 mL of diphenylamine ($(C_6H_5)_2NH$) indicator solution were added. The excess chromic acid was titrated against 1 N ferrous sulfate ($FeSO_4$) until a purple color appeared that flashed to green upon further addition of $FeSO_4$ drops.

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$$\text{Organic Carbon content (\%)} = \frac{V1 - V2}{W} \times 0.003 \times 100 \quad \text{(Eq.1)}$$

where: V1 = volume of 1 N $K_2Cr_2O_7$, V2 = volume of 1 N $FeSO_4$, W = weight of soil taken.

Soil pH was determined using a pH meter (3510, Jenway, UK), while electrical conductivity (EC) was measured using an EC meter (Orion 150A+, Thermo Electron Corporation, USA). The content of potassium (K^+) and sodium (Na^+) cations was determined using a flame photometer [PFP7, Jenway, UK], while calcium (Ca^{2+}) and magnesium (Mg^{2+}) cations were evaluated by the versene titration method (Jones, 2018). The carbonate (CO_3^{2-}) and bicarbonate (HCO_3^-) anions were determined by titration against 0.1 N hydrochloric acid (HCl) using phenolphthalein and methyl orange as indicators. Sulfate (SO_4^{2-}) anions were determined by precipitation as barium sulfate ($BaSO_4$) using barium chloride ($BaCl_2$) in slightly acidic media using a UV/Visible Spectrophotometer [Unicam UV 300, Thermo Spectronic, USA]. Chloride (Cl^-) ions were determined by titrating the soil extract against 0.1 N silver nitrate ($AgNO_3$) using 1% potassium chromate (K_2CrO_4) as an indicator (Jones, 2018). The calcium carbonate ($CaCO_3$) content was determined by adding 100 mL of 1 N HCl to 5 g of soil, stirring vigorously for an hour, then adding drops of indicator phenolphthalein solution and titrating against 1 N sodium hydroxide (NaOH). The calculation was done using a blank titration (Jackson, 1973).

Vegetation analysis

The quantitative estimation of community structure and composition was determined using the "list-count quadrat" method. Accordingly, ten quadrats (10 x 10 m each) were used to investigate the plant community dominated by *Helichrysum conglobatum* in Agiba, Marsa Matrouh, during the four seasons, from autumn 2023 to summer 2024. Each species in all quadrats was identified and counted according to the following calculations (Ambasht, 1988; Mahajan and Fatima, 2017).

$$\text{Density (D)} = \frac{\text{Total No.of individuals of one species}}{\text{Total No.of quadrats}} \quad \text{(Eq.2)}$$

$$\text{Relative density (RD)of species} = \frac{\text{No. of individuals of the species in all quadrats}}{\text{No. of individuals of all spp. in all quadrats}} \times 100 \quad \text{(Eq.3)}$$

$$\text{Frequency \% (Fr \%)} = \frac{\text{No. of quadrats in which species present}}{\text{Total No. of quadrats}} \times 100 \quad \text{(Eq.4)}$$

$$\text{Abundance} = \frac{\text{Total No. of individuals of one species}}{\text{No. of individuals of the species in all quadrats}} \quad \text{(Eq.5)}$$

Statistical analysis

Estimations of soil moisture content and soil chemical properties analyses were carried out in triplicate (n = 3), and the results were expressed as mean values ± standard

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deviation (SD). Two-way analysis of variance (ANOVA) followed by Tukey's multiple comparisons post-hoc test was used to compare the soil moisture content among the four seasons at the two depths. For soil chemical properties, the unpaired two-tailed t-test was used to detect the statistically significant difference between the properties studied at the two depths. $P < 0.05$ was considered as the significance value for all statistical analyses that were conducted using GraphPad Prism 8 Software (version 8.0.2).

Table (A). *Key for the relation between frequency percentage and its frequency class*

Frequency %	Frequency class
0-20	1
21-40	2
41-60	3
61-80	4
81-100	5

Results

Macro-morphological studies

Helichrysum conglobatum (Viv.) Steud. (*Figs. 1 and 2*) is a grayish-green woolly perennial herb up to10–40 cm tall with a woody base "frutescent". Stems erect to ascending, slender, and leafy. Leaves are simple, narrowly linear to linear-lanceolate, 1.0–3.5 x 0.15–0.25 cm (L x W), sessile with clasping base, revolute margins, and obtuse apices. In addition, *Helichrysum conglobatum* has terminal inflorescences, corymbose capitula in compact heads of 0.4–0.95 x 0.2–0.8 cm (L x W). Heads ovoid in bud and campanulate at anthesis. The length of the peduncle is in the range of 0.15–0.8 cm. Phyllaries 5–7-seriate, imbricate, bright yellow, glossy; the outer 0.1 x 5 x 1 mm, elliptical, obtuse; the middle longer, obovate, obtuse; the inner is twice as long as the outer, oblong-spathulate to oblong-linear, acute. Female florets 8–18; bisexual florets 15–40; corolla-tube 0.35–0.45 cm. Achenes 0.6–0.8 mm, cylindrical, with scattered 3–celled white hairs. Pappus of 10–20 white barbellate bristles. The woolly perennial herb, sessile leaves with clasping base, and terminal corymbose inflorescences are shown in *Fig. 2*.

Figure 1. *Helichrysum conglobatum during spring season*

Figure 2. *Herbarium specimen of Helichrysum conglobatum (Viv.) Steud.*

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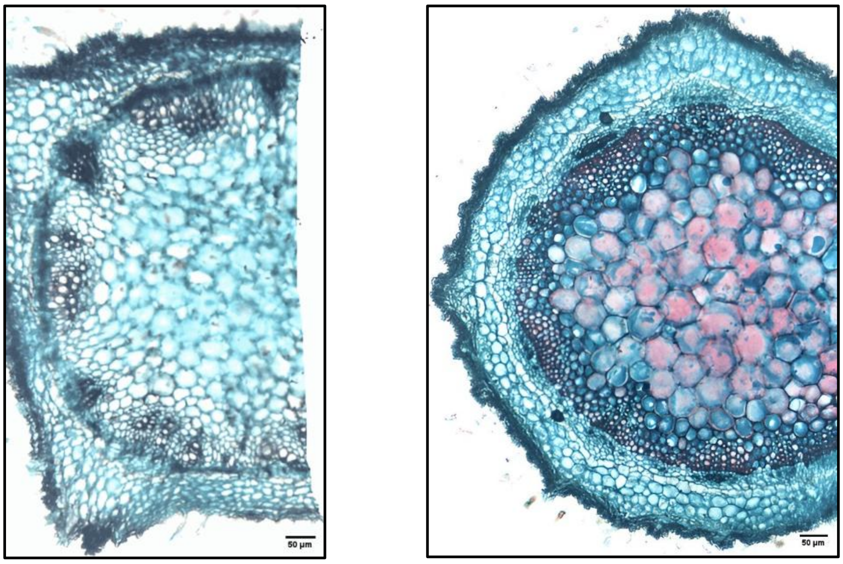
Micro-morphological studies

The observed anatomical differences between winter and summer were consistent across all replicate slides (100%).

Stem anatomy

a) In winter, the outline in cross-section is quadrate and has a few ridges (*Fig. 3A*). The epidermal cells are radially elongated, mixed with papillose, and covered with thick, smooth cutin. The cortex is narrow and composed of continuous 2-3 layers of compact collenchymatous cells followed by 3-4 layers of chlorenchymatous cells. The vascular cylinder consists of 17-18 separate vascular bundles, each with small, compressed patches of phloem and well-defined xylem separated by wide medullary rays (4-6 seriate). The pith is wide, solid, and composed of thin- walled rounded to irregular parenchymatous cells.



(A) (B)

Figure 3. *Stem anatomy of Helichrysum conglobatum (Viv.) Steud. (A) = winter season, (B) = summer season*

b) In summer, the stem anatomy is comparable to that in winter, except that the outline in cross-section is terete with few ridges. The vascular bundles (phloem and xylem) form a continuous ring. On the other hand, the druse crystals are present in the phloem (*Fig. 3B*). Pith is wide, solid, and made of thick-walled polygonal parenchymatous cells.

Leaf anatomy

a) In winter, the outline of the cross-section shows that the wings are duplicated. Epidermal cells are radially elongated except at the lower midrib region, where they are tangentially elongated and covered with thick, smooth cuticles. Stomata are semi-depressed. Mesophyll is dorsiventral and composed of palisade and spongy tissues. Palisade cells are loosely arranged in two discontinuous layers at the midrib region. Spongy tissue is composed of 3–4 layers of loose cells. The midvein is one large bundle enveloped by a sheath of wide parenchyma with a well-defined xylem. 1–2 layers of

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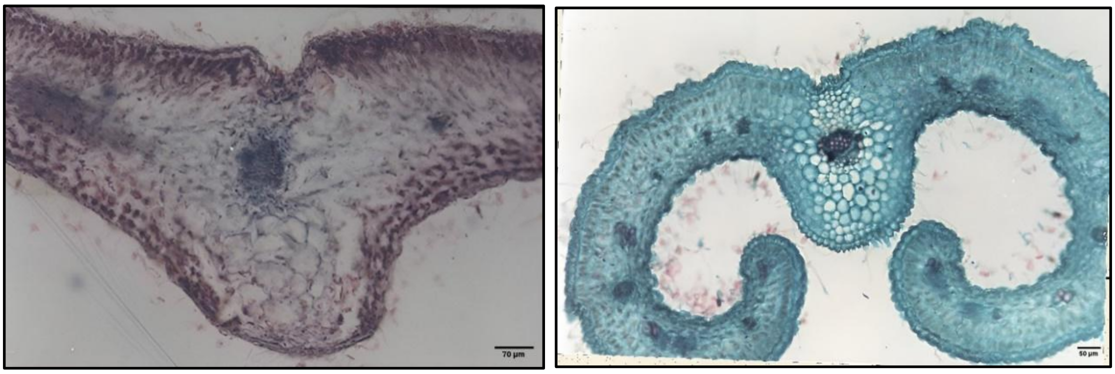
collenchyma at the midrib region record mechanical tissues. Veinlets (lateral veins) are 8–9 at each wing (*Fig. 4A*).



(A) (B)

Figure 4. *Leaf anatomy of Helichrysum conglobatum (Viv.) Steud. A = winter season, (B) = summer season*

b) In summer, the leaf anatomy closely resembled that of winter, with some notable distinctions. The cross-sectional outline of the leaf became more distinctly folded, and the number of repeated vascular bundles increased. Epidermal cells in the midrib region were radially elongated and exhibited papillose structures, a feature less prominent in winter. The number of lateral veins (veinlets) ranged from 5 to 9 per wing, these adaptations to environmental stress, such as drought and increased temperature (*Fig. 4B*).

Ecological studies

There is a range of ecological conditions under which plant species, or a community, can grow and adapt in a certain habitat. It is quite important to know the environmental conditions of the plant habitat, including climatic and edaphic factors, and their effects on its vegetation. The present work was carried out in Agiba, 20 km west Marsa Matrouh habitat, where *Helichrysum conglobatum* (Viv.) Steud. dominates and flourishes.

Climatic factors

The climatic data, including mean maximum, mean minimum, and monthly mean temperatures (°C), relative humidity % (R.H.%), evaporation power (mm/day), rainfall (mm) as well as wind velocity (km/h) were collected for the studied area during the period of investigation (2023–2024) from the meteorological station at Marsa Matrouh (*Fig. 5*). The mean maximum temperature varied from 16.9°C in February to 31.1°C in August, while the mean minimum temperature varied from 8.3°C in February to 22.9°C in July. However, the mean monthly temperature was 12.6°C in February and 26.8°C in July. From the obtained results, it is indicated that the habitat is distinguished by moderate temperature regime during the growth season. In addition to temperature, R.H. is known to have direct effects on the growth of plants. The observed R.H. ranged from 61.0% as a minimum in October to 73.3% as a maximum in June. The rate of evaporation reflects the combined effects of the other climatic factors. The minimum amount of evaporation reported in the present study was 9.2 mm/day in February, while the maximum evaporation was 25.3 mm/day in April.

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The results obtained showed that the total annual amount of rainfall was 43.1 mm during the year of investigation. On the other hand, the dry period covered five months, from April to August, which reflects the severe conditions under which the plant struggles for existence and survival. In addition to the previously investigated climatic factors, our results showed that the wind velocity reached its maximum value of 23.2 km/h in February and its minimum value of 12.4 km/h in August.

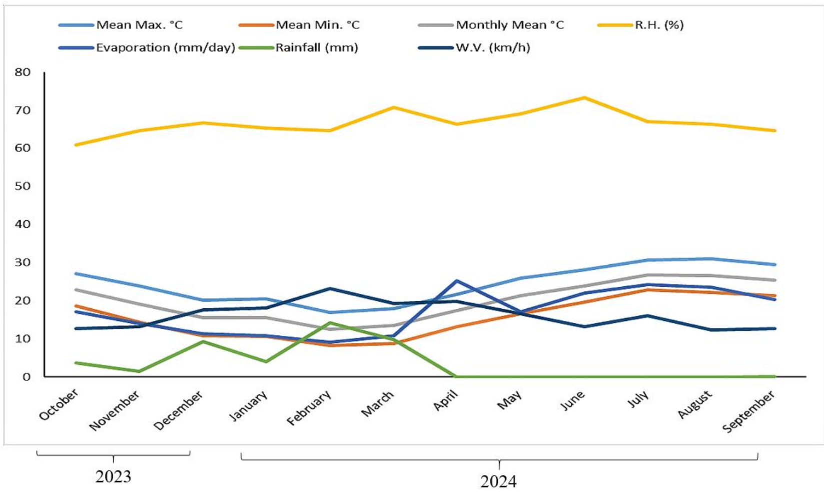

Figure 5. *Climatic factors of Marsa Matrouh during the period of investigation, from autumn 2023 to summer 2024*

Edaphic factors

Physical properties of the soil

a, Soil texture

Results of granulometric analysis of the soil that support *Helichrysum conglobatum* indicated that the soil is sandy gravel in texture at Agiba, Marsa Matrouh region (*Table 1*). The detected percentages of fine gravel were high (28.02%) at the bottom layer (21-40 cm depth) and low (20.49%) at the surface one (0–20 cm depth). The values of coarse sand were 25.46% and 27.61% at the bottom and surface layers, respectively, while the percentages of medium sand were 22.31% and 19.20% at the bottom and surface layers, respectively. Meanwhile, the percentages of fine sand were 9.14% and 8.66% at the bottom and surface layers, respectively. On the other hand, the values of very fine sand were 15.40% and 6.88% at the bottom and surface layers, respectively. The values of silt and clay reached their maximum values of 9.63% at the bottom layer and decreased to 7.20% at the surface one at the studied habitat.

b, Soil moisture content

Seasonal variation in the soil moisture content is compatible with the seasonal climatic factors. The values exhibited a highly significant ($P < 0.0001$) increase in winter compared to other seasons at the two depths, coinciding with winter rains, and reached their minimum in summer, associated with drought, high rate of evaporation, and moderate relative humidity. Upon comparing the soil moisture contents at the two studied depths (*Fig. 6*), no significant differences were observed during the seasons analyzed,

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with the exception of spring. In that season, a highly significant difference ($P < 0.0001$) was noted in the bottom layer (21–40 cm depth) when compared to the surface layer (0-20 cm depth). This significant difference does not represent an increase, but rather a depth-related variation, which is likely due to reduced evaporation and better water retention in the deeper soil layers.

Table 1. *Granulometric analysis of the soil supporting Helichrysum conglobatum during spring season (2024)*

Soil depth (cm)	Soil texture	Granulometric analysis of soil fraction mm					
		Fine gravel 2.0–1.0	Coarse sand 1.0–0.5	Medium sand 0.5–0.25	Fine sand 0.25–0.125	Very fine sand 0.125–0.063	Silt & clay < 0.063
0–20	Sandy gravel	20.49	25.46	22.31	9.14	15.40	7.20
21–40	Sandy gravel	28.02	27.61	19.20	8.66	6.88	9.63

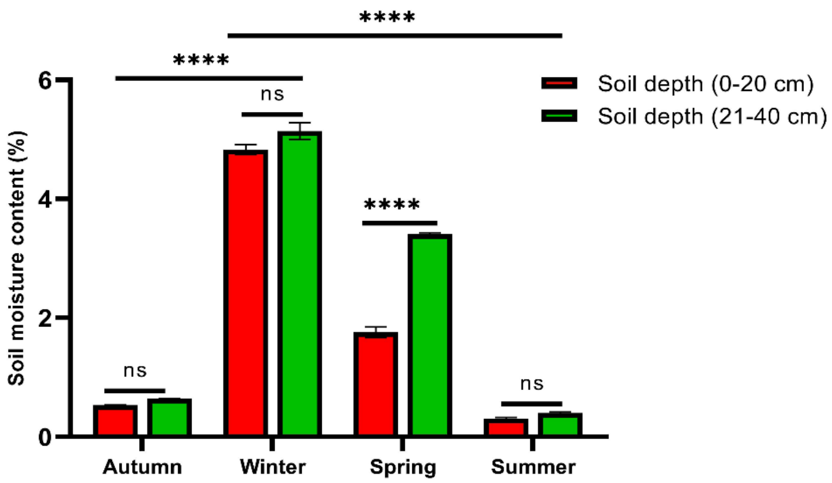

Figure 6. *Soil moisture content of Helichrysum conglobatum during the period of investigation (2023 – 2024). Data are represented as mean values ± SD (n = 3) and were evaluated by were evaluated by one-way ANOVA followed by Tukey's multiple comparisons post-hoc test. ns = non-significant difference (P > 0.05); ****= P < 0.0001*

Soil chemical properties

a, pH value and calcium carbonate ($CaCO_3$) content

The soil is alkaline in reaction, with a pH of 9.23 ± 0.02 at the surface layer (0–20 cm depth) and 8.76 ± 0.27 at the bottom layer (21–40 cm depth) of the studied habitat, while the $CaCO_3$ percentages were 54.71 ± 0.2% and 52.06 ± 0.28% at the surface and bottom layers of the studied habitat, respectively (*Table 2*).

b, Organic matter

According to the standard soil fertility classifications (Rowell, 2014), soils with organic matter content below 1.0% are considered poor. In this study, the organic matter content was 0.83 ± 0.02% at the surface layer and 0.71 ± 0.06% at the bottom layer (*Table 2*), which means both levels are clearly in the poor category, showing low fertility and few nutrients available.

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Table 2. *Chemical analysis of the soil supporting Helichrysum conglobatum during the spring season (2024)*

Soil depth (cm)	**pH**	**$CaCO_3$ (%)**	**Organic matter (%)**	**EC (dS m^{-1})**	**Analysis of the soil saturation extract**							
					Soluble cations (meq/100g)				**Soluble anions (meq/100g)**			
					Na^+	**K^+**	**Ca^{2+}**	**Mg^{2+}**	**CO_3^{2-}**	**HCO_3^-**	**Cl^-**	**SO_4^{2-}**
0–20	9.23^{ns} ± 0.02	54.71*** ± 0.2	0.83* ± 0.02	0.81* ± 0.03	4.52* ± 0.04	0.09^{ns} ± 0.02	2.26**** ± 0.08	1.69** ± 0.01	0.00	2.00*** ± 0.03	5.00**** ± 0.12	1.56^{ns} ± 0.17
21–40	8.76^{ns} ± 0.2	52.06*** ± 0.28	0.71* ± 0.06	0.99* ± 0.09	4.23* ± 0.13	0.08^{ns} ± 0.004	3.50**** ± 0.06	2.60**± 0.15	0.00	2.30*** ± 0.03	6.31**** ± 0.07	1.80^{ns} ± 0.03

Data are represented as mean values ± SD (n = 3) and were evaluated by unpaired two-tailed t-test. ^{ns} = non-significant (P > 0.05); *= P < 0.05; **= P < 0.01; ***= P < 0.001; ****= P < 0.0001

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c, Electrical conductivity (EC)

The recorded soil EC was 0.81 ± 0.03 dS m^{-1} at the surface layer (0–20 cm depth) and 0.99 ± 0.09 dS m^{-1} at the bottom layer (21–40 cm depth) (*Table 2*).

d, Cations content

The major cation content was Na^{+} ions that reached 4.52 ± 0.04 meq/100 g at the surface layer (0–20 cm depth) and 4.23 ± 0.13 meq/100 g at the bottom layer (21–40 cm depth) of the studied habitat (*Table 2*). On the other hand, Ca^{2+} ions represented the second major cation in the soil, reaching 2.26 ± 0.08 meq/100 g at the surface layer and 3.50 ± 0.06 meq/100 g at the bottom layer. The third major cation after Ca^{2+} ions was Mg^{2+} ions, with 1.69 ± 0.01 meq/100 g at the surface layer and 2.60 ± 0.15 meq/100 g at the bottom layer. On the contrary, the least cation content was represented by the concentration of K^{+} ions, which reached 0.09 ± 0.02 meq/100 g and 0.08 ± 0.004 meq/100 g at surface and bottom layers, respectively, at Agiba habitat (*Table 2*).

e, Anions content

The highest content of soluble anions was represented by the concentration of Cl^{-} ions that reached 5.00 ± 0.12 meq/100 g in the surface layer (0–20 cm depth) and 6.31 ± 0.07 meq/100 g in the bottom layer (21–40 cm depth) of the studied habitat (*Table 2*). The HCO_3^{-} anions represented the second most prominent anions in soil samples of the studied habitat, where they reached 2.00 ± 0.03 meq/100 g in the surface layer and 2.30 ± 0.03 meq/100g in the bottom layer, while SO_4^{2-} anions reached 1.56 ± 0.17 meq/100 g and 1.80 ± 0.03 meq/100 g in the surface and bottom layers, respectively. On the contrary, soluble CO_3^{2-} anions were absent from soil samples at the two studied depths.

Vegetation analysis

The study of ten quadrats (10 x 10 m each) at the studied habitat gives knowledge about the vegetation structure and the changes in the development of vegetation from one season to the other. An analysis of the plant transects of Agiba, Marsa Matrouh habitat revealed that most of the present species were perennial (*Tables 3 and 4*). The dominant species was *Helichrysum conglobatum,* with densities of 6.9, 7.5, 8.2, and 6.3 in autumn, winter, spring, and summer, respectively, with the frequency class “5” for each (*Tables 3 and 4*). The second reported dominant species was *Limoniun pruinosum*, with densities of 6.7, 6.9, 7.0, and 6.0 in autumn, winter, spring, and summer, respectively, with the frequency class “5” for each. Meanwhile, *Limonium tubiflorum* resembled the third dominant species in the area studied with densities of 4.7, 5.1, 5.4, and 4.0 in autumn, winter, spring, and summer, respectively, with the frequency class “5” in autumn, winter, and spring and frequency class “4” in summer. The subsequent dominant species were *Ferula marmarica, Euphorbia bivonaes, Lotus corniculatus,* and *Pituranthos tortuosus*.

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Table 3. *Vegetation analysis of ten quadrats (10 × 10 m each) representing Helichrysum conglobatum community at the studied habitats of Agiba during autumn and winter seasons (2023–2024)*

Species	Autumn (2023)						Winter (2024)					
	Total No.	**D**	**RD %**	**A**	**Fr %**	**Fr. C**	**Total No.**	**D**	**RD %**	**A**	**Fr %**	**Fr. C**
Helichrysum conglobatum	69	6.9	9.2	6.9	100	5	75	7.5	7.4	7.5	100	5
Limonium pruinosum	67	6.7	8.9	6.7	100	5	69	6.9	6.8	6.9	100	5
Limonium tubiflorum	47	4.7	6.2	5.2	90	5	51	5.1	5.0	5.1	100	5
Ferula marmarica	45	4.5	6.0	4.5	100	5	55	5.5	5.4	5.5	100	5
Euphorbia bivonae	45	4.5	6.0	4.5	100	5	48	4.8	4.7	4.8	100	5
Lotus corniculatus	44	4.4	5.8	4.9	90	5	52	5.2	5.1	5.2	100	5
Pituranthus tortusus	42	4.2	5.6	4.2	100	5	45	4.5	4.4	4.5	100	5
Limoniastrum monopetalum	38	3.8	5.0	4.8	80	4	40	4.0	3.9	4.4	90	5
Jasonia Montana	37	3.7	4.9	4.1	90	5	42	4.2	4.1	4.2	100	5
Suaeda fruticosa	31	3.1	4.1	3.1	100	5	38	3.8	3.7	3.8	100	5
Asphodelus microcarpus	30	3.0	4.0	3.8	80	4	35	3.5	3.4	4.3	80	4
Atriplex halimus	30	3.0	4.0	5.0	60	3	35	3.5	3.4	4.3	80	4
Ononis vaginalis	25	2.5	3.3	3.6	70	4	30	3.0	3.0	3.8	80	4
Alhagi maurorum	25	2.5	3.3	3.6	70	4	30	3.0	3.0	4.3	70	4
Retama raetam	22	2.2	2.9	3.1	70	4	28	2.8	2.8	3.5	80	4
Fagonia cretica	22	2.2	2.9	2.4	90	5	25	2.5	2.5	2.5	100	5
Atriplex leucoclada	20	2.0	2.7	2.9	70	4	25	2.5	2.5	3.1	80	4
Anabasis articulate	18	1.8	2.4	3.0	60	3	20	2.0	2.0	2.9	70	4
Onopordum alexandrinum	18	1.8	2.4	2.6	70	4	20	2.0	2.0	2.5	80	4
Asteriscus graveolens	17	1.7	2.3	3.4	50	3	47	4.7	4.6	7.8	60	3
Reaumauria vermiculata	13	1.3	1.7	3.3	80	4	18	1.8	1.8	2.0	90	5
Pancratium arabicum	10	1.0	1.3	1.7	60	3	15	1.5	1.5	2.1	70	4
Morcandia nitens	8	0.8	1.1	1.3	60	3	9	0.9	0.9	1.3	70	4
Suaeda vermiculata	5	0.5	0.7	1.3	40	2	9	0.9	0.9	1.3	70	4
Salsola tetrandra	4	0.4	0.5	1.0	40	2	5	0.5	0.5	1.0	50	3

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Species	**Autumn (2023)**						**Winter (2024)**					
	Total No.	**D**	**RD %**	**A**	**Fr %**	**Fr. C**	**Total No.**	**D**	**RD %**	**A**	**Fr %**	**Fr. C**
Salvia aegyptiaca	4	0.4	0.5	1.0	40	2	5	0.5	0.5	1.0	50	3
Lycium shawii	4	0.4	0.5	1.0	40	2	5	0.5	0.5	1.0	40	2
Capparis orientalis	4	0.4	0.5	1.0	40	2	5	0.5	0.5	1.0	50	3
Noaea mucronata	3	0.3	0.4	1.0	30	2	4	0.4	0.4	1.0	40	3
Phlomis floccose	3	0.3	0.4	1.0	30	2	3	0.3	0.3	1.0	30	2
Thymelaea hirsute	3	0.3	0.4	1.0	30	2	3	0.3	0.3	1.0	30	2
Mesembryanthmum nodiflorum	-	-	-	-	-	-	89	8.9	8.8	8.9	100	5
Diplotaxis acris	-	-	-	-	-	-	10	1.0	1.0	1.4	70	4
Trigonella stellata	-	-	-	-	-	-	10	1.0	1.0	1.4	70	4
Hypocrepis cyclocarpa	-	-	-	-	-	-	9	0.9	0.9	1.3	70	4
Sinapis arvensis	-	-	-	-	-	-	7	0.7	0.7	1.0	70	4
Total No. of all species	**753**						**1016**					

D = Density; RD = Relative density %; A = Abundance of species; Fr % = Frequency %; Fr. C = Frequency class

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Table 4. *Vegetation analysis of ten quadrats (10 × 10 m) representing Helichrysum conglobatum community at the studied habitats of Agiba during spring and summer seasons (2023–2024)*

Species	Spring (2024)						Summer (2024)					
	Total No.	**D**	**RD %**	**A**	**Fr %**	**Fr. C**	**Total No.**	**D**	**RD %**	**A**	**Fr %**	**Fr. C**
Helichrysum conglobatum	70	7.0	6.5	7.0	100	5	60	6.0	9.0	6.0	100	5
Limonium pruinosum	54	5.4	5.0	5.4	100	5	40	4.0	6.0	5.0	80	4
Limonium tubiflorum	59	5.9	5.5	5.9	100	5	43	4.3	6.4	4.3	100	5
Ferula marmarica	52	5.2	4.8	5.2	100	5	42	4.2	6.3	4.7	90	5
Euphorbia bivonae	55	5.5	5.1	5.5	100	5	40	4.0	5.0	5.0	80	4
Lotus corniculatus	47	4.7	4.4	4.7	100	5	38	3.8	5.7	3.8	100	5
Pituranthus tortusus	41	4.1	3.8	4.6	90	5	38	3.8	5.7	4.8	80	4
Limoniastrum monopetalum	45	4.5	4.2	4.5	100	5	30	3.0	4.5	3.8	80	4
Jasonia Montana	40	4.0	3.7	4.0	100	5	30	3.0	4.5	3.0	100	5
Suaeda fruticosa	40	4.0	3.7	4.4	90	5	25	2.5	3.7	3.6	70	4
Asphodelus microcarpus	36	3.6	3.3	4.5	80	4	24	2.4	3.6	4.0	60	3
Atriplex halimus	32	3.2	3.0	3.6	90	5	20	2.0	3.0	3.3	60	3
Ononis vaginalis	31	3.1	2.9	3.9	80	4	20	2.0	3.0	3.3	60	3
Alhagi maurorum	30	3.0	2.8	3.3	90	5	21	2.1	3.1	3.0	70	4
Retama raetam	27	2.7	2.5	2.7	100	5	20	2.0	3.0	2.9	80	4
Fagonia cretica	30	3.0	2.8	3.3	90	5	15	1.5	2.2	2.5	60	3
Atriplex leucoclada	22	2.2	2.0	2.8	80	4	15	1.5	2.2	3.0	50	3
Anabasis articulate	20	2.0	1.9	2.5	80	4	15	1.5	2.2	2.1	70	4
Onopordum alexandrinum	50	5.0	4.6	8.3	60	3	15	1.5	2.2	3.8	40	3
Asteriscus graveolens	19	1.9	1.8	2.1	90	5	11	1.1	1.6	1.4	80	4
Reaumauria vermiculata	17	1.7	1.6	2.1	80	4	9	0.9	1.3	1.5	60	3
Pancratium arabicum	10	1.0	0.9	1.3	80	4	7	0.7	1.0	1.2	60	3
Morcandia nitens	10	1.0	0.9	1.4	70	4	4	0.4	0.6	1.0	40	3
Suaeda vermiculata	6	0.6	0.6	1.2	50	3	4	0.4	0.6	1.0	40	3
Salsola tetrandra	6	0.6	0.6	1.2	50	3	4	0.4	0.6	1.0	40	3

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Species	Spring (2024)						Summer (2024)					
	Total No.	**D**	**RD %**	**A**	**Fr %**	**Fr. C**	**Total No.**	**D**	**RD %**	**A**	**Fr %**	**Fr. C**
Salvia aegyptiaca	5	0.5	0.5	1.3	40	3	4	0.4	0.6	1.0	40	3
Lycium shawii	5	0.5	0.5	1.0	50	3	4	0.4	0.6	1.0	40	3
Capparis orientalis	4	0.4	0.4	1.0	40	3	3	0.3	0.4	1.0	30	2
Noaea mucronata	3	0.3	0.3	1.0	30	2	3	0.3	0.4	1.0	30	2
Phlomis floccose	3	0.3	0.3	1.0	30	2	3	0.3	0.4	1.0	30	2
Thymelaea hirsute	90	9.0	8.3	9.0	100	5	-	-	-	-	-	-
Mesembryanthmum nodiflorum	12	1.2	1.1	1.5	80	4	-	-	-	-	-	-
Diplotaxis acris	10	1.0	0.9	1.4	70	4	-	-	-	-	-	-
Trigonella stellata	10	1.0	0.9	1.3	80	4	-	-	-	-	-	-
Hypocrepis cyclocarpa	7	0.7	0.6	1.0	70	4	-	-	-	-	-	-
Sinapis arvensis	7	0.7	0.7	1.0	70	4	-	-	-	-	-	-
Total No. of all species	1005						607					

D = Density; RD = Relative density %; A = Abundance of species; Fr % = Frequency %; Fr. C = Frequency class

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Discussion

This study investigated for the first time the anatomical studies of *Helichrysum conglobatum* grown in the region of Agiba, Marsa Matruh. The morphological features of *Helichrysum conglobatum* showed that the plant is a grayish-green perennial herb with a woody base, up to 10–40 cm tall. It has simple, sessile leaves with terminal inflorescences and corymbose capitula. The plant has erected ascending stems, slender leaves, terminal inflorescences, and a pappus of 10–20 white barbellate bristles. However, *Helichrysum plicatum* subsp. *Plicatum* and *polyphyllum*, each plant is a perennial plant with glandular, taproot-like leaves and stems. *Helichrysum plicatum* subsp. *Plicatum* has a subglobose capitula and dense corymbs, but subsp. *polyphyllum* has a spherical to hexagonal capitula, branched stem, and linear cauline leaves. These plants have oblanceolate to spatulate phyllaries and yellow tomentose tubular flowers. *Helichrysum plicatum* blooms between June and August and has taproot, erect or curved stems, and lanate tomentose facial hairs (Elkiran et al., 2015). The cortex of *Helichrysum conglobatum* is narrow and composed of continuous 2–3 layers of compact collenchymatous cells followed by 3–4 layers of chlorenchymatous cells as similar as the cortex of *Helichrysum plicatum* subsp. *Plicatum* is composed of 2–4 layered, while the cortex of *Helichrysum plicatum* subsp. *Polyphyllum* is composed of 1–2 layered (Elkiran et al., 2015). The current study showed that the leaf anatomy is more duplicated with several repeated vascular bundles in the summer. This is because leaf rolling enhances the leaves' metabolic processes and builds their resistance to water shortage, both of which are beneficial for the plant's survival (Seleiman et al., 2021). However, full or high-level rolling reduces this efficiency and has a negative impact on the plant (Nar et al., 2009; Singh et al., 2017). Climatic factors are important for determining the development, distribution, and density of vegetation on earth (Zahran, 1989). Among the climatic factors, rain is considered the most important factor affecting the growth, density of coverage, and distribution of plants in the different seasons of the year (Zahran, 1989). Moreover, the main source of irrigation water in the coastal region of the Northwestern Mediterranean is rainfall. The results obtained showed that the total annual amount of rainfall was 43.1 mm during the period of investigation. On the other hand, the dry period covered five months, from April to August, which reflects the severe conditions under which the plant struggles for existence and survival. In addition to the previously investigated climatic factors, wind has a physiological effect on plants, where it enhances the rate of transpiration and has an effect on drying the soil in wet regions during spring (Zahran, 1989). The climate of Marsa Matruh shows that a lot of rain is received in winter, with December and January exhibiting the most, while in the spring, only around 10% falls were observed. In the summer season, observations reported revealed very little or no raindrops, whereas in the fall, occasional strong rains were reported (Galal, 2019). The obtained results revealed a gradual increase in soil moisture content with increasing soil depth, which may be due to the subjection of the surface layers of the desert soil to intense evaporation, while the deeper layers were protected against evaporation. In addition, the observed increase in soil moisture content with increasing soil depth may be due to the presence of a permanently wet layer in the desert soil below a certain depth, which supplies deep roots with available water (Mielke and Schaffer, 2010). On the other hand, the seasonal variation in the soil moisture content is compatible with the previously reported seasonal variation in *Helichrysum conglobatum* water content, organic matter, total carbohydrates, soluble and insoluble carbohydrates, total nitrogen, total proteins, as well as total lipids (El-Moaty et al., 2023). Drought stress decreased the plant's total sugar

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content because it decreased photosynthesis, which is associated with an increase in respiration rate (Mielke and Schaffer, 2010). Numerous factors, such as the sandy texture, adequate aeration, and inadequate management techniques, could be responsible for this. Collectively, these factors could contribute to the low amount of organic matter in such soil by speeding up the decomposition of organic matter. The obtained results were comparable to previously reported findings on another wild plant species, *Opuntia littoralis*, grown on the western Mediterranean coast of Egypt (El-Moaty et al., 2022). Soil EC is a measure of the soil's ability to conduct an electric current, which is principally determined by the concentration of soluble salts in the soil solution (Schillaci et al., 2025). EC is a soil characteristic that affects both the crop growth and yield (Kaya et al., 2022; Tedeschi et al., 2023). The obtained results regarding the cation and anion contents indicated that the studied habitat was enriched with Na^+ and Cl^- ions resulting from soluble NaCl salt dissolved in soil water, thus leading to detrimental effects of salinity on plants (Brower et al., 1998). The decrease in soil water resources in the summer and the increase of soil salinity may be linked to the accumulation of some amino acids such as proline. This may aid in the regulation of cell osmoregulation by altering the total nitrogen and protein content as observed in *Helichrysum conglobatum* plant (El-Moaty et al., 2023). Plants produce proteins and chemical substances as a defense against biotic and abiotic stress (Payá Montes, 2023). The analysis of the plant transects revealed that most of the species grown in Agiba habitat were perennial, where *Helichrysum conglobatum* was the dominant species due to the presence of secondary metabolites, which protect it (El-Ghazooly et al., 2003; Polatoğlu et al., 2016; Zengin et al., 2020).

The findings of this study provide practical implications for agriculture and biodiversity management. The ability of *Helichrysum conglobatum* to dominate under saline, nutrient-poor, and drought conditions, as demonstrated by its high frequency and consistent anatomical structure across seasons, highlights its ecological resilience. These traits make it a promising candidate for cultivation in marginal or degraded lands, where conventional crops may fail. Additionally, understanding the plant’s seasonal anatomical adaptations such as increased vascular bundle duplication and leaf folding can inform cultivation timing and harvesting strategies, particularly for maximizing the yield of bioactive compounds used in traditional medicine and trade. Furthermore, the detailed soil analysis offers a baseline for soil amendment practices if domestication is considered. By aligning the plant's natural growth preferences (e.g. sandy gravel texture, alkaline pH, and low organic matter) with managed growing environments, future agricultural applications can be optimized. Overall, this integrative ecological and anatomical assessment contributes to the sustainable utilization of *Helichrysum. conglobatum* and encourages its inclusion in conservation-based agriculture and herbal industry strategies.

Conclusion

This study investigated the impact of climate during the dry and rainy seasons on the anatomical structure of both the stem and leaf of *Helichrysum conglobatum*. The observed micromorphology of the stem and leaf in summer is the same as in winter, except that the outline in cross-section of the stem is terete with few ridges, and the leaf diagram is more duplicated in summer. Seasonal variation in the soil moisture content is compatible with the seasonal climatic factors. The values reached their maximum in winter, coinciding with winter rains, and their minimum in summer, associated with drought. Studying the physicochemical properties of the soil showed that the nature of the soil is salty, sandy

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gravel, and poor in the content of organic matter. The analysis of the plant transects in Agiba, Marsa Matruh habitat revealed that most of the present species were perennial, and the dominant species was *Helichrysum conglobatum*, with densities of 6.9, 7.5, 8.2, and 6.3 in autumn, winter, spring, and summer, respectively, with the frequency class "5" for each. Although *Helichrysum conglobatum* is ecologically dominant in its natural habitat, it faces long-term threats of drought stress. Conservation is therefore important not due to current rarity, but to prevent future decline, ensure sustainable use, and protect its unique genetic and medicinal traits from overexploitation and habitat degradation. This justifies conservation not due to current vulnerability, but as a proactive strategy tied to its ecological and economic value. Moreover, this integrative study could motivate subsequent efforts to research additional taxa in the community and decipher what they offer.

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potential of *Helichrysum stoechas* subsp. *barrelieri* extracts obtained via five extraction techniques. – Process Biochemistry 91: 113-125.

APPENDIX

Figure 1. *Satellite map showing the location of the study area in Agiba, 20 km west of Marsa Mattrouh, Egypt*

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