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Size Structure of *Cupressus sempervirens* L. and *Pistacia lentiscus* L. Populations in Wadi Alkuf, East of Libya

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Abstract: Wadi Alkuf is one of the richest of all the phytogeographical regions of Al-Jabal Al-Akhder. The present work aims to study the size structure of *Cupressus sempervirens* L. and *Pistacia lentiscus* L. populations in relation to their physiographic and soil conditions in Wadi Alkuf, northeast of Libya. Eighteen terraces (25 m × 25 m) were selected at Wadi Alkuf of Al-Jabal Al-Akhder at three different levels (six downstream, midstream, and upstream). The number of individuals of each species was counted while the height (H) and mean crown diameter (D) were measured. The size index of each individual was calculated and then used to classify the population into 7 size classes: 1 m to 7 m. The height, mean diameter, height to diameter ratio, size index, and volume per individual in each size class were determined. Generally, the height to diameter ratio was more than unity for *C. sempervirens* L., this means that the diameter of these species tend to expand vertically rather than horizontally, while the height to diameter ratio was less than unity for *P. lentiscus* L, this means that the diameter of these species tends to expand horizontally rather than vertically. The total size structure of *C. sempervirens* L. in the study area is characterized by the preponderance of the young individuals comparing with the old ones, while that of *P. lentiscus* L. showed a reverse pattern (i.e., preponderance of mature individual compared with the young ones). Five forms of size distributions along the different elevations were recognized: more or less inverse J-shaped distribution, positively skewed distribution, bell-shaped distribution, more or less J-shaped distribution, and more or less stationary size distribution biased to large size. The study's results show that density histograms of size distributions are good indicators of future trends in population numbers for the studied species. The field observations were consistent with the results of the investigation of soil properties. The soil downstream has the highest values of pH, EC, HCO^{-3}, SO_4^{-2}, Cl^- and Na^+, while that of the upstream has the lowest values except for K^+.

Keywords: Population Dynamic; Size Distribution; *Cupressus sempervirens* L.; *Pistacia lentiscus* L.; Wadi Alkuf, Libya.

INTRODUCTION

The human impacts and their effects on plant vegetation and biodiversity became a field of major interest in the last few years. Many human activities occurred in the AL-Jabal AL-Akhdar area as a result of an increase in the development activities and growth of the population (Kamal Shaltout et al., 2014).

Although this region is one of the important areas of wildlife in Libya, it suffers from extreme biodiversity destruction and degradation. It is imperative now, more than ever, to begin extensive environmental studies and conservation programs, including not only soil and biodiversity conservation but also beauty conservation and attention to local inhabitants because they play an important role in the ecological systems throughout the

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whole area (El-Barasi & Saaed, 2013). The main natural reasons affecting these degradation processes are often climate and aridity, which lead to a reduction in the plant cover and soil depth. Besides these, the human-induced reasons leading to this process are fires, felling, and overgrazing (Kosmas, Kirkby, & Geeson, 1999); Desertlinks, 2001).

There is no doubt that these activities adversely affected not only size structure but also species diversity in the area under study. The structure of plant populations can be described in terms of the age, size, and forms of the individuals that compose it (J. Harper & White, 1974). Since the fecundity and survival of plants are often much more closely related to size than to age (Caswell, 1986; J. L. Harper, 1977; KH Shaltout & Ayyad, 1988; Watkinson & White, 1986; Weiner, 1986), it is better to classify the life history of plants by size rather than age which is the most widely used classification for unitary organisms (Caswell, 1986; Kirkpatrick, 1984; Werner & Caswell, 1977)

The present study aimed at analyzing the population structure of *Cupressus sempervirens* and *Pistacia lentiscus* populations in Wadi Alkuf. *Cupressus sempervirens*, the Mediterranean cypress, is a species of cypress native to the eastern Mediterranean region, in northeast Libya, southern Albania, southern coastal Croatia (Dalmatia), southern Greece, southern Turkey, Cyprus, northern Egypt, western Syria, Lebanon, Israel, Malta, Italy, western Jordan, and also a disjunct population in Iran. *Cupressus sempervirens* is a tall tree (usually 15 - 20 m high but can reach 30 - 40 m) with a well-developed trunk (up to 3 m in circumference). It grows quickly until the age of 20 and can live to be 500. Its leaves are evergreen, dark green, acicular (in young stages), or very small, scale-like, and overlapping in four ranks. The female cones are globular (2 - 4 cm.), shiny, with 6-12 woody, peltate, unequal scales, opposed crosswise on a short axis (Zohary, 1973). The seeds are jagged, shiny brown, and narrowly winged. Flowering takes place in spring; the cones mature the following spring. The Cupressus genus includes, for the sake of convenience, an aggregate called *Cupressus sempervirens* aggr, formed by a group of three species that are often confused and usually very close to each other (Greuter, Burdet, & Long, 1984); Farjon, 2013).

Pistacia lentiscus is a shrub or dioecious tree, with separate male and female plants, an evergreen from 1 to 5 m high, with a strong smell of resin, growing in dry and rocky areas in Mediterranean Europe. It resists heavy frosts and grows on all types of soils, and can grow well in limestone areas and even in salty or saline environments, making it more abundant near the sea. It is also found in woodlands, Dehesas (almost deforested pasture areas), oak and Kermes oak woods, Garrigue, Maquis, hills, gorges, canyons, and rocky hillsides of the entire Mediterranean area. It is a very typical species that grows in Mediterranean mixed communities of myrtle, Kermes oak, Mediterranean dwarf palm, buckthorn, sarsaparilla, etc., and serves as protection and food for birds and other fauna in this ecosystem. It is a very hardy pioneer species dispersed by birds. When older, it develops large trunks and numerous thicker and longer branches. Within appropriate areas, when allowed to grow freely and age, it often becomes a tree of up to 7 m. However, logging, grazing, and fires often prevent its development (Mohannad G & Duncan M, 2011; Zohary, 1952).

The present work aims to study the size structure of *C. sempervirens* L. and *P. lentiscus* L. populations in relation to their physiographic and soil conditions in Wadi Alkuf, northeast of Libya.

MATERIALS AND METHODS

Wadi Alkuf is located at 32° 41' N latitude

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and 21° 38' E longitude, at an altitude of 360 m in Al Jabal Al Akhder of Libya (Figure. 1). The valley is about 22 km long, starting from Benghazi-Albaida road towards the north and ends in the Mediterranean Sea. The soil varies from clay to clay loam at different locations. It is rich in calcium carbonate (25%) with pH 8 and nitrogen. Organic matter content were about 0.33 and 7%. The average annual rainfall in the valley is 450.5 mm, most of which is received during the months from December to February. The temperature shows significant fluctuations in summer and winter. The minimum temperature drops to 12° on cold frosty nights of January, and the maximum rises up to 27° in June. Relative humidity ranges from 50-55 (May and June) to 65-70% (November to January) Source: Meteorological data of Shahat station (Figure.2).

Figure: (1). Location map indicating the study area. (Source: Google Earth, 2016).

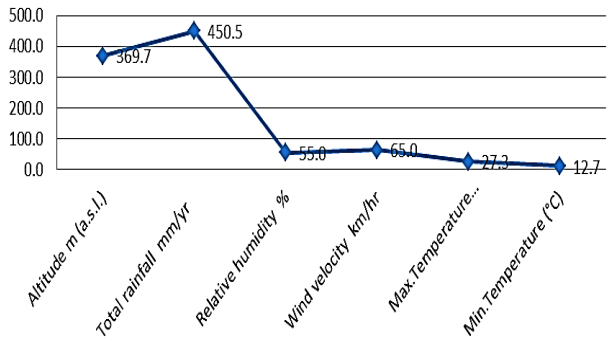

Figure: (2). Metrological data recorded at Shahat from January 2018 to January 2019.

A total of 18 sample plots were selected along the Wadi Alkuf under study (upstream, midstream, and downstream parts, including the different wadi tributaries) in the period from January 2018 to January 2019. Vegetation was sampled using a transect/quadrant method. A stratified sampling technique was utilized. The stand size was 25 × 25 m (approximate the minimal area of the plant communities). In each stand, the following data were recorded: 1- a list of species, 2- first and second dominant species, and 3- a visual estimate of the percentage total cover and the cover of each species according to the Braun-Blanquet dominance abundance scale. Voucher specimens of all plant species were collected. Species identification followed (Ali & Jafri, 1976; Jafri, 1977, 1993; Tackholm & Boulos, 1974), and the Latin names were following (Boulos, 1972, 1977; Boulos, 1979; Boulos, 1995; Boulos, 2005, 2009; Loutfy & Boulos, 1979).

The population structure of these species was evaluated in terms of size distribution. For achieving this, the height and mean crown diameter of each individual in the whole locations were measured (based on 2-4 diameter measurements / ind.) and its volume was calculated as a cylinder. The size index of each individual was calculated as the mean of its height and diameter [(H+D)/2]. The size estimates were then used to classify the population into nine size classes. The size classes (m / ind.) are (1=0< 1, 2=1.1-2, 3=2.1–3, 4=3.1–4, 5=4.1–5, 6=5.1–6 and 7= 6.1–7). The soil was analyzed following (Richards, 1954; Ryan, Garabet, Harmsen, & Rashid, 1996). The data were statistically treated using ANOVA and the simple linear correlation coefficient (SPSS, 1999).

RESULTS

The relationships between the individual heights and diameters of *Cupressus* and *Pistacia* species are simple linear with r values of 0.335 for *Cupressus sempervirens* and

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0.279 for *Pistacia lentiscus* (Figure 5). Generally, the height to diameter ratio was more than unity for *Cupressus sempervirens.* This means that the diameter of these species tends to expand vertically rather than horizontally, while the height to diameter ratio was less than unity for *Pistacia lentiscus*. This means that the diameter of these species tends to expand horizontally rather than vertically.

Cupressus sempervirens

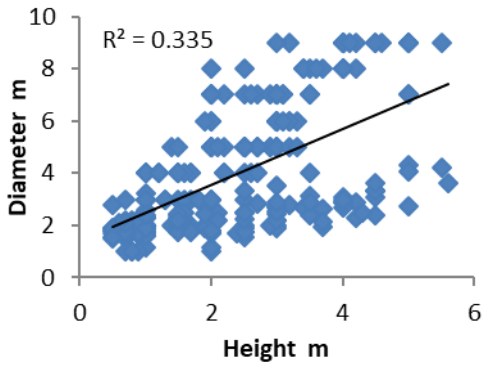

Figure: (3). The relationships between the individual heights and diameters of *Cupressus sempervirens.*

Pistacia lentiscus

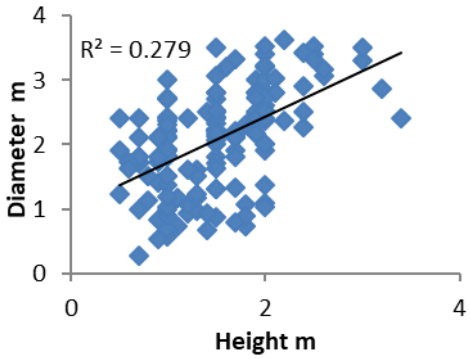

Figure: (4). The relationships between the individual heights and diameters of *Pistacia lentiscus* species.

Regarding the variation in relation to habitat type, both the height and diameter of *Cupressus sempervirens* (8.4 and 4.1 m) and *Pistacia lentiscus* (4 and 5.23 m) have the highest values downstream, respectively, and the lowest values upstream were for *Cupressus sempervirens* species (3.6 and 2.7m respectively). *Pistacia lentiscus* shows the lowest value for height and diameter in midstream (2 and 4.5m, respectively) (Table .1).

Table: (1) Mean (±) standard deviation of some demographic variables: (H: Height, D: Diameter, r simple linear correlation coefficient between height and diameter and size index.

Species	site	H (m)	D (m)	H/D	r	Size index (m)
Cupressus sempervirens L. var. horizontalis (Mill.) Gord.	Downstream	8.4 ± 3.130	4.1 ± 0.962	2.4 ± 0.645	0.964	6.75 ± 0.966
	Midstream	5.1 ± 0.629	3.1 ± 0.751	1.6 ± 0.387	0.696	4.6 ± 0.784
	Upstream	3.6 ± 0.401	2.7 ± 0.392	1.3 ± 0.111	0.534	2.5 ± 0.588
Pistacia lentiscus L.	Downstream	4 ± 0.719	5.23 ± 0.582	0.8 ± 0.253	0.551	4.5 ± 0.774
	Midstream	2 ± 8.21	4.5 ± 6.69	0.75 ± 0.301	0.263	3.15 ± 5.51
	Upstream	3± 0.326	3.5 ± 0.787	0.4 ± 0. 292	0.243	3.25 ± 0.703

The diagrams illustrating the size distribution of *Cupressus and Pistacia* populations in the three different levels could be classified into (Figure 5).

1) More or less stationary size distribution for *Cupressus sempervirens* populations in the downstream and J-shape for *Pistacia lentiscus* populations in the downstream level.

2) Inverse J shape for *Cupressus sempervirens* populations upstream and Bell shape for *Cupressus sempervirens* populations in the midstream level.

3) More or less stationary size distribution for *Pistacia lentiscus* populations downstream and Bell shape for *Pistacia lentiscus* populations in the midstream level.

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4) Positively skewed distribution towards the small individuals (i.e saplings) of *Cupressus sempervirens* populations in the downstream level.

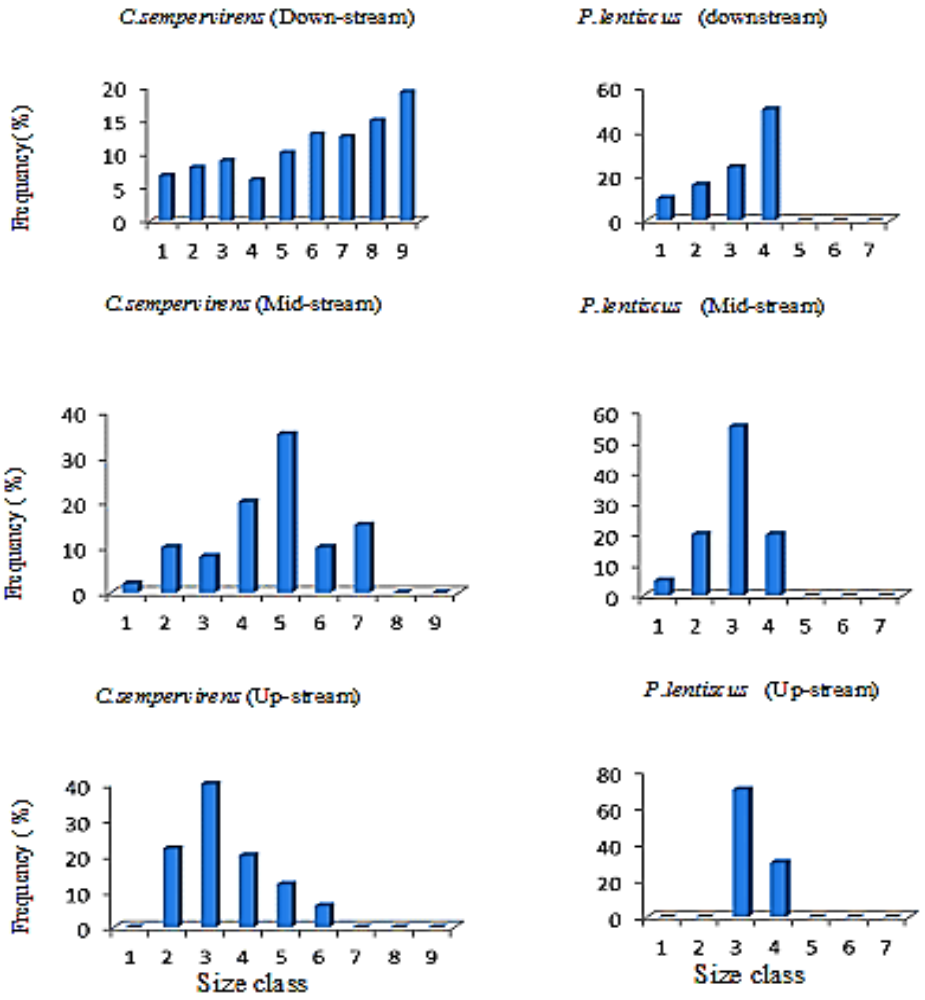

Figure: (5) Size frequency distribution of *Cupressus sempervirens and Pistacia lentiscus* populations from three levels. The mean volume within each size class is also indicated. The ranges of size classes are: 1>1 , 2=1.1-2, 3=2.1-3 ,4=3.1-4 ,5=4.1-5, 6=5.1-6, 7=6.1-7

The soil of the downstream level has the highest values of pH, EC, $HCO^{-3,}$ SO_4^{-2}, Cl^-, and Na^+ (8.20, 0.337, 3.81, 3.26, 1.9, and 1.55, respectively) while that of the upstream has the lowest values except for K^+. Calcium and magnesium have the highest values in the soil of midstream (0.28 and 0.26 respectively), while the lowest values were for Na^+ and K^+ (0.67 and 0.12, respectively). Soil of the upstream level has the lowest values of pH, EC, $HCO^{-3,}$ SO_4^{-2}, Cl^-, Ca^{+2}, Mg^{+2}, and Na^+ (7.89, 0.226, 2.54, 1.88, 1, 0.12, 0.13, and 1.12, respectively). (Table 2).

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Table: (2) Means ± standard errors of some soil variables in each of the three habitats recognized in the study area.

Sites				Downstream	Midstream	Upstream
Physical analysis	Sand (%)			10.33 ± 0.02	11.38 ± 0.017	12.34 ± 0.002
	Silt (%)			41.28 ± 0.02	30.88 ± 0.03	31.02 ± 0.01
	Clay (%)			42.31 ± 0.03	42.72 ± 0.01	48.54 ± 0. 01
	Soil texture			Clay-Silt	Clay	Clay
Chemical analysis	pH			8.20 ± 0.01	8.16± 0.03	7.89± 0.01
	E.C ds/m			0.337 ± 0.01	0.263 ± 0.01	0.226± 0.02
	HCO^{-3}			3.81 ± 0.01	3.33 ± 0.03	2.54 ± 0.01
	SO_4^{-2}	Anions	m.eq./L	3.26± 0.2	2.11± 0.01	1.88± 0.1
	CI^-			1.9± 0.01	1.30 ± 0.1	1± 0. 1
	Ca^{+2}			0.25 ± 0.1	0.28 ± 0.1	0.12 ± 0.1
	Mg^{+2}	Cations		0.16 ± 0.001	0.26 ± 0.01	0.13 ± 0.01
	Na^+			1.55 ± 0.02	1.33 ± 0.04	1.12 ± 0.01
	K^+			0.18 ± 0.1	0.12 ± 0.1	0.28 ± 0.01

DISCUSSION

The height/diameter ratio gives an idea about the growth habit of the plant. In the present study, the height to diameter ratio was more than unity for *Cupressus sempervirens*, which means that the diameter of these species tends to expand vertically rather than horizontally. While the height to diameter ratio was less than unity for *Pistacia lentiscus*, this means that the diameter of these species tends to expand horizontally rather than vertically. On average, its height and hence individuals of these species tend to expand horizontally rather than vertically.

This may be a strategy of the desert shrubs in order to provide safe sites for their self-regeneration, as the horizontal expansion usually provides shade, which leads to a decrease in the severe heating effect and an increase in the soil moisture (KH Shaltout & Mady, 1993). On the other hand, the height to diameter ratio in some species was exceeding unity, such as *Cupressus sempervirens*, which means that their individuals tend to expand vertically rather than horizontally. This may be attributed to the high density or consequently high intra-specific competition of these plants (Galal, 2011).

The distribution of plant species along elevation gradients is governed by a series of interacting biological, environmental, and historical factors (Colwell & Lees, 2000). Our results show that density histograms of size distributions are good indicators of future trends in population number for the studied species, especially for *C. sempervirens* L. Furthermore, (Gray, 1975) reported that the positively skewed distribution is indicative of a self-perpetuating species, with markedly more frequency of the smaller (younger) size classes. A similar conclusion was made by (KH Shaltout & Ayyad, 1988).

In the present study, there was more or less stationary size distribution for *Pistacia lentiscus* populations in the downstream level and Bell shape for the *Pistacia lentiscus* populations midstream. This distribution characterizes a declining population; because the population has a large proportion of larger individuals than smaller ones (i.e., limited regeneration capacity). This may indicate that the recruitment of these species is rare, which may be related to hyper-aridity and low fertility (Kamal Shaltout et al., 2014; K. H. Shaltout et al., 2015).

The study endeavors to establish factors re-

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lated to local management; that may have caused the declines that we can observe. It is recognized that there are undoubtedly many reasons for such degradation in the natural vegetation. These include the nature of the soils, the extreme weather, alongside human land use. Assumptions are often made in terms of landscape change, desertification, and climate change, but the role of local inhabitants and their impacts may outweigh other influences. This may be due to the soil in Wadi El-Kouf. The nature of the soil surface characteristics is one of the most important factors influencing the floristic richness of the landforms along with the climatic variations.

CONCLUSION

In conclusion, the total size structure of *C. sempervirens* L. in the study area is characterized by the preponderance of the young individuals compared with the old ones. While that of *P. lentiscus* L. showed a reverse pattern (i.e., the preponderance of mature individuals compared with the young ones).

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التوزيع الحجمي لمجموعات السرو *Cupressus sempervirens L.* و البطوم *Pistacia lentiscus L.* في وادي الكوف شرق ليبيا

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المستخلص : وادي الكوف من أغنى المناطق الجغرافية النباتية في الجبل الأخضر. يهدف البحث الحالي إلى دراسة التركيب الحجمي لأفراد السرو *Cupressus sempervirens L.* والبطوم *Pistacia lentiscus L.* فيما يتعلق بظروف التربة في وادي الكوف شمال شرق ليبيا. تم اختيار ثمانية عشر مدرجًا (25 م × 25 م) في وادي الكوف بالجبل الأخضر على ثلاثة مستويات مختلفة (ستة في أعلى الجبل، ستة في المنتصف، وستة أسفل المجري). تم تقييم التركيبة السكانية لكل نوع وتم قياس الارتفاع (H) و متوسط قطر تاج الشجرة (D) لعدد من الأفراد لكل الأنواع. و حساب مؤشر الحجم لكل فرد باستخدام التصنيف السكاني إلى 7 فئات: 1 م إلى 7 م. تم تحديد الارتفاع ، متوسط القطر ، نسبة الارتفاع إلى القطر، مؤشر الحجم، والحجم لكل فرد في كل فئة حجم. بشكل عام كانت نسبة الارتفاع إلى القطر أكثر في السرو *C. sempervirens L.* وهذا يعني أن قطر هذه الأنواع يميل إلى التوسع عموديا بدلا من أفقيا، في حين كانت نسبة الارتفاع للقطر أقل في البطوم *P. lentiscus L.* ، وهذا يعني أن قطر هذه الأنواع يميل إلى التوسع أفقيا بدلا من عموديا. يتسم هيكل الحجم الكلي للسرو *C. sempervirens L.* في منطقة الدراسة بغلبة صغار السن مقارنة مع الكبار ، بينما أظهر البطوم *P. lentiscus L.* نمطًا عكسيًا (أي كثرة الفرد الناضج مقارنة بالصغار). تم التعرف على خمسة أشكال لتوزيعات الحجم على طول الارتفاعات المختلفة: توزيع عكسي على شكل حرف (J) إلى حد ما ، توزيع منحرف إيجابي ، توزيع على شكل جرس ، توزيع على شكل(J) أكثر أو أقل، وتوزيع حجم ثابت إلى حد ما منحاز إلى الحجم الكبير. أظهرت نتائج الدراسة أن الرسوم البيانية للكثافة لتوزيعات الحجم هي مؤشرات جيدة للاتجاهات المستقبلية في عدد السكان للأنواع المدروسة. كانت الملاحظات الميدانية متوافقة مع نتائج التحقيق في خصائص التربة. تحتوي تربة أسفل المجري على أعلى قيم الأس الهيدروجيني و EC و HCO^{-3} و SO_4^{-2} و Cl^- و Na^+ ، بينما تحتوي تربة أعلي الجبل على أدنى قيم باستثناء. K^+ .

الكلمات المفتاحية : ديناميكا سكانية، التوزيع الحجمي، السرو، البطوم، وادي الكوف، ليبيا.

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