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# Study of the Soil's Diversity of the Ouled Bechih Forest, Souk-ahras (North East of Algeria)

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**ABSTRACT**

Northern Algeria has a real forestry potential that can be developed for the production of woody resources for the industrial and economic development of the country as well as for the protection of the environment and even for social purposes near densely populated centers. The forest of Ouled Bechih occupies an area of 6582 ha, it is known by the diversity of its ecosystems, it is in this area that can be described as one of the most beautiful rainforests of North Africa, thanks to its geographical position and its diversity both biotic and biotic. And it is considered a regional park in the process of creation. To study and determine the diversity of the soil cover of this forest we based on a sampling of soils in three stations which were randomly undertaken in the forest and chosen according to their plant composition. The three types of formation selected here are: the subera (Quercus suber) which is located at the bottom of the forest, the zenaie (Quercus canariensis) which is located at the top of the forest and the mixed forest of cork oak and zea oak, which is located in the middle of the forest, then we made several physicochemical analyses such as: the granulometry, the hydrogen potential, the electrical conductivity, the hygroscopic humidity, the organic matter and the porosity. The results showed a very highly diversified soil substrate which is exposed to several ecological and climatic factors such as, the nature of the vegetation cover and climate, altitude, etc. The characterization and determination of the soils of this forest have allowed to divide these soils into three categories: soils moderately acidic, not calcareous, with a clayey-silt texture and which is moderately rich in organic matter. Soils with a clayey texture, which do not retain water, with a clearly acidic character and which are rich in organic matter. And non-saline, acidic, coarse-textured soils that develop at very high altitudes. The results obtained show a clear richness and diversity of the soils of the forest of Ouled Bechih (Souk-Ahras), and that there is an important link between the nature of existing plant groups and its substrate. And it is imperative to preserve this natural wealth to protect the forest ecosystem and the environment.

***Key words :*** *Soil, Diversity, Forest, Ecosystem, Environment.*

## Introduction

The forest is a complex and rich ecosystem, offering many habitats to numerous animal, plant, fungal and microbial species and populations, most of which are interdependent. It is also a place of production and economic valuation, but most importantly the forest has become a living space, a place of relaxation and recreation (Buck and Katila, 2009).

Forests are ecosystems of great specific richness, present under various climatic, geographical and ecological conditions (FAO, 2021). Forests play a fundamental role in regulating the global climate, carbon and water cycles, and form ecosystems that provide many habitats for organisms living in and on the ground. They mitigate the impact of natural disasters such as floods, droughts, landslides and avalanches. Forests are also an economic resource and contribute to the development of local communities (Gobat and Aragno, 2010). Forests have three main functions: economic, ecological and social. The forest is at the same time a permanent vegetation cover of the soils, a regulator of the runoff and infiltration water, a landscape decoration, a factory to manufacture woody material, an unequalled source of oxygen, an invaluable bank of genes, a precious reservoir of biological diversity, a particular dust collector and filter, an unparalleled depollutant and a regulator of the climatic factors. It is for all these reasons that the forest has been described as a heritage of humanity (Faroun and Bendabdeli, 2010).

The Algerian forest is a delicate task insofar as it is difficult to give an overview as summary as it is this sweet kingdom of trees, so diverse because this region has different and contradictory facies if we believe the landscapes that we discover. This diversity makes that there is a forest richness (Louni, 1994). Among this forest richness we mention the soil which is a component of the ecosystems essential to life on earth, and its diversity gives a remarkable value to the forests and the environment in general.

Soils are formed at the expense of the geological substratum, under the influence of climate, topography and living beings. The formation of soils requires several thousands of years, which makes them non-renewable on a human scale. The great variability of the situations presiding over their formation has generated a natural diversity of soils, which mapping attempts to account for (FAO, 2020). Forest soils are as diverse as the vegetation that covers them: they can be shallow or deep, rich or poor. Vegetation cover has a clear influence on soil formation processes. Root growth alters the bedrock, and litter (Dead Leaves and Roots) contributes to the formation of soil organic matter. The canopy provides protection from heavy rainfall and roots structure the soil, both of which prevent erosion (Amossé and *al.,* 2014). The diversity of soils is related to the diversity of factors in their formation. Indeed, soils are derived from the weathering of rocks outcropping on the surface of the globe. Depending on the nature of these rocks, the climate, and the activity of living organisms, these rocks undergo different and more or less pronounced weathering processes giving rise to varied soils (Bunning and Jiménez, 2003).

Today's soils are the result of several thousands of years of evolution, and in some cases hundreds of thousands. Depending on the age of the soils, different stages of evolution are reached and again produce great diversity (Haygarth and Ritz, 2009). This diversity generates soils of different colors, consistencies and textures. These soils have varying physical or chemical properties, making them more or less able to fulfill their functions. The knowledge of this natural diversity becomes essential for a sustainable management of soils and environment (Gouyon and Leriche, 2010).

In Algeria, oak forests provide essential economic functions, they are the only forests capable of producing hardwoods suitable for fine carpentry, furniture, for railway sleepers and high quality mechanical resistance (Letreuch-Belarouci, 1995).

In the forest of Ouled Bechih (Souk-Ahras), located in the north-east of Algeria, the forest flora is divided into three well-defined strata, the oak groves of cork oak occupies the lower part of the forest, then a transitional forest which is composed of a mixture between the cork oak with the oak zeen and higher in altitude we meet the subseries of oak zeen (Samai, 2015). This diversity of plant groups was the subject of the study of soils which is the essential support of these plant formations, which we will give a physico-chemical characterization of the soils to determine the diversity of the latter between the different types of vegetation existing in the for-

est of Ouled Bechih (Souk-Ahras).

## Materials and Méthods

Our study area is located in the North of the wilaya of Souk-Ahras, which is located in the North-East of Algeria. The forest of Ouled Bechih occupies an area of 6 582 ha. It is installed at the gates of Algeria in a natural passage between Tunisia and the rest of the country (Samai, 2017). It is limited:

To the Northwest by the wilaya of El-Taref;

In the Northwest by the wilaya of Guelma;

In the South by the wilaya of Tébessa;

In the South-West by the wilaya of Oum-El-Bouaghi;

In the East by Tunisia (Fig.1).

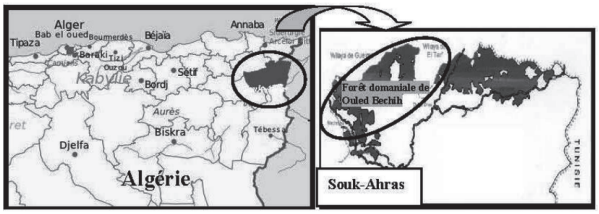


**Fig. 1**. Map of geographical situation of Souk-Ahras.

Our study area belongs to the Mediterranean climate, characterized by an average annual temperature of 16 ° C, and an average annual precipitation of 625 mm, with an important atmospheric humidity 68%. And according to the climagram of Emberger (1955), this region is under the cool subhumid bioclimatic stage.

### Sampling technique

This study was undertaken at 3 stations randomly distributed in the forest and selected according to their plant composition. The three types of formation selected here are: the suberaie (Quercus suber) which is located at the bottom of the forest, the zenaie (Quercus canariensis) which is located at the top of the forest and the mixed forest of cork oak and zea oak, which is located in the middle of the forest of Ouled Bechih (Souk-Ahras).

For each station a profile was made with an auger or a natural profile, these three stations are: El-Kelkhi (under cork oak forest), Ain Talhi (under mixed forest of cork oak and zeen oak), Sidi Abdallah (under zeen oak forest) (Fig. 1). In our opinion, they represent the different soils of the region.

The sampling of these stations was done on the whole profile, that is to say on all these horizons.

The collected soil samples were dried, crushed and sieved, and then analyzed in the laboratory.

On the fine fraction of the soil the following physico-chemical analyses were made :

Granulometry ⟶ International pipette method. (Baize, 2000).

The hydrogen potential (pH) ⟶ pH meter (Baise and Girard, 1995).

Electrical conductivity (EC) ⟶ Conductimètre. (Bonneau and Souchier, 1979)

Hygroscopic humidity (H) ⟶ Oven drying (24h at 105°C). (Delcour, 1981).

Organic matter (MO) ⟶ Incinération au four à moufle (4h à 450°C) (Morel, 1986).

The real density ($D_R$) ⟶ Pycnomètre. (Delcour, 1981).

And on the unmilled soil fraction, only one analysis was performed:

The apparent density ($D_A$) ⟶ with kerosene (Baize, 2000).

## Results and Discussion

Station1: El-Kelkhi (under cork oak forest)

The granulometric analysis shows the dominance of silt in all the profile. They are associated with sands on the surface, and at depth with clays, (Fig.2); this alternation is at the origin of the massive texture observed on the ground.

The determination of the actual acidity (pH water) shows that this soil presents a low acid reaction in all the horizons, because the totality of the values are higher than 6,36 (Fig.3).

The potential acidity follows the same evolution as the current acidity, which indicates a weak presence of acidifying cations on the adsorbent complex of this soil.

The evaluation of the electrical conductivity indicates that the soil is not salty (Fig.4). According to (Duchaufour, 1983); the electrical conductivity is proportional to the quantity of ionizable salts; it constitutes a good indicator of the degree of mineralization of the soil solution.

The measurement of hygroscopic moisture gives very low values, especially at depth (Fig.5), which implies that the soils do not retain much water.

The organic matter content drops sharply from the surface to the depth (Fig.6); this shows that biological activity is more intense at the surface than at

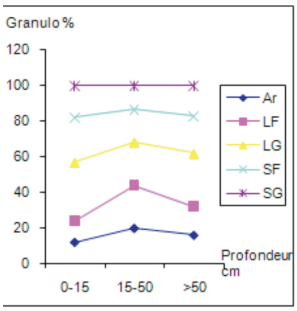


**Fig. 2.** The granulometry

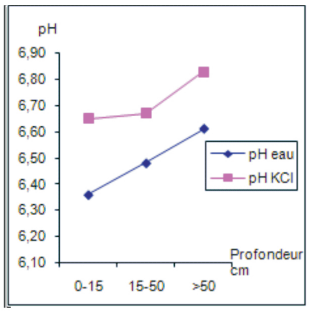


**Fig. 3.** pH water, pH KCl

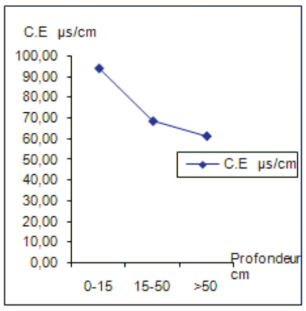


**Fig. 4.** The eclectic conductivity

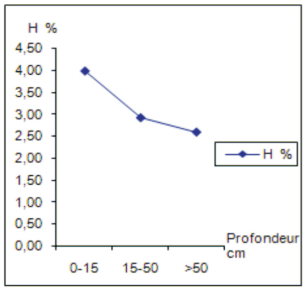


**Fig. 5.** Hygroscopic moisture

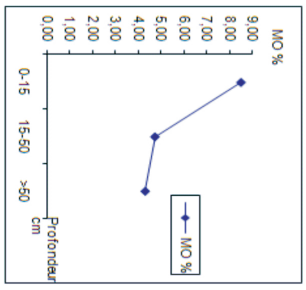


**Fig. 6.** Organic matter

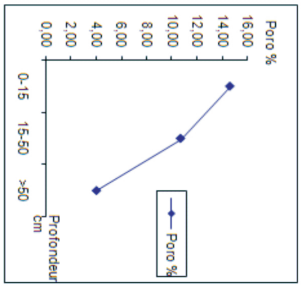


**Fig. 7.** Porosity

depth; and this biological activity follows the litter supply at the surface.

The porosity is very low in all horizons, especially at the base of the profile where it becomes compact and this is due to the clay texture at the bottom of the profile (Fig. 7)

**Analysis of variance pH water**

| Source | DL | Som Car adjust | CM adjust | Value of F | Value of P |
|---|---|---|---|---|---|
| Depth | 2 | 0,093800 | 0,046900 | 469,00 | 0,000 |
| Error | 6 | 0,000600 | 0,000100 | | |
| Total | 8 | 0,094400 | | | |

Analysis of variance pH KCL

| Source | DL | Som Car adjust | CM adjust | Value Of F | Value of p |
|---|---|---|---|---|---|
| Depth | 2 | 0,058400 | 0,029200 | 292,00 | 0,000 |
| Error | 6 | 0,000600 | 0,000100 | | |
| Total | 8 | 0,059000 | | | |

Analysis of variance EC µs/cm

| Source | DL | Som Car adjust | CM adjust | Value of F | Value of P |
|---|---|---|---|---|---|
| Depth | 2 | 1802,78 | 901,390 | 1345,36 | 0,000 |
| Error | 6 | 4,02 | 0,670 | | |
| Total | 8 | 1806,80 | | | |

Analysis of variance H%

| Source | DL | Som Car adjust | CM adjust | Value Of F | Value of p |
|---|---|---|---|---|---|
| Depth | 2 | 3,214 | 1,6069 | 4,77 | 0,058 |
| Error | 6 | 2,020 | 0,3367 | | |
| Total | 8 | 5,234 | | | |

**Analysis of variance MO%**

| Source | DL | Som Car adjust | CM adjust | Value of F | Value of P |
|---|---|---|---|---|---|
| Depth | 2 | 32,3574 | 16,1787 | 4758,44 | 0,000 |
| Error | 6 | 0,0204 | 0,0034 | | |
| Total | 8 | 32,3778 | | | |

**Analysis of variance Poro**

| Source | DL | Som Car adjust | CM adjust | Value of F | Value of P |
|---|---|---|---|---|---|
| Depth | 2 | 172,695 | 86,3473 | 863473,00 | 0,000 |
| Error | 6 | 0,001 | 0,0001 | | |
| Total | 8 | 172,695 | | | |

The analysis of variance with a single criterion of classification of the physico-chemical parameters of the soil of this station of the Ouled Bechih forest (Souk-Ahras) showed a highly significant difference for pH water, PH KCl, Poro %, MO% and C.E µs/cm p= 0.000, However, we did not notice any difference p= 0.058 for the H%.

**Station 2:** Ain Talhi (under mixed forest of cork oak and zeen oak)

The granulometric analysis of the different horizons shows the dominance of fine sands on the surface and in the middle, and fine and coarse silts at depth, while clays are weak on the surface and become null at depth (Fig. 8). These values define a sandy-silty texture.

The physico-chemical characterisation shows that we are in the presence of a weakly acidic soil at the surface and it becomes clearly acidic at depth. (Fig.9).

The pH KCl measurement confirms the acidic character and shows that the adsorbent complex is weakly saturated to unsaturated.

The evaluation of the electrical conductivity shows that we are in the presence of a non-saline soil and no risk of salinity is to be feared. (Fig.10).

The hygroscopic moisture content is low throughout the profile (Fig. 11); this is related to the physical characteristics of the soil, which retains only a small amount of water when subjected to natural drying conditions.

The monitoring of organic matter according to Lambert, 1975 reveals that the surface horizon is rich. This richness is related to the high input of litter from either tree or herbaceous vegetation; whereas the deeper layers record low values (Fig. 12); this result shows the speed of organic matter disappearance under the influence of good biological activity maintained by a light texture.

The relationship between apparent density and real density defines the porosity of the soil, which is very low at the surface and becomes almost confined at the bottom of the profile (Fig. 13).

This situation favours an average biological activity at the surface and an accumulation of products at depth.

**Analysis of variance pH water**

| Source | DL | Som Car adjust | CM adjust | Value of F | Value of P |
|---|---|---|---|---|---|
| Depth | 3 | 2,606 | 0,8687 | 4,82 | 0,034 |
| Error | 8 | 1,443 | 0,1803 | | |
| Total | 11 | 4,049 | | | |

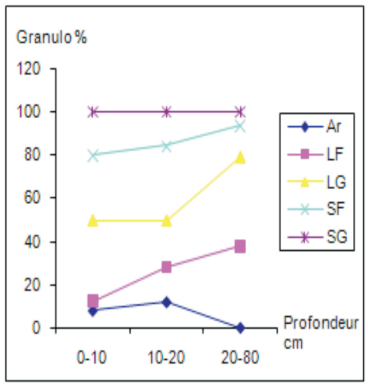


**Fig. 8.** Granulometry

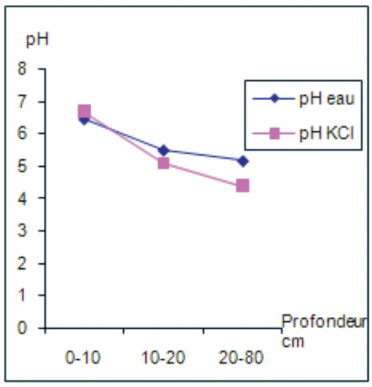


**Fig. 9.** pH water, pH KCl

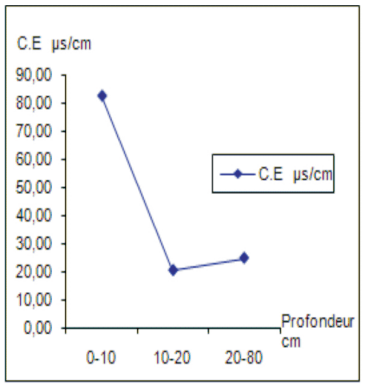


**Fig. 10.** Eclectic conductivity

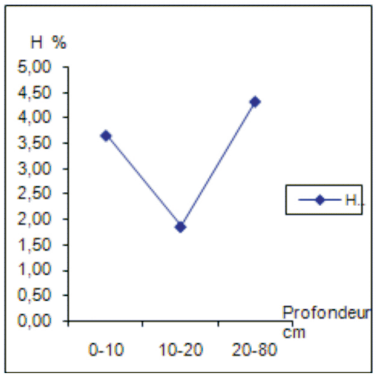


**Fig. 11.** Hygroscopic moisture

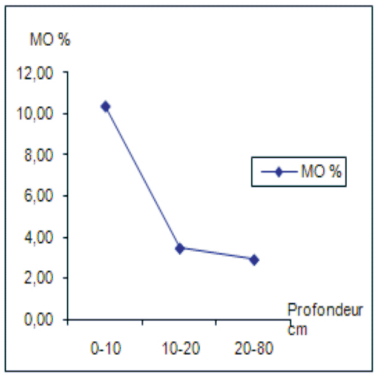


**Fig.12.** Organic matter

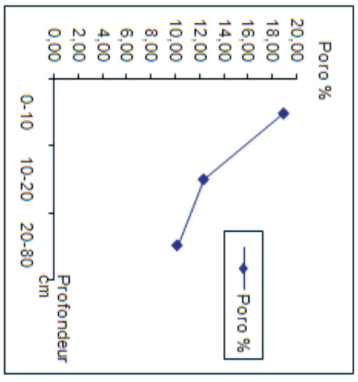


**Fig. 13.** Porosity

**Analysis of variance pH KCl**

| Source | DL | Som Car adjust | CM adjust | Value of F | Value of P |
|---|---|---|---|---|---|
| Depth | 3 | 8,482 | 2,8274 | 5,87 | 0,020 |
| Error | 8 | 3,856 | 0,4820 | | |
| Total | 11 | 12,338 | | | |

**Analysis of variance EC µs/cm**

| Source | DL | Som Car adjust | CM adjust | Value of F | Value of P |
|---|---|---|---|---|---|
| depth | 2 | 7181,40 | 3590,70 | 1056088,15 | 0,000 |
| Error | 6 | 0,02 | 0,00 | | |
| Total | 8 | 7181,42 | | | |

**Analysis of variance H%**

| Source | DL | Som Car adjust | CM adjust | Value of F | Value of P |
|---|---|---|---|---|---|
| Depth | 2 | 9,78980 | 4,89490 | 48949,00 | 0,000 |
| Error | 6 | 0,00060 | 0,00010 | | |
| Total | 8 | 9,79040 | | | |

**Analysis of variance MO%**

| Source | DL | Som Car adjust | CM adjust | Value of F | Value of P |
|---|---|---|---|---|---|
| Depth | 2 | 103,415 | 51,7075 | 517075,00 | 0,000 |
| Error | 6 | 0,001 | 0,0001 | | |
| Total | 8 | 103,416 | | | |

**Analysis of variance Poro%**

| Source | DL | Som Car adjust | CM adjust | Value of F | Value of P |
|---|---|---|---|---|---|
| Depth | 2 | 123,127 | 61,5636 | 615636,00 | 0,000 |
| Error | 6 | 0,001 | 0,0001 | | |
| Total | 8 | 123,128 | | | |

The analysis of variance with a single criterion of classification of the physico-chemical parameters of the soil of this station of the Ouled Bechih forest (Souk-Ahras) showed a highly significant difference for pH water, pH KCl, PORO %, MO%, H% and EC µs/cm p= 0.000

Station 3: Sidi Abdallah (under zeen oak forest)

The physical and chemical analyses carried out on this profile show that each horizon has a different texture to the other; the first surface horizon has a sandy-silty texture, the second has a silty texture, the third and the last have a clayey-silty texture; the dominance of silts and fine sands is noticeable (Fig.14).

The chemical characterisation of the different horizons shows that we are in the presence of an acid profile (Fig.15).

The potential acidity expressed by the pH KCl gives acidic to very acidic values, which shows that the adsorbent complex is moderately saturated; (the difference between pH water and pH KCl <1).

The hygroscopic humidity is low in this profile (Fig. 16), and it presents a low electrical conductivity which decreases with depth and becomes very low (Fig. 17).

The organic matter monitoring shows that the surface soil is well humified; according to Duthil (1975), a soil is humus-bearing when the percentage of organic matter is close to 10%; and we notice in our profile that this organic matter decreases with depth (Fig. 18).

The porosity corresponding to the relative volume of voids present in the rock (dimensionless number) (Saidi, 2010). The results show that the porosity is average at the surface, probably due to biological activity, and becomes very low at the base of the profile (Fig. 19).

**Analysis of variance pH water**

| Source | DL | Som Car adjust | CM adjust | Value of F | Value of P |
|---|---|---|---|---|---|
| Depth | 3 | 1,74480 | 0,581600 | 5816,00 | 0,000 |
| Error | 8 | 0,00080 | 0,000100 | | |
| Total | 11 | 1,74560 | | | |

**Analysis of variance pH KCl**

| Source | DL | Som Car adjust | CM adjust | Value of F | Value of P |
|---|---|---|---|---|---|
| Depth | 3 | 0,275625 | 0,091875 | 91,87 | 0,000 |
| Error | 8 | 0,008000 | 0,001000 | | |
| Total | 11 | 0,283625 | | | |

**Analysis of variance EC µs/cm**

| Source | DL | Som Car adjust | CM adjust | Value of F | Value of P |
|---|---|---|---|---|---|
| Depth | 3 | 1067,47 | 355,823 | 138183,81 | 0,000 |
| Error | 8 | 0,02 | 0,003 | | |
| Total | 11 | 1067,49 | | | |

**Analysis of variance H%**

| Source | DL | Som Car adjust | CM adjust | Value of F | Value of P |
|---|---|---|---|---|---|
| Depth | 3 | 4,82802 | 1,60934 | 629,06 | 0,000 |
| Error | 8 | 0,02047 | 0,00256 | | |
| Total | 11 | 4,84849 | | | |

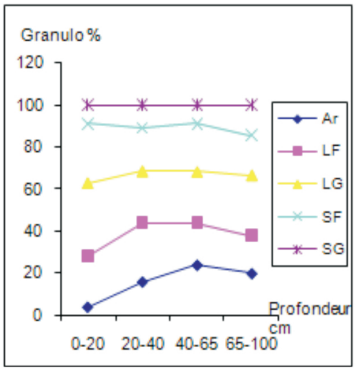


**Fig. 14.** Particle size

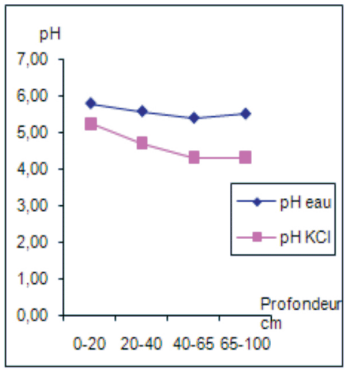


**Fig. 15.** pH water, pH KCl

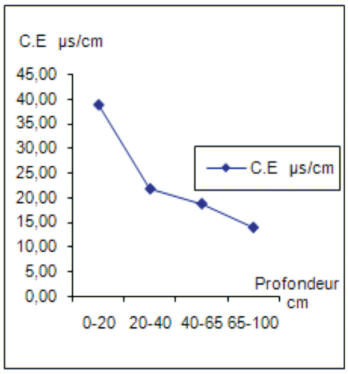


**Fig. 16.** Eclectic conductivity

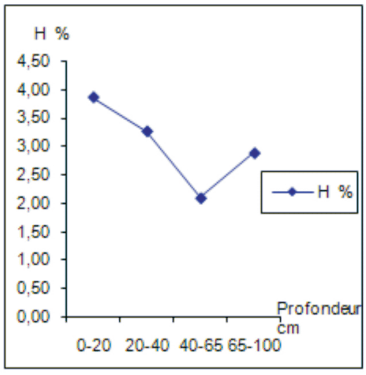


**Fig. 17.** Hygroscopic moisture

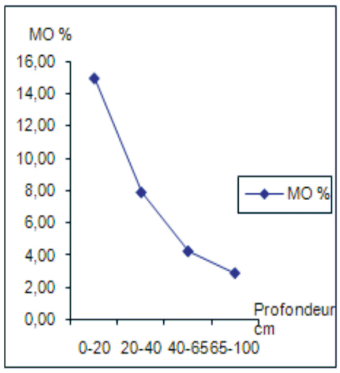


**Fig.18.** Organic matter

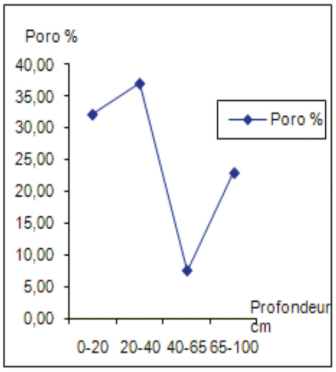


**Fig. 19.** Porosity

**Analysis of variance MO%**

| Source | DL | Som Car adjust | CM adjust | Value of F | Value of P |
|---|---|---|---|---|---|
| Depth | 3 | 261,684 | 87,2281 | 872281,00 | 0,000 |
| Error | 8 | 0,001 | 0,0001 | | |
| Total | 11 | 261,685 | | | |

**Analysis of variance Poro%**

| Source | DL | Som Car adjust | CM adjust | Value of F | Value of P |
|---|---|---|---|---|---|
| Depth | 3 | 1500,29 | 500,096 | 1999,78 | 0,000 |
| Error | 8 | 2,00 | 0,250 | | |
| Total | 11 | 1502,29 | | | |

The single-criteria analysis of variance for the classification of the physico-chemical parameters of the soil of this station in the Ouled Bechih forest (Souk-Ahras) showed a highly significant difference for pH water, pH KCl, Poro %, MO%, H% and C.E µs/cm p= 0.000.

## Conclusion

The forest of Ouled Bechih (Souk-Ahras) is a region with high biodiversity, it is known by the diversity of its ecosystems which are linked to a rich and diversified vegetation cover by the cork oak groves and the zeen oak suberaies. This vegetation cover maintains a close relationship with the substrate that supports it and offers the soil an important quality that represents the quantity of organic matter and mineral elements that the plants need and makes them very rich and diverse. The characterisation of the soils in these three formations has shown the existence of three major soil types, whose pedogenesis is under the direct control of the supply of organic matter. Thus, we find brown forest soils under the Zeen oak forest, eroded brown soils under the mixed forest, and soils that are not very advanced under the cork oak forest.

The relationship between soil and vegetation in this area is controlled by the supply of organic matter; however, the existence of a high cattle load in this region can compromise the conservation and evolution of these soils.

It is therefore necessary to determine the animal load accurately, and to calculate the forest produc-

tion of organic matter, in order to establish a balance between the soil, the vegetation and the animals.

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