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Physico-chemical and biological characterization of the edaphic substrate of *Arbutus unedo* L.

Case of the Tamalous forest (Skikda, Algeria)

Khadidja Bouzid^{1*}, Aman Bouzid²

¹ Graduate School of Agronomy, Mostaganem, 27000, Algeria

² University of Mostaganem, Faculty of Sciences and the Natural Sciences and Life,
BP300, Mostaganem 27000, Algeria

Abstract: *The understanding of the ecological behavior of Arbutus unedo L. in the context of its valuation is the objective assigned to this work. Two different observation sites were selected in Tamalous forest (Skikda) presenting different habitat contexts along a north-south transect. The methodological approach adopted is that of the comparative analysis of the physico-chemical and biological characteristics between a soil under cover of Arbutus unedo L. and bare control soil. The results obtained highlighted quite significant differences between the soils covered with strawberry tree, show that they are acidic in nature, an increase in the rate of organic matter, of the CEC which increases significantly as well as the concentration of exchangeable cations. As for the soil fauna, we observe a clear increase in biomass than in density at the level of all families of individuals, in particular the stations under the strawberry tree cover.*

Keywords: strawberry tree, analysis, soil, fauna, Tamalous, forest

Introduction

Soil is a complex system responsible for many natural functions, in direct interaction with the other compartments of the ecosphere. As a place of agricultural production, the soil has long been considered a support for crops and reservoirs of organic and mineral matter. Characteristics and properties of soils change

under the effect of natural and anthropogenic processes [1]. The Mediterranean forest is one of the most important in the world, it occupies about 65 million hectares of wooded forests and 19 million hectares of sub-forest formations [2, 3].

The strawberry tree (*Arbutus unedo* L.) is one of the most common fleshy fruit species in the Mediterranean region. This small tree is mainly limited to the Mediterranean and Macaronesian zone, with some Atlantic locations in France and Ireland [4].

It is particularly abundant in the southwestern mountain ranges (Sierra Morena and Montes de Toledo), growing mainly in the evergreen forests of *Quercus suber* L. and *Quercus ilex* L. This species can be found from sea level up to 800-1200 m and grows in different soil types although like many Ericaceae species it has a certain preference for acidic soils [5].

The strawberry tree is a species from the Mediterranean region with some incursions further north into Atlantic Europe. In Morocco, this species grows in semi-arid to perhumid bioclimates with hot to cool variants in the thermo-mediterranean and meso-mediterranean on calcareous and siliceous soils [6].

The strawberry tree has a very great ecological importance since it is one of the essential trees of Mediterranean fauna and plays a particularly important role in the ecosystem of the Lebanese middle mountain. It is highly responsive due to its drought tolerance and its ability to regenerate and recolonize burnt forests.

The Strawberry tree is poorly exploited, little known from an edaphic point of view. In this context, the present work consists of a study of the impact of *Arbutus unedo* L. on the physicochemical and biological characteristics of the soil, with a view to better exploitation and valuation.

Materials and methods

Study area

The study area is located in the North-East of Algeria (Wilaya of Skikda), known under the geographical name of Tamalous. It is an area characterized by a subhumid Mediterranean climate. The selected resorts are located in a mountainous area, the Tamalous state forest (Fig. 1). In the field, four stations were chosen (Table 1), according to the edaphic and climatic aspects, the natural presence of the genus *Arbutus unedo* L. and the availability of data on the environment.

Fig. 1. Study area (BOUZID Khadidja, 2020)

Table 1. Geographical characteristics of the stations

Characteristics	Station	Latitude North	Longitude East	Altitude m	Exposure
Stations represented by <i>Arbutus unedo</i> L.	S1	X= 29° 79' 51" N	Y= 40° 79' 77" E	606	North
	S2	X= 29° 78' 47" N	Y= 40° 79' 59" E	630	South
The control stations (without <i>Arbutus unedo</i> L.)	S3	X= 29° 91' 19" N	Y= 40° 80' 43" E	530	North
	S4	X= 36° 84' 20"N	Y= 67° 36' 25" E	540	South

Methodological approach

The methodological approach adopted is that of the comparative analysis of the physico-chemical and biological characteristics between a soil under cover of *Arbutus unedo* L. and a bare control soil.

Sampling and observations

The months from March to July during the year 2020 were chosen to carry out the observations and analyzes. The survey dates during the selected periods were included in weeks without precipitation, sunny with a weak wind.

As for the soil samples for the physico-chemical analysis, they were taken at the stations selected with and without *Arbutus*. At the level of each station, a soil profile was carried out. As well as at each horizon,

samples were taken and kept in airtight bags accompanied by a label mentioning the profile number and the thickness of the corresponding horizon. Then they sent to the pedology laboratory of the Higher School of Agronomy in Mostaganem for physico-chemical analysis.

The soil samples are left to air dry for a few days. Once dried, the soil is sifted through a 2 mm mesh sieve [7], separating coarse elements from fine soil less than 2 mm. The methods used are those described by [8] in his manual of soil analysis.

At each station, plots of 50 cm × 50 cm were chosen. In order to optimize the efficiency of field samples concerning soil fauna, 2 kg of soil was taken from each square of this plot, a total of 8 kg. Samples were taken at random under shade from *Arbutus unedo* L., and other unshaded control samples from *Arbutus unedo* L. nearby.

Physical analysis

Granulometry

The purpose of particle size analysis is to quantify the soil particles by weight in percentage (sands, silts and clays), and to define the texture of the soil. Its principle is based on the sedimentation rate of the particles separated and dispersed by destruction of their cement (limestone and organic matter). The fractionation of these particles is done by means of the Robinson pipette which allows the determination of the fine clayey and silty fractions. Then fine and coarse sands are measured by sieving. Coarse silts are extrapolated by calculation from the results obtained [8]. These results are reported as a function of the percentages of clays, silts and sands in the textural triangle [9], to determine soil texture.

Chemical analysis

pH

The principle consists in measuring the electromotive force of an aqueous solution of the soil (Water/soil ratio) using a calibrated pH meter (AD 1200). It allows defining its acid-base status.

Determination of carbon and organic matter content

The carbon in organic matter is oxidized by potassium dichromate in the presence of sulfuric acid. By knowing the quantity of dichromate necessary for this oxidation, we can calculate the percentage of organic carbon and humus in the soil (The ratio% humus /% CO_x = 1.724) [8].

Soil moisture (Gravimetric method)

Is measured using a conductivity meter depending on the electrolyte concentration in a 1/5 aqueous extraction solution, this depending on the electrolyte concentration. This method consists in drying (passing in an oven at 105°C) a soil sample and then knowing by final weighing (brought back to the initial weighing) the weight of water contained [10].

Electrical conductivity

The saturated paste was obtained after having kneaded two hundred grams of sifted earth at 2 mm, using a spatula, while gradually adding distilled water and left to stand for 4 hours minimum. An aqueous extract was obtained after extracting the paste using a vacuum pump, then diluted with a ratio of 1/10. Finally, the electrical conductivity EC was measured by an AD 3000 type conductivity meter. The tests were carried out on 10 samples. The salinity of the soil is classified according to the electrical conductivity of the aqueous extract 1/10 [11].

Determination of total limestone (CaCO_3)

Based on the characterized reaction of calcium carbonate (CaCO_3) with hydrochloric acid (HCl), the determination of total limestone is carried out using the Bernard Calcimeter [8].

CEC cation exchange capacity

The cationic and anionic compositions of the soil extract were produced according to the method described by [12].

Soil biology

For soil macro and micro-fauna analysis, four soil samples were analyzed by station, several steps have been followed. The first step concerns the inventory and consisted of a sample of individuals observed on sight and resulting from the sieving of the topsoil. The sieve used was a colander with a radius of 20 cm with a mesh of 1 mm. The individuals which could be determined on sight were noted and counted; those presenting identification difficulties were kept in test tubes in order to be identified with a binocular magnifying glass in the laboratory.

Identification of specimens

Identification of the micro and macro-fauna of the soil is carried out under a type binocular magnifying glass (25×10, or 25×40 magnification), at the level of the laboratory of the Higher School of Agronomy of Mostaganem. The recognition techniques used for the different families can be found in the books we have consulted.

Results

Field observations

Station 1 culminates at an altitude of 606 m (Fig. 2). In this station, *Arbutus unedo* L. is characterized by:

- A rough trunk and heavily branched branches with green leaves.
- Its height is 10 m.
- The exposure of the station 1 facing the Mediterranean sea gives it a very humid soil.

- Floristic procession: *Quercus suber* L. – *Myrtus* – *Erica arborea* L.

In station 2 (Fig. 3) which is at an altitude of 630 m, the strawberry tree has the following characteristics:

- Green-yellow leaves with a thin trunk.
- The strawberry tree reaches a height of 2 to 3 m.
- Floristic procession: *Calicotome spinosa* L. – *Cistus* – *Erica arborea* L. – *Quercus suber* L.

Fig. 2. Sampling area in Station 1 (Photo: BOUZID Khadidja, 2020)

Fig. 3. Sampling area in Station 2 (Photo: BOUZID Khadidja, 2020)

Physico-chemical analysis

The results of analysis of soil samples under and without *Arbutus unedo* L. are summarized in Table 2 and Table 3.

Table 2. Analytical results of soils under *Arbutus unedo* L.

Parameters	Station 1			Station 2	
Horizon cm	0-25	25-55	55-95	0-15	15-30
pH	6.5	6.3	5.8	5.8	5.4
OM %	7.9	2.62	0.8	4.5	2.65
C%	4.5	2.15	0.72	2.6	0.86
Humidity %	22.21	18.3	10.2	5.96	3.4
EC mS / cm	0,33	0,25	0,19	0,27	0,17
CaCO ₃ %	3.2	3.9	4.2	4.1	4.8
Ca ⁺⁺	8.5	8.8	8.9	5	2.3
Mg ⁺⁺	4.1	5.6	5.8	1.6	1.9
K ⁺	0.6	0.4	0.5	0.5	0.3
Na ⁺	1.2	1.8	1.9	0.3	0.3
CEC cmol kg ⁻¹	14.4	16.6	17.1	7.4	4.8
Clay %	48	45	52	42	54
Silt %	41	43	30	30	22
Sand%	11	12	18	28	24
Soil texture	Clayey silt			Clayey silt	

Notes: pH; OM% - organic matter; total carbone- C%; CaCO₃%- total carbonate; Ca⁺⁺(cmol kg⁻¹)- exchangeable calcium; Mg⁺⁺ (cmol kg⁻¹)- exchangeable magnesium; K⁺ (cmol kg⁻¹) - exchangeablepotassium; Na⁺ (cmol kg⁻¹) - exchangeable sodium; CEC (cmol kg⁻¹) - Cations Exchange Capacity.

Table 3. Analytical results of soils without *Arbutus unedo* L.

Parameters	Station 3			Station 4	
Horizon cm	0-25	25-55	55-95	0-15	15-30
pH	6.3	6.4	6.2	6.1	5.9
OM %	0.15	0.07	0.03	1.7	0.8
C %	2.01	0.84	0.53	1.92	0.65
Humidity %	12.1	8.04	4.23	13.66	7.35
CE mS / cm	0.38	0.29	0.19	1.34	1.02
CaCO ³	3.8	3.3	4.8	4.2	4.5
Ca ⁺⁺	4.5	3.3	3.8	3	1.2
Mg ⁺⁺	1.8	1.4	2.5	1.1	1.3
K ⁺	0.4	0.3	0.3	0.2	0.1
Na ⁺	0.3	0.2	0.5	0.3	0.2
CEC cmol kg ⁻¹	7	5.2	7.1	4.6	2.8
Clay %	45	43	46	40	40
Silt %	39	30	37	28	28
Sand %	26	27	17	25	25
Soil texture	Clayey silt			Clayey silt	

Granulometry

The fine particle size analysis is very homogeneous with a predominance of stringers on clays and sands, all soil samples have a clayey-silty texture. Its confirms the predominance of fine elements in the upper part of the soil. The sum of clays and silts often reaches and sometimes exceeds 50% fine soil.

pH

All soils are acids with a pH that varies between 5.4 and 6.5 it is a characteristic common to all the soils of the region on rock mass eruptives and crystallophyllians. These pH values reflect an acidification which is confirmed by the analysis of the absorbent complex. It is fully saturated.

Salinity

All the samples analyzed show increasingly reduced salinity values with the depth of the profile, it oscillates between 0.17 mS/cm and 0.33 mS/cm. We notice that the salinity rate is slightly high in station 4 compared to station 1 with a content of 1.34 mS/cm observed on the horizon 0-15 cm.

Organic material

According to the results of the organic matter analysis, Station 1 has a high content compared to station 2. The rate of organic matter follows a very regular decrease from the surface to the deep horizons. From 7.9% on the surface, it gradually decreases to 2.62% around 25 cm, 0.8% around 55 cm for station 1 and from 4.5% around 15 cm on the surface, 2.65% around 30 cm for station 2. Organic matter retains a lot of nutrients.

Carbon

The soils studied are slightly calcareous. Carbon content decreases with depth. The rates vary between 0.53% to 4.5%.

Cation exchange capacity

The cations of the soil solution, The Ca^{++} cation is the most represented with a rate which varies between 2.3% and 8.9%. Mg^{++} comes in second position with contents varying between 1.8% and 5.8%. Na^+ is in third position with concentrations varying between 1.2% and 1.9%, while K^+ comes in last position with contents varying between 0.3% and 0.6%.

CaCO_3 total

Most horizons contain low levels of calcium carbonate. The percentage rates between 3.2% and 4.8%. The soils are slightly calcareous. This is probably due to the surfacing of solutions containing calcium. This content can come from a calcaireo-dolomitic substrate, an average content of limestone favors the development of the stable structure but precipitates in the form of crystalline in depth.

Analysis of the fauna under cover of *Arbutus unedo* L.

Table 4 and Table 5 which follow summarize the results obtained in terms of macro and microfauna of soils under *Arbutus unedo* L. and in bare soil. The diversity in biocenosis varies considerably from one station to another, according to the two gradients selected, altitudinal and from north to south; the number of individuals observed under *Arbutus unedo* L. are more numerous than on soil without *Arbutus unedo* L.

The Fig. 4 shows a disproportion between the specific diversity composing each family studied. Visually, station 1 is the richest in specific diversity, with a rate of 71.25% of the specific total of the 7 inventoried families. Station 2 is individualized by a zoocenosis reduced to 23.75% with the absence of Myriapod, Station 3 and station 4 without *Arbutus unedo* L., is individualized by a very reduced zoocenosis down to 5% with 1 species (ants).

Table 4. Assessment of soil fauna under cover *Arbutus unedo* L.

Biology		Station 1		Station 2		Total
		March	August	March	August	
The insects	Beetle larvae	5	3	2	1	11
pterygotes	Ants	16	10	12	3	41
Myriapods	Geophile	10	2	3	0	15
	Woodlouse	8	1	1	0	10
Scarabaeidae	Chafer	6	2	2	1	11
Ringed worms	Earthworms	15	2	4	1	22

Table 5. Assessment of soil fauna without *Arbutus unedo* L.

Biology		Station 3		Station 4		Total
		March	August	March	August	
The insects	Beetle larvae	0	0	0	0	0
pterygotes	Ants	4	16	2	9	31
Myriapods	Geophile	0	0	0	0	0
	Woodlouse	0	0	0	0	0
Scarabaeidae	Chafer	0	0	0	0	0
Ringed worms	Earthworms	0	0	0	0	0

Fig. 4. Comparison of faunal results between the four stations

Discussion

To interpret the results, we compared our results with those of studies [13] of two species of *Arbutus* L. in Western Anatolia. The stations studied are at the same bioclimatic level but anthropogenic activities somehow modify the station conditions.

Station 1

Very bright, with an average density which varied from 220 plants per hectare; this station is subject everywhere to strong pressures from berry harvest. Other forms of degradation have been reported, in many burnt and degraded places it is above all the incessant grazing of herds, clearing, illegal logging and logging for the making of beehives. This affects the state of stands in its structure, composition and productivity.

Station 2

Much less frequented, is not subject to any other threat. Strawberry tree thrives on generally deep, moist soils which allow good microbiological activity. Our results of the *arbutus* floristic procession are similar to those of Başlar et al. [13], who found that *A. andrachne* and *A. unedo* develop with species of *Cistus* and *Juniperus oxycedrus* L., *Quercus coccifera* L., and *Pinus brutia*.

The observation to note arising from the physico-chemical analysis of the soil at the two stations is the concentration of nutrients in the surface horizon of the soil with the *Arbutus unedo* L.; organic matter gradually decreases in depth. The organic matter content is high under *Arbutus unedo* L. and also decreases significantly with depth at both stations. It is the decomposition (foliage and defoliation) of fine roots and leaves that contributes to these high levels of organic matter. *Arbutus unedo* L. has a capacity to accumulate organic matter mainly in the first twenty cm justifying an increased presence of individuals.

According to Soltner [14], organic matter (humus) has a capacity of adsorption of chemical elements (cations and anions) ten times more than clay; and undoubtedly, organic matter improves the structural stability of the soil by boosting the microbial activity of the soil and increasing water retention.

The analysis of the fine fraction shows a very slight dominance of clay and silt accompanied by a relative poverty of the sand fraction. Indeed, the particle size analyzes showed that the installation of the strawberry tree was favored by the presence in the 15 first few centimeters of the soil, with a relatively high fine element content compared to the underlying horizons.

However, the *arbutus* is distinguished by the fact that it is very often located on soils whose first five centimeters offer a clay-silty texture. This character is mainly due to oblique entrainment, under the effect of runoff water, but also to the nature of the substrate. Most of the clay content is increased at the expense of silt. These results compared to those of Başlar et al. [13] show that *Arbutus unedo* L. in Southern Anatolia is found in humid and sub-humid bioclimatic zones, the soil samples have different textures of clay-loam, sandy-clay-loam and loamy.

The cation exchange capacity and cation concentration are generally higher under the *Arbutus unedo* L. of the Tamalous forest compared to those of Başlar et al. [13] whose results of analysis of the plants showed that the concentrations of calcium, nitrogen, phosphorus and potassium were normal in both species. The results obtained in the skikda study area (Algeria) remain very appreciable and constitute a reference that can be used to justify such plantings in the dominale forest of Tamalous (Skikda).

It is noted that the increase in the cation exchange capacity is positively correlated with the clay content of soil, organic matter and acidic pH. However, its increase with depth may be linked to an accumulation of clay material at depth under the effect of porosity and infiltration capacity. According to [15]: "Each percentage of organic matter contributes to the increase in cation exchange capacity". They differ in the calcium carbonate content of the soil, but flourish on nitrogen-rich soils with adequate levels of phosphorus and potassium.

The pH results compared to those of Başlar et al. [13] show that *Arbutus unedo* grows on neutral to slightly alkaline soils, the pH is between 6.78 and 7.80. In another study [16], it was reported that *Arbutus andrachne* can grow on acidic soils, this agrees with our results.

According to Huetz De Lempis [17], pH has an influence on three important components of soil fertility, biological activity, structural stability and the bioavailability of nutrients.

The soil climate is characterized by the persistence of sufficient humidity; Humidity, altitude and temperature are determining factors in optimal habitat for wildlife; they have the ability to influence the reproduction rate and growth of individuals. The moisture content depends on the nature of the soil, its richness in organic matter, the period and the location of the sample [18].

On the other hand, altitude is certainly a factor of diversification but the data are still quite insufficient for a detailed ecological study of this problem. In addition, the systematic collection of fruits constitutes a major handicap and a major constraint for the natural regeneration by seed; the nature of the substrate has an influence on the vegetative who develop there; on the other hand, the exposure, the slope and of course the human interventions are key factors of the biological richness of these environments.

The rates of electrical conductivity of soil samples under cover of *Arbutus unedo* L. show very low levels, indicating that these soils are unsalted. The rate of soluble salts in soils is a function of depth, texture, evapo-transpiration as well as the humidity of the profile [19].

The control soil from station S3 has the highest value which is 1.34 ms/cm, which indicates that these analyzed soils are very salty soils. Indeed each station differs from the other by the degree of salinity because the mineral salts especially Na^+ moves from one horizon to another under the action of various factors such as; the physical state of water, temperature, texture and water regime of the soil.

Regarding electrical conductivity, our results are in agreement with those of Başlar et al. [13], Soil salinity values of *Arbutus andrachne* and *Arbutus unedo* range from 0.25% to 0.124%. According to the salinity classification [20], both species prefer non-saline soils.

Arbutus unedo L. has the capacity to accumulate organic matter by the large presence of individuals. The number of fauna is higher in the superficial horizons (depth of 20 cm). On the other hand, there is a significant decrease in the total number of individuals in soils without *Arbutus unedo* L.

Humidity, altitude and temperature are determinants of optimal habitat for wildlife, they have the ability to influence the rate of reproduction and growth of individuals and their vertical distribution along a profile [21]. Indeed, a fairly significant biological diversity is recorded at the level of the S1 station, the one which conceals the best edaphic potential.

In the spring period (month of May), the number of individuals is significantly more abundant than in the cold season (November) for the 4 stations. It should be noted that the differences between stations seem particularly marked and individualized in the composition of the communities.

Conclusion

The use of the results obtained, mainly based on a comparative approach between soil with *Arbutus unedo* L. and control soil, brings out the following observations: *Arbutus unedo* L. significantly influences the physico-chemical characteristics of the soil (structure, organic matter, salinity, etc.), withstands the fauna and constitutes a focus of accumulated biological activity. The analysis of the results obtained also makes it possible to underline that the organic matter obtained from *Arbutus unedo* L. constitutes a potential indicator of improvement of the edaphic and biological properties of soils. Soil analysis has shown that these taxa grow on different types of soils with clayey-silty texture. In view of the very encouraging results recorded, *Arbutus unedo* L. could be recommended and generalized under climatic and edaphic conditions similar to those of the experimentation for the development of soils in mountain areas, forest management and regeneration for the natural ones.

References

- [1]. Jolivet, C.; Boulonne, L.; Ratié, C., Soil Quality Measurement Network Manual. Info Sol Unit, INRA, Orléans, France, **2006**.
- [2]. Seigue, A., The Mediterranean forest and its problems. Agricultural techniques and Mediterranean productions. New house and Larose, Paris, **1985**, p. 502.
- [3]. López Bermúdez, F.; Rognon, P., Water erosion, desertification and development in the semi-arid Mediterranean environment. University of Murcia, Network 8: Desertification and Planning, **1996**.

- [4]. Villar, L., *Arbutus* L. In: Castroviejo, S.; Aedo, C.; Gómez, C.; Laínz, M.; Montserrat, P.; Morales, R.; Muñoz, F.; Nieto, G.; Rico, E.; Talavera, S.; Villar, L. *Flora ibérica*, CSIC, Madrid, **1993**, 4, 514-516.
- [5]. García, R., Flora y vegetación de interés conservacionista de Sierra Madrona y su entorno (Ciudad Real, Sierra Morena, España). *Ecosistemas*, **2007**, 16(1), 97-111.
- [6]. Aafi, A.; Sghir Taleb, M.; Fechtal, M., Remarkable species of Moroccan flora. MCEF, DREF. Rabat. **2002**, p. 146.
- [7]. Afnor, N., Soil quality. Methods of analysis. Collection of French standards. Paris, **1987**, p. 135.
- [8]. Baize, D., Guide to current analyzes in pedology. INRA, Paris, **1988**, p. 172.
- [9]. Duchaufour, P.H., Summary of pedology, soil, vegetation, environment. Masson, Paris, **1997**, p. 291.
- [10]. Richards, L.A., Diagnosis and improvement of saline and alkali soils. AIBS Bulletin, **1954**, (4) 3, p. 14.
- [11]. Mathieu, C.; Pielain, F., Chemical analysis of soils. Technical and documentation edition. Lavoisier, Paris, **2003**, p. 292.
- [12]. Jackson, M.L., Soil Chemical Analysis. International Institute for Tropical Agriculture (IITA). Manual Series, **1962**, 1, 70.
- [13]. Başlar, S.; Doğan, Y.; Mert, H., Studies on the soil-plant interactions of two *Arbutus* L. species in West Anatolia. *Botanika Chronika*, **2002**, 15, 63-74
- [14]. Soltner, D., The basics of crop production. Volume 2. 6th edition. Agricultural science and technology. Sainte Gène on the Loire, 49310, France, **2003**.
- [15]. Janssen, R.; Rietveld, P., Multicriteria analysis and geographical information systems: an application to agricultural land use in the netherlands. In: Scholten HJ, Stillwell JCH. (eds) Geographical Information Systems for Urban and Regional Planning. The *Geo Journal Library*, **1990**, 17, 129-139. Information systems for urban and regional planning, Springer, Dordrecht.
- [16]. Anonymous, Bitkilerden Elde Edilen Boyalarla Yün Liflerinin Boyanması. Ankara, **1991**.
- [17]. Huetz De Lemps, A., The vegetation of the Earth. Masson, Paris, **1970**.
- [18]. Aubert, M., The spontaneous polarization method in hydrogeology of volcanic soils. *Journal of Water Sciences*, **2003**, 16(2), 219-235.
- [19]. Bendaanoun, M., Cynecological and dynamic study of the halophilic and hydro-halophilic vegetation of the Bou-Reg Reg estuary (Atlantic Morocco). Application and planning perspective. Doctoral thesis. University of St Jérôme. Aix-Marseille III, **1981**, p. 221.
- [20]. Anonymous., Soil Survey Staff. Handbook 18, Washington, **1951**.
- [21]. Bouzid, A., The study of the interaction of the genus *Atriplex* on the physico-chemical and biological characteristics of the West Algerian soil. Doctoral thesis, Abdelhamid Ibn Badis University, Mostaganem, **2011**, p. 164.