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Study of the Soils' Diversity of Annaba Plain, Algeria

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ABSTRACT

The aim of this work is to highlight the diversity and the physico-chemical characterization of the soils of the plain of Annaba, North East Algeria. For this purpose we based on a systematic sampling plan. In order to identify the diversity of the soils in this plain, a qualitative characterization of the soils that integrate this plain was made, of which 12 stations representative of the area in question were chosen; Several physico-chemical parameters were carried out such as, the granulometry, the hydrogen potential, the electrical conductivity, the hygroscopic moisture, the organic matter and the total limestone to define and valorize the quality and the pedological richness of this region. The physico-chemical parameters analyzed allowed to define the characteristics of the soils namely the pH which is slightly alkaline with a clayey-silt texture, the conductivity which is moderate and a limestone rate which means that the soils of our study area are moderately calcareous. This situation suggests a strict control of organic matter inputs in the soils of this plain because this organic matter is the major element for the structural stability and the balance of the soil.

Key words: *Soil, Diversity, Plain, Organic matter, Soil richness.*

Introduction

Biodiversity is currently a major issue in ecological research, both regarding its role in ecosystems, its determinism and its valuation in the field of environmental preservation (Solbrig *et al.*, 1994 in Kaci, 2017).

And to preserve the environment it is necessary to conserve the soil which is a fragile resource, and the need to protect it (Curry and Schmidt, 2007). It is a complex compartment, a multifunctional cross-roads, in relation to the lithosphere, hydrosphere, atmosphere and biosphere. It is the result of the alteration, reworking and organization of the upper layers of the earth's crust under the action of life and the energy exchanges that take place there (Gobat *et al.,* 1998; Lozet and Mathieu, 1997).

The diversity of soils is linked to the diversity of the factors of their formation. Indeed, soils are derived from the alteration 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 marked alteration processes, giving rise to a variety of soils (Bunning and Jiménez, 2003).

This diversity generates soils of different colors, consistencies and textures. These soils present variable physical or chemical properties, making them more or less suitable to fulfill their functions. The knowledge of this natural diversity becomes essential for a sustainable management of soils and environment (Gouyon and Leriche, 2010).

Soil is a living and dynamic entity, which is necessary for the functioning of terrestrial ecosystems (Doran *et al.,* 1999). Also it is a support of biodiversity, support of vegetation, carbon storage, filter, water storage (Pey, 2018). The soil is a superficial layer of the earth's crust, performs many functions essential to humans and their environment (Jouquet *et al.,* 2006). Although it is a non-renewable resource of the globe, soil is subject to many anthropogenic stresses that degrade its properties and can lead to the loss of essential functions (Séré, 2007).

It is for this reason that we access our work on the soils of North East Algeria, which is characterized by a great eco-systemic diversity with an invaluable biological wealth. This eco-systemic heterogeneity is reflected in the great geomorphological diversity (valleys, plains, swamps, lakes, dunes, hills ... etc.), edaphic (clayey soils, sandy, halomorphic and limestone) and climatic (the interweaving of various bioclimatic stages of vegetation, humidity, subhumid and semi-arid (Benslama *et al.,* 2007).

This area is located in the North East of Algeria where a Mediterranean climate prevails, the effect of climatic factors on a mother rock has favored the formation of different types of soil.

The region of Annaba is considered as an area that is characterized by a highly productive agricultural plain, that is why we tried to evaluate and characterize the diversity existing between the different types of soils of this plain.

Materials and Methods

The wilaya of Annaba is the industrial capital of Eastern Algeria, it is located between latitudes 36°30' North and 37°03' and longitudes 7°20' East and 8°40' East. With an area of 1411.98 km^2, Annaba is bordered to the North by the Mediterranean Sea, to the West by the willaya of Skikda, to the South and to the East by the willayas of Guelma and El Tarf (Debieche, 2002). The study area is located in the North-East of Algeria and covers, practically, the area of the Seybouse valley oriented approximately North-South in the plain of Annaba. The field of investigation is in the form of a low plain limited: (Figure 1).

-To the North, by the Mediterranean Sea.

-To the West, by the Massif of Belelita (287 m) and Bouhamra (152 m) separated from the main massif of the Edough (1008 m) and the Fetzara lake located more to the southwest.

-To the south, by the eastern Numidian chain.

-To the east, by the Bouteldja aquifer system. (Abour *et al.,* 2018).

The plain of Annaba has a large surface area, the collection of each sample was done according to a systematic sampling, which we have chosen 12 representative squares of the area in question.

The collected soil samples were dried, crushed, sieved and analyzed in the laboratory. The following physico-chemical analyses were performed on

Fig. 1. Presentation of the study area

the fine fraction of soil: pH water, pH KCl by pH meter. Electrical conductivity by Conducti meter. Hygroscopic moisture by oven drying (24h at 105°C). Organic matter by incineration in a muffle furnace (4h at 450 °C). Total limestone by tetrimetric method. Granulometry by the international pipette method. Real density by Pycnometre.

The fractionation of humic matter according to Duchufour and Jacquin, (1966).

And on the fraction of soil that was not ground, only one analysis was performed: Bulk density by kerosene. (Samai *et al.*, 2020).

Results and Discussion

The soil samples collected from the different stations were processed according to the appropriate protocols and then made by statistical analyses.

Granulometry

Using the textural triangle of (Jamagne, 1967), The particle size of a soil is important because it has a direct effect on porosity. Fine particles (clay) increase water retention, but decrease aeration (Soltner, 1987).

Particle size analysis is used to determine the texture of the soil. According to the values, we can see that we are in the presence of soils with varying texture;

- The granulometric result of the samples A, B, E, L, describes the relative proportions of the various sizes of the solid particles of the soil (clays, silts and sands); from the data provided by the analysis of these samples, it appears the dominance of clays and silts, (Figure 2); According to Duchaufour (1970) soils rich in silt offer a particular texture that is often very unfavorable; the quantity of mineral colloids is insufficient to allow the formation of aggregates.

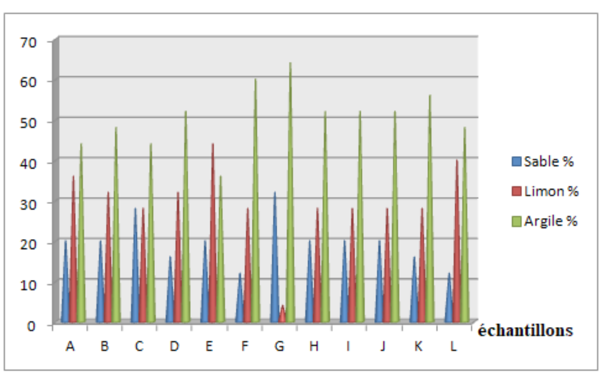

Fig. 2. Variation of particle size in studied soils.

- Physical and chemical analyses carried out on samples C, D, F, G, H, I, J, k, show that the texture is clearly clayey (more than 52% clay) (Fig. 2).

Hydrogen potential (pH)

pH water

The pH is a measure of the acidity of water, that is, the concentration of hydrogen ions (H^+). The pH of natural water can vary from 6 to 8.5 depending on the acidic or basic nature of the soil (Devillers and *al.*, 2005).

The pH indicates the concentration of H+ ions present in the water. The reading of Figure 3 shows that the pH values of the soil range from neutral to basic pH. They are under the control of several factors which are mainly; the topographic position, the nature of the parent rock and the nature of the vegetation cover.

Therefore these soils are divided into two classes:

- Soils with a neutral pH between 6.5-7.5:

These soils have a neutral or near-neutral reaction and are A, B, C, D, F. They contain an average amount of $CaCO_3$, and develop under the same conditions of vegetation and parent rock.

It is therefore felt that the pH is directly related to the content of limestone ($CaCO_3$).

The second class: basic soil, pH >7.5

In this category, we find the majority of our samples: E, F, G, H, I, J, K, L, (70% of the total analyzed); they cover the largest surface of the Annaba plain and they develop under different vegetation covers (Figure 3). They are either agricultural or urban or reconstituted, but all are characterized by an important content (>20%) of limestone CaCO3.

pH KCl

The pH kCl expresses the exchange acidity or potential acidity. It is an experimental index of the degree of saturation of the absorbing complex, as well as the chemical nature of the fixed ions.

The values of the pH kCl of the totality of the studied soils (evolve in the same direction as the pH water.

This situation allows us to say that the absorbing complex is sufficiently saturated, and that there is a certain equilibrium between the actual acidity and the potential acidity.

The difference between pHwater and pHkCl does not exceed one unit, which is linked to the

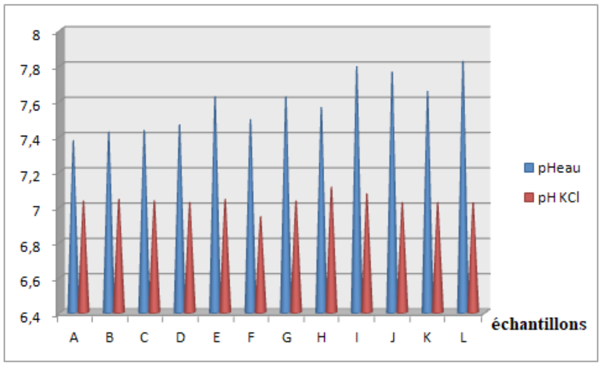

Fig. 3. Relationship between pHw and pH KCl in the different soils studied

presence of a quantity of limestone that provides the soil with a fairly significant buffer capacity. The analysis of these two "2" parameters pH water and pH kCl shows that our soils present a certain stability and resist quite well to all brutal modifications of the soil reactions.

Electrical conductivity (E.C.)

Electrical conductivity is important to know because it gives us a general idea about the salinity of a soil. It is directly proportional to the quantity of mineral salts dissolved in water (Durand, 1983). 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 results of our analysis show that the majority of soils have a low to medium electrical conductivity (< 1000 μs/cm²) such as the sample: B, C, D, E, F, J, L, (Figure 4); this is regardless of the nature of the substrate and the type of soil.

Soils with high electrical conductivity are located in areas of accumulation and stagnation of irrigation water where drainage channels rarely function, such as sample: A, H.

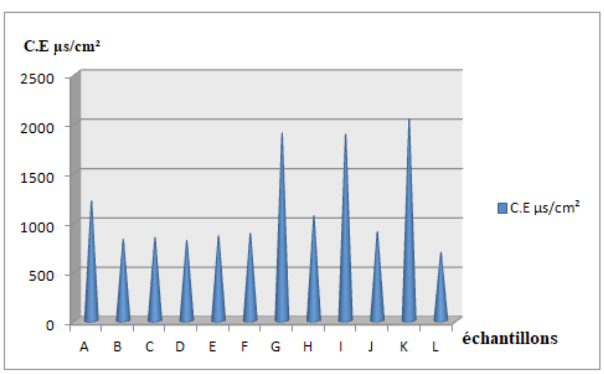

Fig. 4. Variation of the electrical conductivity of the studied soils.

The clay texture also favors the accumulation of electrolytes, and this is the explanation for the increase in eclectic conductivity that exceeded 1890 μs/cm²; this is the case of soils I and K.

Hygroscopic moisture (H%)

Hygroscopic moisture comes from atmospheric moisture and forms a thin layer around soil particles. It is highly energetically retained and cannot be used by soil fauna or flora (Mbakwiravyo, 2009).

Hygroscopic moisture is the amount of water that can be retained by a soil under natural drying conditions. It is also the amount of water retained on the outer surface of soil particles and in equilibrium with atmospheric pressure and moisture.

The results obtained (Figure 5), show that this humidity is between 4% and 5.8%; these values are related to the texture of the soil, because fine-textured clay soils retain more water than sandy soils with a particulate structure.

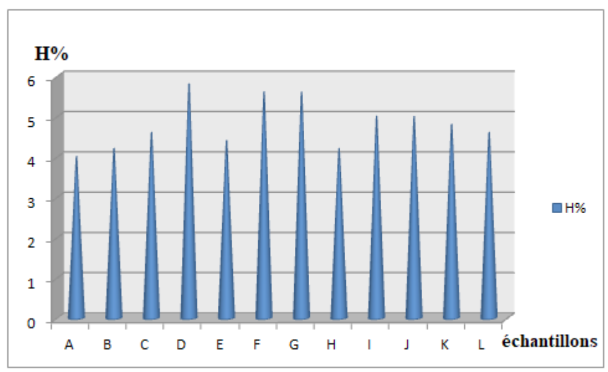

Fig. 5. Variation in hygroscopic moisture in soils in the study area.

Porosity (Poro%)

The relationship apparent density real density defines the porosity of the soil,

The porosity of the soil, represents the volume of the pores of a soil and their dimensions. It depends on the granulometric composition and the structure of the soil; in our plain the texture of the soil is clayey silty where it offers an average porosity it is the case of sample; A, B, E, F, L. This granulometric composition changes in the rest of the plain with an increase of the clay rate where it becomes almost compact in the sample: C, D, G, H, I, J and K. whose values between 3.89% and 7.02% (Figure 6).

Organic matter (OM%) and ash content TxCend%

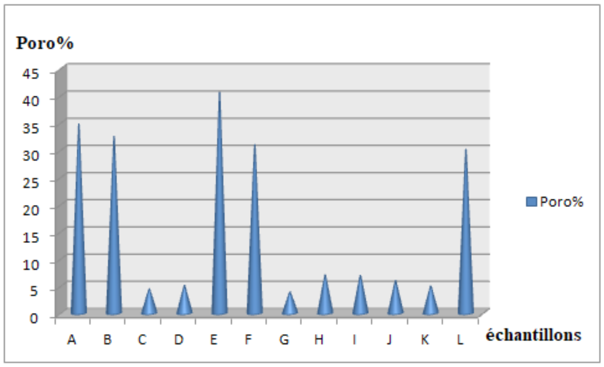

Fig. 6. Variation in porosity in soils in the study area.

Organic matter plays a very important role in the physical, chemical and biological functioning of the soil. It improves the coherence of structural elements, favors the retention of useful water, participates in the reversible storage of nutritional elements, limits the development of certain parasites, and increases soil aeration. It is formed essentially by flows of plants in stages of decomposition, animal excrement and microbial cells (Davet, 1996).

The evaluation of the rate of organic matter and according to Lambert, 1975 made it possible to classify the soils of this plain in 3 classes:

- Soils with an organic matter rate between 1 and 2%: these are soils poor in organic matter such as the sample: G. They are either characterized by a low contribution or by a high biological activity. It is in these soils that the mineralization process dominates. The totality of the organic matter is integrated in the soil.

- Soils with an organic matter rate between 2 and 4%: This class represents the vast majority of our soils (samples: A, D, C, E, K, L, and shows that in these soils, there is a low accumulation of organic matter, thus soils moderately rich in organic matter.

- Soils with an organic matter content between C > 4%: This class includes some soils that are characterized by a strong accumulation of organic debris (samples: B, F, H, I, J; therefore they are soils rich in organic matter (Figure 7).

The rate of ash confirms the mineral character of the soils of the plain of Annaba (Figure 8).

Total limestone ($CaCO_3$%)

The dosage of total limestone in our soils shows relatively high values especially for soils developed on

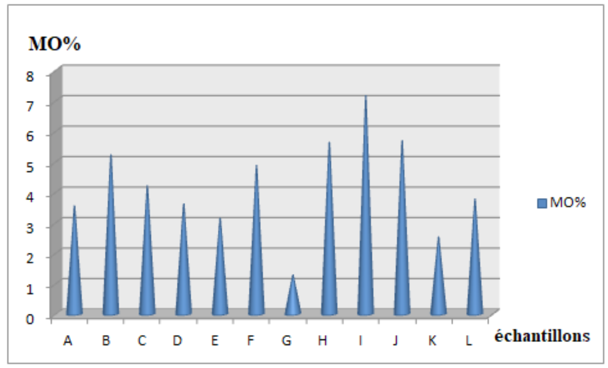

Fig. 7. Distribution of organic matter in soils of the study area

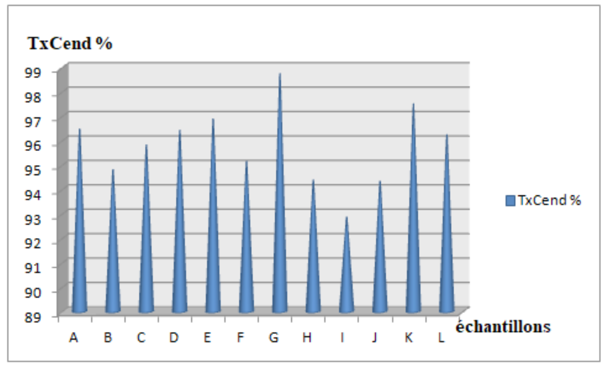

Fig. 8. Distribution of ash content in soils from the study area.

sand or in reconstituted soils. The presence of limestone played a great role in the ionic equilibrium, especially in the pH values.

The total limestone values recorded in our study area are between 23.97% and 24.95% (Figure 9). The limestone content related either to the nature of the substrate or to the various artificial contributions to correct the pH of the soil and to reinforce the buffering capacity of these studied soils.

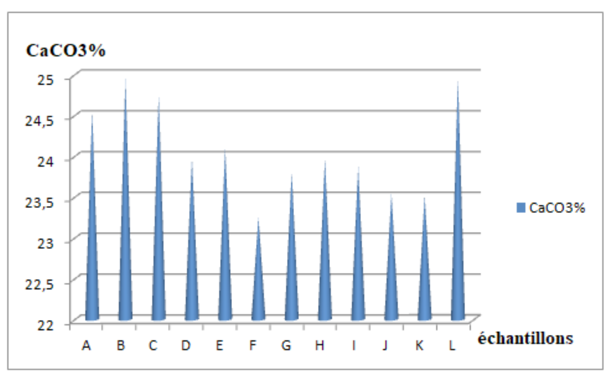

Fig. 9. Variation of total limestone content in soils of the study area

Fractionation of organic matter

The fractionation of the organic matter of the soils has allowed to obtain the following results. The examination of these results shows that all the soils studied have a very high humification rate of about 80%. This rate of humidification is mainly represented by humin which is a stable fraction of organic matter, it represents almost 30% in all the soils of the plain. We also noted the absence of humic acid which represents the condensed and polymerized fraction of organic acids, it is about 0% in all the samples.

The presence of very high levels of fulvic acids, (of the order of 50%), indicates that the organic matter is rapidly transformed and these acids whose molecular weight is low, and they are soluble in water. The fulvic acids witness a rapid physico-chemical transformation of this organic matter. The light fraction, which is linked to organic parts that are difficult to biodegrade, is moderate in all samples (between 20% and 26%).

The stational distribution of the fractionation results (Figure 10), shows a slight difference from one station to another.

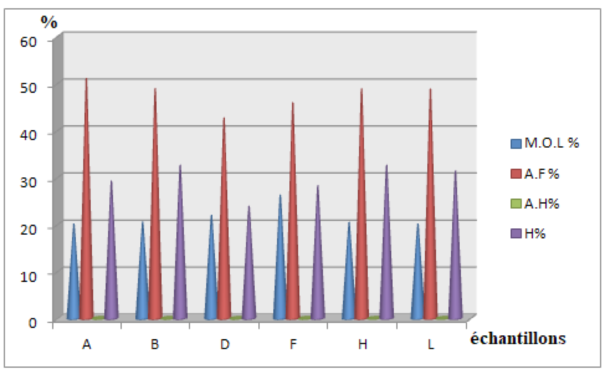

Fig. 10. Distribution of the different fractions of the organic matter of the soils of the Annaba plain.

Statistical analysis

Statistical analysis was performed using MINITAB software. Data were analyzed using ANOVA analysis of variance and STUDENT'S T TEST, comparison of means was made by TUKEY'S TEST. The test was applied at a probability level of p = 0.05 to find significant differences between means. These analyzes were carried out with the aim of comparing the physico-chemical characteristics of the soils of Annaba plain.

Table 1: Physical constituents of the soils studied

The grain size analysis (Table 1) from the quantitative point of view shows the dominance of the clay fraction (50%) in the soils of Annaba plain. (Mean ± SD; n= 12 repeats each corresponding to one characteristic; the mean values followed by the same letter are not significantly different at 5% level by Tukey's test).

The analysis of variance with a single criterion of classification of the physical parameters of soil for the soils of the plain of Annaba showed a highly significant difference for Sand (%), Silt (%) and Clay (%) ($p < 0.001$).

The pH results (Table 2) indicate that the soils of Annaba plain have a pH-water=7.593, and therefore, characterized by a basic reaction, the pH-water is higher than the pH –KCl=7.020. (Mean ± SD; n= 12 repeats each corresponding to one characteristic; the mean values followed by the same letter are not significantly different at 5% level by Tukey's test).

The results of the one-factor ANOVA indicate a highly significant effect on potential soil acidity ($p<0.01$).

Table 2. The variance of the hydrogen potential (pH)

Source	ddl	SCE	CM	F_{obs}	P
Physical constituents	2	6277	3138,69	52,62	0,00***
Residual error	33	1968	59,64		
total	35	8246			

Table. Analysis of variance with one classification criterion of data on the variance of the hydrogen potential (pH) of the soils of Annaba plain.

pH	pH water	pH KCl
Mean ± SD	7,593±0,04 **a**	7,020±0,01 **b**

Conclusion

The soil is the most poorly known component of the

Table 1. Analysis of variance with a classification criterion of data on the physical constituents of soils of the plain of Annaba

Granulometry(%)	Sand (%)	Silt (%)	Clay (%)
Mean ± SD	18,67±0.37 a	30,58±0.52 b	50,67±0.28 c

Source	ddl	SCE	CM	F_{obs}	P
Hydrogen potential	1	1,9608	1,96082	157,49	0,00***
Residualerror	22	0,2739	0,01245		
total	23	2,2347			

environment even though it is the direct support of most human activities (Robert, 1996). Indeed, by its position of interface between the organic and inorganic world, it is the seat of several chemical reactions ensuring the passage from one world to the other.

Within the framework of the study of the diversity of the physicochemical characterization of soils, our work was directed towards the analytical analysis of the soils of the plain of Annaba, North East of Algeria.

The physico-chemical characterization of the soils of the Annaba region has allowed to highlight the slightly alkaline character with a water pH higher than 7 and an electrical conductivity which rarely exceeds 500 µm/cm^2, with a clayey-silt texture.

The total limestone content shows a clear separation between the soils of the plain and those of the forest zone. The low water content is probably related to the drying time.

These informative results are the subject of the study of organic litter, which appears to be very important in stabilizing the soil, hence the need to preserve plant cover in order to increase the productive potential of the soil and increase its diversity.

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