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Physicochemistry of salty soils of the municipality of Loul Sessène (Fatick-Senegal)

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Abstract: The municipality of Loul Sessène under the effect of climate change is facing a strong advance of salty land in recent decades. The purpose of this article is to analyze the physicochemical characteristics of salty soils. The methodological approach is based on the determination of the electrical conductivity (EC) from a suspension of 20 g of soil and 200 ml of distilled water according to the ratio of the extract 1/10, the pH determination from of a suspension of 20 g of soil and 10 ml of distilled water at a ratio of 2/5, the method of extraction of soluble salts to determine the ionic balance by a mixture of 50 ml of distilled water and 20 ml of distilled water of soil and granulometric analyzes carried out with Robinson sieve and pipette method. The results obtained show that, except for the soils of "flooded tans" by the surface tide, which are slightly acidic to very alkaline, the tannic soils are on the whole very acidic. The pH is generally less than 5.3. Soil salinity is ascending; the maximum electrical conductivity of the sites is noted on the surface. A sharp advance of extremely salty soils to the detriment of salty and slightly salty soils is noted. Soils are characterized by a dominance of sodium ions (Na^+) on potassium (Ka^+), magnesium (Mg^{2+}) and calcium (Ca^{2+}). They are sodium chloride and are sandy-loamy in shrub and herbaceous tans; silt-sandy-clay in bare tanns.

Keywords: Municipality of Loul Sessène, Physicochemistry, saline soil, electrical conductivity, ionic balance, granulometry, organic matter

INTRODUCTION

Three periods of intense drought affected the Sahelian countries of West Africa during the 20th century[1]. These are the droughts of the 1910s, 1940s and the great drought that began[1] in 1968. This drought, which appeared in the late 1960s and early 1970s, resulted in annual rainfall deficits[2] of up to 20 to 25%. These long droughts have accentuated, in recent years, the salty soil formation processes of the Senegal River Delta, the lower Casamance Valley and the Saloum Estuary[3]. In the Commune of Loul Sessène, an integral part of the Saloum estuary, about 8,109.3 ha of land are affected by salinization[4]. These salty lands have covered almost all of the eastern part, more than a third of the area of the municipality[4]. This chemical degradation of the land led to the disappearance of more than 5000 ha of vegetation[4] between 1988 and 2010, a cropland insufficiency[5], a decrease in the productivity of the land, which resulted in an appreciable fall in yields agricultural[6].

PRESENTATION OF THE ENVIRONMENT

The commune of Loul Sesséne (**Figure** 1) is located between the latitudes 14 ° 24 'and 14 ° 10' N and between the longitudes 16 ° 43 'and 16 ° 24' W. It is located in the district of Fimela in the department of Fatick. It covers an area of 328 km^2. The commune is limited to the North by the commune of Tattaguine, to the South by the commune of Djilasse, to the East by the commune of Diouroup and to the West by the commune of Nguéniene in the department of Mbour.

The municipality of Loul Sesséne is part of the Ogolien dune cord of Fimela. Its relief is characterized by vast plains which extend on the whole of the commune.

In terms of climate, the municipality of Loul Sessène is part of the North-Sudanian domain. The study environment is swept for 6 to 7 months by the Atlantic monsoon and 5 to 6 months by the continental trade winds (Harmattan).

The average wind speed is 2.4 m / s from 1991 to 2014. Sunstroke averages 2,735.8 hours during the period 1991 to 2014. Temperatures are generally high with an annual average of 28.7 ° C. Evaporation and relative humidity showed respective averages (1991 to 2014) of 2,325.8 mm and 57.5%. The municipality receives rainfall totals between 500 and 1000 mm. The average rainfall from 1985 to 2014 is 579.6 mm. The municipality of Loul Sessène, like all of West Africa is marked by a very severe drought in the late 1960s and early 1970s **(Figure** 2). This drought is characterized by rainfall deficits of more than 30%.

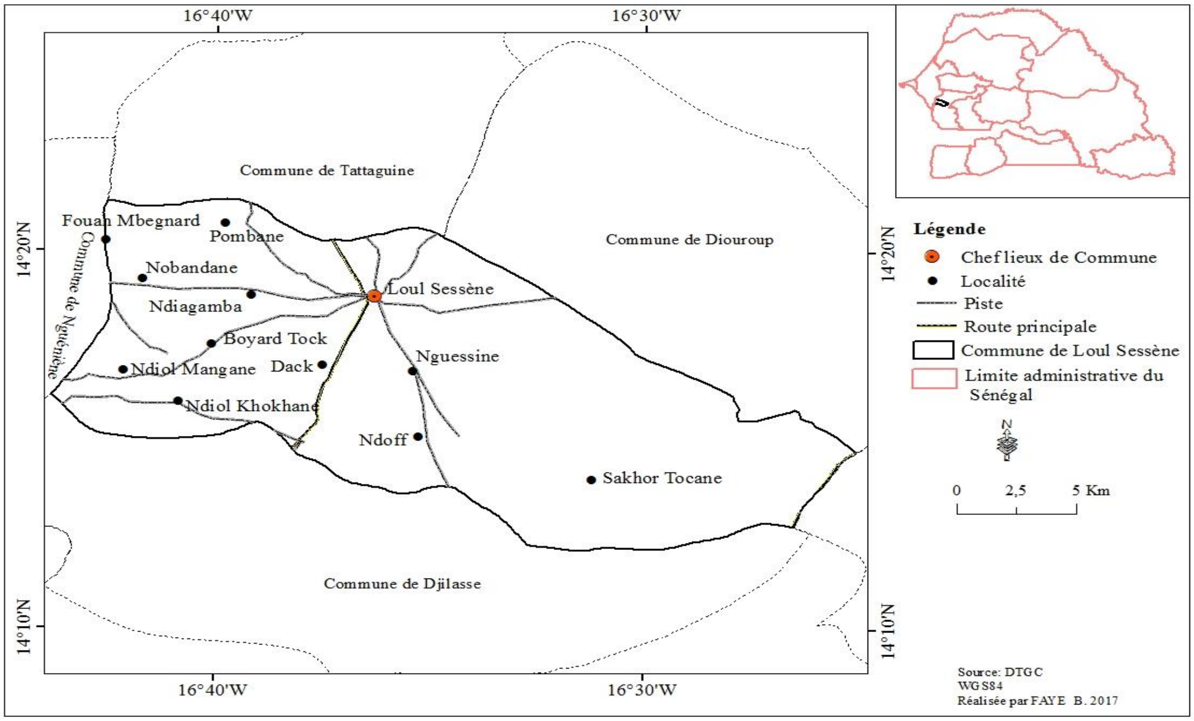

Figure 1: Location of Loul Sesséne

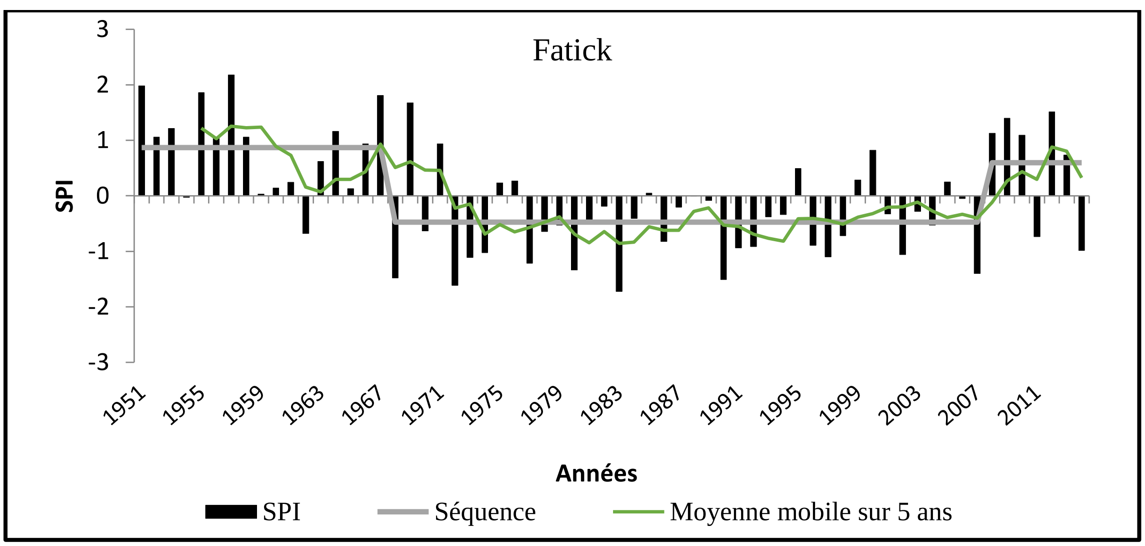

Figure 2: The Standardized Rainfall Index of Fatick Station

The main types of soils are ferruginous soils with little or no leaching (Diors), which represent 20% of the area of the municipality, the ferruginous soils leached on sandy-clay sandstones (Deck) which represent 40% and the salty soils which occupy 25%, the low input soils represent the remaining 15%. These so-called tanned soils are located in the eastern part of the municipality.

2.1. Sample collection and preparation: The sampling sites are located in the village of Ndoff. The choice of this village was based on the visibility of its toposequence more visible in this environment and its accessibility.

***Baretan* =** extremely salty soil which is characterized by a total absence of vegetation because of the excessive concentration of salts

Herbaceous tan = Very salty soil that is covered with herbaceous vegetation

Shrubby tan = Salty soil characterized by shrubs such as Combretum glutinosum, Balanites aegyptiaca,

In the interest of a good physicochemical characterization of the salty lands, the samples are taken according to the toposequence. That is to say, bare tan, herbaceous tan to shrub tan. A sample of about 600 g of soil is taken from the horizons 0-20 and 20-40 cm using a auger type Australian.The samples taken are dried in the open air and sieved with a mesh screen of 02 millimeters to extract the fine elements.

2.2. Chemical analyzes: The chemical analyzes carried out with these fine elements relate to the pH, the electrical conductivity and the ionic balance. The pH is measured with a pH meter equipped with an electrode from a suspension of 20 g of soil and 10 ml of distilled water at a ratio of 2/5.

The measurement of the electrical conductivity is made with a conductivity meter equipped with an electrode. It is determined from a suspension of 20 g of soil and 200 ml of distilled water according to the ratio of the 1/10 extract. The method for extracting soluble salts to determine the ionic balance is made by a mixture of 50 ml of distilled water and 20 g of sol.

The ionic balance: The soluble salts of the soil comprise a set of cations Na^+ (sodium), K^+ (potassium), Ca^{2+} (calcium), Mg^{2+} (magnesium) and anions Cl^- (chloride), HCO_3^- (bicarbonate), CO_3^{2-} (carbonate), SO_4^{2-} (sulfate).

Soluble salts extraction method: 20 g of soil sieved with a 2 mm sieve are weighed into a 200 ml beaker. 50 ml of distilled water are added. The suspension is homogenized for 5 mm and filtered in a 250 ml volumetric flask. The percolation is continued by successive fraction of 50 ml of distilled water until 200 ml (4 times). At the last fraction, the earth contained in the beaker is poured on the funnel and the suspension is adjusted with distilled water.

Once the extract obtained, Ca^{2+}, Mg^{2+}, Na^+, K^+, CO_3^{2-}, HCO_3^-, Cl^-, SO_4^{2-} and organic matter (MO) are determined.

Assay for Ca +Mg: 20 ml of the aqueous extract are measured in a 250 ml Erlenmeyer flask. Then 5 ml of buffer solution and a few drops (2 to 3 drops) of Eriochrome black T are added to the extract. Then, the solution is titrated by the 0.02N complexion to the blue turn of the initially red wine solution. The number of ml of complexion poured is noted.

Assay for Ca^{2+}: 20 ml of the aqueous extract are measured in a 250 ml Erlenmeyer flask. Then, 5 ml of sodium hydroxide and 2 to 3 drops of indicator are added to the extract. The solution is titrated by the complexon until the sharp turn and disappearance of the fluorescent color. The number of ml of complexon poured is thus noted.

Determination of Na^+ and K^+: The determination of Na^+ and K^+ is done by atomic absorption. They are assayed with the flame spectrophotometer by comparison with the previously drawn calibration curves.

CO_3^{2-} Assay: 20 ml of the aqueous extract are measured in a 250 ml Erlenmeyer flask. 2 to 3 drops of phenolphthalein are added. If the extract remains colorless, there are no carbonates in the sample. But when the color turns pink, there is presence of carbonate ions. The solution is titrated with sulfuric acid (H_2SO_4) until the color disappears and the volume of the sulfuric acid poured is raised.

Determination of HCO_3^-: 20 ml of the aqueous extract are measured in a 250 ml Erlenmeyer flask. 5 to 6 drops of green bromcresol are added. Then, the solution is titrated with sulfuric acid until the turn yellow and the volume of sulfuric acid poured is noted.

Cl^- assay: 10 ml of the aqueous extract are measured in a 250 ml Erlenmeyer flask. 5 drops of potassium dichromate (K2Cr2O7) are added. The extract is titrated with 0.1N AgNO3 silver nitrate solution, stirring continuously until a brick-red color appears and the silver nitrate volume used is also noted.

Assay for SO_4^{2-}: 25 ml of the extract are put into a 100 ml Erlenmeyer flask. 10 ml of the NaCl-HCl solution, 2 ml of acacia gum and 1 g of barium chloride powder are added to the extract. After stirring the solution by hand, the volume is adjusted with distilled water to 100 ml. After homogenization and preparation of a reference control according to the same previous protocol, the absorbance measurement for each sample is made with a spectrophotometer set at 600 nm after adjustment to 0.00. Previously, the mother solution and daughter solutions of sodium sulphates are prepared.

Determination of organic carbon: For the determination of carbon, finely ground and sieved with a 0.2 mm sieve is used. 0.2 g of soil for soils rich in organic matter or 1 g of soil for soils that are moderately rich in organic matter are weighed in a 250 ml conical flask. 10 ml of 8% potassium dichromate and 20 ml of concentrated sulfuric acid are added thereto. Then, the suspension is stirred vigorously for one minute. It is left to rest for 30 minutes. 150 to 200 ml of distilled water, 10 ml of concentrated phosphoric acid and 10 to 15 drops of the ferroin indicator solution are added to the suspension. When the turquoise color appears, the excess of potassium dichromate ($K_2Cr_2O_7$) is titrated with the 0.5 N ferrous sulphate solution (Mohr salt) until the appearance of the final brown coloration. The poured volume of the ferrous sulphate solution is noted. This volume must not exceed that of the white control. The preparation of the blank control is identical to that of the carbon test, except that the soil is not put in the solution.

2.3. Physical analyzes: Physical analyzes mainly concern particle size. It is carried out using Robinson's sieving method and pipette.

The analysis of the coarse grain size: In practice, the sieving makes it possible to determine the coarse fraction (proportions of sand according to their size or diameter). It is carried out after washing and drying the samples (oven 105 ± 5 ° C) using a sieve column classified from top to bottom in decreasing order of mesh size (20 µm, 630 µm, 200 µm and 63 µm). µm) on a vibro-magetic sieving machine.

Fine particle size analysis: The Robinson pipette is used to determine the fine fraction (clay and silt). The measurements of clays (A) and clays plus silt (A + L) are made by two successive samples using the Robinson pipette following well defined deposition times. The first and second samples are taken successively, 4 minutes and 7 hours after the preparation of the solution (20 g of sieved soil + 100 ml of hydrogen peroxide) and the complete destruction of the organic cements by heating under a hood. A dispersing agent, sodium hexametaphosphate $(NaPO_3)_6$ is added to this mixture and after readjustment of the test piece with water. The particles will then settle according to their size and the temperature of the water. Samples at different time steps make it possible to recover the particles remaining in solution. Thus, the first sample, that of clays plus silt (A + L) is carried out (4 min) after these operations and the second

(7 h of time after the first sampling) concerns the clays (A). The difference between these two measurements therefore makes it possible to determine the rates of clays and silts.

3. RESULTS AND DISCUSSIONS

3.1. Spatial distribution of chemical characteristics: This is the spatial distribution of pH, electrical conductivity (EC) of organic matter (OM) and ion balance (BI).

3.1.1. Spatial distribution of pH: At Ndoff, soil pH is very acidic at the surface and at depth with an average less than 5 **(Table 1).** The pH is 7.6 to 3.6. On the surface, in the majority of samples, the pH is acidic (pH <5.3) except for flooded tanns where the pH is slightly alkaline to moderately acid (7.9 <pH <5.6). The soils of herbaceous and shrub tanns are totally very acidic. They have a pH below 5.3.

Table 1: Distribution of the minimum, maximum and average pH

	water pH	
Perimeter of Ndoff	**Depth (0-20 cm)**	**Depth(20-40 cm)**
Minimum	3,6	3,5
Maximum	7,6	7,5
Average	4,9	4,7

3.1.2. Spatial distribution of salinity: In depth, as on the surface, the pH of the Ndoff sequence is very acidic under the herbaceous, shrubby and bare tanns. It is less than 5.3 in almost all the soils of these geomorphological units.

The average global salinity of surface horizons is estimated at 4 208 µs / cm (**Table 2).** It varies from 82 to 13 210 µs / cm. Most soils are extremely salty with electrical conductivities that far exceed 2000 µs / cm. They represent 64.2% of the total samples. The very salty soils record 7.5%. The salty and slightly salty soils together account for 13%.

In depth (20-40 cm), the average salinity slightly exceeds that of the surface horizon (0-20 cm). It is 4,274 µs / cm (Table 2). The values of the electrical conductivity are between 85 and 18 140 µs / cm. extremely salty soils have increased compared to salty surface soils. They represent 66% of the samples. On the other hand, very salty soils show a decrease in depth. They went from 7.5 to 3.8%. The salty and slightly salty soils together account for nearly 14%. It should be noted that most soils of the lower level are characterized by extreme salinity.

Soil salinization is marked by an ascending vertical gradient. It increases deep horizons from the ground to the surface. In fact, salinization increases from the lower part (20-40 cm) to the upper part (0-20 cm) on more than half of the samples, ie more than 52%. The accumulation of salts increases in depth only on 48% of the samples. The highest electrical conductivity is noted at the bottom. It is 18 140 µs / cm.

Table 2: Distribution of the minimum, maximum and average electrical conductivity

Perimeter of Ndoff	Electrical conductivity (CE) in µs / cm	
	Depth (0-20 cm)	**Depth (20-40 cm)**
Minimum	82	85
Maximum	13210	18140
Average	4208	4274

3.1.3. Ionic balance of the soil solution: The ionic balance is composed of cations (calcium, magnesium, sodium and potassium) and anions (bicarbonate, carbonate, chloride and sulfate). These ions are generally those determined in the characterization of salty soils[7].

3.1.3.1. Concentration of cations and anions: Sodium (Na^+) is the most important cation in the Ndoff site with an average of 85.1 meq / 100g, more than 59% of the total cation. It is followed by potassium (K^+) which has an average of 43.8 meq / 100g, ie less than 31%. The contents of both cations (sodium, potassium) are relatively more important in surface than in depth and in extremely salty soil than in salty soil. Magnesium (Mg^{2+}) comes in third with an average of 12.5 meq / 100g, almost 9%. Calcium (Ca^{2+}) comes in last place with an average of 2.2 meq / 100g, less than 2%.

Chlorides (Cl^-) are the most common anions in the soil solution of all samples in the Ndoff sequence. They record an average of 64.6 meq / 100g, more than 95% of the sum of the anions. Their concentrations increase from superficial pedons to deep horizons. On average, the surface depth, it goes from 63.5 meq / 100g to 81.5 meq / 100g. The bicarbonates follow with an average of 1.9 meq / 100 g, almost 3%. Sulphate ions ($SO_4{}^{2-}$) are present in very small amounts with an average of minus 1 meq / 100 g. The carbonate ions ($CO_3{}^{2-}$) are completely absent in all the samples of the sequence **(Table 3).**

Table 3: Ionic balance of the Ndoff site

			Cations meq/100g					Anions meq/100g				
Prof (cm)	**CE**	**pH**	**Ca^{2+}**	**Mg^{2+}**	**Na^+**	**K^+**	**∑Cations**	**$CO_3{}^{2--}$**	**$HCO_3{}^-$**	**Cl^-**	**$SO_4{}^{2-}$**	**∑Anions**
Nd1 (20-40)	651	4,1	1	3,2	8,4	12,2	24,9	Traces	1,5	33	0,1	34,6
Nd2 (0-20)	5620	4	4,5	14,7	99,7	45,7	164,6	Traces	0,5	62	1,4	63,9
Nd2 (20-40)	6190	3,7	2,7	16,9	95,8	34,9	150,3	Traces	4,75	75	0,6	80,3
Nd3 (0-20)	6660	4,4	1,9	12,6	113,1	68,1	195,7	Traces	0,5	65	1,8	67,3
Nd3 (20-40)	6800	4,7	1	15	108,3	58,2	182,5	Traces	2,25	88	0,2	90,4
Moyenne	**5184,2**	**4,2**	**2,2**	**12,5**	**85,1**	**43,8**	**143,6**	**Traces**	**1,9**	**64,6**	**0,8**	**67,3**

Pedon: Another term used in Soil Science to describe the horizon

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These analyzes show that the soil geochemistry of the commune of Loul Sessène is dominated by chloride and sodium. This is not surprising, if we remember that the salinity of these soils is essentially of marine origin. Indeed, the soils of commune were covered by the sea in the recent Quaternary. Chlorides being very abundant in seawater, it is normal that they are also in these soils[8].

3.1.3.2. Chemical facies of soils: The nature of the dominant anion in these salty soils was used to determine the three major facies of anions: chlorinated, sulphated and bicarbonate-carbonated. The dominant cation was used to identify the different facies of the cations.

Salt soils with cationic sodium facies are characterized by a predominance in the soil solution of sodium and potassium on calcium and magnesium and a predominance of sodium over potassium. The cationic composition of the soil solution is:

$Na^{+} k / Ca^{+} Mg > 1$ and $Na / K > 1$.

Salty soils with cationic potassium facies are distinguished by a predominance in the soil solution of sodium and potassium over calcium and magnesium and a predominance of potassium over sodium. The cationic composition of the soil solution is:

$Na^{+} k / Ca^{+} Mg > 1$ and $Na / K < 1$.

Cationic cationic salt soils are characterized in the soil solution by a dominance of calcium and magnesium over sodium and potassium and a dominance of calcium over magnesium. We have in the soil solution:

$Na^{+} k / Ca + Mg < 1$ and $Ca / Mg > 1$.

Magnesium cationic facies salt soils are characterized in the soil solution by a dominance of calcium and magnesium over sodium and potassium and a magnesium dominance over calcium. We have in the soil solution:

$Na^{+} k / Ca^{+} Mg < 1$ and $Ca / Mg < 1$.

In the Ndoff site, the soil solution is characterized by a dominance of sodium (Na +) over potassium (K^{+}), magnesium (Mg^{2+}) and calcium (Ca^{2+}). The $Na^{+} K / Ca^{+} Mg$ ratios are everywhere greater than 1. Na / k ratios far exceed 1 except in a single sample where the ratio is less than 1 (**Table 4).** Salty soils have cationic sodium facies **(Figure 3A).** The ranking order of the cations is then

$Na^{+} > Ka^{+} > Mg^{2+} > Ca^{2+}$.

The chloride ion (Cl^{-}) is the most important anion in the soil solution. Even the ratios Cl / HCO_3 and Cl / SO_4 highlight the predominance of chlorides on bicarbonates and sulphates. The ratios are greater than 1 for all samples **(Table 4).**

The soil is characterized by chlorine-type anionic facies **(Figure 3B).** The order of classification of the anions is $Cl^{-} > SO_4^{2-} > HCO_3^{-}$. The salty soils of Ndoff have a chemical hyperchloride sodium facies (**Figure 3C**).

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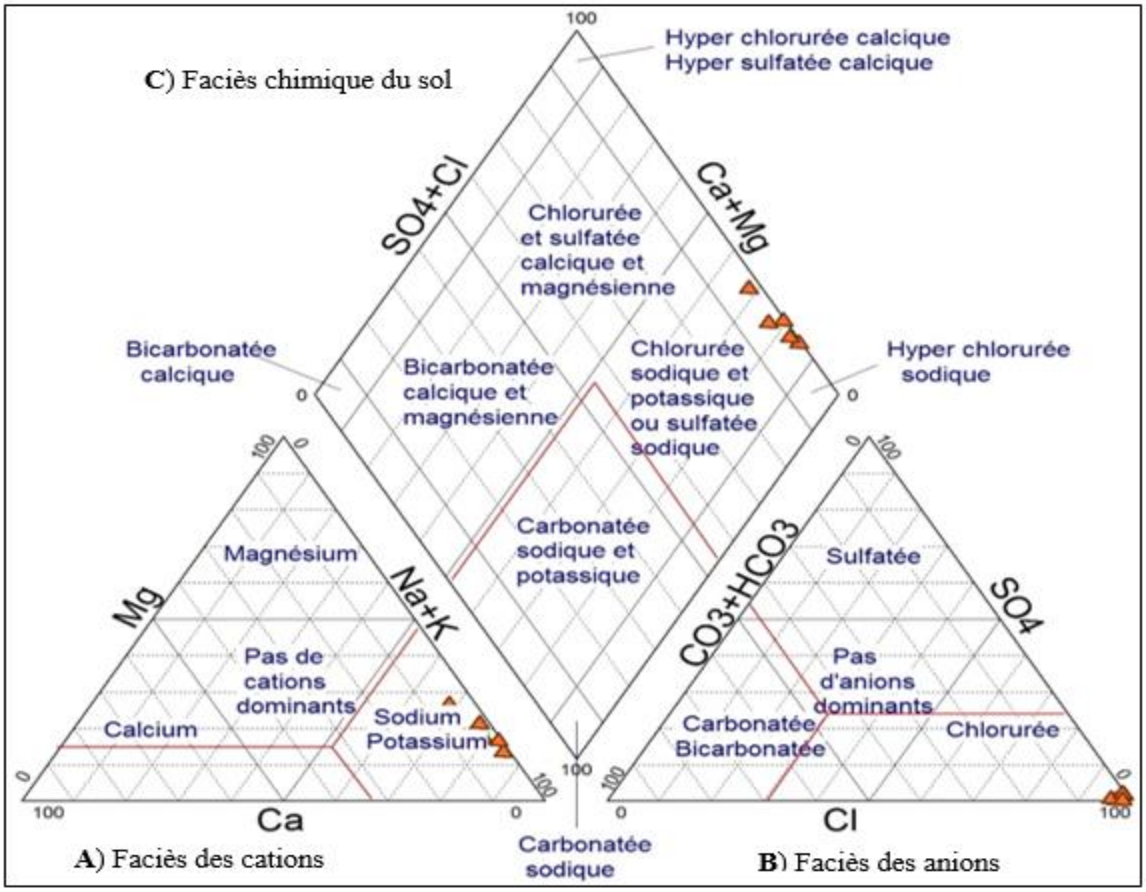

Figure 3: Representation of cations and anions in the Ndoff site on the Piper diagram

Table 4: Facies of cations and anions in the Ndoff site

Death (cm)	CE	pH	(Na+K) / (Ca+Mg)	Na/K	Cl/HCO$_3$	Cl/SO$_4$
Nd1 (20-40)	651	4,1	4,9	0,7	22,0	336,3
Nd2 (0-20)	5620	4	7,6	2,2	124,0	44,2
Nd3 (20-40)	6190	3,7	6,7	2,7	15,8	127,4
Nd4 (0-20)	6660	4,4	12,5	1,7	130,0	35,7
Nd5 (20-40)	6800	4,7	10,4	1,9	39,1	570,7

Overall, the salt soils of the municipality of Loul Sessène are characterized by a dominance of sodium ions (Na^+) on potassium (Ka^+), magnesium (Mg^{2+}) and calcium (Ca^{2+}). The concentration of chloride (Cl^-) is also higher than that of bicarbonates (HCO_3^-) and sulphates (SO_4^{2-}). The comparison of these ions with each other makes it possible to classify the cations and the anions in the orders defined in **Table 5**. Finally, we can say that the salty soils of the Ndoff site are sodium chlorides.

Tableau 5: Order of classification of the ions in the samples of the Ndoff site

Nature of the ions	Orders
Cations	$Na^{+} > Ka^{+} > Mg^{2+} > Ca^{2+}$
Anions	$Cl^{-} > SO_4^{2-} > HCO_3^{-}$

3.1.4. Spatial distribution of organic matter: The results of analyzes (**Table 6)** highlight the lack of organic matter in most soils. Organic matter is generally less than 0.76% in the majority of samples. It varies according to the types of tannes.

The organic matter content varies on average from 0.29 to 2.75% **(Table 6**). In addition to the superficial portion of the flooded bare soil, which revealed a rate of 4.01%, all soils recorded rates of less than 0.76%. Organic matter content decreases with depth. The maximum (4.01%) is noted on the surface. On average, the highest rates are recorded on the bare tan (2.15 and 0.64%) and the lowest rates are recorded on the herbaceous and shrub tanns (0.29%).

Table 6: Distribution of organic matter in the Ndoff site

Sample	**type of tanns**	**CE (µS/cm)**	**C (%)**	**MO (%)**	Average **(%)**
NdTa1 (0-20 cm)	Tanns shrub	337	0,2	0,35	0,29
NdTa1 (20-40 cm)		337	0,13	0,23	
NdTa2 (0-20 cm)		604	0,24	0,41	0,44
NdTa2 (20-40 cm)		558	0,27	0,46	
NdTa3 (0-20 cm)	Herbaceous tanns	82	0,08	0,13	0,29
NdTa3 (20-40 cm)		651	0,26	0,45	
NdTa4 (0-20 cm)	Tanns naked	5620	0,38	0,66	0,64
NdTa4 (20-40 cm)		6190	0,36	0,62	
NdTa5 (0-20 cm)	Tanns naked flooded	6660	2,32	4,01	2,15
NdTa5 (20-40 cm)		6800	0,17	0,3	

In sum, according to the contents of organic matter, two classes are distinguished:

- The first class is insufficient in organic matter. It is represented by shrubby, herbaceous and bare tannic soils. MO rates are generally less than 0.76%.
- The second class is rich to very rich in organic matter. It is represented by the soils of flooded bare tanns. The OM content on flooded bare tan is 2.15%.

3.2. Spatial distribution of physical characteristics

The physical analyzes relate to the determination of coarse and fine fractions.

3.2.1. Spatial distribution of soil texture: Soil texture is defined by the relative proportions of clay, loamy and sandy particles that make up the fine earth ≤ 2,000 µm. The dimensions used to size these particles are 2000-630 µm (coarse sands), 630-200 µm (medium sands), 200-63 µm (fine sands), (20-50 µm) coarse silt, (2-20 µm) thin silt and (0-2 µm) clay.

Soil texture is dominated by sands in all soil samples. The sands represent rates ranging from 45.7 to 90.7% **(Figure 4**). A clear dominance of fine sands is noted with an average of more than 56%. The coarse silts follow with an average of 20.7%. Middle sands come third. They represent an average of nearly 11%. The clay fraction in fourth position averages 7.3%. Particles of fine silt and coarse sands are very low in the soil with respective rates of 4.1 and 0.2%.

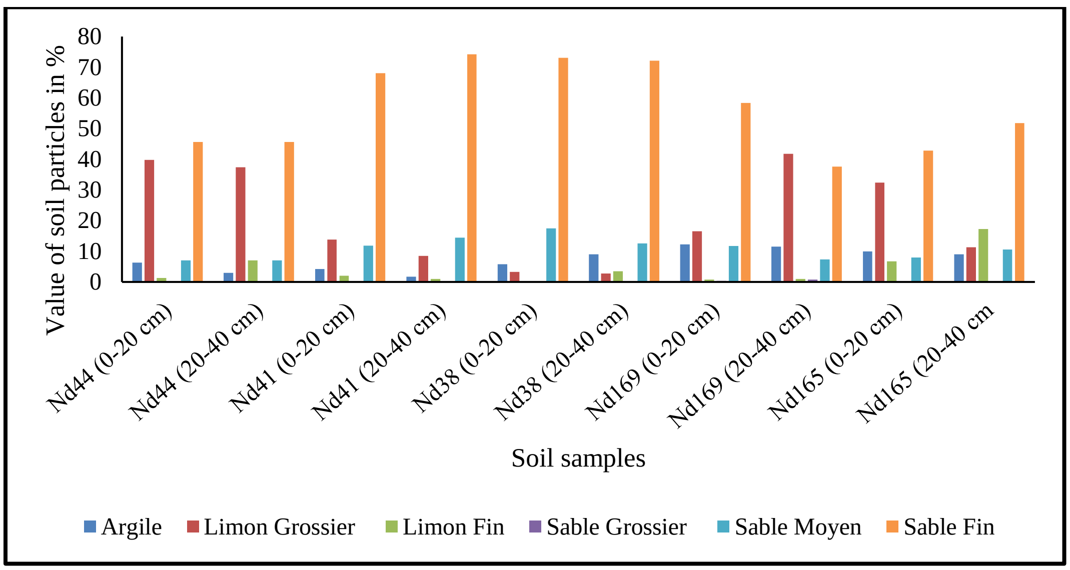

Figure 4: Relative Proportions of Clay, Loamy and Sandy Particles in the Ndoff Site

3.2.2. Spatial distribution of textural classes: From the grain size analysis data, we constructed the textural triangle to graphically interpret the clastic elements of the Ndoff soils. The triangle has made it possible to accurately determine the different textural classes of soils. The latter are sandy loam (LS) in almost all samples **(Figure 5).** However, soils with sandy texture (S), silty sand (SL) with sandy loam (LAS) are distinguished.

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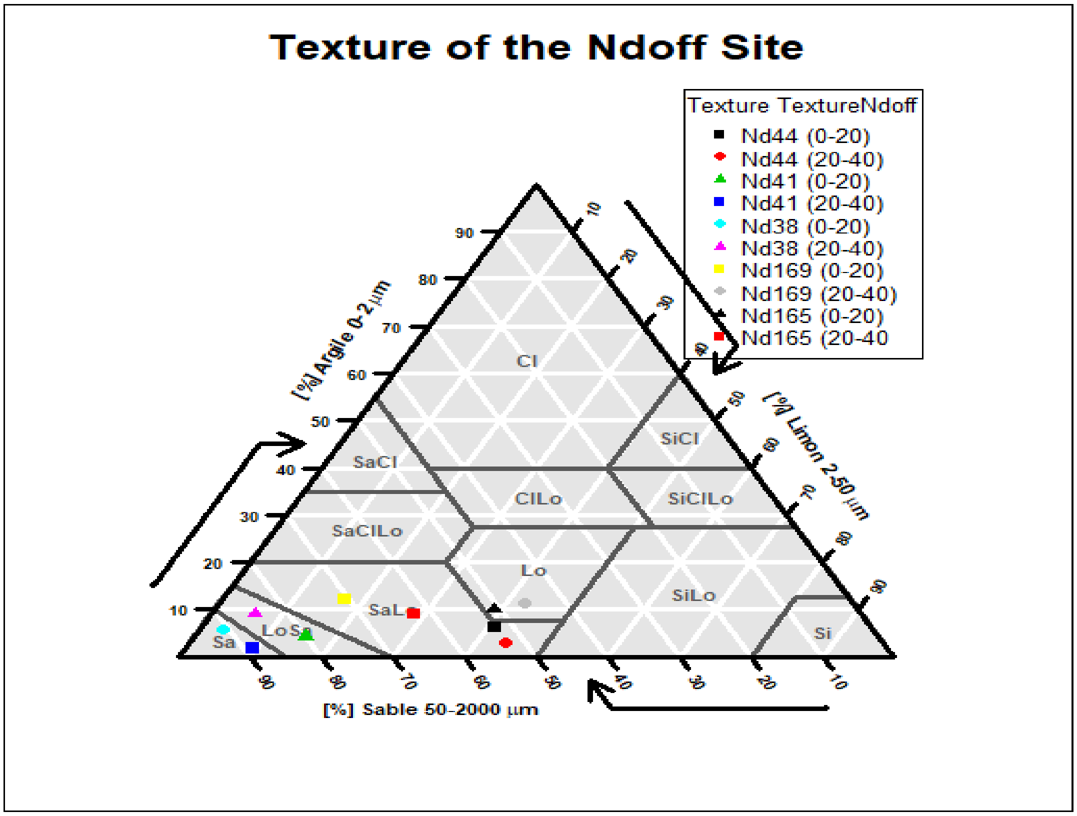

Figure 5: Textural Triangle of Soils at the Ndoff Site

Shrubby and grassy tannic soils have textures of types (SL) and (LS), that is silty sand and sandy loam. The textures of the bare tan soils are of sandy loam (LS) and sandy loam (LAS) types **(Table 7**).

Table 7: Distribution of soil texture in the Ndoff site

Sample	**Type of tanns**	**CE (µs/cm)**	**Textural class**
Nd44 (0-20 cm)		337	Limestone (LS)
Nd44 (20-40 cm)		337	Limestone (LS)
Nd41 (0-20 cm)		604	Sandy loam (SL)
Nd41 (20-40 cm)	Tanns shrub	558	Sandy (S)
Nd38 (0-20 cm)	Herbaceous tanns	82	Sandy Limestone (LS)
Nd38 (20-40 cm)		651	Sandy loam (SL)
Nd169 (0-20 cm)		5620	Sandy clay loam (LAS)
Nd169 (20-40 cm)		6190	Sandy clay loam (LAS)
Nd165 (0-20 cm)	Tanns naked	6660	Sandy Limestone (LS)
Nd165 (20-40 cm)		6800	Sandy Limestone (LS)

CONCLUSION

Ultimately, salty soil texture is dominated by sands throughout the Ndoff site. The sands show an average of 62% with the predominance of fine sands which alone represent averages greater than 50%. The contents of coarse sands and fine silts are very low. These two fractions have levels of less than 6%. Soils are sandy loams in shrubby and herbaceous tans and sandy-clay loam in bare tans. We can deduct from this study that the soils are generally very acidic with pH values below 5.3. Salinity, which is of ascending type, is sodium chloride. Soils that are very deficient in organic matter are generally sandy loam on herbaceous and shrubby tans and sandy-clay loam.

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