Contribution of electromagnetic and tomographic technique to the study of the impact of salinity in soils of the experimental station of Al Ain Atti (Errachidia, Morocco)

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Abstract. Soil salinity is widespread particularly in arid areas. Much work has been done to remedy this natural contamination and make them more favorable to receive experimental soil of vegetation adapted to grow in these contrasting environments of scarce water resources. Over the 80 years, Morocco has experienced excessive dryness whose effects have been severely felt in the region of Errachidia. The depletion of the Quaternary alluvial aquifer has required the exploitation of deep reservoirs. In order to optimize the use of salt water in arid, the Institute of Agricultural Research tested soil experimenting three plant species; the Triplex, Acacia and Cypress. This experiment was not only economic objectives; increasing agricultural yields and production, but also reduce the impact of desertification in this region. So these are environmental reasons which have led researchers to realize this experiment whose purpose is to examine the ability of these plants to grow and adapt to irrigation by saline water from the deep aquifer in place. The experimental site is located on the left bank of the national road to Erfoud (Errachidia). In its entirety, the redesigned covering about 10 hectares. The studies that have been conducted mainly concerned pedogenetic analyzes and observations the development height of the plantation tested, regardless of the experimental ground heterogeneity. This is why we undertook a geophysical survey which aims to provide information on the quality of the tested soils and accumulation of salinity at different depths of the experimental ground.

To achieve our goal, we used the technique of electrical and electromagnetic investigation in order to identify the main lines of a possible spatial heterogeneity. Recall that the work of OKAY (2010) on an experiment coring by examining the evolution of the newly formed fracturing have proved that the result of resistivity measurement is correlated with that of the chargeability. The electrical resistivity is closely related to the concentration of mineral particles. Characterization studies at the La Ronde tailings mine (Agnico-Eagle Ltd, in Abitibi), showed quite encouraging results (Campos, 2004; Anterrieu, 2006). Since it is a salt-bearing areas (highly conductive) and given that the induced polarization is very sensitive to the ground conductivity; by measurement of residual potential, so we took measures chargeability tomography, the result is compared to the resistivity measured at different soils (control and irrigated), which will better clarify the impact of salinity on the quality of the disturbed soil. Indeed, the chargeability response it possible to characterize the different irrigated soils and its variation is attributed not only to the effect of saline irrigation but also the existence of an heterogeneity of the original ground. Prospecting in electrical tomography has displayed vertically and horizontally anomalies existing within the experimental site of the station of Ain Al Atti, it showed that:
- accumulation of salinity becomes wider going from the control ground to that of Acacias.
- surveyed the ground at least appear more homogeneous in surface, but their conductivity varies in depth.
- salinity origin and the concretion formed on the surface greatly influenced chargeability and resistivity measured on the different experimental soils.

**Keywords.** Drought, depletion of groundwater, Al Ain Atti experimental site, saline irrigation, technique electromagnetic, electrical tomography, induced polarization.

1. Introduction

The region-Tafilalet Errachidia is located in the southern Atlas region of Morocco. It faces enormous challenges including scarcity and poor water quality, following long periods of severe drought affected who in recent years and whose ecological consequences are considerable, as evidenced by the decline in irrigated area under the action of desertification and rising saline soils.

Agriculture represents 90% of the economic activity of the population. Agricultural activity is, however, directly related to the availability of wadis, springs, and khettaras that have been used since ancient times by the people in place. In order to optimize the use of salt water in arid areas, the National Institute for Agricultural Research (INRA) tested soil experimenting four plant species; Atriplex, Acacia, Eucalyptus and Palm. This experiment was not only economic goals; increasing agricultural yields and production, but also reduce the impact of desertification in this region. So these are environmental reasons which have led researchers to realize this experiment whose purpose is to examine the ability of these plants to grow and adapt to irrigation by saline water from the deep aquifer up.

It should be recalled that the previous work has borrowed several methods including soil analysis technique. The aim of our work is the introduction of the electrical tomography technique to better visualize vertically and horizontally the impact of salt water on soil amendment, firstly, and secondly, to highlight the heterogeneity that crosses the prospected ground. The result then requested provide useful lessons that will enrich the aforementioned work. The working procedure involves the construction of six profiles in pseudo-section, three concern the measure induced polarization and three in the measurement of electrical resistivity. Which will compare the results of the two respective techniques.

2. Presentation of the study area

2.1 Geographic Location and geological setting

The experimental Site Ain Al Atti is situated on the left bank of the road leading from Errachidia to Erfoud. It is part of the Cretaceous basin-Boudnib Errachidia (Morocco Southeast), this one is recognizable by its morphological characters cliff; it is regular, continuous, uniform and includes all land Cretaceous outcrop between Tinghir in west and Boudnib in east.

The basin-Boudnib Errachidia is limited: in the north by the South Atlas accident, the south by the mountain chain of the Anti-Atlas, to the east by outcrops of tertiary Hamada Guir. It occupies the western part of the Cretaceous basin “Ziz-Guir” [1] and to the west, the basin tapers into a narrow channel that reaches its minimum width in Tinghir, at which it connects to the Ouazarzate basin (Figure 1).
Regarding its lithostratigraphy, the Cretaceous basin Errachidia-Boudnib is characterized by a stratigraphic series that runs from Paleozoic to Quaternary. The Paleozoic outcrops south of the basin at Erfoud. It is formed mainly by limestone, conglomerates, shale, marl and quartzite sandstone.

For the Mesozoic Triassic outcrops Foum Zaabel in Tunnel located north of Errachidia, it unconformable overlies Paleozoic series. It is represented by a lagoon series of Anhydrous red marl and red marl, separated by diabase basalts.

Jurassic outcrops on the northern edge of the basin, it generally has layers of red sandstone and red or green marl and then alternating marl and limestone, red clay and conglomerates.

The Cretaceous is characterized by Cenomanian-Turonian transgression on the Middle Jurassic which invaded the Moroccan Southeast. Sedimentation is performed in epicontinental regime and has significant variations in thickness and facies. The Infra-Cenomanian corresponds to glyptogenic continental formations, resulting from the destruction of anti-Cretaceous reliefs [3].

The Infra-Cenomanian consists of continental deposits (coarse sandstones and conglomerates) and lagoon (sand, clay and marl). After the regression Albian and early Cenomanian, seas (Mediterranean and Atlantic) meet in the South Atlas furrow where the Cenomanian-Turonian platform develops [4]. In the outcrop, the Cenomanian Turonian is formed by limestone benches resting directly on the red clay to gypsum. At the top of the Cretaceous series, detrital deposits for overcoming the Turonian limestone. Senonian is composed of clay-grése continental formations very heterogeneous, with gypsum and anhydrite, varying in thickness from 70m to the east and 500m north.

Quaternary present various facies (poudinges, gravel, silt and alluvium). It forms varying thickness layers between 5 and 40 m.

2.2 Climatological, hydrological and hydrogeological context

The climate that reigns in the Errachidia Boudnib-basin is an arid climate, strong continental influence. It is characterized by large variations in temperature and seasonal distribution of rains are scarce and very irregular.

The hydrographic network is represented by Oued Ziz that starts in the High Atlas and crosses the North region in the South. Groundwater resources play a key role in meeting water needs. These resources consist of groundwater, located along the valleys, and deep aquifers that are divided from...
north to south in three well separated hydro-geological units [2]: The High Atlas, the Cretaceous basin Errachidia-Boudnib and the Anti-Atlas (fig.2).

![Figure 2. Water system in Guir, Ziz, Rheris and Maider basin and hydro-geological map showing the various layers of Errachidia Basin.][5]

The aquifer Infra-Cenomanian consists of continental deposits (coarse sandstones and conglomerates) and lagoon (sand, clay and marl).

The Turonian aquifer consists of fractured limestone and marine origin dolomite as karst facies.

South of the basin (tablecloths of Tafilalet), quaternary aquifer is formed at the base more or less cemented conglomerate and sandstone limestone lake, which contain the essential reserves of the tablecloth. [6]

3. Geophysical measurements in the experimental station of Ain AL Atti

3.1 Recall of measures result electrical prospecting in station of Ain AL Atti

The test site Ain Al Atti covers about 10 hectares. The Institute for Agricultural Research, which tested the development of four plant species: Atriplex, Acacia, Eucalyptus and Palm, has stopped halt saline irrigation there are already several years. We recall also that the interpretations of geophysical measurements were obtained taking into account the drilling data (Fig. 3) dug in the purpose of this experiment.
Electrical methods to better understand the subsurface structure through the study of electrical resistivity formations that compose it. The resistivity was measured by injecting into the soil a continuous current whose intensity $I$ is measured by means of two metal electrodes denoted A and B planted in the ground and connected to the two terminals of a DC generator. The potential difference resulting from the current flow is measured by means of two other electrodes denoted M and N. The electrical resistivity ($\rho$) is obtained from the potential difference ($\Delta V$), the current ($I$) and the geometry of the electrodes ($K$) according to the following relationship:

$$\rho = \frac{K \Delta V}{I}$$

Several devices can be used depending on the objective sought exploration. For vertical survey, the transmitting electrodes are spaced apart progressively. Horizontal exploration, measurement is obtained by a constant dimensions device and the base moves with constant field prospecting. These two techniques are often used in hydro-geological exploration.

With the aim of characterizing the heterogeneity within experimental soils, more oriented profiles (NE-SW) were carried out to map the resistivity in the control plot and in the Atriplex. The control plot (Fig.4) shows a well individualized conductive anomaly in the middle of the edge of the profile, its resistivity value is considerably high (155 ohm-m), where the field conglomeratic resistant comes into contact with a conductive zone (30 ohm -m) to the SW, which reflects the location of an anomaly of fracturing ground prospected. Another conductive zone appears to the Northeast part to be related to a discontinuity of conglomeratic field. In the rest of the profile, the area surveyed appears more homogeneous and least conductive.

Figure 3. Stratigraphic log of drill Ain AL Atti (No. 4042/57).
The result of the diagram (Fig.5) shows a heterogeneous field likely reflecting the real quality of the field, strongly affected by the accumulation of soil salinity prospected surface. The apparent resistivity has a large variation along the profiles, the accumulation of this salinity occurs therefore not uniformly during the irrigation periods. Note that it must not neglect the heterogeneity related to the natural terrain.

The resistivity response obtained in the irrigated parcel and planted by the triplex is very different from the control field.

3.2 Result of measures in electromagnetic prospecting

With the aim to enrich the results of the electrical prospecting, we brought upon the VLF electromagnetic measurements technical (very low frequency method) using a fixed transmitter. Parameters measured ellipticity ($b/a$) is the ratio between the smallest and largest polarization axis; equivalent to the imaginary component ($\text{Im} = \text{secondary field}$) and the inclination or tilt ($\theta$) the major axis of polarization with respect to the horizontal; equivalent to the real component ($\text{Re} = \text{secondary field}$).

$$\frac{b}{a} = \frac{H_z \cdot \sin \alpha \cdot \sin \varphi}{H_p} \equiv \frac{I_p}{H_p}$$
\[
\tan \theta = \frac{H_s \sin \alpha \cos \varphi}{H_p} = \frac{\text{Re}}{H_p}
\]

with \( \alpha \) angle between \( H_p \) and \( H_s \) and \( \varphi \) the phase shift between \( H_p \) and \( H_s \).

Figure 6. Schematic representation of the electromagnetic prospecting. A-production fields and induction phenomenon, B -setting out of a VLF receiver with two orthogonal coils.

This instrument can also be used for measuring the electrical resistivity. Indeed, the primary field radiates as two components in the direction of the issuer; a vertical electric component and the other horizontal magnetic \( H_y \) perpendicular to the first. After induction in the ground, another horizontal electric component \( E_x \) occurs along the direction of propagation. The electrical resistivity is given by the ratio \( E_x / H_y \) in Form magneto-telluric (also referred to as MT-VLF):

\[
\rho_t = \frac{1}{\sigma \mu} \left| \frac{E_x}{H_y} \right|^2
\]

With \( \omega = 2\pi f \) and \( \mu \) is the magnetic permeability (\( \mu = 4\pi \times 10^{-7} \)).

The investigation by this technique is limited to a very shallow (about 10 m), that is why we do not often use to explore the deeper formations.

Five profiles spaced of 40 m and oriented NE-SW were realized by this technique in Ain AL Atti station.

Profile (Fig. 7) is carried out at the West edge experimental field. The resulting response suggests the existence of an anomaly of contact with a relatively strong field located at the beginning of the profile (\( d = 20 \) m) where the inclination has a maximum of 2\%, while the ellipticity is at minimum. For the rest of the profile, tilt opposes the ellipticity. The first presents negative values, while the other is positive and the curve which shows no substantial changes with distance, it is therefore a zone is relatively homogeneous and conductive.

The second profile made within the experimental field relates to the plot planted with the palms. The graph curves (Fig.7) show a variation comparable to that observed in the first profile (control field). But after the strong anomaly (in beginning of the profile), the tilt drop maintains a relatively lower value than that observed at the natural terrain (Profile 1). This is attributed to the effect of saline irrigation has received this experimental ground.
Figure 7. Variation of inclination and ellipticity according to the distance (Profile 1 and 2, step= 20 m spacing = 40m, NE-SW)

Regarding profile 3 (Figure 8, Eucalyptus plots and Atriplex), the response suggests that there is no opposition between the two components, according to the two curves, this response must be attributed to a homogeneous and conductor ground.

Figure 8. Variation of inclination and ellipticity according to the distance (Profile 3 and 4, step= 20 m spacing = 40m, NE-SW)

Profile 4 (Fig.8) begins first by a conductor field which stretches over a distance approximately 100 m and represents the border of the land concretionary following the discharge of salt water from the irrigation canal. In the middle of the profile, the signal shows the area indicated by the heterogeneity electrical profile (fig. 3), which marks the transition to a relatively resistant ground for which the tilt and the ellipticity significantly increase in natural area with no undergoes significant transfer of salinity.

Profile 5 (Fig. 9) is made at the unirrigated natural ground. The first part of the profile seems more affected by the spill salt water, this is the reason why the field components show negative values at the beginning of the profile. At about 280 m, the two parameters become almost constant for the rest of the profile, so they mark the transition to a homogeneous and slightly resistant field.
Figure 9. Variation of inclination and ellipticity according to the distance (Profile 5, step= 20 m spacing = 40m, NE-SW)

Electromagnetic profiles made at the experimental station Ain Al Atti allowed to characterize the heterogeneity of the original land they have also allowed to highlight the impact of spraying salt water on experimental soils.

Comparing the first four profiles, it is noted that the inclination has a negative maxima (-4%) for the profiles 1, 2 and 4, while the maximum is especially lower (-5%) for the profile 3 (forest plots; Eucalyptus and Atriplex), following the accumulation of salts in irrigated soil.

At the control plot, inclination has a negative maximum of -5% related to the concretion of the ground surface which becomes very compact but driver. The anomaly resistant is individualized for the profile 4.

From the electrical and electromagnetic profiles, we were able to identify two types of anomalies:
- Abnormal fracturing, in the middle of profiles and marked by resistivity measurements.
- An abnormality of contact with a compact ground, located at the northeastern edge of the terrain and marked by electromagnetic surveys.

The importance of accumulation of salinity differs depending on whether the plot concerned is irrigated or not. Thus for irrigated soils, salt deposits accumulate progressively irrigations (decrease of surface dilution). While for the non-irrigated soil, the contamination occurred by side chemical transfer.

Figure 10. Schematic Figure illustrating the location of the anomalies identified in the experimental station Al Ain Atti
3.3 Result electrical tomography measurements realized in the experimental station Ain Al Atti

In order to obtain better recognition site studied, we have made the electrical tomography, which allows to obtain an image of the basement, that is to say a cutting resistivity or chargeability depending depth. This electrical imaging inform in detail on the impact of this salty irrigation on soil quality, and on the heterogeneity of the land surveyed.

The induced polarization is the origin of the electrochemical processes that occur when the current passes from one medium at ionic conductivity (water) in a medium at electronic conductivity or from ionic conductivity medium in somewhat conductive medium, or in contact with a different ionic conductivity medium.

The polarization measurement technique caused also called electric chargeability, consists of measuring the delay of the response of a medium subjected to an external electric field. This delay is linked to a non-zero time required for a medium to return to the equilibrium when the injected current is cut (phase shift, chargeability).

It can be measured in the time domain (PPT) or frequency (PPS). In the same way as for resistivity, induced polarization measurements are carried out using a quadruple and the results are in the form of profiles or of pseudo-sections. The interpretation can be improved by combining the profiles in the form of a pseudo-sectional three-dimensional image. [8]

In the time domain, applying a direct current in the ground, followed by its stoppage will produce a voltage-time curve (Figure 11). The voltage Vo is one that is observed and measured and is due to the application of the current and polarization effects. The continuous voltage Vs is that which would be observed immediately after the power was cut. This current was applied long enough for V0 reaches its maximum. It is easily seen that:

\[ V_s = V_0 - V \]

The real chargeability of a medium can be measured only in places where there are heterogeneities. What we really measure is the apparent chargeability (ma) which depends on real resistivity and chargeability of surveyed materials.

Measuring the voltage-time curve is very complicated (lack of fitted equipment), then another measurement voltage which can be expressed as:

\[ V_t = F(m, V_0, t) \]

Since Vo is known, the function F (ma, Vo, t) depends only on ma. If the measurements are made at set times so you can get an idea of Vt relative values for different m.

\[ m = \frac{1}{V_0} \int_0^t V_t(t) dt \]

For significant figures, there will be measures in ms or mV / V.
Electrical tomography surface allows to obtain a resistivity of cutting (electric image of the basement) according to the depth by measuring the resistivity profile for different combinations of current electrodes and potential.

To achieve our goal, we realized three electrical tomography profiles (type Wenner) in the test site Al Ain Atti (Figure 12). To interpret the various pseudo-sections, we made use of NIRZ 4042/57 drilling data realized in the study area (Figure 3).

![Figure 12](image1.png)

**Figure 12.** Location of electrical profiles made at the test site of Al Ain Atti (taken from Google Earth)

The procedure involves the use of an electrical panel based on an acquisition system (ABEM, fig.13) for controlling the measurements. ABEM connected to a resistivity measuring the apparent resistivity with a base electrodes 64 made of stainless steel and 4 cables to connect the electrodes to the acquisition system. With a 12 V battery, the device injects the electric current between the electrodes A and B and measuring the electrical potential between the electrodes M and N. The data-logger can choose from the following devices (Schlumberger, Wenner, dipole - dipole ...).

![Figure 13](image2.png)

**Figure 13.** Investigation by the device of tomography and principle of building a pseudo-section

Both resistivity and chargeability parameters are closely related to the mineralized structures. Recently, in an experiment performed on a coring by combining the results of resistivity measurements and the chargeability measures OKAY (2010) showed that newly formed fractures are sub-vertical structures moving in depth and without solid fill (open fractures). In this sector, as pFG1 drilling (Figure 14), the depth of the new fracture crossing is 75 cm. This result confirms the vertical extension of the EDZ characterized by resistivity of inverted sections (Figure 15).
Figure 14. Drilling pFG1 (depth 75 cm). The purple dots represent the location of the electrodes. Small points concern the location of sensors for seismic LCPC (OKAY, 2010).

Figure 15. Sections resistivity and chargeability paid for the Wenner-α devices, Wenner-Schlumberger and dipole-dipole on the longitudinal profile to strike in the eastern gallery of the 96-Tournemire experimental station in June 2008 (OKAY, 2011). (The dipole-dipole device is acquired only in resistivity mode C: fracture filled with calcite, arrows indicate a probable path of the desideration process, injection slot: 1 s, the number of iterations used for inversion: 4)

The electrical resistivity is closely related to the water content, the concentration of mineral particles and the nature of dissolved solids, that is why we have combined the chargeability. Characterization studies at the LaRonde tailings mine (Agnico-Eagle Ltd), located in Abitibi, showed fairly conclusive results (Campos, 2004; Anterrieu, 2006). The geophysical measurements on the dump from a height of about 25 m were used to map several anomalies on the slopes and in the heart of the dump with strong resistivity contrasts. These anomalies are associated with particular particle size segregation and compaction level (resulting from construction mode). Anterrieu (2006) coupled the results of electrical
measurements with data from geochemistry and hydrogeology to propose a preliminary model of the internal structure of the dump (Figure 16).

![Figure 16](image)

**Figure 16.** (a) Electrical model of the internal structure of halde- (b) reversed synthetic section (following the proposed model (a)) - (c) reversed section (actual measurements) (adapted Anterrieu, 2006)

This model shows that the upper bed (h <14 m) is formed in part of an alternation of oblique resistive and conductive layers. This alternation is caused by the successive discharge of these variable size materials.

In the station Ain Al Atti, the first profile analysis (Figure 17) suggested a large vertical variation and horizontal discontinuities in chargeability. It is low for level surface formations and higher for those located deep. This is related to atmospheric precipitation inputs (after stopping irrigation salt) that led to the dilution and the mobilization of the mineralization, its lateral transfer and its vertical infiltration. This is why the formation (10 to 40m) seem more conductive (chargeability between 500 and 800 mV / V) in depth of forest plots (Eucalyptus and Acacia). The presence of clay in depth (about 50m) also amplified accumulation of the salinity level of the overlying formations.

In the Atriplex, the chargeability is relatively low (30-100 mV / V), the soil of this land has not been overhauled and has not also suffered significant salty irrigation.

The end of the profile (SW side) is marked by the presence of strong chargeability values over a relatively large depth (20 to 40m). This is likely related to the transition of a fractured area indicated by electrical dragged (Figure 4) [7].
Regarding the resistivity measurements, the pseudo-section (Figure 18) suggests that it is high (> 50 ohm.m) in surface formations and small in depth, this is related to both the presence sometimes conglomerates and also the concretion which is taking place after the iron oxide from the salt water. This concretion, which increases the hydraulic resistance is less pronounced in the plot of Atriplex.

In depth, the ground appears slightly conductive for the entire profile with lower resistivity values at Eucalyptus plots and Acacia (5 to 7 ohm.m), relating to the accumulation of salinity in a transition to marl areas.

These results confirm those obtained by the result of the chargeability. The observed response to the passage of the fractured area seems less pronounced compared to that obtained by the chargeability.

The second profile of chargeability (Figure 19) is realized out in the experimental field, at 30 meters south of the first profile and in the same direction (NE-SW). The variation in chargeability was made...
in the same manner as in the first profile, it is strong in the areas where the lateral flow is from forest heavily irrigated areas (Acacia and Eucalyptus) and low in the areas related party of less irrigated (Atriplex vegetation). But note that the values obtained by this pseudo-section are proportionally lower than those observed in the first profile. Indeed, the phenomenon of lateral transfer salinity is amplified by the presence of a deep sand (20 to 28m), located by electrical surveys and mechanical boreholes drilled in this zone [7]. Contamination of land surrounding the experimental site is done especially during rainy periods. Note also that this profile met the fractured zone observed in SW flank where the chargeability is high (300 mV / V).

**Figure 19.** Pseudo-section of the chargeability obtained in ground control at the southern end of the experimental station (c.l: X = 616,428.44 m, Y = 507028.81m and Z = 854m).

**Figure 20.** Pseudo-section resistivity obtained in ground control at the southern end of the experimental station.
According to the pseudo-section (Figure 20), the resistivity shows the same variation as chargeability. Subsurface formations are less conductive and correspond to dry silt and gravel. The deep formations (13-43 m) are conductive and licks whose resistivity varies between 6 and 13 ohm-m. The resistivity values are substantially the same as those encountered with the first profile. The conductivity of sand and clay formations in depth is important in terms of forest plantation (Eucalyptus and Acacia) and slightly lower in the Atriplex (middle profile).

The analysis of these two profiles provided important lessons for the Contrast met by the side of prospecting different experimental soils. Indeed, the contrast obtained by the analysis of chargeability profiles seems more better than that observed by the variations in resistivity. The result has confirmed the location of the heterogeneous natural terrain marked by electromagnetic profiles.

The third profile (Figure 21) is the other ground control (outside of the experimental station) parallel to the first, but its location is in the north and upstream of the natural flow of water that affect this area of experimentation.

The response shows no horizontal or vertical variation of chargeability and the recorded value is approximately 40 mV/V, it corresponds to a silty-sandy clays and conductive formation (Infra-Cenomanian). The prospected ground seems more homogeneous. The only observed heterogeneity is marked by the presence of a narrow area marked on the side NE at a depth of 8m (upper 183mV/V) which must correspond to the location of an area contaminated by the transfer from water spills drilling used for irrigation and located on the side of the land (approximately 100 m).

**Figure 21.** Pseudo-section of the chargeability obtained in ground control at northern part of the experimental station (c.l X = 506942.33m, Y = 616,435.95 m and Z = 851m).
Figure 22. Pseudo-section of resistivity obtained in ground control at the northern part of the experimental station Ain Al Atti.

The formations identified by the profile (Figure 22) show a sub-table structure. The resistivity values obtained confirm the variations observed by the measures chargeability.

On the surface, dry and relatively resistant alluvium based on wet and conductive sand formations which overcome the sandy loams of Infracenomanien (around 6 ohm.m) and located at a depth 26m. The conductivity is related to the accumulation of the likely outcome salinity evaporate formations towards contaminating all smooth sheet of the region. In depth (50 m) appears the conductive sandy-clay formation (20 ohm-m).

On the surface, induced polarization measurements results show no significant variation between the experimental plots (around 40mV/V), this is mostly related to lateral transfer salinity and infiltration depth under the effect of precipitation atmospheric.

In depth, the response of the chargeability provides sufficient contrast to distinguish between the different plots. It is considerably high at the forest units (> 500 mV/V) than at Atriplex (<40 mv / v). The response of the two pseudo-sections obtained in ground control shows that the north side was not affected by salt contamination, lateral transfer salinity is therefore carried from North to South in the direction of the natural flow groundwater.

4. Conclusion

The coupling of both electromagnetic and electrical tomography techniques has provided information significantly important and rewarding to study the impact of salinity in soil of Al Ain Atti station. He has displayed vertically and horizontally different heterogeneities that exist within the land surveyed.

The pseudo-sections obtained have characterized the impact of spraying salt water on the quality of soil amendment. They showed, in a causal manner, the location of the fracture conductive anomalous zone that crosses the field prospected according a alignment oriented in NNE-SSW and identified by the result of electrical and electromagnetic measurements.

In depth, the contrast of chargeability seems better than that obtained by the resistivity measurements.
It is also noted that saline irrigation has caused not only buildups of surface soils, but also an important clogging pedogenetic horizon amendment. Which resulted in a lateral anisotropy of the ground explored is why the signal obtained by chargeability seems discontinuous. It must be said that the result would have been better if the measures had been carried out during irrigation periods. For non-irrigated ground, soil contamination occurred side by chemical transfer, without forgetting the part of salt that rise subsurface under the effect of evapo-transpirator phenomenon during drought period.

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