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Localization and Delimitation of the Arid Soils by Remote Sensing and *In-Situ* Measurements in an Arid Area: Case of Oued Djedi Watershed, Biskra, Algeria

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Abstract: The purpose of this study was to connect to data sets of different nature: remote sensing and observational data from the field. The main target was to find an efficient method, to help us in identifying, locating and mapping the soils, in particular the gypseous soils which are not well-known and mapped delimited of the vast arid regions. The methodology consisted to plot on a three-color Landsat 7 ETM+ images, a spectral profile of 300 pixels matched exactly with a toposequence studied on a ground of 9000 m in length located, by GPS, upstream Piedmont of Djebel Tenia and downstream Oumache Sebkha depression of Oued Djedi sub-watershed within the wilaya of Biskra at 500 km in the south-east of the capital Algiers (Algeria). In order to discrete efficiently of aridsols, their validations therefore require in situ surveys on the toposequence. The collected and analyzed samples in the laboratory (moisture, granulometry...) were identified by GPS and squared accurately with reflectance and absorption peaks at the spectral profile. The in-situ surveys and measures have improved the identification and delineation of different areas with shallow gypsum, i.e. gypsic horizons, were discriminated from areas with deep gypsum phases the petrogypsic horizons. This distinction between shallow and deep gypsum horizons is very useful for resource management planning. The maps produced by supervised classification of maximum likelihood based within situ surveys which were extrapolated into the study area serve for localization and evaluating the suitability of land for production.

Key words: Localization · Gypseous · Remote sensing · Spectral profile · Toposequence · Arid soils

INTRODUCTION

Climate and topography are two important soils forming factors affecting genesis, evolution and classification of soils. Many soil proprieties and pathogenic features like calcium carbonate, calcium sulfate and sodium salts are climate dependent. Gypsiferous and calcareous soils are two important groups of soils formed in arid and semiarid (annual P 300-400 mm) environments of Algeria [1-4]. The extent of gypseous soils in the world has been estimated at 207 million ha [5] and broad gypseous areas also occur in Algeria, about 7966, 3 km^2 [6]. Morphology, amount and size of gypsum in soils are affected by pedogenic processes. Most soils in our region are composed of gypseous soil, or gypsum ($CaSO_4$, $2H_2O$) which is common in geologic materials, groundwater and surface area [7]. Also, all soils present gypseous formations ranging from endured crusts to a few contents of sulphate in the soil solution [8,9]. In most cases, gypsum is associated with other salts of calcium, sodium and magnesium [6]. All these minerals have an average solubility in water [9,10], because of this solubility, these minerals are altered easily and can be deposited in other places and in other mineral forms. In addition to their pedogenic involvement,

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Photo 1: Gypseous soil management problems (chlorosis palms of *Phoenix dactylifera*)

soil carbonate and sulfate soil carbonate and sulfate minerals contribute mainly into the soil management problems in agriculture: fixation of phosphorus, availability and iron chlorosis [11] (Photo 1). Gypsiferous soils are very fragile and easily eroded because of low organic matter content, poor structure and sparse vegetation cover [12]. Gypsum and gypsiferous deposits cause's impervious layers may hinder the growth of plant roots and that the soil will be less productive [13]. Gypseous soils should a specific management practices when using gypseous lands for agriculture or for urban development's [9].

The purpose of this work is to find an efficient method in means and time for identifying, locating and mapping the soils in particular gypsids soils in the vast arid regions. The surface of these soils is currently not well-known [14] and also is not well delimited. The traditional mapping studies of soils based on proven techniques, such as aerial photographs, have long existed in our country. Only a small number of mapping studies devoted to gypseous soils are currently available. This information is still very fragmented compared to the salty surfaces in the Algeria land and taking in account the significant cost of implementation of soil mapping using the conventional methods. Remote sensing has been advocated as a powerful tool to play an important role in identifying, mapping and monitoring soil salinity. Remote sensing of salt-affected soils is favored by a set of factors and conditions peculiar to halomorphic soils, especially the concentration of salts at the soil surface in the form of white crusts with high reflectance and the characteristic reflectance features controlled by salt mineralogy [15,16].

To date, there is significant number of satellite image applications in many parts of the world. Several studies have found correlations between multispectral airborne images of the bare soil and soil properties related to moisture content, organic matter, soil texture and minerals assemblages; [16-21]. Also, many review papers have described the usefulness of remote sensing for salinity mapping [15,22-25] and several researchers have applied remote sensing problems of gypseous soils [5,10,26-30].

The objective of this study was to connect two data set of different nature: the remote sensing and the resultant data on- the- spot observations (based on field observations) to typify and map delimited of gypseous soils. This information will be useful for the sustainable management of these soils and their associated resources and for new studies regarding their morphology and behavior. For this reason, the gypsum content (Gypsic or petrogypsic horizon) and the depth should be considered during the planning of gypseous soil management.

Study Area and Characterization of the Natural Environment: The study toposequence occupies the central part of the sub -watershed of Oued Djedi, situated at 450 km south-east of Algiers (Figure 1). The site is located at the foot of the Saharan Atlas between the latitudinal coordinates 43, 85°- 34, 53° N and longitudinal coordinates 5, 49°-5, 48° at altitude of 124 m (Djebel Boughzel). The study area belongs to the lower arid bioclimatic level (200 < P > 100 m) with mild winters. Rainfalls are almost always falling as heavy downpours. The released water is concentrated in the valleys of wadis and carried along to the chotts (Chott Melrhir). The average temperature throughout the year is 22.39 ° C with a high seasonal variation. The maximum temperature is around 36, 4 ° C for the month of July with 420.8 mm of evapotranspiration while the minimum temperature is about 9.3 ° C for the month of January with 110.8 meters.

General lithological character of the site is occupied according to Lafitte, [31,32] and [31], by a formation called "Deb-deb" which may be related to the medium quaternary, represented by several layers of crusted piedmont slopes (gypsum and limestone), but the deposit probably continues today [3].

The natural vegetation cover is determined by the morpho-pedological arrangement [7]. In fact, it is xerophytic type structured in several groups: (1) the gypsophytes (Limoniastrum guyonianum) on gypsum and limestone, (2) the halophytes (Salsola vermiculata), (3) the hyperhalophiles (Halocnemum strobilaceum) on the saline facies and (4) psammophytes (Aristida pungens) on aeolian formations.

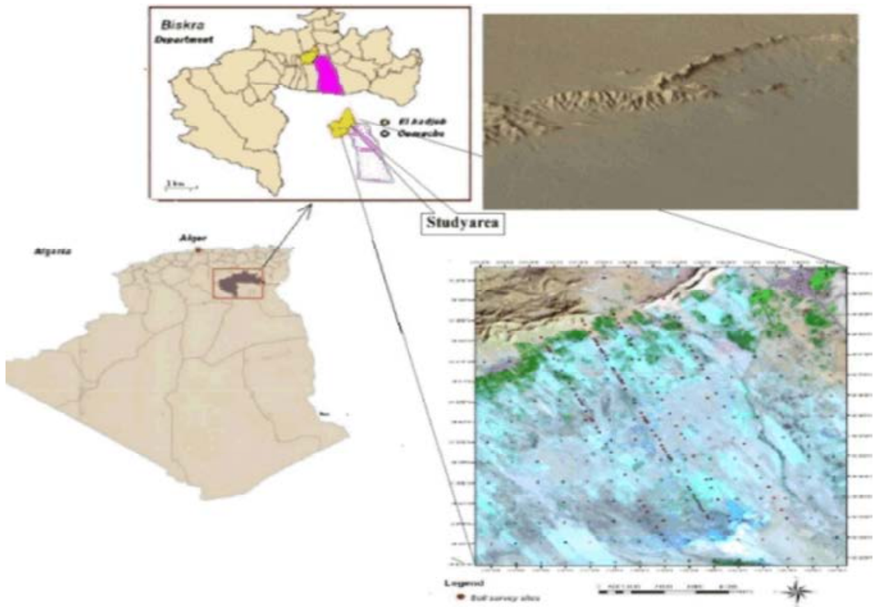

Fig. 1: The study area and its associated color combination TM images and a digital elevation model (MNA-Aster)

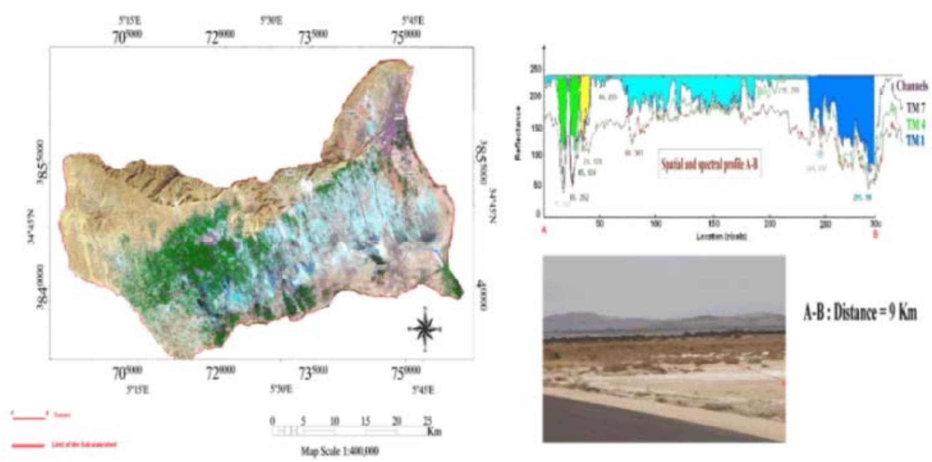

Fig. 2: TM Multispectral satellite images taken in the study area acquired in October 9, 2009 and spectral profile A-B.

MATERIALS AND METHODS

Multispectral Satellite Images: At high resolution TM Multispectral satellite images at high resolution TM are provided free by the NASA and the used satellite data are those acquired on October 9th, 2009 from the Landsat TM 5 at (30 x 30 m) spatial resolution (Figure 2). This is a dry period where the soils are bare. The colour combination was made on a Windows of 3847 lines and 2385 columns of pixels, for channels 1 (blue), 4 (red) and 7 (near infrared) analysis by photo-interpretation of the trichromacy reveals the variety of existing themes. The image processing had been carried out by the ENVI software (version 4.6) de l'ITT Inc [33].

The region of Biskra can be considered a zone which supports the use of remote sensing from several aspects such as: geographical, climatic and hydrological. Indeed, we noticed:

A favorable geographical position and climatic condition:

- A vast territory;
- Little relief;
- Resulting few geometric distortions in images;
- Few clouds, which is important for visibility over long periods;
- Scarcity of vegetation allows a good view of the surface.

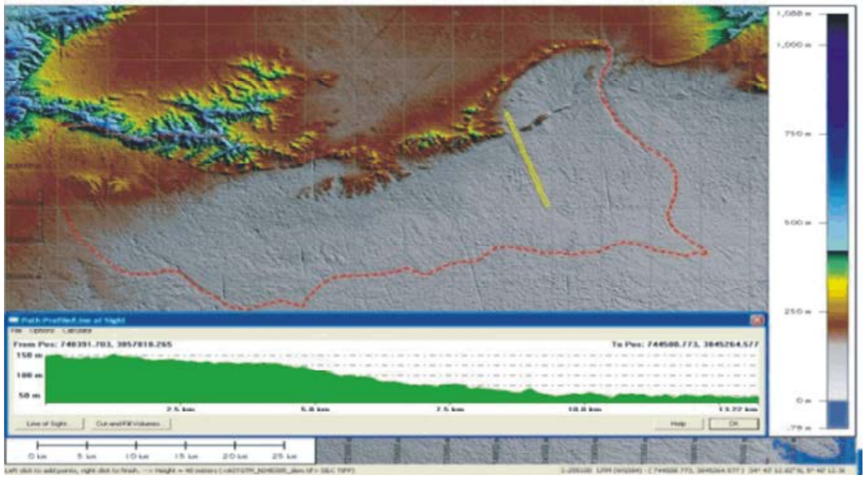

Fig. 3: Digital elevation model (GDEM -Aster)

GDEM[1] Data (ASTER[2]): They were performed in collaboration between NASA and METI (Japan) in December 1999 and are available all around the world (except for extreme latitudes). They are available for a pixel pitch of 30 m and a planimetric accuracy of 30 m and altimetry of 20 m from the Terra Aster satellite. These data are for free from 29/06/2009 (Figure 3). They were incorporated into the GIS to analyze the spatial distribution of soils. This data could be combined with multispectral images to realize better view of the landscape.

Exogenous Data: They are available thematic data such as topographic bases, pedologic map at 1: 500 000 [34], the geological map 1: 200 000 [32], the hydrographic network map: 1: 50 000 and climatic data [35].

In Situ Data: Field investigations were carried out in 2007, 2008 and 2009 to help identifying the boundaries of the watershed and to establish a typology based on basin morphostructure, the nature of soil and vegetation. The following are the criteria that were used to identify the soils: At the morphological level, they were based on surface form including the presence and / or absence of gypseous crust, as well as gypseous and salt efflorescence's, colour, texture, structure, stoniness, roughness, etc. At the analytical level, granulometry, organic matter (OM), water pH, CaCO3%, the % CaSO4. Observations and field surveys (pits, auger surveys and sampling) were located by GPS corresponds accurately to the reflectance peaks observed on the spectral profile.

The data collected were computerized and factorial layers were performed and integrated into a (ESRI ArcGIS 9.3). The transect or toposequence method was selected by what it can cover and ensure the regularity of the spatial distribution and the representativeness as all over the territory.

Methodological Approach: The methodology consisted to plot on a three-color (R = TM7, TM4 = V, B = TM1) Landsat TM 5 images from 09/10/2009, one spectral profile of 300 pixels matched exactly with a toposequence studied on ground of 9000 m in length located, by GPS, upstream Piedmont of Djebel Tenia and downstream Oumache sebkha depression of Oued Djedi sub-watershed. In order to discrete efficiently of arid-sols, their validations therefore require in situ surveys (auger surveys and profiles) on the toposequence. The collected and analyzed samples in the laboratory (moisture, granulometry, % CaCO3, % CaSO4, pH, EC, color) were identified by GPS and squared accurately with reflectance and absorption peaks at the spectral profile. Four profiles were selected in each physiographic unit and described and classified according to Keys to Soil Taxonomy [36]. The in-situ surveys and measures have improved the identification and delineation of different areas with shallow gypsum, i.e. gypsic horizons, were discriminated from areas with deep gypsum phases the petrogypsic horizons. This distinction between shallow and deep gypsum horizons is very useful for resource management planning. The maps produced by supervised classification of maximum likelihood based within situ surveys which were extrapolated into the study area serve

[1]Digital Elevation Model

[2]Advanced Spaceborne Thermal Emission and Reflection Radiometer.

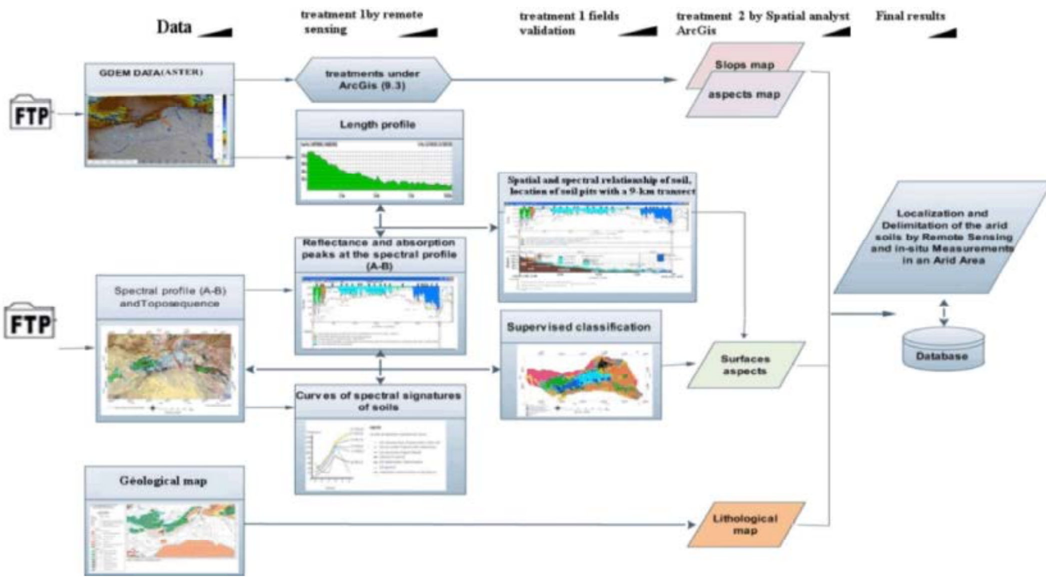

Fig. 4: A methodological approach of the soil mapping using remote sensing and GIS.

for localization and evaluating the suitability of land for production. The link between remote sensing, GIS and pedology (Figure 4) provided very useful data for understanding a spatial distribution of gypseous soil compared to conventional methods. The introduction of external knowledge (analytical data, field observations and the integration of the physical parameters) could reinforce this technique from the treatment phase

RESULTS AND DISCUSSION

Thematic Interpretations: Analyses of Landsat ETM+ [37] and GDEM DATA Aster images [38] made it possible to define three main landscapes in the study area: i) glacis, ii) plains and iii) endoreic depressions. Moreover, it is possible to recognize the different landforms within these landscapes (Figure 6).

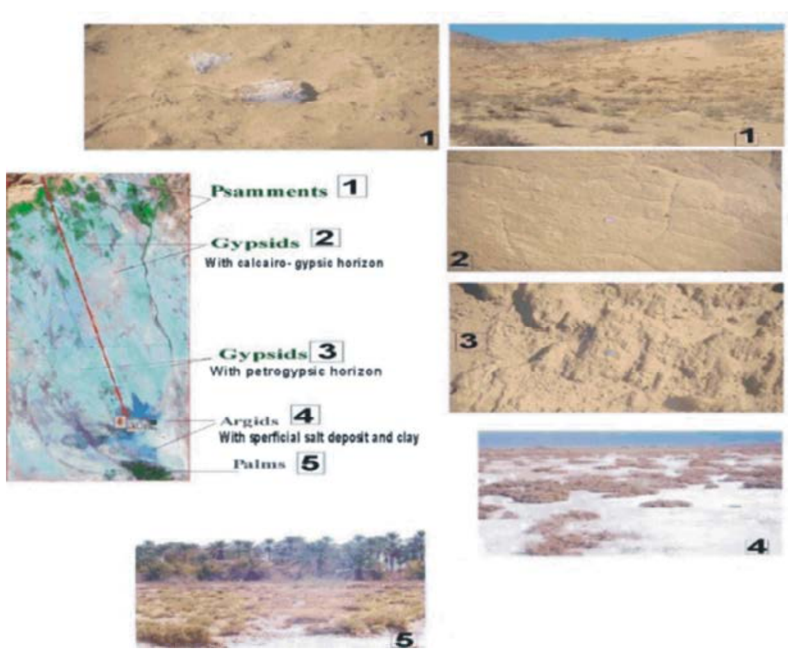

Fig. 5: Photo-interpretation of a three-color TM 7, 4, 1 in October 9, 2009. With land surfaces and vegetation formations photos

Table 1: Identified themes by photo-interpretation of the TM three-color sub-watershed

Surface appearance	Geomorphological unit	reflectances	Photo-interpretation	Texture	Munsell color (soil)	Surficial formations	Surface soil moisture
Gypsids with calcico-gypsic horizon	glacis and plains	moderately high	Cyan colour patches.	Sandy	7.5 YR 8/2	Macrostructure polygonal occur in surface crusts that have 10 to 40 cm wide and separated by slits up the lower part of the crusting. clusters and nodules of gypsum ; moisture horizon of calcairo Gypsic (Deb-Deb)	wet
Gypsids with petrogypsic horizon	plains	Very high	Cyan colour	Sandy	7.5 YR 8/2	Crusting and crust very indurate.	dry to very dry
Argids	endoreic depressions	high	bluish tinge	Clay-loam - sandy	7.5 YR 8/6	Argillic horizon with superficial salt deposit and clay	wet
Xeropsamments	plains	Very high	Light colour Very light colour	Sandy	5 YR 6/6 à 7.5 YR 6/6	Boundary an aeolian beads of sebkha; paleodunes. Shifting sands; aeolian formations made ??by lenticular crystals of gypsum and salts reworked, transported and deposited on the dunes.	dry
Phoenix dactylifera (date palm) and Vegetation	plains	Low	Dark green Bright green			Grasses (*Phoenix dactylifera*) date palm. Cereal crops halophytes, gypsum and psamophytes.	

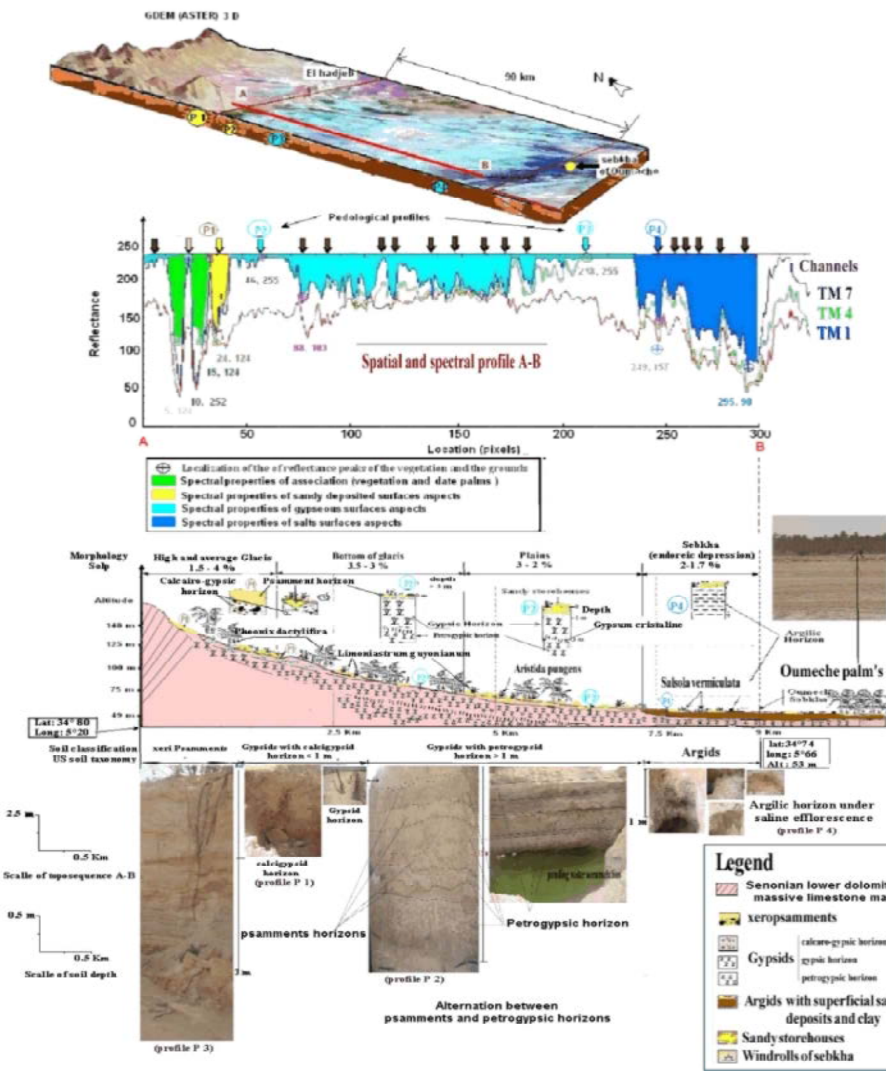

Fig. 6: Spatial and spectral relation of soils with implementation of soil pits on a toposequence of 9 km.

Areas are often identified by the presence of white patches of precipitated gypsum and efflorescence salt that are closely associated with the morphological soil position and occurrence of small depressions where evaporation and capillary processes are favored. We identified five (05) themes using photo-interpretation of the TM three-colour of watershed showed in Figure 5 and Table 1. Four (04) themes were related to soil surface aspects as follows: 1) Gypsids with gypsic horizon, 2) Gypsids with petrogypsic horizon, 3) Xeropsamments, 4) Argids with superficial salt deposit and clay and also (01) related to land use: Phoenix dactylifera (date palm) and vegetation.

Contribution of the Field Observations: The field works were performed between April and May 2010 and allowed to compare the spectral signature peaks with the observations and laboratory tests (Figure 6).

For this purpose, 50 soil pits were opened, 1.5 m deep; only 23 profiles were selected with GPS localization, where each observation site coincides exactly with the surfaces aspects class peak of the monitored soil on the spectral profile. Only nine (09) profiles have been studied in detail and 34 for the established auger shots all around the profiles. Sampling was limited to surface horizons (0-50 cm), which has the highest variability in chemical composition. The horizons were differentiated according to their color, moisture, texture and structure (Table 3).

However, in this study we analyzed only the soil samples corresponding to the strong reflectance peaks.

Relationship Between Spectral Signatures and In-situ Data

The Topography of the Slope: Terrain attributes were derived from digital elevation model (DEM) data acquired from US geologic survey national elevation Dataset with a resolution of 30 m. Terrain attributes calculated from these DEM included slope gradient, slope aspect, profile (down slope) and relative slope position. From a morphological point of view, the region is characterized by a single model of association piedmont slopes nested in gypseous crusts, sloping gently from north to south. It is characterized by microtopography from an altitude of 160 m to less than 50 m (Figure 6). The relief of the slope would have shaped during the quaternary and a series of successive phases of erosion and deposition at downstream. The substrate of the region is generally formed from the sandy and gypseous clays of Middle Pliocene.

The slopes are cut by wadis originating from the most important reliefs at the north of Djebel Tenia and Boughzel and flowing into the depression (sebkha of Oumache) of slopes ranging around 3%. The slopes accentuated upstream and decreased downstream. There are convex forms in upstream and concave in downstream.

Table 2: Relation between soil types and the physical environment

Units	Surface aspects' Formations	vegetations	Morphology	U. S. soil taxonomy (2010)
I	Gypseous, wet	*Phoenix dactylifera* (date palm) and the species gypsophytes (Limoniastrum guyonianum)	Glacis;	Xeric calcigypsid
II	Gypseous, dry	*Phoenix dactylifera* (date palm) and the species gypsophytes (Limoniastrum guyonianum)	plains	Gypsids
III	Eolian, gypseous and salty surface formations	psammophytes (Aristida pungens)	Plains and concave shapes	Xeropsamments
IV	Efflorescence of salt deposit and clay	halophytes (Salsola vermiculata) and hyperhalophiles (Halocnemum strobilaceum)	Endorheic depression	Argids

Table 3: Physical and chemical properties of some selected profiles

Physical and chemical analyzes	Horizon Ys	Horizon 1	Horizon Ys	Horizon Ym	Horizon 1
Profile	P1	P2	P3	P3	P4
Depth (cm)	20-100	0-200	20-50 cm	50	50-100
pH (H2O)	8.3	8.4	8.6	8.3	8.05
EC (mmhos/cm)	1.3	0.66	1.2	4	18
OM %	0.6	0.22	0	0	0.32
$CaCO_3$ % total	25	2%	40 %	32 %	0
$CaSO_4$, $2H_2O$ %	95	33	60	60	10
Texture	Sandy	Sandy	Sandy	Sandy	Clay
Structure	massive	No structure	Indurations massive	power	
Color Munsell	10 YR 7/4	10 YR 8/3	4 YR	7.5 YR	7.5 YR 2/0

Morphological and Physicochemical Characteristics: A toposequence (A-B) was conducted to describe the relationship between soil formation, morphology and vegetation nature. This is especially to allow cross-checking information outcome from remote sensing, MNA and those collected in the field (physicochemical characteristics of soils).

The studied toposequence was mapped using a Garmin GPS. It illustrated the characterized distribution of soil surface aspects, the morphology and plant groupings (Figure 6). Starting from the upstream of the Jebel Boughzel to the downstream of the Oumache sebkha, there were four areas of maximum diversity of surface aspects associated with four plants on four models and four classes of soils according to the U.S soil Taxonomy [36] classification (Table 2).

The current soil moisture regime in our area study is aridic. The phenomena "per ascensum" dominant phenomena "per descensum", gypsum tends to accumulate at the surface form scabs and crusts. It is possible to recognize the different landforms within these soils as the following:

- Glacis (low elevated)

The morphological description and laboratory analyses indicate that the soils of glacis are differentiate with gypsic deposits with depth < 100 cm. The soil had a calcigypsid horizon (profile P1), classified in xeric calcigypsid soil in U. S soil taxonomy classification, the colour patches are Cyan (7.5 YR 8/2). The soil texture is sandy, structure form massive friable, wet. The percent of organic matter (OM) is very low it not exceeds 0.60%. The percent of calcium carbonate ($CaCO_3$) is 37 % and 70 % of gypsum ($CaSO_4$, $2H_2O$). A pH (H_2O) was basic (7.6 to 8.7) in all soil horizon. The electrical conductivity (EC) values are very low 1 mmhos/ cm; continuous horizon (crust) gypsum. Presence of roots and rootlets. Split into polygonal plates whose leader is visible in the underlying horizon is always a horizon (gypsic);

- Plaine (I)

The soil was developed on the moderate slop. The color of soil varied between the hue 7.5 YR and 10. The soil had a petrogypsic substrate (profile P2 > 100 cm). The gypsum substrate had a brighter color than the other calcigypsid soil in glacis deposit, dry, with massive and indurate structure in the uppermost and in the deep horizon. The soil texture is sandy. The percent of calcium carbonate (CaCO3) is 0 % and 86 % of (CaSO4, 2H2O). The percent of OM is low 0.1 to 0.42, the electrical conductivity (EC) values are very low 2 mmhos/ cm 25°C; basic pH (H2O) (7.9 – 8.3). Horizon petrogypsic in relation to the water table or a lateral flow of irrigation water, without roots and rootlets;

- Plaine and concave shapes

It includes the land forms of almost flat aeolian deposits classified in Xeropsamments soils, the depth of profile (P3) is 0-3 meters, there are layers of sands formations interspersed wind and fluvial thin layers, the latter being attributed to the near the wadis. Are 5 YR 6/6 and 7.5 YR 6/6 color, the soil texture is sandy, structure is poorly developed, their fragility and sensitivity to wind erosion are great. They offer a comprehensive high porosity (45- 48%), the wet flat surface of salt efflorescence and also Gypsids soils with petrogypsic horizon are Cyan colour 7.5 YR 8/2, dry. The soil texture is sandy. The percent of OM is low 0.6; the percent of ($CaSO_4$, $2H_2O$) is high ranged from 65 to 70 %, pH (H2O) (7.8 to 8.2);

- Endoreic depressions (sabkhas)

Sabkha is a flat surface of thick salt crust. The soils are almost flat aeolian deposits are bluish tinge 7.5 YR 8/6 the soil texture is Clay-loam-sandy, wet (profile P4). There is the formation of thin films slightly swollen created by clumps of vegetation. Electrical conductivity (EC) varied from 12 mmhos/ cm 25°C to 18 mmhos/ cm 25°C, showing that some depth soil horizons had salinity hazard. Sebkha is a hub of salts. There is the formation of thin crust slightly swollen created by clumps of vegetation; the capillary salts were accumulated in surface during the dry months (April to October). Can be seen also a particles lenticular gypsum surface and their mobilization by the wind.

Relations of Reflectance Soil Surface Aspects: The reflectance of soil is a direct result of their compositions and colors [17,39,40]. We can see that radiometry along the toposequence is very heterogeneous in the three TM channels (7, 4 and 1). This variability is related to the soil nature that has a decisive effect on soil properties, soil moisture [19,41] and texture, position (slope and aspect), the depth and climate. Hashemi *et al*., [30] suggested that the amount of gypsum accumulation depended on soil moisture regimes rather than soil temperature regimes.

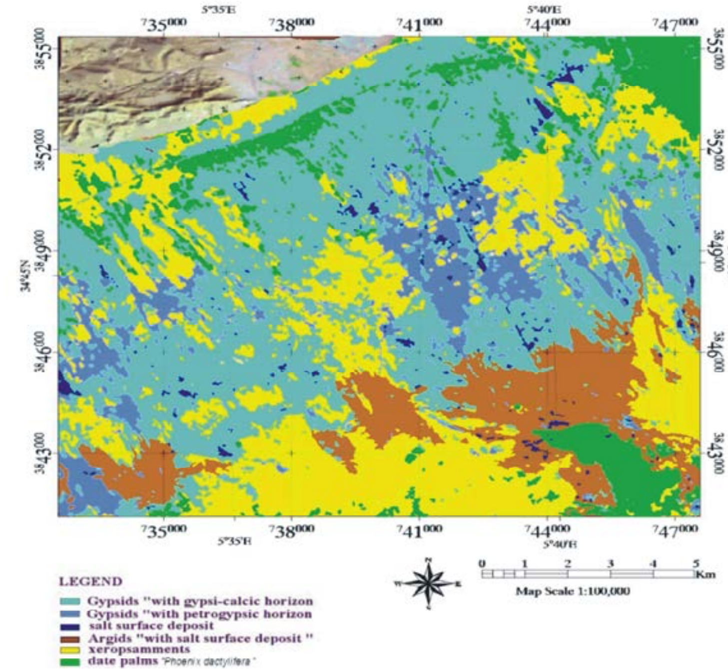

Fig. 7: Map of thematic classes in El-Hadjeb obtained by supervised classification.

Radiometric values of whitish color surfaces tend to reflect more of net radiation, which was a very high albedo (Figure 6). These high radiometric values were observed at coordinates (10-252, 46-255, 218-255) corresponds to the high reflectance of gypseous, sandy (strong sand in transition). These values ??had a relationship with texture, mostly sandy, which was composed of large amount of macropores (pore diameter > 10 microns) and also by the influence of slope and the aspect which had a major impact on soil moisture [42]. The soils faced directly at the sun were warmer where strong precipitation of salts by evaporation. The position of the soil on steep slopes may be eroded and lose their fine particles and gives a whitish color to the land. These accumulated materials can be welded and become impenetrable to roots and to the infiltration of water. There was also the depth of the profile that affected the moisture content of soil.

In addition, darker soils were noticed in (24 -124) corresponding to paleodunes (fossil or stabile dunes, covered by sparse vegetation). Another aspect of salted surface showed absorption peaks due to soil moisture and hygroscopic water located in small depressions.

However, the radiometry was also low at coordinates (5, 15 and 124, 124) which corresponded to the chlorophyll absorption of the *Phoenix dactylifera* (date palm) and cultivated land. The effect of vegetation cover on the absorption varied with the density, height, shape, orientation and color of the date palms.

Classification: For the graphical representation of the classification (Figure 7), we have done a smoothing to eliminate the isolated pixels. From Table 4 and 5, we can see that the gypsids surface soils with gypsy-calcic horizon were classified (6705 pixel) whether (603.45 hectares) and the confusion with gypsids surface soils with petrogypsic horizon (1024 pixels/ 92.16 hectares) and salted surface aspects (105 pixels/9.45 hectares) was often due to similar points of soil (gypseous crystals) and color (clear). This confusion was up after the integration of field data (observation, substratum and relief.). Remember that the analysis did not take into account the individual values ??of pixels, but it recorded only the relations between pixels.

The quality of the classification was estimated by the Cohen's kappa (K) [43] which indicated that the classification results were good (kappa = 0.82). According to [18], the classification was considered statistically acceptable when the agreements represent 80% or more of the pixels of the reference parcels.

Confusions were observed between the class of *Phoenix dactylifera* (date palm) and crops (olives, etc...) which may be associated with their physiognomic similarity.

These confusions were pronounced far from challenging the spectral classification that carried out in this work and permit therefore the contrary to highlight structural similarities between the training soils.

Table 4: Confusion matrices (per pixel) I: Aspects of gypsids surface "with calcigypsid horizon"; II: Aspects of gypsids surface "with petro gypsic horizon; III: Aspects of sandy surface (sharp sand), IV: Aspects of salty deposit surface, IV: *Phoenix dactylifera* (date palm) vegetation.

Class	I	II	III	IV	V	Total
I	6705	1024	105	75	0	7909
II	809	3636	612	24	0	5081
III	319	510	6684	0	0	7513
IV	91	74	0	351	0	516
V	0	2	0	0	530	532
Total	6762	2163	837	450	530	10742

Table 5: Thematic class.

Themes	Area (hectare)	%
I	603.45	38.19
II	327.24	20.71
III	601.56	38.07
IV	351	22.22
V	47.7	3.02
Total	1579.95	100

General Discussion: Four main factors influence the soil reflectance in remote sensing images: mineral composition, soil moisture, organic matter content and soil texture (surface). Size and shape of the soil aggregate also influence the reflectance in the images.

Overall, the reflectance of soil surface appearances varied greatly in average amplitude. Indeed, there was a whole range of situations between soil surface aspects of that reflect strong solar radiation (very sandy, very calcareous or gypseous...) and the soil surface aspects of more or less dark which absorb the majority of the radiation (heavy clay, rich in organic matter, moisture, etc.) by [40,44-47].

Supervised classification is most appropriate for the identification of soil surface aspects in arid regions especially crusting and gypsids soils [28]. It offers effective practice to the operator since he knows some reference surface aspects or when he can identify by visual interpretation, ground units with a minimum of certainty. As for the spectral profile A-B marked on the image, it has reduced the number of classes and gave an easier interpretation, thus helping to a better delineation of the thematic classes.

By checking other similar places in the field, we could conclude that the exo-atmospheric spectral signatures (Figure 6) corroborate the observations and physicochemical analytical data of each unit or soil class. Topographic data and exogenous information were used to differentiate between different types of soil surface aspects. They have allowed distinguishing between gypsids soil surface aspects from Xeropsamments soils surface aspects (sandy). This landscape unit is in fact a small dune unit (nebkhas) developed at the shelter in a depression or from a barrier formed by vegetation clumps (bush) and sandy veil that covers the gypsids soil from the plain of Bouchagroun.

Some variations on the reflectance curves did not reflect significant changes in the surface aspects and vice versa. On the same transect, the reflectance values of the same class (gypsids) had strong reflectance of two different geomorphological units (slopes and depressions). As against the same unit of raw mineral soils of aeolian contribution existing in reflectances probably different due to gypseous crust outcrops of (Deb-deb) or to the fine particles of gypseous crystals and / or salts carried by the wind and deposited on sand dunes.

CONCLUSION

The study shows that the distribution of soils in the study area are organized in sequence is expressed differently depending on whether you are at a glacis, plain or depression. It shows calcigypsid and sand deposits in plains and the concave parts of the ground petrogypsic and argilic soil endoreic depressions (sabkhas).

Considering the obtained results, we can say that the widely used photo-interpretation method allowed us to identify, localize by GPS and delineate the homogeneous objects. It also made possible for us to properly conduct the field survey. The main classes of soil surface aspects have been well characterized by different exo-atmospheric spectral signatures (relationship between soil properties and reflectance spectra "the reflection and absorption peaks") in the visible area and in infrared. In arid areas, salts (CaSo4, 2H2o, CaCo3, Nacl, etc.) tend to concentrate on the soil surface favoring the use of remote sensing tools. Remote sensing can detect, with reasonable accuracy, the presence of salt in the surface layer of the topsoil. This will need traditional sampling and laboratory analyses to obtain the ground data. The traditional approach to soil mapping from sole field observations and laboratory determinations is challenged, arguing that it is expensive and time-consuming.

Remote sensing techniques allow us to identify and mapping gypsum content of the soil in the short term and with a desired resolution. It is clear that the contribution of remote sensing, the digital elevation model (DEM), the field observations and the results of laboratory tests offer real possibilities for the detection of soils in arid regions and especially gypseous soils. This suggested that the distribution of the different gypseous formations is certainly not a simple reflection of the topography, the substrate and the water table. The relationship between these factors is so complex and our study does not offer any explanation of their distribution. It is clearly that the soils and vegetation have been influenced by human. This human influence is mainly due to the method of irrigation and the quality of water with high salt concentrations and the mode of field exploitation, which is incompatible with his vocation.

Finally, integration of all descriptive data and geographic database in a geographic information system is important for monitoring and updating maps and can also help the local authorities to manage their land (hydro-agricultural development) and to protect them from degradation and desertification.

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