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Identification of Gypsiferous Soils in North-West Iraq by Using MODIS Data for Determining Dust Storms Sources

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Abstract: Gypsiferous soils are found in various countries in the world especially arid and semiarid areas, where rains fall is not sufficient to remove the gypsum section of the soil. In this study MODIS sensor data at drought day (2011/08/26) in north-west of Iraq (Al-Jazeera) was used to distinguish gypsiferous soils of the North-West Iraq. This area could be a source of dust storms. This region is characterized by the desert regions of arid and semi-dry because of scarcity of rain and vegetation cover, especially during the summer season as identified by satellite imagery in recent decades. Gypsiferous soils have been identified in Al-Jazeera region using one composite image in true colors and two composite images in false colors for MODIS sensor data. Unsupervised classification method was used to calculate the areas of these soils after that mapping gypsiferous soils in the north-west of Iraq was carried out using Arc GIS.

Keywords: *Gypsiferous soil; Gypsum; Dust storm; MODIS data.*

1. INTRODUCTION

Gypsiferous soil and soils with gypsum accumulation covers large parts of the world. Iraq is considered one of the countries that contain a large area of gypsiferous soils. It is about 47,792 km^2 which is equivalent to about 11.0 % of total country area [1]. The northern part of the upper AL-Jazeera region has a slightly gypsiferous soil which is formed over gypsum bed rocks with gypsum content below 6 %. In the southern part of upper AL-Jazeera the gypsiferous soils are formed over gypsum and anhydrate rocks, and they are considered moderately to highly gypsiferous, with a gypsum content range from a few percentages to more than 60%. The lower AL-Jazeera is characterized by gypsum desert where primary gypsum bed rock which is the main source of gypsum accumulation in other region [1].

Many studies, methodologies and techniques have been used to characterize gypsiferous, especially in gypsiferous soils of semiarid and arid region. J. Porta [2] studied gypsum from different points of view, complementary and necessary to obtain a general overview of the methodologies used to study gypsum in soils. G. R. Zehtabian *et al.* [3] used Landsat ETM+ data images composite for mapping the marginal playa soils in Damghan playa, Iran. D. P. Shrestha *et al.* [4] used imaging spectrometer data to detect and map desert- like surface features and analyzed and correlated with soil properties such as soil color, soil salinity and gypsum content. S. J. Nield [5] used Landsat 7 ETM data (used image composite and indices) to facilitate digital mapping of gypsic and nitric soil areas in the upper Colorado River drainage. J. L. Boettinger *et al.* [6] analyzed Landsat spectral data using commercially available image processing software, classification analyzing methods to recognize soil- landscape patterns. M. A. Al- Dabbas *et al.* [7] compared between gypsiferous soil in Samarra and Karbala areas, Iraq by proposed engineering classification of gypsiferous soils. A. M. AL-Omary [1] studied three types of gypsiferous soils namely: Al-Muhallabeia, Al-Jarin and Al-Slmanii using filter paper technique. The investigated soils were located in Nineveh province and found to have gypsum content about 35, 23 and 6% respectively. Also R. A. Mahmood *et al.* [8] showed the gypsum content and the distribution of gypsiferous soils in surface soils in some regions in eastern part and the neighborhood regions of the western part in Basrah governorate south of Iraq.

In this paper different spectral bands of MODIS sensor and some techniques of remote sensing such as image composite and unsupervised classification were used to identify gypsiferous soils in the north west of Iraq. This region exported dust storm in the last decade. This paper gives information about the properties of some soils in the north west of Iraq.

2. MATERIALS AND METHODS

2.1 Study Site

The study area (Al-Jazeera), which lies north of Samarra, the Tigris and the Euphrates north of Hit and extends west to Syria and Mesopotamia to Turkey. Locally it extends between (40.7º-43.9º) longitude and (34.2º-36.5º) latitude. Fig. 1 shows the study site [9]. Study area (Al Jazeerah) is located north of Samarra, towards Syria in the west. Soil of this region varies from Gypsiferrous type in the north of Euphrates river and surrounding Tharthar valley to deep erosional gravel towards Syrian borders. A shallow brownish soil that covers gypsum, sand and clay layers exists in the south and west of Mosul area. This region suffers from wind erosion due to drought and scarcity of vegetation cover [9].

2.2 Methods

Data Source: Moderate Resolution Imaging Spectrometer (MODIS) images were utilized in this study because of their significant temporal and areal converge. It provides a wide range of wavelengths from 0.4 to 14.4 µm, from visible to thermal infrared, in 36 bands. The spatial resolution is 250, 500 and 1000 m. In this study multi-bands at different time were used to extract different indices for detecting soil moisture. Table 1 shows MODIS data that are used in the study.

Image Composite: In displaying a color composite image, three primary colors (red, green and blue) are used. When these three colors are combined in various proportions, they produce different colors in the visible spectrum. Associating each spectral band (not necessarily a visible band) to a separate primary color resulted in a color composite image [10].

Many colors can be formed by combining the three primary colors (Red, Green, and Blue) in various proportions. The display color assignment for any band of a multispectral image can be done in an entirely arbitrary manner. In this case, the color of a target in the displayed image does not have any resemblance to its actual color. The resulting product is known as a false color composite image. There are many possible schemes of producing false color composite images. However, some scheme may be more suitable for detecting certain objects in the image [10].

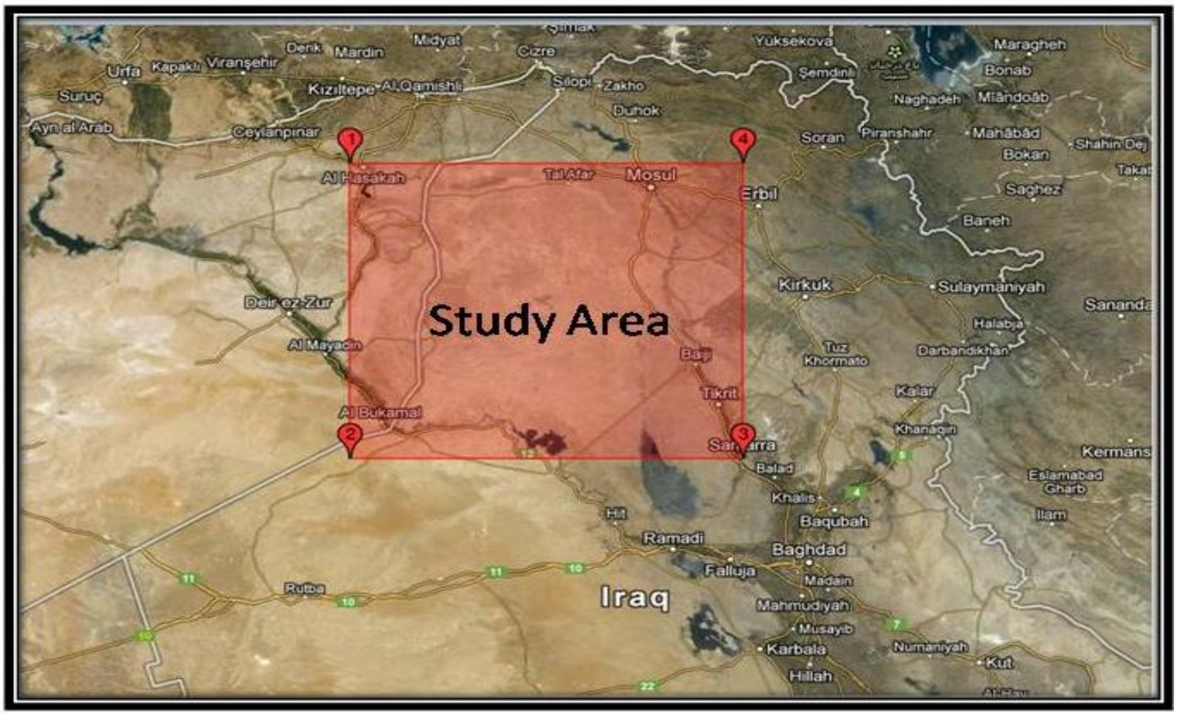


Fig. 1. Location of study area

Table 1. MODIS data used

Data type	Acquisition data	Spectral band	Spatial resolution
		Band 1 (620-670)nm	250m
MODIS Terra		Band2 (841-876)nm	250m
	(2011/08/26)	Band 3 (459-479)nm	500m
		Band4 (545-565)nm	500m
		Band6 (1628-1652)nm	500m
		Band7 (2105-2155)nm	

Unsupervised Classification: Unsupervised classification involves algorithms that examine unknown pixels in an image and aggregate them into number of classes based on the natural groupings or clusters present in the image values [11]. The clustering algorithm is the statistical analysis of the sets of measurement pixels to detect their tendency to form clusters in multidimensional measurement space. Therefore clustering algorithm is used in unsupervised classification to partition sets of data points into a given number of clusters. The points that have similar features should be grouped together and points having different features to different groups for the given data set. This leads to two conditions, first, the cluster should exhibit internal cohesion, and points within a cluster should be closed to one another at least within the local area. Second, the cluster should have some degree of external isolation. External isolation requires that a relatively empty area of a space exist between dense regions points [12].

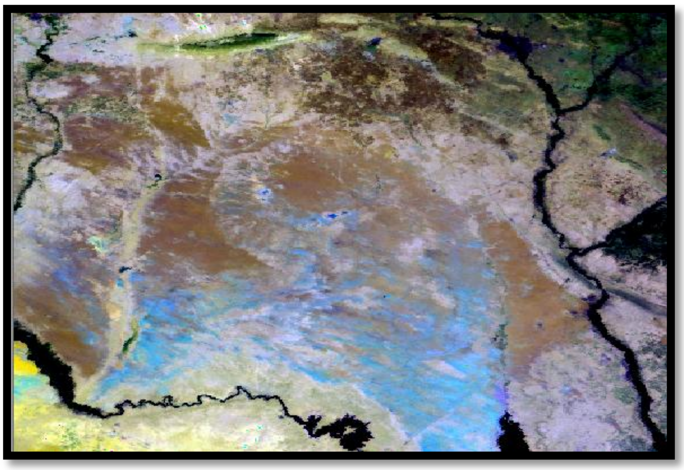
3. RESULTS AND DISCUSSION

The specific objective of this research is to identify the gypsifereous soils in the north-west of Iraq. This objective was realized using different composite images and unsupervised classification technique. The bands used to composite images are suitable for identifing the spectral reflectance characteristics of gypsifereous soil. MODIS data on 26 August 2011 were used to produce three RGB composite images obtained from bands (1,4 and 3), (7,6 and 3) and (6-7, 2 and 3) to illustrate gypsiferous soil in the study region (see Fig. 2). Bands 1, 4, and 3 assigned to red, green, and blue, respectively that shown in Fig. 2.A presents the appearance of gypsiferous soil over the region in white color. Bands 7, 6, and 3 assigned to red, green, and blue respectively presents the gypsifereous soil in turquoise blue color as in Fig. 2.B. Fig. 2.C illustrates gypsiferous soil in magneta color by using band difference (6-7) as red, band 2 as green and band 3 as green.

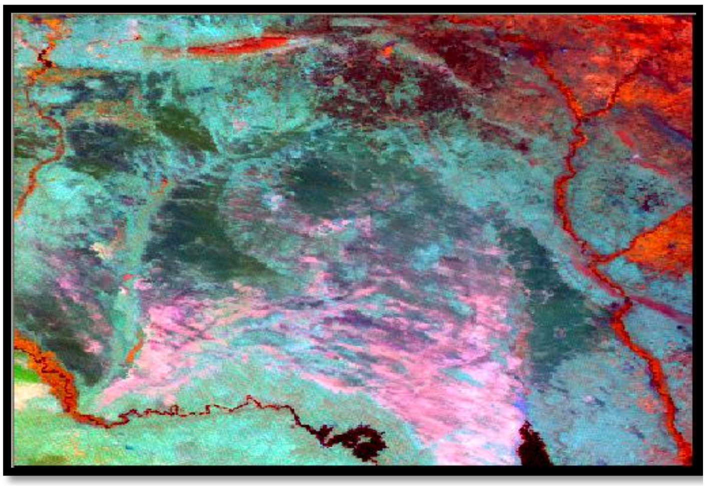
The better distinction of gypsiferous soil was noted in band combinations (7, 6 and 3) and the band combinations (6-7, 2 and 3). Modis spectral plots for seven locations of gypsiferous soil revealed much higher reflectance in SWIR band 6 than band 7 (see Fig. 3). The reflectance of bands (1, 2, 3, 4, 6 and 7) for the seven locations are shown in Fig. 3.B. Gypsifereous soil spectral refelectance at band 6 show highest values followed by band 5 and 2 while the lowest observed reflactance was that of band 3. Bands 1 and 7 show comparable reflectance. Band 4 has an intermidiant spectral reflactance. Aformentioned statements enabled us to choose the wright combination for our analyses.

It is noted that the spectral difference in the regions of band 6 versus 7 using MODIS data is similar to broad spectral patterns indicated by numerous spectral plots for gypsum viewable at S. J. Nield and *et al.* [5] used Landsat 7 ETM data. In contrast to the USGS plots for gypsum, visible light reflectance values for the training areas rich in pedogenic gypsum near the soil surface are low.

(A) MODIS composite image in true color (R(1), G(4),B(3)) illustrate **gypsiferous** soil in white color.



(B) MODIS comosite image in false color (R(7), G(6),B(3)) illustrate **gypsiferous** soil in turquoise blue color



(C) MODIS composite in false color (R(band6-band7), G(2), B(3)) illustrate **gypsiferous** soil in magneta color.

Fig. 2. MODIS composite images at (2011/08/26) illustrate gypsiferous soil in the north-west of Iraq.

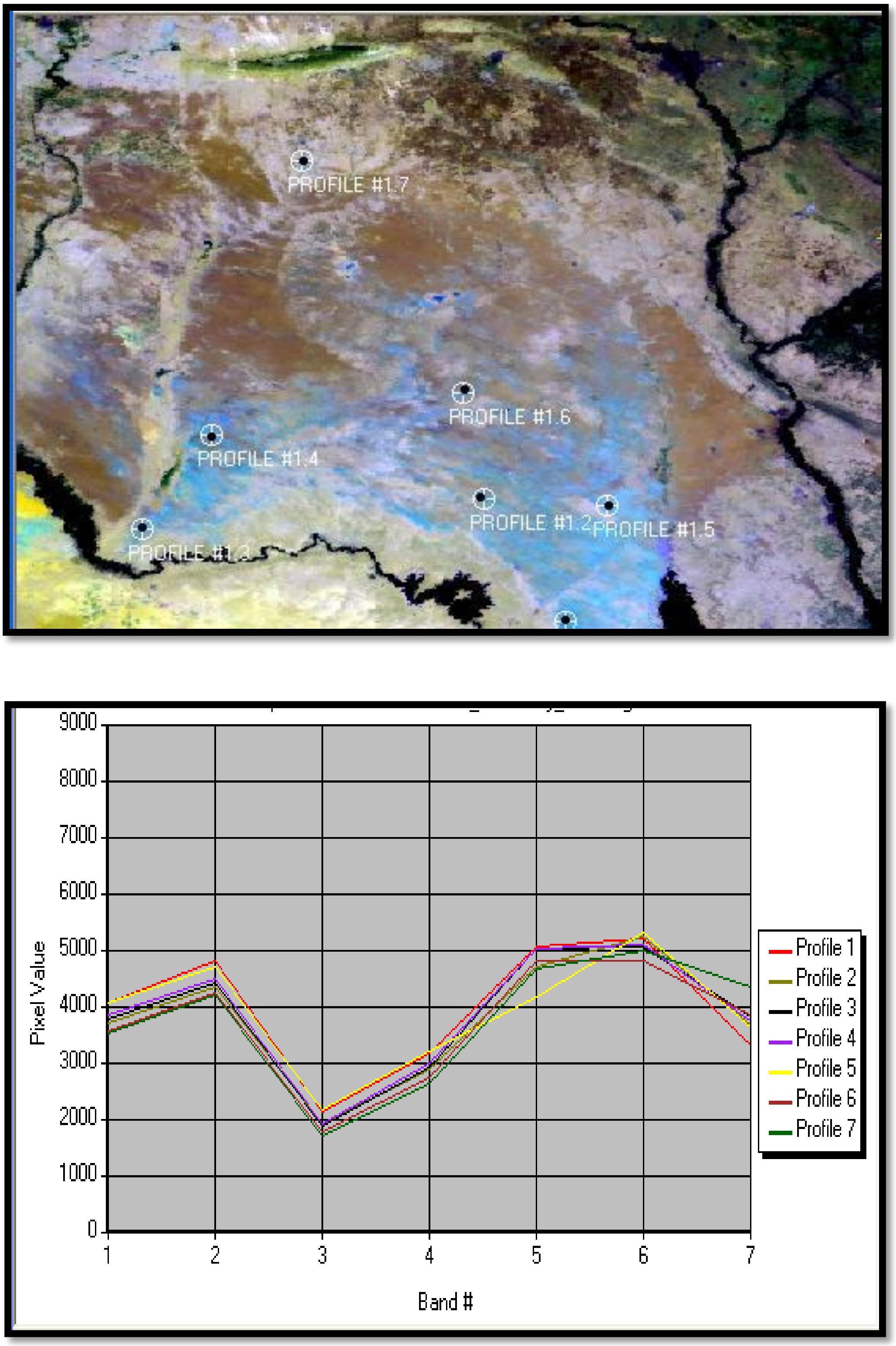
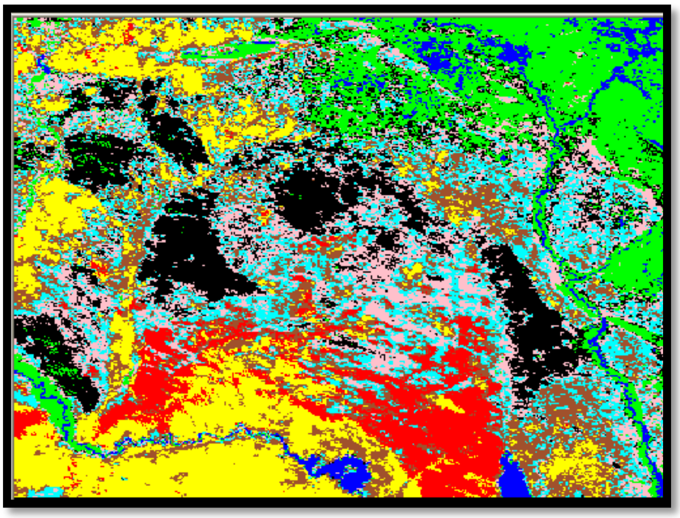
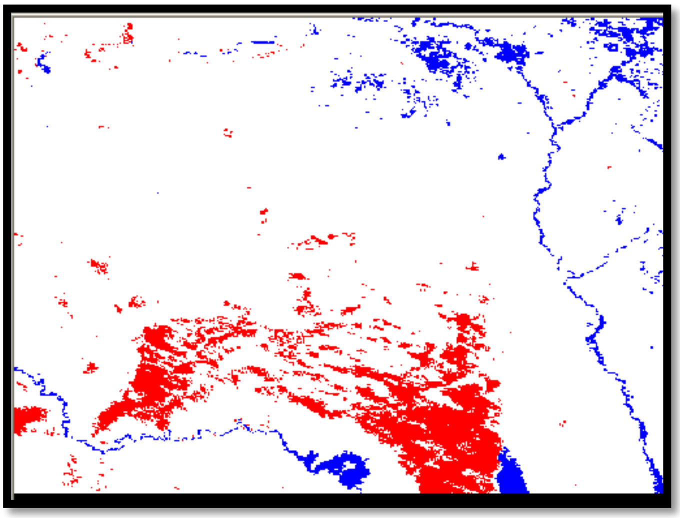


Fig. 3. MODIS spectral band profiles of seven locations dominated by gypsiferous soil (A) –note the peak in SWIR band 6 (1628-1652) nm, and the bsorption in Vis band 3(459-479) nm and SWIR band 7 (2105-2155) nm, (B)



MODIS unsupervised classification image illustrating 8 classes in norh-west Iraq.



MODIS unsupervised classification image illustrating gypsiferous soil class in north-west Iraq that appread in red color.

Fig. 4. MODIS unsupervised classification images at (2011/08/26) that appeared gypsiferous soil in red color.

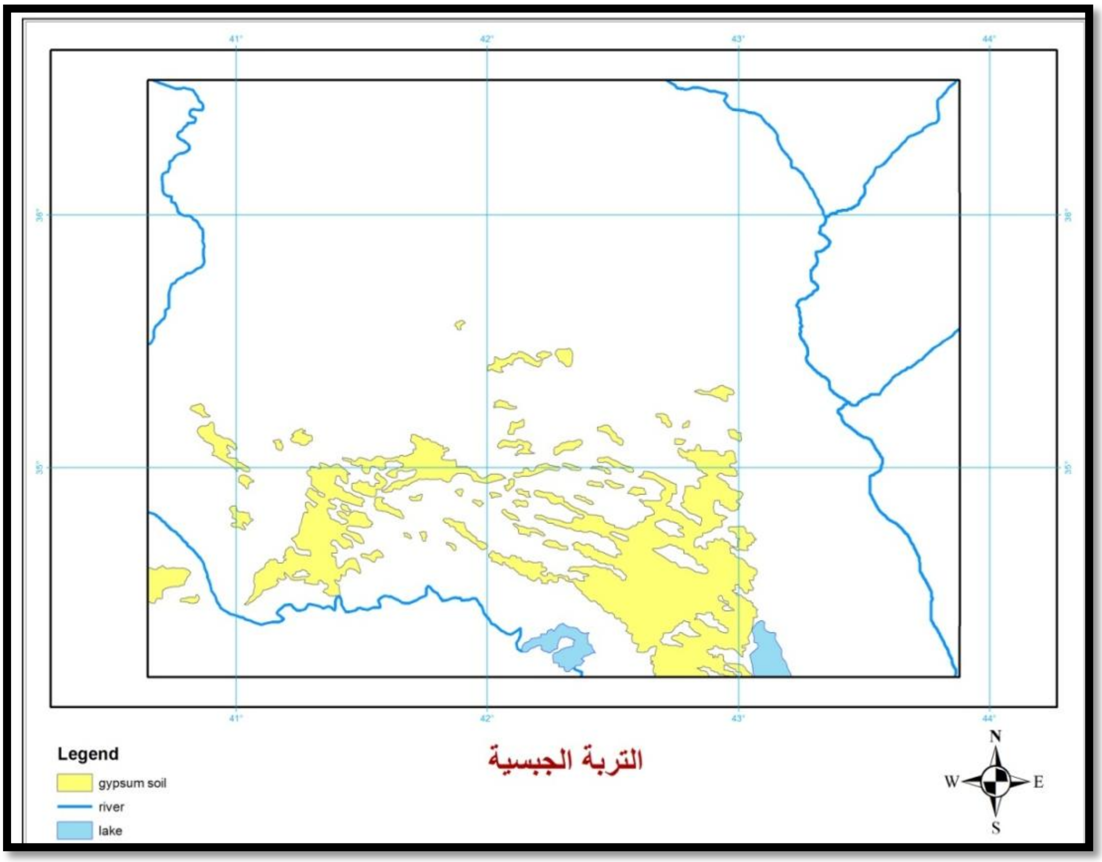
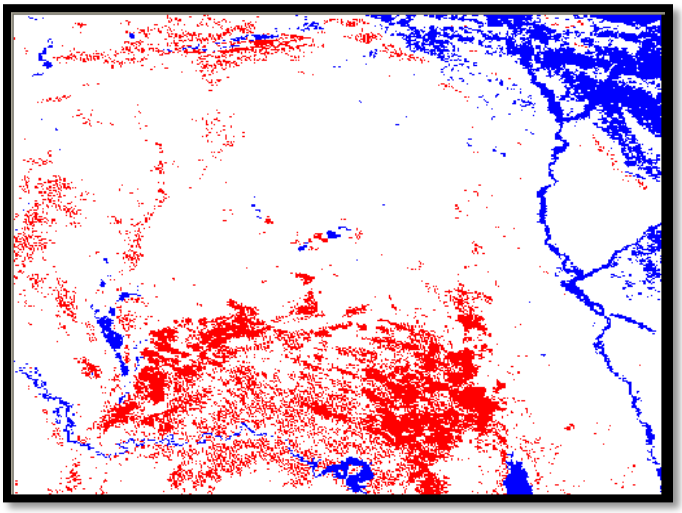
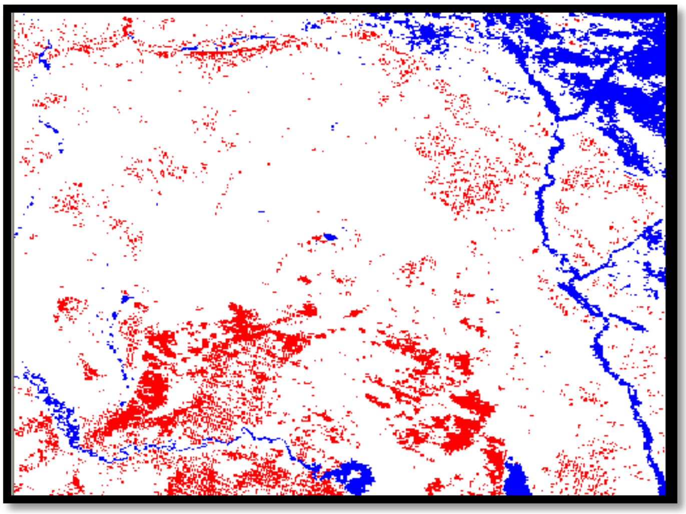


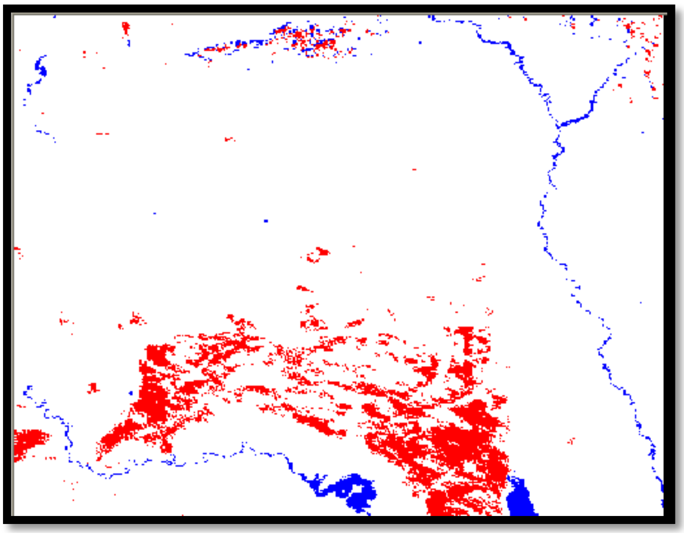
Fig. 5. Map for gypsiferous soil in north-west of Iraq



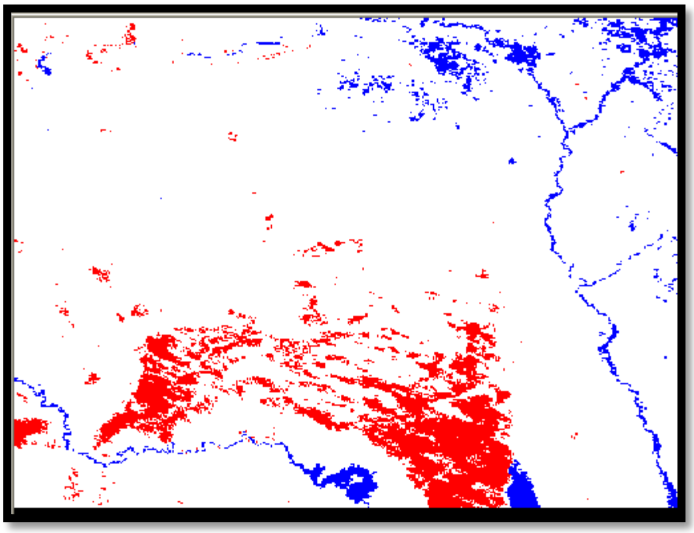
(A) MODIS Unsupervised classification image at (2011-01-07) after rainfall in 7 days, gypsiferous soil about 10.7%



(B) MODIS unsupervised classification image at (2011-01-21) after rainfall in 17 days , gypsiferous soil about 8.9%



(C) MODIS unsupervised classification image at (2011-04-13) after dust storm in one day, gypsiferous soil about 6.38%



(D) MODIS unsupervised classifcation image at (2011-8-26)drought day, gypsiferous soil about 7.4%

Fig. 6. MODIS unsupervised classification images at different seasons in north-west Iraq.

RGB MODIS composite (6-7, 2, 3) was classified into 8 classes using unsupervised classification method; Results are shown in Fig. 4.A. Gypsiferous soil class appeared in red color. Fig. 4.B shows the extracted gypsiferous soil class.

The area of gypsiferous soil in the study area represents 7.4% of the total area. These images are expected to draw digital map by using Arc GIS illustrating gypsiferous soil in north-west of Iraq. Fig. 5 shows a map gypsiferous soil.

The results clearly releaved that gypsiferous soils area increases during the rainy season (high moisture containt) and decreses in the dry season. The area is 6.38 to 7.4% in the dry season (2011-04-13 to 2011-08-26) and 8.9 to 10.7% in the rainy season (2011-01-07 to 2011-01-21) (See Fig. 6)

4. CONCLUSIONS

It can be concluded that spectral reflectance data represent real physical properties of environmental varieties on land surface. The data illustrated in MODIS images specially image composites that predict gypsiferous soil in north-west of Iraq. Image composite in false color bands (763) showed gypsiferous soil in turquoise blue color is better than image compoistes where showed gypsiferous soil in magneta color as in figure (2B,2C). The images gives a better distinction of gypsiferous soil than image composite in true color.

The gypsiferous soil is a complex subject which is affected by diferrent parameters such as moisture content and temperature. Therefore, to monitor gypsiferous soil and the effect rain at different seasons in the presence of gypsiferous soils in the areas studied, more invistigations are needed.

The over look of the results in this study require intensive study of the physical and chemical properties of gypsiferous soil taken from the case study region to verify its gypsiferous image. The future work requires comparing the properties of the gypsiferous soil taken from the field with dust storm sedimentary samples collected from regions within dust storm trajectory.

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