Bionatura
Latin American Journal of Biotechnology and Life Sciences

Bionatura Issue 1 Vol 8 No 1 2023

Article

The relationship between the spectral band data and some soil characteristics in some areas of Basra Governorate

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Available from: http://dx.doi.org/10.21931/RB/ 2023.08.01.30

ABSTRACT

Remote sensing techniques and geographic information systems were used to study the relationship between spectral band data and soil characteristics in some areas of Basra Governorate. The satellite image for the year 2020 was used with eleven spectral bands. The spectral band values were extracted using ArcMap10.4.1 software, after which SPSS 22 was used to conduct correlations between spectral bands and some soil characteristics to find the best statistical relationships. 15 surface samples representing the study area were determined using the GPS device to conduct the required laboratory analyses to study some physical and chemical characteristics. The results of the study showed that the values of the spectral reflectivity of all the sites showed a similar pattern for all the spectral bands. This indicates that the used spectral bands are specialized for the properties and factors of the soil. However, with different sensitivities, interference and similarity occurred in their spectral reflectivity. Spectral band B2 showed the lowest values for spectral reflectivity, followed by spectral band B3. It is noticed through the curve of the spectral reflectivity of the spectral bands that there is a gradual increase in the values of the spectral reflectivity of the spectral bands B4, B3, B2, B5, and B6 at all sites and that the highest reflection in the values of the spectral reflectivity was in the spectral bands B4, B6, B5 and B7 for all sites. A positive correlation was found with a correlation coefficient of 0.75 for sand content and a negative correlation relationship for both silt and clay with a correlation coefficient of 0.55 and 0.57, respectively.

In contrast, a highly significant positive correlation was observed between the soil content of calcium carbonate, calcium sulfate, soil salinity, and the numerical values of the spectral reflectivity. Calcium carbonate showed the strongest positive correlation with highly significant positive correlation with bands B2, B3, B4, B5, B6, B7, and B8 and spectral reflectivity rate with a correlation coefficient of 0.89, 0.88, 0.84, 0.87, 0.84, 0.77, 0.85 and 0.85, respectively. In contrast, the relationship between soil moisture and each of the B2, B4, B5, and B6 bands was negative, with the value of the correlation coefficient being 0.53, 0.69, and

0.48, as it is noticed that there is a certain trend in the spectral characteristics that have an important weight in influencing the relationship and it was related. A negative effect, with an increase in the presence of water, leads to a decrease in the value of soil reflectivity within these bands.

Keywords:- Remote sensing, Soil characteristics, spectral band, GIS

INTRODUCTION

The spectral characteristics of each soil are related to what it contains different components, so this relationship has become important in the scientific specializations to understand the effect of the behavior of different soils with the fields of electromagnetic radiation and to exploit this in finding ways to predict the characteristics of different soils by sensing the relationship between these rays and the soil. The great developments in the field of sensors and the platforms that carry them have increased the possibility of exploiting electromagnetic data, especially space data, in detecting soil characteristics. It has become possible to investigate the characteristics of soils in hard-to-reach areas and the continuous quantitative extrapolation of the spatial distribution of soil characteristics and link this with other databases of information related to the same soils. [1, 2] found the existence of correlations with different degrees of significance linking spectral data with soil characteristics, such as bulk density, soil content of clay, silts and sand, salinity, organic matter, gypsum, and lime, and recommended further studies to arrive at mathematical models. Especially in studying the relationships between soil particles and spectral data. [3] found that the spectral reflectivity of soil within the visible range of the electromagnetic spectrum depends on the color of the soil and the roughness of its surface. Soils with fine particles give relatively higher reflectivity than coarse ones. The reflective behavior of soil within the visible and near-infrared range depends on several factors, such as (moisture content, texture, iron oxides, and organic matter). The researcher found that the dry soil has a light tone and is within the near-infrared band. [4] Indicated that the reflectivity of sunlight from the surface of barren (uncultivated) soils depends on several interrelated factors such as moisture content, texture, surface roughness, presence of iron oxides, and organic matter. It has a low moisture content, so its reflectivity is high, while the fine-textured soil is poorly drained, so it retains a high percentage of moisture, which reduces its reflectivity. The bare soil showed, for days, significant differences in reflectivity affected by its moisture content highly related to the soil texture. [5] found in his study on the characterization and Classification of soil units of the North Kut project that the use of all spectral bands can be useful in inferring the content and quality of the salts in the soils of the study area, as it was observed that most of them are related to the presence of salts and gypsum, Thus, he showed that the characteristics of salinity and gypsum had surpassed other soil characteristics by their effect on spectral reflectivity values, whether in terms of salinity degree or terms of the nature of the types of salts prevailing in soils of the study area. The study aimed to use the spectral band data extracted from the satellite image to find the best statistical relationships between some soil characteristics and their spectral reflectivity.

MATERIALS AND METHODS

Study Area

The study area is located in the north of Basra Governorate, in southern Iraq, within the administrative boundaries of the Qurna and Medina districts. The study area is bordered by the Euphrates River in its southern part and is within the hot and dry desert climate. Its soils are characterized by sedimentary origin material that returns to the order Entisols. As for its geographical location, it lies between latitudes 30°57'10" – 31°13'52" north and longitudes 47°12'39" – 47°27'10" east and has an area of 600,537 km^2. 15 surface samples representing the study area were determined using the GPS device, Figure 1.

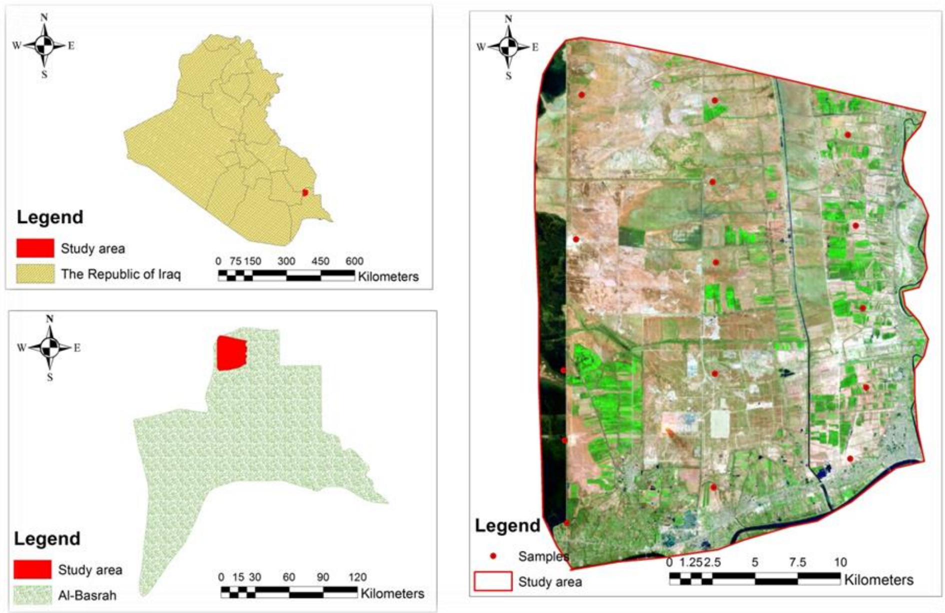

Figure 1. Study area

Selection of study sites

The satellite image for the year 2020 was used to survey the soil, as it was observed during the field visits that most of the lands of the study area are not agricultural use, with some lands cultivated with seasonal crops and some water swamps. A soil survey was performed using spectral reflectivity from the satellite image data. The satellite image captured by the Landsat 8 satellite, The Operational Land Imager (OLI), with eleven spectral bands on 11/20/2020, with a discrimination capacity of 30 m, was used to perform the unsupervised Classification in order to determine the dominant varieties in the study area as in figure 2.

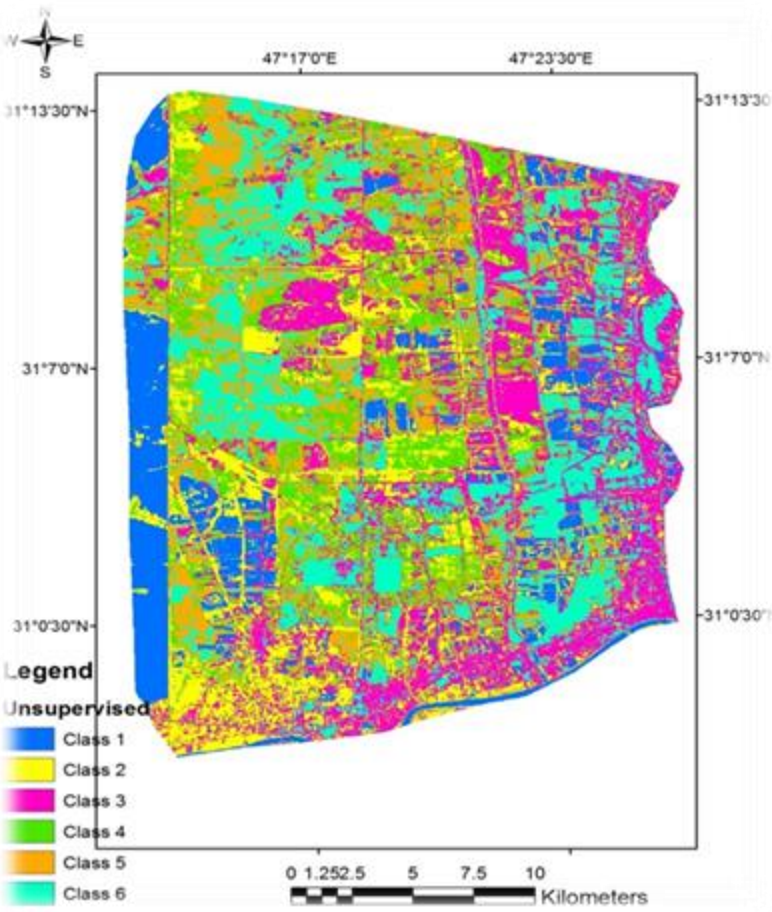

Figure 2. Unsupervised Classification

Field and laboratory procedures

The GPS device was used to locate and project surface samples to the map. Surface soil samples were taken to conduct the required laboratory analyses to study some of the physical and chemical characteristics. Soil texture was estimated according to the method described in [6]. Furthermore, calcium carbonate, according to [7], and the electrical conductivity of the saturated soil paste extract were estimated by following the method described in [6]. The moisture content of soil and gypsum was estimated according to the method mentioned in [8].

Statistical Relationships

The values of the spectral bands were extracted using ArcMap10.4.1 program, after which the SPSS 22 program was used to conduct the correlation between the spectral bands and soil characteristics to find the best correlation relationships.

RESULTS

Spectral reflectivity values of the satellite image bands in the study area

The results in Table 1 and Fig. 3 show a variation in the values of spectral reflectivity between the study area sites within one spectral band and between the different spectral bands.

These results reflect the state of variation in the properties of the soil for the study area in addition to the discrepancy in the sensitivity of the spectral bands between them.

Sample number	Spectral band values							
	B2	B3	B4	B5	B6	B7	B8	Average
1	0.12448	0.12198	0.14234	0.19002	0.24622	0.2173	0.11416	0.165214
2	0.13326	0.13538	0.1569	0.20348	0.2536	0.22534	0.14394	0.178843
3	0.12306	0.12544	0.15014	0.21036	0.2497	0.20054	0.13208	0.170189
4	0.10806	0.10232	0.11946	0.17094	0.2094	0.16796	0.12194	0.142869
5	0.13812	0.13842	0.16058	0.2063	0.2535	0.22848	0.1422	0.181086
6	0.1613	0.17684	0.20826	0.258	0.3038	0.27422	0.18398	0.223771
7	0.13508	0.13534	0.15562	0.20384	0.25868	0.22814	0.13902	0.179389
8	0.1281	0.13102	0.14986	0.2175	0.24614	0.20456	0.1147	0.170269
9	0.1275	0.1355	0.15066	0.19808	0.25268	0.2114	0.13072	0.172363
10	0.07128	0.05876	0.04886	0.02968	0.01422	0.00896	0.05476	0.040931
11	0.10196	0.09778	0.09558	0.21614	0.17466	0.12848	0.08906	0.129094
12	0.08114	0.06642	0.06042	0.05604	0.02856	0.0194	0.0664	0.054054
13	0.16662	0.18698	0.22342	0.2687	0.31566	0.2881	0.20566	0.236449
14	0.13536	0.14192	0.16194	0.2145	0.27784	0.25662	0.1394	0.189654
15	0.11064	0.10822	0.12044	0.17592	0.18062	0.14562	0.0853	0.132394

Table 1. The spectral reflectivity values of the satellite image bands for the year 2020 in the study area

The results in Figure 3 show the distribution pattern of the values of the spectral reflectivity, as it is noticed that the spectral reflectivity values of all the sites showed a similar pattern for all the spectral bands, and this indicates that the used spectral bands are specialized for the properties and factors of soil but with different sensitivity and therefore interference and similarity occurred in their spectral reflectivity.

The spectral band B2 is the lowest value of the spectral reflectivity, followed by the spectral band B3, as it ranged between 0.07128 - 0.16662 and 0.05876 - 0.18698 each, respectively, and this is a result of the presence of water and vegetation cover in varying proportions in the soil, especially in the sites mentioned above, as these two bands are affected by the presence of water that Spectrum areas prepare for water absorption. The lowest values of spectral reflectivity in the band 2 (B2) were at sites 10 and 12 and were 0.07128 and 0.08114, respectively.

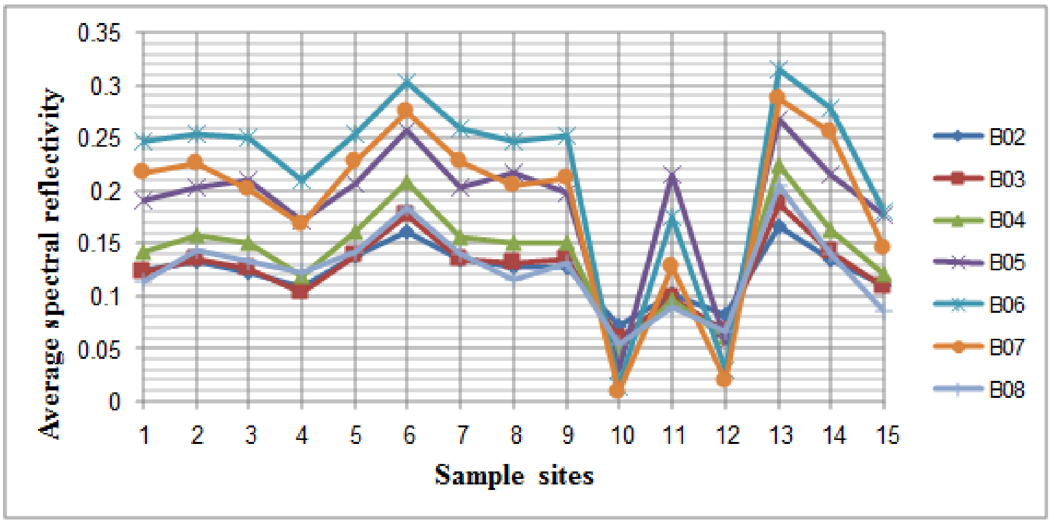

Figure 3. Spectral reflectivity curve for satellite image bands in the study area

Relationship between spectral bands and some soil properties

The results in Table 2 show some physical and chemical characteristics of the soil in the study area. The statistical analysis between soil characteristics and the data extracted from the satellite image was performed using the SPSS V. 20 statistical program. It was noticed that there was a variation in the effect between soil characteristics and spectral reflectivity.

Sample number	clay	silt	Sand	EC	$CaCO_3$	$CaSO_4$	Water content %
	gkg^{-1}			**dsm^{-1}**	**gkg^{-1}**		
1	230.8	538.1	231.1	8.06	385	2.82	20
2	218.7	443.6	337.7	12.19	400	2.15	21
3	273.3	514.4	212.3	9.22	390	0.17	33
4	358.8	538.1	103.1	7.44	380	2.82	18
5	457.2	492.7	50.1	17.87	415	0.1	16
6	357.4	213.1	429.5	32.66	430	4.17	22
7	440.4	459.5	100.1	15.05	410	0.16	27
8	187.5	738.9	73.6	9.55	390	0.15	28
9	379.4	437.4	183.2	11.87	400	0.33	26
10	357.4	213.1	429.5	4.65	350	0.38	20
11	442.9	457.6	99.5	8.06	380	0.36	10
12	420.8	372.7	200.5	9.44	370	6.17	11
13	357.4	213.1	429.5	35.11	470	5.99	38
14	470.4	459.5	70.1	23.21	420	3.16	39
15	460.4	459.5	80.1	7.01	385	0.18	38

Table 2. Some physical and chemical properties in the study area

Soil texture

The results in Figure 4 showed the relationship between the content of (clay, silt, and sand) and the spectral reflectivity, where a positive correlation was found with a correlation coefficient of 0.75 for the content of sand and a negative correlation relationship for both silt and clay with a correlation coefficient of 0.55 and 0.57, respectively

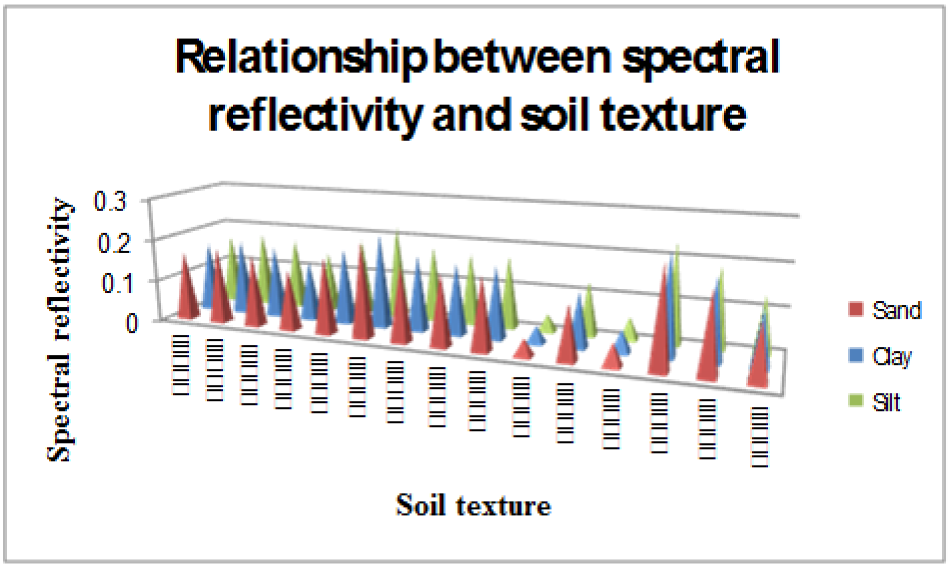

Figure 4. The relationship between soil texture and spectral reflectivity

Calcium carbonate, calcium sulfate, and soil salinity

It is noticed from the results of Figures 5, 6, and 7 the relationship between each of the soil content (calcium carbonate, calcium sulfate, and soil salinity) and the values of the spectral reflectivity, as it was observed that there is a high positive significant correlation between (calcium carbonate, calcium sulfate, soil salinity) and numerical values of spectral reflectivity. Calcium carbonate showed the strongest highly significant positive correlation with the wavelengths B2, B3, B4, B5, B6, B7, and B8 and the spectral reflectivity rate with a correlation coefficient of 0.89, 0.88, 0.84, 0.87, 0.84, 0.77, 0.85 and 0.85, respectively. This is due to the ability of calcium carbonate to reflect the largest amount of radiation. The results showed that there was a highly positive significant relationship between the soil content of gypsum and spectral bands B2, B3, B4, B5, B6, B7, and B8 and the spectral reflectivity rate with a correlation coefficient of 0.62, 0.65, 0.77, 0.61, 0.63, 0.61, 0.61 and 0.64, respectively.

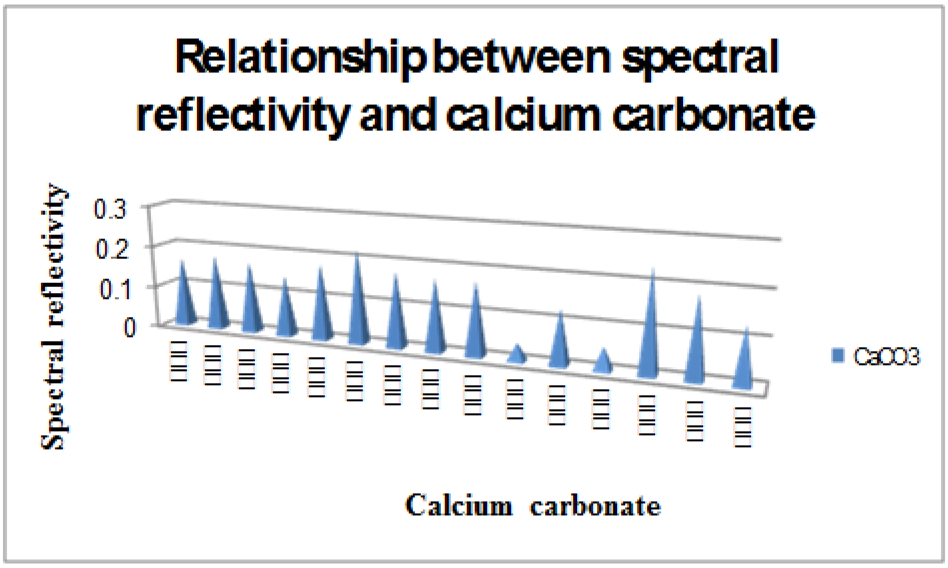

Figure 5. The relationship between calcium carbonate and spectral reflectivity

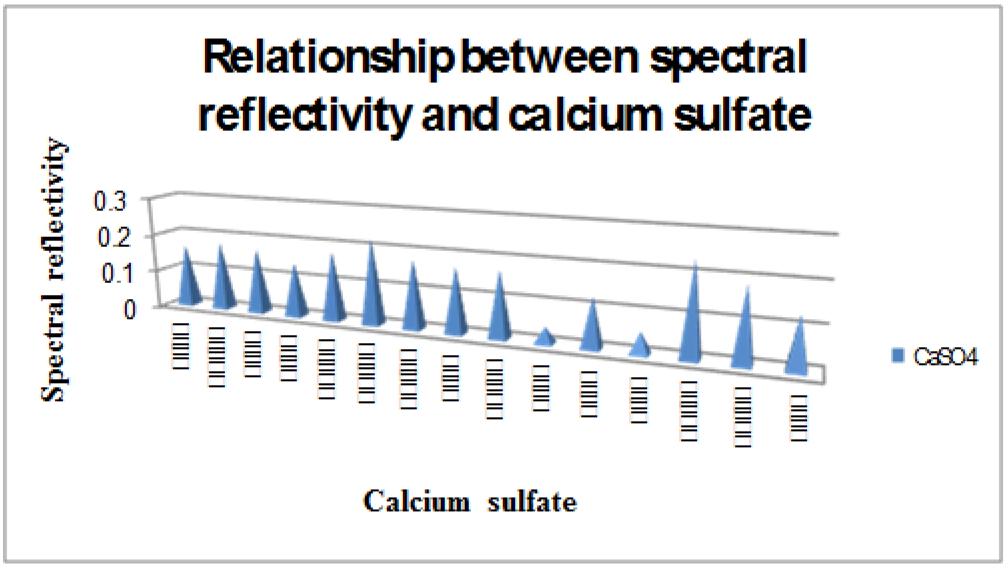

Figure 6. The relationship between calcium sulfate and spectral reflectivity

Soil moisture

Figure 8 shows that the highest effect in this relationship was for the green band B3, which was negative and had a correlation coefficient of 0.77. It is noticed that the relationship between soil moisture and each of the B2, B4, B5, and B6 bands was negative as the value of the correlation coefficient was 0.53. 0.69 and 0.48, as it is noticed that there is a certain trend in the spectral characteristics that have an important weight in influencing the relationship, and they had a negative effect with the increase in the presence of water, which leads to a decrease in the value of the reflectivity of the soil within these bands

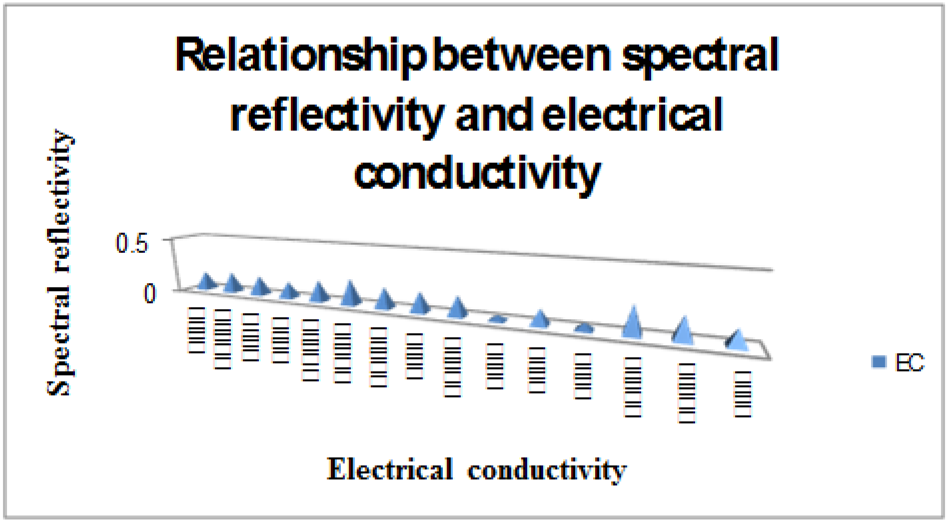

Figure 7. The relationship between soil salinity and spectral reflectivity

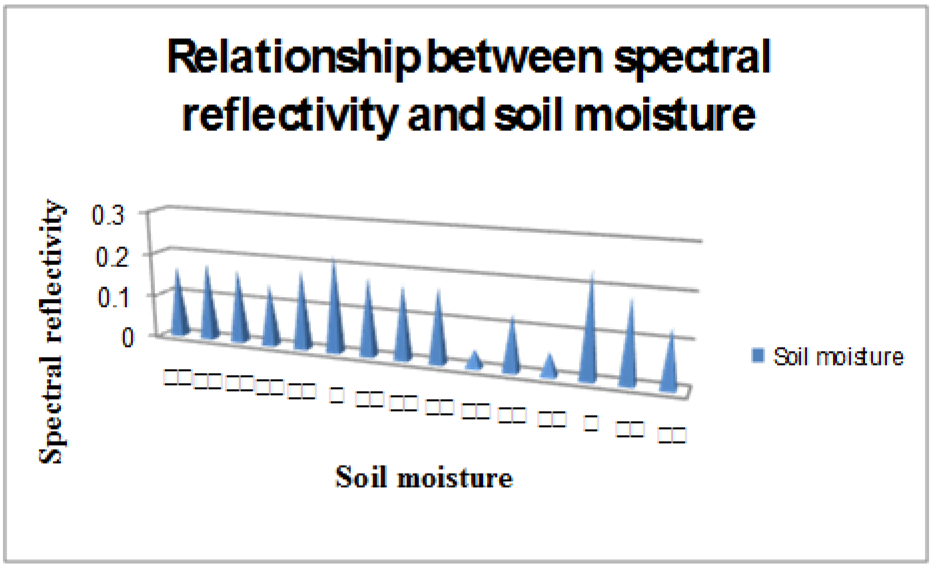

Figure 8: shows the relationship between soil moisture and spectral reflectivity.

DISCUSSION

It is noticed that all the spectral bands at sites 10 and 12 were less than the values of the rest of the sites. There was a decrease in the values of their spectral reflectivity, especially spectral band B2, due to the increase in absorption due to the occurrence of these sites in agricultural areas, an increase in its moisture and organic matter content and a decrease in its content [9]. The panchromatic band B8 showed little values of reflectivity compared to the other bands except for the B2 and B3 bands, as it ranged between 0.05476 - 0.20566, and this is due to the ability of soil components to absorb it more than in the rest of the spectral bands, so its sensitivity was weak. Therefore, its use in distinguishing the ground covers was less. It has a 15m spatial resolution compared to other OLI sensor spectral bands of 30 m. It is observed through the results in Figure 3 of the spectral reflectivity curve of the spectral bands that there is a gradual increase in the spectral reflectivity values of the spectral bands B4, B3, B2, B5, and B6 in all locations and that the highest reflection in the values of the spectral reflectivity was in the spectral bands B4, B6, B5, and B7 for all sites, as their values ranged between 0.22342 - 0.04886, 0.05604 - 0.2687, 0.31566 - 0.01422 and 0.2881 - 0.00896, respectively, while there was a decrease in the spectral reflectivity values of the two spectral bands B7 and B8, respectively. Sites 10 and 12 showed the lowest values of spectral reflectivity for all spectral bands since these sites were located in cultivated areas with distinct vegetation cover, and a decrease in the soil content of salts led to a decrease in the reflectivity values of the spectral bands, while the highest values of spectral reflectivity for all spectral bands appeared. In sites 6 and 13 for their presence in barren lands completely devoid of vegetation cover, in addition to the high soil content of salts that led to an increase in the reflectivity values of the spectral bands, and this was confirmed by [10] in his study that the soil components showed a variation by influencing the values of spectral reflectivity. The soil content of carbonate minerals and salinity showed a positive and significant relationship with the spectral reflectivity values. In contrast, the soil organic matter content showed a negative significant relationship with the spectral reflectivity values of the soil. Generally, most of the sites of the study area were characterized by their high salt content and their general absence of vegetation cover, with the presence of swollen soils in some sites. Most of the sites of the study area are characterized by their high salt content and the spread of marshy lands, as well as the high content of carbonate minerals, which led to an increase in the spectral reflectivity values because they are associated with positive significance and highly significant correlations with all spectral bands. These results are in agreement with many researchers, among them [11]. The results show that the spectral reflectivity increases with increasing the soil salt content, while it decreases with increasing the moisture content.

And it is noted that the least correlation happened between spectral reflectivity and both silt and clay, while the value of sand correlation with spectral reflectivity increased, as [11] was able to obtain significant differences between the spectral reflectivity values of fine, medium and coarse soil particles, and that coarse sand particles absorb light more than clay and silty particles and that there is a possibility to predict particle sizes using spectral ratios. [10] indicated a positive correlation between the spectral reflectivity of the soil with both the content of silty and sand particles and that the ratio of the clay content was associated with a negative relationship with the spectral reflectivity.

[13] indicated in their study that the gypsum soils showed the highest values of spectral reflectivity compared to the rest of the soils of desert regions in Iraq. In contrast, the reflectivity values of some pedons were characterized by the high percentage of salts in them, especially the sodium chloride salt with reflective characteristics in the wavelengths B1, B2. , B3, and B8, as the electrical conductivity values increased in these pedons. The results of the study showed that the effect of the soil content of salts on the spectral reflectivity depends on the quality of the salts prevailing in the soil, and among the salts that have a positive effect in increasing the values of reflectivity are the salts of sodium chloride and calcium sulfate, as positive and highly significant correlations were found with the B2 spectrum band, B3, B4, B5, B6, B7, B8 and the spectral reflectivity rate with a correlation coefficient of 0.82, 0.81, 0.80, 0.74, 0.80, 0.75, 0.81 and 0.80 respectively, and this is in agreement with many researchers, including Zain [10] as he indicated that Soil components showed a variation in their

effect on the spectral reflectivity values, as the soil content of calcium carbonate, calcium sulfate, and salinity showed a positive and significant relationship with the spectral reflectivity values of the soil.

The presence of water in the soil has a role in decreasing the spectral reflectivity of the soil, as the soil works to absorb and retain moisture due to its dark color, which results in a decrease in the value of the spectral reflectivity of the soil despite its low content in the study area, so there is a clear effect of surface soil water in differences Its reflectivity within the visible and near-infrared parts of the NIR spectrum [12].

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Received: May 15, 2023/ Accepted: June 10, 2023 / Published: June 15, 2023

Citation: Hasan W.B., Al-Atab. S.M.S; Kadhim M., A. The relationship between the spectral band data and some soil characteristics in some areas of Basra Governorate. Revis Bionatura 2023;8 (2) 90. http://dx.doi.org/10.21931/RB/ 2023.08.01.31