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THE RELATIONSHIP BETWEEN REFLECTIVITY AND THE SOME PHYSICAL PROPERTIES OF DESERT SOILS USING GEOSPATIAL TECHNIQUES AND SPECTRORADIOMETER IN NAJAF GOVERNORATE OF IRAQ

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Abstract

The study area lies between longitudes 44° 13' 31.41" - 44° 2' 32.99" E and two latitudes 31° 59'15.94" -31° 53'1.65" N, the study area is located inside the Najaf Sea depression in the southern desert of Iraq, with an area of 166,556 square kilometers. 55 surface samples were taken, Soil reflectance was found for three sources: The first spectrophotometer with spectral range of 350-2500 nm, the second source of Landsat 8 OLI 1C Level 2, the third source is Sentinel-2. The results of the physical analysis of the soil showed that the dominant texture is Loamy Sand followed by sandy and then Sandy Loam texture, the percentage of sand content ranged from 38.1-91.88% with mean of 73.59%, silt content ranged from 2.86-58.67% with mean 22.16%, clay content ranged from 0.2-18.8% with mean 4.24%, soil bulk density ranged from 1.04-1.75 Mg/m^3 with mean 1.36 Mg/m^3, gravel ratio ranged from 0-20.47% with mean 3.69%, soil moisture content ranged from 0.42-26.99% with mean 4.84%. Spectroradiometers received the highest correlation of -0.798*** at 1994 nm with moisture content and 0.337** at 1416 nm with a clay content, Sentinel 2 obtained the highest correlation with the sand content of 0.786*** in band 9 and -0.764*** with silt content in band 9 followed by 0.453*** with soil bulk density in band 11 and 0.378** with gravel ratio In band 12 is superior to the rest of the sources, the results show the importance of spectral integration to increase the accuracy of the results.

Key words: Reflectance, Remote Sensing, Desert Soil, Spectroradiometer, Sentinel 2, Landsat 8.

Introduction

We understood the soil, its quality, function through chemical, physical and biological analyses of the soil (Isa and Muhaimeed, 2014), The need for large quantities of good quality, inexpensive, necessary soil data for environmental monitoring and proper management for these reasons. Spectral analysis of the behavior of electromagnetic radiation is needed, which is a considered as good alternative that can be used to enhance or replace laboratory methods of soil analysis because it overcomes some of its shortcomings and remote sensing is faster, timely, less expensive, direct and sometimes more accurate than laboratory analysis (Rees and Pellika, 2010). In addition, a single spectrum permits the simultaneous description of different soil characteristics and these technologies are adaptable for field use (Rossel *et al.,* 2006), These data should be of high quality and record the same area with short time periods Claverie *et al.*, (2018), Studies on soil samples in laboratory conditions showed that the reflectance in all wavelengths in the range 0.4-2.5 μm decreased with increasing moisture content Bowers and Hanks, (1965) and Hoffer and Johannsen, (1969). Predicting soil moisture from remote sensing data is still somewhat difficult, because soil reflection is not just a reflection of moisture but is affected by other soil Characteristics such as the amount of organic matter, soil texture, mineral composition and soil color (Hoffer and Johannsen, 1969, Stoner and Baumgardner, 1981, Escadafal *et al.,* 1989, Stoner and Baumgardner, 1981). Mougenot and pouget, (1993) indicated that the spectral reflectivity decreases by increasing the soil moisture clearly and pointed to the similarity of the reflectance curve for both humid salts and dry salts, but the reflectivity values for the wet salts decrease, Rossel and McBratney, (1998) showed that the infrared reflectance of the soil

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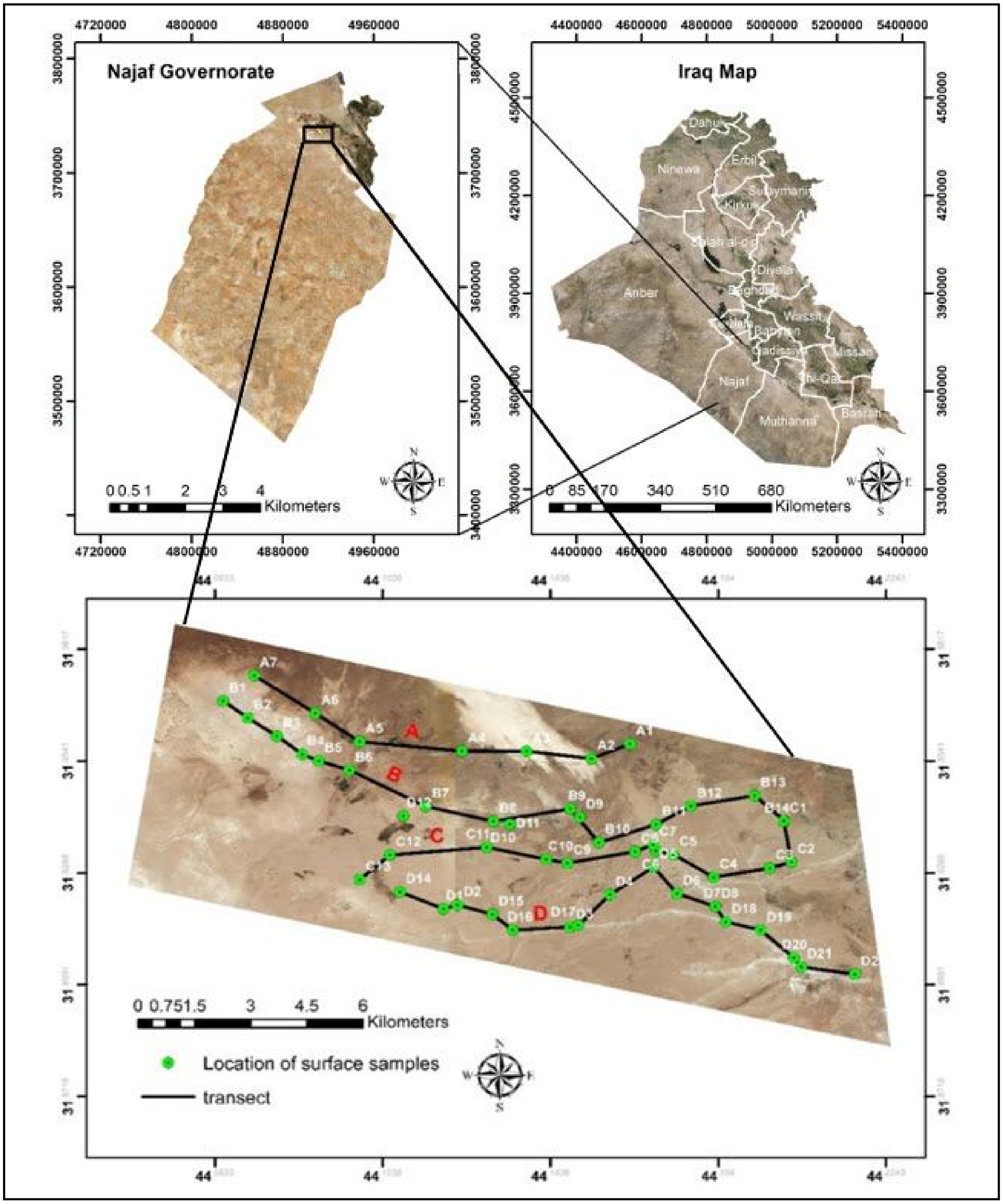

Fig. 1: The study area and locations of study samples.

sample decreased with increasing clay content in the samples and the largest reflectance was obtained from the pure sand sample, *i.e.* 0% clay, The results of AL-Daghastini and Hameed, (2011) indicate that it is possible to Differentiation between the rocks and the resulting soils through the water absorption packages near the wavelengths 2.5, 1.9 and 1.4 µm as they are clear in the soil and weak in the rocks, Kojima, (1958) studied the relationship between soil color (reflectance) and soil particle sizes with ranges of clay to sand and observed a high increase in reflectivity by decreasing particle size, it became necessary to use spectral integration by using and applying multiple spectral bands using multiple sources of remote sensing at the same time. For this to succeed, these sources should be similar to the basics of work, or, use images of sensors with differential spectral and spatial capabilities with large wavelength range and divided into small parts (Band) in order to improve results and to obtain more accurate spectral reflectivity.

This study aims to

First: A study of the relationship between the spectral behavior of soils with different wavelengths and different remotely sensed data sources with variation in soil properties and the possibility of predicting the values of some physical properties using the values of spectral reflectance.

Second: Comparing the different methods for estimating the reflectance values of the soil and knowing the most appropriate ones.

Third: Achieving the principle of spectral integration to increase the efficiency of remote sensing operations.

Materials and Methods

The study area is located between the longitudes 44° 13' 31.41" -44° 2' 32.99" E and latitudes 31° 59' 15.94"- 31° 53' 1.65" N, it is located inside the Najaf Sea depression in the southern desert of Iraq, with an area of 166.556 Km^2 fig. 1. This area was chosen for the purpose of achieving the objectives of the study, as this area is characterized by a dry climate, the diversity of the mineral state of the soil and the lack of vegetation in it, which is ideal in the ground reflectance readings and the breadth of the area, according to Burt, (2014) the first survey was conducted on 19-4-2018 to identify and diagnose Lands, Soils and natural plants to determine the best areas to study. Then the study area was determined and the number of sampling transect was determined, 55 surface samples obtained fig. 1, as variable as possible with physical characteristics according to Soil Science Division Staff, (2017), the soil samples were divided into two parts, one of which was air dried, hand grinded with a plastic hammer, part passed through a sieve with a diameter of 2 mm openings, kept in plastic boxes, the other was preserved in plastic boxes. The percentage of moisture was estimated on the basis of dry weight in the thermo-gravimetric method according to (Aoda and Mahdi, 2017), the percentage of moisture was entered to adjust soil weights in laboratory analyzes according to (Aoda and Mahdi, 2017), bulk density was estimated using the core sampler method, according to (Aoda and Mahdi, 2017). The particle size distribution was estimated using the hydrometer method as described by (Aoda and Mahdi, 2017). Then the texture class was estimated.

Soil reflectance of remotely sensed data

Source 1: Spectroradiometers was used as a portable multi-spectral reflectivity measuring device with a wave length range of 350-2500 nm with a scanning speed of 100 milliseconds of a wireless connection of 45.72 meters' version of the field Spec 3 Hi-Res FS3 350-2500 designed for external conditions of vibration and heat High, Soil samples were obtained (not raised) using plastic tubes with dimensions of 7 cm diameter and height of 7 cm with thickness of 3 mm, the lower end is sharp to facilitate insertion into the soil.

Table 1: The spectral bands used for Landsat 8 and Sentinel 2.

Landsat 8			
Sensors	**Band**	**Spectral R. nm**	**Spatial R. m**
Landsat 8 operational imager (OLI)	1	430 - 450	30
	2	450 - 510	30
	3	530 - 590	30
	4	640 - 670	30
	5	850 - 880	30
	6	1570 - 1650	60
	7	2110 - 2290	30
Sentinel 2			
sensors	**Band**	**Spectral R. nm**	**Spatial R. m**
visible/near infrared (VNIR) and short wave infrared spectral range (SWIR)	1	430 - 450	60
	2	540 - 570	10
	3	540 - 570	10
	4	640 - 680	10
	5	690 - 710	20
	6	730 - 740	20
	7	760 - 780	20
	8	770 - 880	10
	8A	850 - 870	20
	9	930 - 950	60
	11	1560 - 1650	20
	12	2090 - 2270	20

Source 2: Landsat 8 OLI / TIRS C1 Level 2 satellite image captured on 19-4-2018 with a spectral range of 430-12500 nm with a time accuracy of 16 days for the second level of Landsat products using the Landsat 8 Surface Reflectance Code (LaSRC) algorithm and spectral reflectance of the packages is obtained 1-7 for OLI table 1 Guide, (2018)

Source 3: The satellite view Sentinel-2 Level-1C, captured on the date of 19-4-2018, the same date of the Landsat 8 capture with a spectral range of 433-2270 nm with a time accuracy of 5 days, updated to the second level of the Sentinel-2 Level 2A products using a program Sentinel Application Platform (SNAP) The dependent visualization platform for this satellite where an external tool (Sen2Cor) was used to convert pixel values from the reflectivity of the top of the Atmosphere to the reflectivity of the bottom of the Atmosphere and correct the interference with the atmosphere and the defect caused by clouds, All Bands except Band 10 were used table 1 according to (Vuolo *et al.,* 2016) and (Main-Knorn *et al.,* 2017).

Table 2: Physical properties of soil samples.

Percentage water (%)	Bulk Density Mg^{m-3}	Gravel (%)	Texture	Clay (%)	Silt (%)	Sant (%)	Sample No.
9.89	1.08	0.00	Loam	7.44	41.98	50.57	**1**
8.40	1.52	0.00	Loamy Sand	6.91	9.14	83.95	**2**
2.37	1.24	0.00	Sand	6.94	2.86	90.20	**3**
23.87	1.23	0.00	Sandy Loam	6.91	43.50	49.58	**4**
1.51	1.36	0.83	Loam	18.80	42.20	39.00	**5**
26.99	1.22	0.00	Silt Loam	3.24	58.67	38.10	**6**
0.63	1.50	8.30	Sandy Loam	7.01	26.66	66.33	**7**
2.23	1.38	0.45	Loamy Sand	6.22	12.03	81.75	**8**
13.97	1.33	0.00	Sandy Loam	7.69	20.42	71.89	**9**
16.33	1.12	0.00	Sandy Loam	7.15	40.78	52.07	**10**
7.44	1.25	0.07	Loamy Sand	1.47	15.58	82.94	**11**
2.35	1.08	0.00	Silt Loam	1.44	50.05	48.51	**12**
1.22	1.44	4.15	Sandy Loam	9.63	30.50	59.86	**13**
3.88	1.52	0.30	Sand	6.51	3.66	89.82	**14**
1.05	1.29	2.94	Sandy Loam	11.30	29.06	59.64	**15**
2.41	1.30	0.22	Loamy Sand	1.43	14.76	83.81	**16**
0.84	1.52	9.89	Loamy Sand	6.84	9.46	83.69	**17**
2.81	1.36	2.94	Loamy Sand	6.73	5.68	87.59	**18**
3.61	1.30	1.13	Sandy Loam	13.45	28.51	58.04	**19**
2.67	1.32	0.90	Sand	1.64	9.66	88.70	**20**
4.73	1.04	3.02	Loamy Sand	3.41	13.66	82.93	**21**
2.31	1.50	1.88	Loamy Sand	1.41	21.77	76.82	**22**
1.32	1.56	7.10	Loamy Sand	2.47	13.57	83.97	**23**
0.74	1.70	19.64	Loamy Sand	2.81	16.86	80.33	**24**
2.72	1.62	20.47	Sand	2.45	6.52	91.03	**25**
0.80	1.75	13.52	Sand	2.03	6.09	91.88	**26**
1.08	1.66	1.88	Sand	4.05	6.88	89.08	**27**
12.12	1.21	0.22	Sand	2.05	6.97	90.98	**28**
2.44	1.51	4.23	Loamy Sand	2.83	20.63	76.54	**29**
1.89	1.40	0.45	Loamy Sand	0.80	26.74	72.45	**30**
0.42	1.08	17.70	Sand	1.20	9.61	89.19	**31**
2.09	1.52	0.98	Sand	0.81	13.61	85.57	**32**
1.05	1.24	6.49	Loamy Sand	1.21	17.08	81.72	**33**
2.06	1.23	0.98	Sandy Loam	1.20	40.80	58.00	**34**
1.26	1.36	0.15	Sandy Loam	6.83	24.89	68.28	**35**
14.97	1.22	0.00	Sandy Loam	6.10	23.80	70.10	**36**
0.63	1.50	9.14	Sand	4.00	7.20	88.80	**37**
0.63	1.38	10.87	Loamy Sand	3.62	11.67	84.71	**38**
3.12	1.33	0.00	Sandy Loam	2.00	28.80	69.20	**39**
0.78	1.12	9.89	Sand	0.61	11.27	88.12	**40**
0.97	1.25	2.26	Loamy Sand	2.41	17.25	80.34	**41**
2.92	1.08	4.53	Loamy Sand	0.20	15.66	84.14	**42**
7.06	1.44	0.00	Sandy Loam	2.24	38.01	59.75	**43**
17.07	1.52	0.00	Sandy Loam	0.21	48.15	51.65	**44**
7.89	1.29	0.00	Sandy Loam	2.28	30.43	67.29	**45**
6.19	1.30	1.05	Sandy Loam	8.30	18.26	73.44	**46**
1.98	1.52	0.26	Sandy Loam	8.59	13.50	77.91	**47**

Table 2 Continue ...

Results and Discussion

Results in table 2, showed that sand content in its study samples ranged from 38.1% at sites 6 and the highest value in site 26 was 91.88% and the mean for samples was 73.59%, that was parallel to what (Al-Janabi, 2012), who showed that the geological formations of the Najaf sea depression contain high proportions of sand rocks, adding that wind deposits are the second source of sand in the study area and the first responsible for the presence of sand dunes in them added to the precipitation of rain run offs. also results showed that the content of the silt ranged from 2.86% at site 3 and the highest value on site 6 was 58.67% with an average of 22.16%, AL- Janabi, (2012) indicated that the most important sources of silt in the Najaf Sea depression are depressions and wind deposits, while clay content ranged from 0.2% on site 42 and the highest value on site 5, reaching 18.8% with an average of 4.24%, The results of the physical analysis of the soil showed that the dominant texture is Loamy Sand followed by sandy and then Sandy Loam texture. Soil bulk density table 2 ranged from 1.04-1.75 Mg/m3 with mean 1.36 Mg/ m3. The soil bulk density values are affected by the soil texture, where the value decreases with increasing clay and silt content and the value increases with increasing sand and gypsum content in the soil and gravel content Miyazaki, (2005). The absence of agricultural activity affected the value of soil bulk density as well as high levels of salts, it is noted that the soil bulk density is high, due to the decrease in the organic matter content and the clay content leading to a decrease in the total porosity in the soil of the study area (Ruehlmann and Körschens, 2009), Al Kawaz, (2015). the study area contained different amounts of gravel of different shapes and sizes as it ranged between 0%- 51.57% the lowest percentage was 0% for 15 sites and the highest value was 20.47% for site number 25 and the average was

Table 2 Continue ...

1.07	1.36	11.55	Loamy Sand	7.80	7.80	84.40	**48**
1.90	1.30	4.07	Sandy Loam	0.20	47.32	52.48	**49**
0.77	1.32	6.04	Loamy Sand	1.68	14.52	83.79	**50**
1.24	1.04	5.36	Sand	1.64	11.87	86.49	**51**
4.07	1.50	5.66	Loamy Sand	2.86	16.76	80.37	**52**
11.93	1.56	1.51	Loamy Sand	0.41	24.44	75.16	**53**
4.82	1.70	0.00	Sandy Loam	1.61	35.60	62.79	**54**
4.80	1.62	0.00	Silt Loam	2.45	55.73	41.82	**55**

3.69%. This is consistent with what Abdul Hussein, (2014) found, where many areas of the southern desert in Iraq are covered with limestone on the surface and in other places covered with various other rocks and explain the great role of torrents formed in the rainy season (flood waves) and their impact on existing surface sediments and the origin materials of some soils of the Najaf sea depression result from sedimentary additives rich in coarse particles of gravel and sand. The moisture content of soil samples calculated on the basis of dry weight ranged from 0.42% at site 31 to 26.99% at site 6 and the average was 4.84% table 2.

The relationship between soil clay content and spectral reflectivity

The results of table 3 and fig. 2, showed the highest correlation coefficient (highly significant positive) between clay content and reflectance values of the Spectroradio meter device, as the correlation coefficient 0.337** at the wavelength 1416 nm fig. 2a. The highest correlation coefficient between clay content and Sentinel 2 Bands spectral reflectance values was with band 1 which reached -0.266 (none significant) as in table 3 and fig. 2b. The highest correlation coefficient between clay content and Landsat8 Bands spectral reflectance values was with band 2 which reached -0.134 (none significant) fig. 2c. This is consistent with (Coleman *et al.*, 1991, Wheib, 2013, Dwivedi, 2017) which attributed the reverse effect of the clay content with its reflectivity due to its high ability to retain water and the effect of its minerals on the color of the soil, which is often dark in color and its effect on the surface roughness, where the roughness decreases with increasing the clay content, all these things reduce the reflectivity.

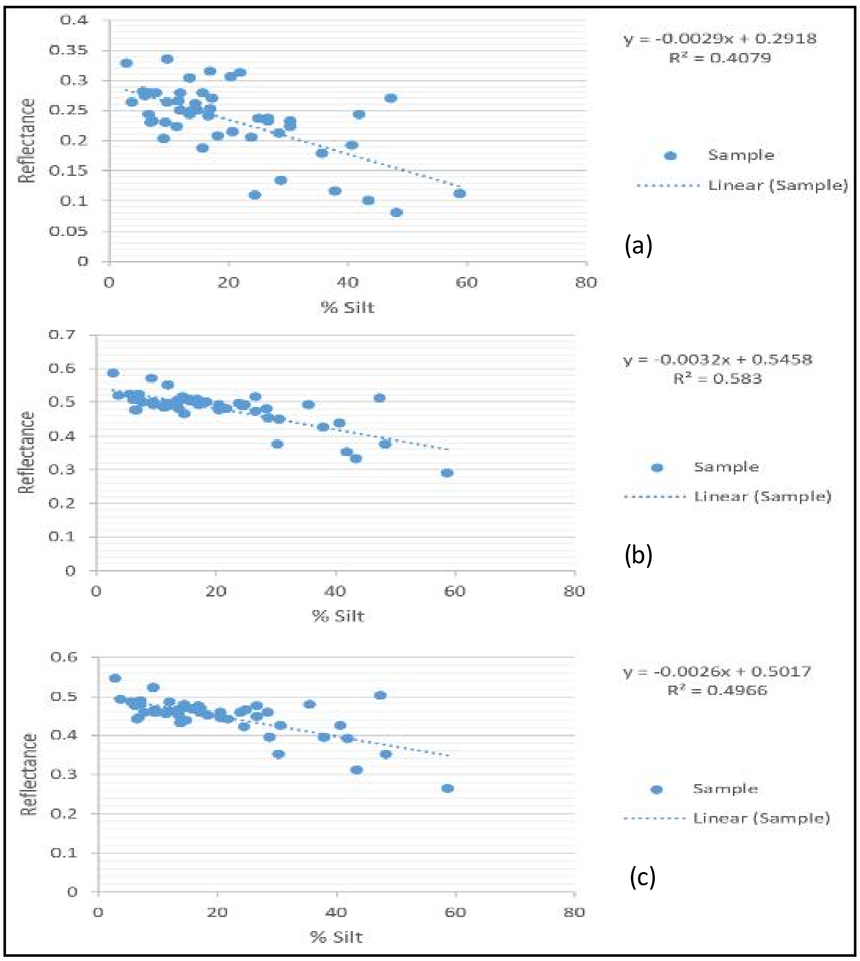

Fig. 3: The relationship between silt content and spectral reflectivity: (a) For Spectroradiometer with a wavelength of 511 nm, (b) For Sentinel band 9, (c) For Landsat band 5.

The relationship between the soil silt content and spectral reflectivity

The results of table 3 and fig. 3, showed the highest correlation coefficient (highly significant negative) between silt content and reflectance values of the Spectroradiometer device, as the correlation coefficient ***0.638- at the wavelength 511 nm fig. 3a. The highest correlation coefficient between silt content and Sentinel 2 Bands spectral reflectance values was with band 1 which reached -0.764*** (highly significant negative) as in fig. 3b. The highest correlation coefficient between silt content and Landsat8 Bands spectral reflectance values was with band 2 which reached ***0.705- (highly significant negative) fig. 3c. This is consistent with (Wheib, 2013).

The relationship between the soil sand content and spectral reflectivity

The results of table 3 and fig. 4, showed the highest correlation coefficient

Table 3: Correlation coefficient values for the relationship between the Soil properties and the spectral reflectivity of Landsat, Sentinel and the Spectroradiometer.

soil properties	Landsat 8	Correlation coefficient	P-Value	Sentinel 2	Correlation coefficient	P-Value	Sentinel 2	Correlation coefficient	P-Value	Spectro radiometer	Correlation coefficient	P-Value
soil clay content	band 1	-0.100	0.492	band 1	-0.266	0.062	band 7	0.003	0.982	1416 nm	0.337	0.017
	band 2	-0.134	0.352	band 2	-0.139	0.337	band 8	0.009	0.949			
	Band 3	-0.120	0.407	band 3	-0.079	0.583	band 8A	-0.007	0.962			
	band 4	-0.063	0.663	band 4	-0.024	0.867	Band 9	-0.074	0.608			
	band 5	-0.019	0.893	band 5	-0.004	0.980	band 11	-0.009	0.949			
	band 6	-0.005	0.973	band 6	-0.003	0.985	band 12	0.016	0.912			
	band 7	-0.028	0.849									
soil silt content	band 1	-0.667	0.000	band 1	-0.646	0.000	band 7	-0.714	0.000	511 nm	-0.638	0.000
	band 2	-0.671	0.000	band 2	-0.619	0.000	band 8	-0.696	0.000			
	Band 3	-0.668	0.000	band 3	-0.674	0.000	band 8A	-0.728	0.000			
	band 4	-0.687	0.000	band 4	-0.679	0.000	Band 9	-0.764	0.000			
	band 5	-0.705	0.000	band 5	-0.721	0.000	band 11	-0.715	0.000			
	band 6	-0.684	0.000	band 6	-0.713	0.000	band 12	-0.556	0.000			
	band 7	-0.505	0.000									
soil sand content	band 1	0.745	0.000	band 1	0.744	0.000	band 7	0.737	0.000	414 nm	0.590	0.000
	band 2	0.742	0.000	band 2	0.710	0.000	band 8	0.734	0.000			
	Band 3	0.735	0.000	band 3	0.740	0.000	band 8A	0.759	0.000			
	band 4	0.744	0.000	band 4	0.741	0.000	Band 9	0.786	0.000			
	band 5	0.745	0.000	band 5	0.747	0.000	band 11	0.747	0.000			
	band 6	0.739	0.000	band 6	0.744	0.000	band 12	0.585	0.000			
	band 7	0.559	0.000									
soil moisture content	band 1	-0.584	0.000	band 1	-0.443	0.000	band 7	-0.709	0.000	1994 nm	-0.798	0.000
	band 2	-0.596	0.000	band 2	-0.500	0.000	band 8	-0.692	0.000			
	Band 3	-0.610	0.000	band 3	-0.590	0.000	band 8A	-0.703	0.000			
	band 4	-0.655	0.000	band 4	-0.648	0.000	Band 9	-0.674	0.000			
	band 5	-0.681	0.000	band 5	-0.675	0.000	band 11	-0.760	0.000			
	band 6	-0.755	0.000	band 6	-0.694	0.000	band 12	-0.782	0.000			
	band 7	-0.783	0.000									
Soil bulk density	band 1	0.302	0.033	band 1	0.326	0.021	band 7	0.383	0.006	356 nm	0.427	0.002
	band 2	0.347	0.014	band 2	0.326	0.021	band 8	0.364	0.009			
	Band 3	0.375	0.007	band 3	0.341	0.015	band 8A	0.414	0.003			
	band 4	0.403	0.004	band 4	0.352	0.012	Band 9	0.414	0.003			
	band 5	0.415	0.003	band 5	0.398	0.004	band 11	0.453	0.001			
	band 6	0.429	0.002	band 6	0.381	0.006	band 12	0.426	0.002			
	band 7	0.402	0.004									
Soil gravel ratio	band 1	0.252	0.078	band 1	0.185	0.198	band 7	0.253	0.077	1943 nm	0.367	0.009
	band 2	0.239	0.095	band 2	0.201	0.162	band 8	0.249	0.081			
	Band 3	0.229	0.109	band 3	0.223	0.12	band 8A	0.269	0.059			
	band 4	0.250	0.080	band 4	0.247	0.084	Band 9	0.249	0.081			
	band 5	0.254	0.075	band 5	0.263	0.065	band 11	0.357	0.011			
	band 6	0.341	0.015	band 6	0.259	0.069	band 12	0.378	0.007			
	band 7	0.362	0.010									

(highly significant positive) between soil sand content and reflectance values of the Spectroradiometer device, as the correlation coefficient ***0.590 at the wavelength 414 nm fig. 4a. The highest correlation coefficient between sand content and Sentinel 2 Bands spectral reflectance values was with band 9 which reached 0.786*** (highly significant positive) as in fig. 4b. This is consistent with the results of the researchers Barnes and Baker, (2000), as we demonstrated the importance of homogeneity of the surface of the soil and the area of the land in increasing the accuracy of the results and the best areas were for the sentinel 2. The highest correlation coefficient between sand content and Landsat 8 Bands spectral reflectance values was with band 1 which reached ***0.745 (highly significant positive) fig. 4c.

The relationship between the moisture content and spectral reflectivity

The results of table 3 and fig. 5, showed the highest correlation coefficient (highly significant negative) between moisture content and reflectance values of the Spectroradiometer device, as the correlation coefficient

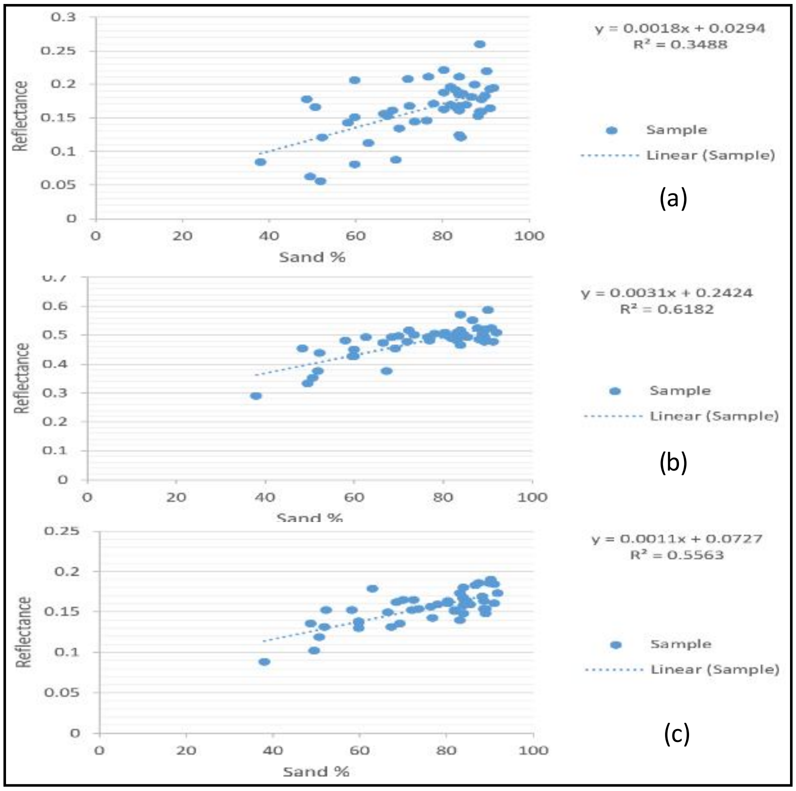

Fig. 4: The relationship between sand content and spectral reflectivity: (a) For Spectroradiometer with a wavelength of 414 nm, (b) For Sentinel band (c) For Landsat band 1.

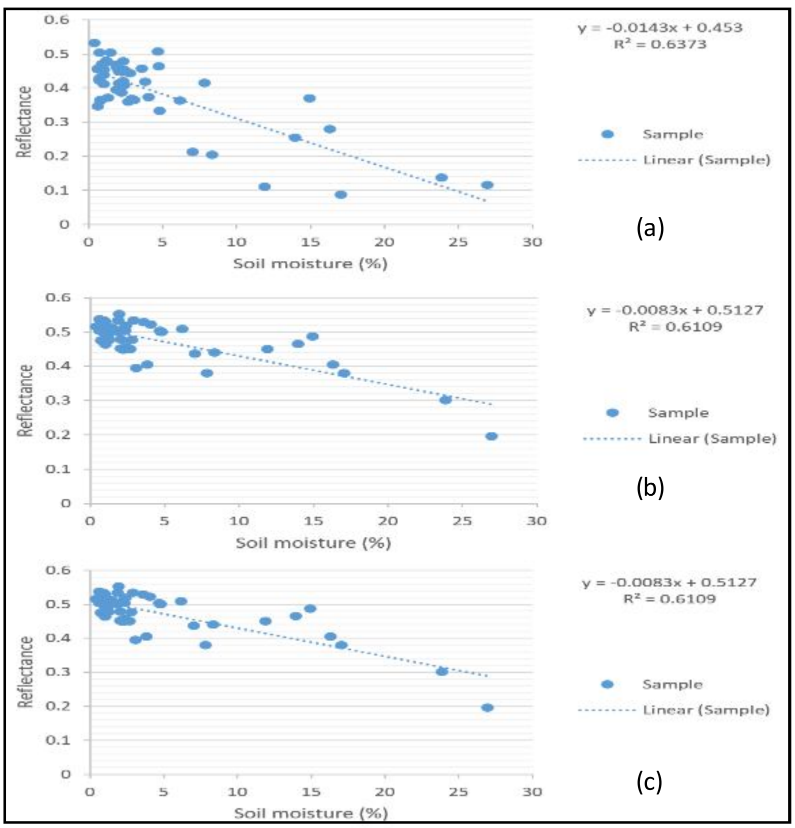

Fig. 5: The relationship between moisture and spectral reflectivity: (a) For Spectroradiometer with a wavelength of 1994 nm, (b) For Sentinel band 12, (c) For Landsat band 7.

0.798- at the wavelength 1994 nm fig. 5a. The highest correlation coefficient between moisture content and Sentinel 2 Bands spectral reflectance values was with band 12 which reached -0.782 (highly significant negative) as in fig. 5b. The highest correlation coefficient (highly significant negative) between moisture content and Landsat 8 Bands spectral reflectance values was with band 7 which reached -0.783*** (highly significant negative) fig. 5c. All of this is consistent with what was mentioned in Drury, (1997) which showed that the electromagnetic radiation reaching the earth and when there is water, most of them are absorbed and a few of them are reflected back into the atmosphere. This is consistent with Wheib, (2013), which showed that reflexivity decreases with increasing wavelengths of incident rays, *i.e.* increased absorption, all this is consistent with the results obtained, as it was the highest absorbance in the high wavelength to the limits of 1994 nm with a Spectroradiometer table 3. The results are also consistent with Mulders (1987) as water-containing soils show the first absorption areas at 1400 nm and the second at 1900 nm (short infrared wavelength) and the sharpness of the decrease in these two areas reflects the amount of water in the soil.

The relationship between the Soil bulk density and spectral reflectivity

The results of table 3 and fig. 6, showed the highest correlation coefficient (highly significant positive) between Soil bulk density and reflectance values of the Spectroradiometer device, as the correlation coefficient **0.427 at the wavelength 356 nm fig. 6a. The highest correlation coefficient between Soil bulk density and Sentinel 2 Bands spectral reflectance values was with band 11 which reached 0.453*** (highly significant positive) as in fig. 6b. The highest correlation coefficient between Soil bulk density and Landsat 8 Bands spectral reflectance values was with band 6 which reached **0.429 fig. 6c. It should be noted that the sentinel 2 gave the highest correlation coefficient with the bulk density of the soil, as the bulk density of the soil is affected by several factors, the most important of which

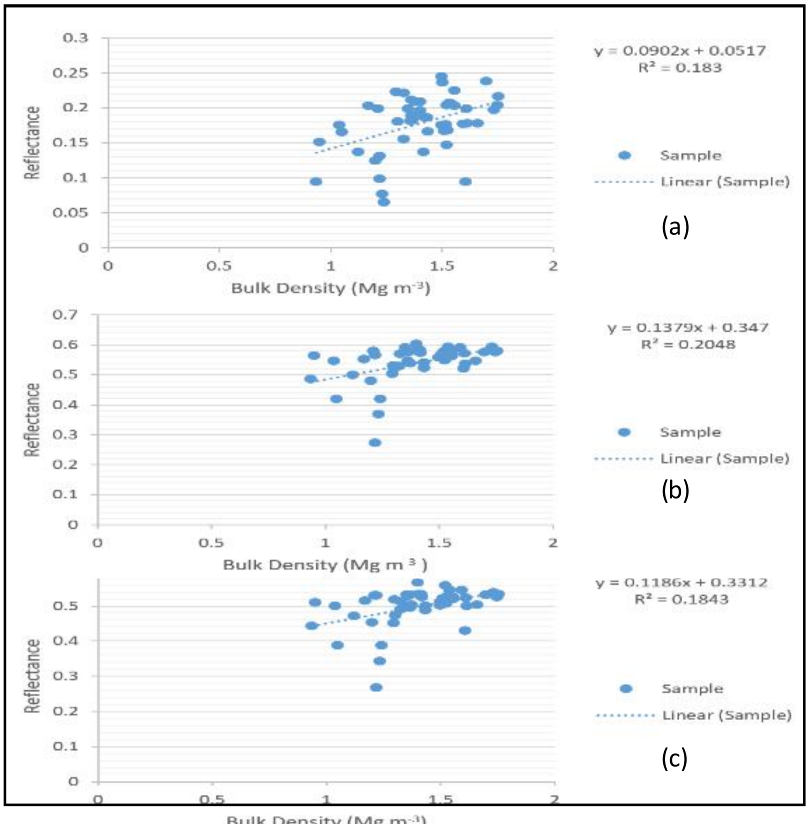

Fig. 6: The relationship between bulk density and spectral reflectivity: (a) For Spectroradiometer with a wavelength of 356 nm, (b) For Sentinel band 11, (c) For Landsat band 6.

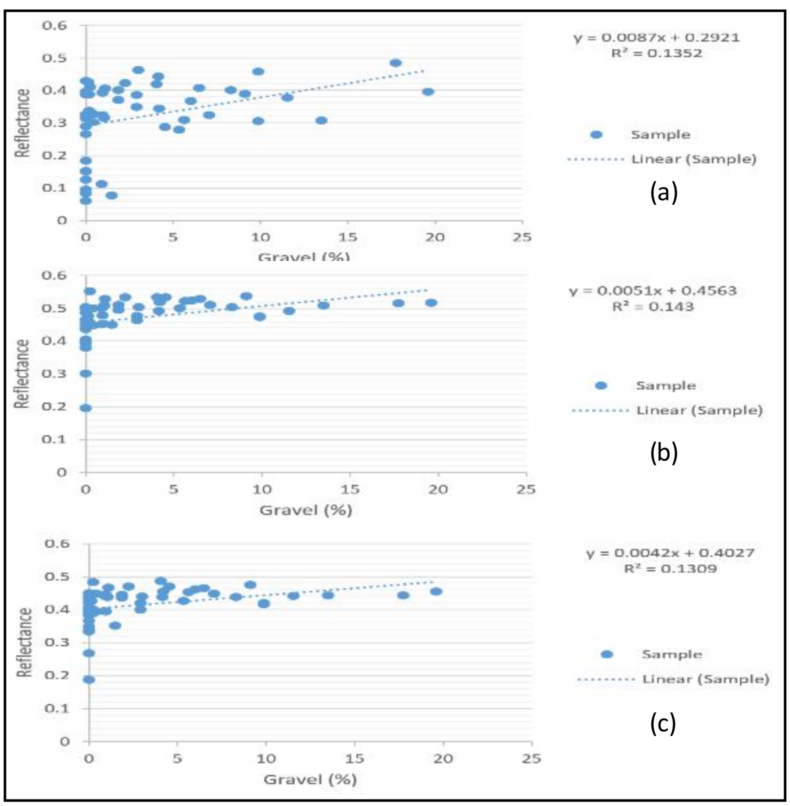

Fig. 7: The relationship between gravel ratio and spectral reflectivity: (a) For Spectroradiometer with a wavelength of 1943 nm, (b) For Sentinel band 12. (c) For Landsat band 7.

is the soil texture (Aoda and Mahdi, 2017), thus, the accuracy of the spatial precision of the sentinel 2 and its effect on soil texture has given the highest degree of correlation. The results are also consistent with Barnes and Baker, (2000). The positive relationship of bulk density with reflectance may be due to the very low content of organic matter in the soil of the study area, as the relationship between organic matter and spectral reflectance is negative, but due to the decrease in the content of organic matter, the influence of soil texture on the correlation relationship has become positive and this is consistent with (Dawood *et al.*, 2017).

The relationship between gravel ratio and spectral reflectivity

The results of table 3 and fig. 7, showed the highest correlation coefficient (highly significant positive) between gravel ratio and reflectance values of the Spectroradio meter device, as the correlation coefficient **0.369 at the wavelength 1943 nm fig. 7a. The highest correlation coefficient between gravel ratio and Sentinel 2 Bands spectral reflectance values was with band 12 which reached 0.378** (highly significant positive) as in fig. 7b. The highest correlation coefficient between gravel ratio and Landsat 8 Bands spectral reflectance values was with band 7 which reached **0.362 (highly significant positive) fig. 7c.

Conclusions

The most important conclusions reached by this study can be summarized as follows:

1. Sentinel 2 was the most accurate and significant in giving the highest correlation coefficient between spectral reflectivity and most physical soil properties (silt content, sand content, moisture content, bulk density, gravel ratio).
2. Spectroradiometer was the most accurate and most important in giving the highest correlation coefficient between spectral reflection and two properties of studied physical properties of soil (clay content, moisture content).
3. The European satellite images Sentinel 2 gave high flexibility in choosing the appropriate image in terms of history and

weather conditions because it is available every 5 days for the same region compared to the American satellite Landsat 8, it is available every 16 days.

4. Spectral integration is very important to control the great complexity of soil properties and all sources of spectral reflectivity have their importance. The researcher should when be examining one of the characteristics of the soil, taking into account the relationship of this characteristic with different sources of reflectivity.

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