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STUDYING THE POSSIBILITY OF ESTIMATING SOIL ORGANIC CARBON OF SOILS UNDER PINUS BRUTIA AND QUERCUS AEGILOPS L. TREES IN SARKE-DUHOK BY USING ASD FIELDSPEC 3 SPECTRORADIOMETER

Kamiran A.M. Gravi [a, *], Salah M. Ibrahim [b]

[a] Dept. of Forestry, College of Agricultural Engineering Science, University of Duhok,Kurdistan Region, Iraq. (kamiran.azeez@uod.ac)

[b] Dept. of Forestry, College of Agricultural Engineering Science, University of Duhok, Duhok, Kurdistan Region– Iraq.

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ABSTRACT:

Visible and Near-infrared (VNIRS) spectroscopy is a very fast non-destructive and environmentally friendly analytical technique. It has been suggested as an alternative to conventional methods for assessing and monitoring soil quality. Accurate VNIRS prediction of soil organic carbon (SOC) has been reported by many researchers in different world regions. Sixteen surface soil samples (0-30cm depth) from Sarke - Duhok were collected, eight samples under Zawita Pine (Pinus brutia) and the other eight-under oak (Quercus aegilops L.) trees. Soil colour was measured in the field and soil samples were air-dried and sieved by using a 2.0 mm sieve and analyzed in the laboratory to estimate the PH, EC, CaCo3, texture, and SOC according to Walk ley and Black methods. Laboratory reflectance spectra were acquired for each sample from 350 to 2500 nm by using the Analytical Spectral Device (ASD) FieldSpec 3spectroradiometer for each of the different spectrum bands (410, 570, 660, 849, 1543 and 2187nm). Results showed that the reflectivity values of soil under both Oak and Pine trees in the IR region (849, 1543, 2187nm) were almost more than that at the visible portion (410,570, 660nm). Also, the determination coefficient (R^2) results indicated that the bands 570, 1543 and 2187nm showed significant relationships between soil reflectivity and SOC% under Oak trees, R^2 was 58.2 %, 89.9%, and 93.9% respectively. While under the Pine tree, the only band that showed a significant relationship was band 1543nm, its R^2 was 58.3%. From the current results, as the main objectives, it is obvious that the ASD FieldSpec 3 spectroradiometer is quite an efficient and undestructive tool that can be used for SOC estimation under Oak & pine trees especially at the IR spectrum (band 1543nm). The relationship between the variables was moderately strong; R^2 was 89.88 and 58.3 alternatively. The standard error was low (0.0399, 0.0185), which indicates that the predicted values are close to the real values. Besides that, under Oak trees results indicated that there was a high R^2 between the variables at bands 570 & 2187 nm, the R^2 values were 58.21 and 93.92, alternatively.

KEYWORDS: Vis-NIR spectroscopy, ASD fieldSpec, PINUS BRUTIA, QUERCUS AEGILOPS, SOC, forest soil, soil reflectivity.

1. INTRIDUCTION

Organic matter (OM) is a fundamental soil property for agriculture and essential macronutrient for increasing soil fertility required for plant growth and development. Soil Organic Matter (SOM) is any material created initially by living organisms (plant or animal) that is come back to the soil and goes through the decomposition process (FAO, 2005). The color of the soil is usually closely related to its SOM content, with darker soils being higher in OM, which indicates the relationship between SOM content and its visible light reflectance. (Boettcher K. et al 2007)

Visible and near -infrared reflectance spectroscopy (VNIRS) has been suggested as an alternative to conventional methods for assessing and monitoring soil quality (Cécillon et al., 2009; Kinoshita et al., 2012). Near-infrared (NIR) spectroscopy is a very fast non -destructive and environmentally friendly analytical technique. The use of infrared (IR) spectroscopy in agriculture started in the 80s for measuring fruits and vegetation qualities. NIR spectroscopy has turned out to be entrenched in agriculture (Wetzel, 1983).

Soil reflectance spectra are very rich in information, which allows inferring chemical, physical or biological properties of soils from a single spectrum (Shepherd et al. 2005; Jia et al. 2014; Heinze et al. 2013).Accurate VNIRS prediction of some soil properties such as total nitrogen and soil organic carbon (SOC) has been reported by many researchers in different world regions (Brunet et al., 2007; Chang and Laird, 2002; Fystro, 2002; Shi et al., 2013).

GAO (2017) measured the SOM of Qixia City, Shandong Peninsula, China by using the Analytical Spectral Device (ASD) FieldSpec 3 portable object spectrometer. Raw spectral reflectance data was transformed by four different methods. The results indicated that hyperspectral remote sensing (HSRS) can quickly and accurately predict SOM content in the brown forest soil areas, the R^2 was 0.875. Ogen, (2018) evaluated the soil spectral detection limit of OM by using ASD FieldSpec 3 for five different soils. Large spectral variations were found between soils with the same OM content and between the two sensors when calculating the detection limit.

Pinheiro et.al, 2017 studied the visible and NIR diffuse reflectance spectroscopy for subtropical , temperate soils and tropical agro-forest regions in the central Amazon. The results

* Corresponding author

showed levels of accuracy comparable to conventional laboratory methods for estimating soil properties. The R^2 for the SOM Was 0.71.

According to our knowledge, there is no published up to now works that investigate the prediction of SOM under forests by HSRS in the Kurdistan region. Therefore, the goals of this research are: 1- To study the possibility of using the ASD FieldSpec 3 spectroradiometer in estimating the SOC content under two different trees (Pinus brutia) and (Quercus aegilops L.) for Sarke area / Duhok governorate. 2- To discover which wavelength is suitable for SOC detection. 3- To discover the typical band that is suitable to estimate the SOC for all the soil Types. 4- To study the effect of soil properties on soil reflectivity value

2. METHODS AND MATERIALS

2.1 The study area

Sarke forest is a mountainous area, which is located between Bagera collection and Sarsink sub-district, at Duhok city-Kurdistan region-Iraq. It is about 20 km away from Duhok city to the north-east. The mean of Sarke area's temperature about 17 ºC, and their manual rainfall about 873mm. The latitude of the area is 36˚58′12"N, and the longitude is 43˚11′28"E, its elevation is about 945 m above mean sea level (fig-1).

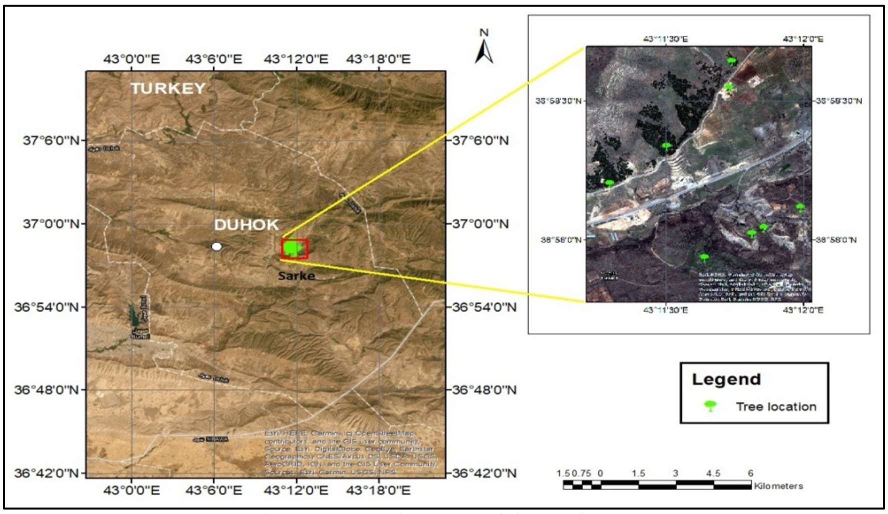


Figure 1. Location map of the study area

2.2 Soil Sampling

The following steps followed when collecting soil samples:

1. Four trees were selected for each of the two tree types Zawita Pine (Pinus brutia) and oak (Quercus aegilops L.).
2. Four surface soil samples (0-20 cm depth) under each tree were collected in the east-west direction (two samples near the tree stem and another two to the outside direction within the border of the tree canopy). Besides two samples for bare soil for both forests.
3. Soil color for each sample was booked by using the Munsell color chart, and the position of each sample was registered by using the Garmin Global positioning system (GPS) receiver.

2.3 Laboratory Analyses

The collected soil samples were air-dried for 24 hours. The following steps were adopted:

1- Stones, roots, and the vegetation litter were removed from the soil.

2- The samples were crushed to pass through a 2 mm sieve.

3- Soil moisture, soil texture, $CaCo_3$, pH, EC, and SOM for all the samples were determined in the laboratory following Walkley and Black, 1934 methods.

4- The two samples that are near the stem for each tree were mixed and also the other two samples near the canopy border to make one sample (because it shows the same analysis results).

2.4 Spectral Measurement and Pre-Processing

The sixteen soil samples were grinded with a sieve of 2 mm diameter and their spectral reflectance were acquired in the laboratory by using ASD FieldSpec 3 Spectroradiometer (fig-2) that was in contact probe mode Sabah et al, 2012, with wavelength ranges between 350-2500 nm to avoid disturbance from surroundings.

The ASD FieldSpec 3 spectral resolution is 3 nm at 700 nm 10 nm at 1400 - 2100 nm. Also, white reference (Spectralon panel) corrections were used for calibrating the instrument (Adeline et al., 2017).

Figure 2. the ASD FieldSpec 3 Spectroradiometer

3. RESULTS AND DISCUSSION

3.1 Soil laboratory analysis results

The study results showed that the SOC content of the soil samples under the oak trees ranged from 1.47 to 5.25% with a mean of 3.51% (tab-1), while it was 1.43 to 4.29% under the pine trees with a mean of 3.0913% (tab-2). Shrestha and Devkota, (2013) found that SOC content in Salyan District, Nepal was higher under Oak forest than of that under the Pine forest due to the higher amounts of leaf litter and higher soil carbon stocks.

Table 1. Some of the soil properties under Oak trees

Sample name	SOC%	Moisture Content%	$CaCo_3$%	Texture	EC d/mole	PH	Soil colour	
							dry	wet
A1	2.1	2.92	12.18719	clay loam	0.293	7.33	YB 7.5YR	DYB 7.5YR
A2	2.37	8.25	14.70868	sandy loam	0.341	7.31	YB 7.5YR	DYB 7.5YR
A3	4.66	2.33	5.883472	clay	0.382	7.35	DYB 10YR	DYB 10YR
A4	5.1	5.50	5.463224	sandy clay loam	0.371	7.35	DYB 10YR	DYB 10YR
A5	5.25	2.68	10.08595	clay	0.37	7.3	DYB 10YR	DYB 10YR
A6	4.98	6.26	7.564464	sandy clay loam	0.403	7.29	DYB 10YR	DYB 10YR
A7	1.47	4.42	23.11364	sandy clay loam	0.306	7.57	DYB 10YR	DYB 10YR
A8	2.15	4.50	23.11364	clay	0.316	7.5	DYB 10YR	DYB 10YR

DYB: Dark yellowish brown YB: Yellowish brown

The laboratory analysis showed that the moisture content of the soil samples ranged from 2.33 to 8.25 % with an average of 4.60 under Oak trees, and it ranged from 0.8 to 8.6 with an average of 3.98 under Pine trees. In addition to that, the laboratory analysis showed that the percentage of $CaCo_3$ in the samples was higher under pine trees; it ranged from 5.46 to 23.11 % with an average of 12.76 under Oak trees, and between 8.4 to 33.64 % with an average of 25.47 under Pine trees. This coincides with what Vahel, (2013) found under Zawita, Koradere and Swaratoka forests, whereas $CaCo_3$% under Oak and Pine trees ranged from 2.84 to 37.38%.

Table -2 Some of the soil properties under Pine trees

Sample name	SOC%	Moisture Content%	$CaC0_3$ %	Texture	EC d/mole	PH	Soil colour	
							Dry	wet
A11	1.91	3.54	31.93885	Clay loam	0.599	7.9	SB 7.5YR	DB 7.5YR
A12	1.43	4.04	33.61984	Sandy loam	0.544	8.02	SB 7.5YR	DB 7.5YR
A13	3.23	8.6	8.825208	Clay	0.411	7.78	RB 5YR	DRB 5YR
A14	4.29	0.82	8.40496	Sandy clay loam	0.432	7.91	RB 5YR	DRB 5YR
A15	3.5	3.6	29.83761	Sandy loam	0.745	8.05	YR 5YR	DRB 5YR
A16	3.5	3.59	32.3591	Clay loam	0.708	8.16	YR 5YR	DRB 5YR
A17	3.78	4.00	28.99711	Sandy loam	0.615	8.19	LYB 10YR	DYB 10YR
A18	3.09	3.68	29.83761	Clay loam	0.525	8.11	LYB 10YR	DYB 10YR

DB: dark brown SB: strong brown RB: Reddish brown

DRB: Dark reddish brown YR: Yellow red LYB: Light yellowish brown

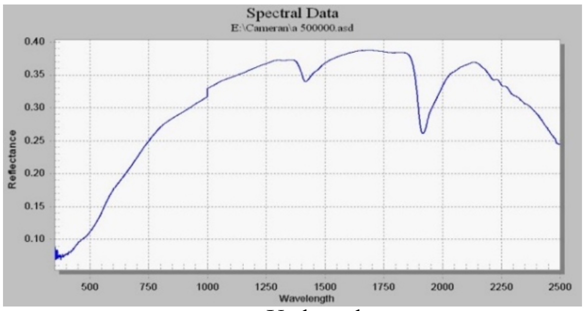
In both tables (1 and 2), Soil pH was approximately neutral under both Oak and Pine trees. It was ranged from 7.29 to 7.57 with an average of 7.37 under Oak trees, and it ranged from 7.3 to 8.19 with an average of 8.015 under Pine trees, which is the same results that Vahel, 2013 registered in the same area, PH values ranged from (7.31 to 8.30).

The EC of studied area ranged between 0.293 -0.403dSm-1 with an average of 0.347 dSm-1 under Oak trees, but there is an increase in the EC values under Pine trees, was ranged between 0.411 to 0.754 dSm-1 with an average of 0.745 dSm-1. Hajar and Salar, (2016) reported that the average EC of soils in Brifka village was 0.36 dSm-1.

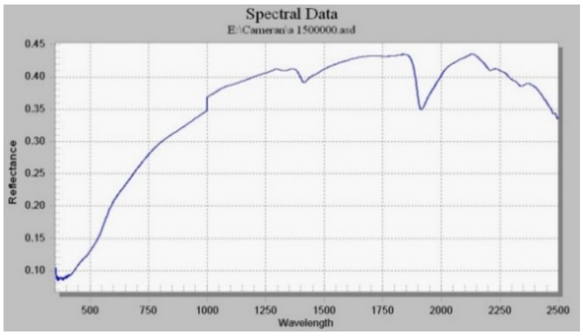
Results also show that soil texture under Oak trees tend to be near Loamy texture, while under pine trees almost indicates a sandy loam texture. Sarbast, (2017) reported that soil texture in some of Duhok dam catchments was also loamy. Soil color in this study measured in both cases wet and dry. It shows dark color in wet and dry cases under Oak trees and it was dark only in wet case under Pine trees. This means that the soil under Oak trees is darker than that under Pine trees.

3.2 Soil reflectivity curves:

Figure-3 a,_b shows the relationship between soil reflectivity that acquired by the ASD FieldSpec 3 under Oak and Pine trees. The overall trend exhibited that the spectral reflectance increased with the increasing wavelength, with a low reflectance at the visible wavelength, and a higher one in the IR spectrum. A deep and large absorption features were observed in the visible region which are primarily associated with iron-containing minerals such as haematite and goethite. They show strong absorption bands between 400 and 660 nm (Sherman and Waite, 1985). In the other hand, clay minerals have characteristic absorption in the IR region (Stenberg et al., 2010; Chabrillat et al., 2002).



a. Under oak trees



b. Under pine trees

Fig 3- soil reflectivity curves acquired by the ASD FieldSpec 3

Table-3 shows soil reflectivity and SOC% at each of the different spectrum bands 410, 570, 660, 849, 1543 and 2187nm under Oak trees. Soil reflectivity was high in the NIR bands (2187, 1543 and 849nm) (He, et al., 2009) and deposits in the VIS (visible) bands (660, 570 and 410nm) (Viscarra/ Rossel et al., 2006). Typically, soil spectrum characterized with reflectance increasing with increasing wavelengths, the wavelengths contributing most to the prediction of SOC content were between 1050 to 2380 nm (Milos and Bensa 2017).

Sun and Niu, (2018) discovered that the spectral curves of the soil with different SOC content grades exhibited a uniform pattern, which increased rapidly in the visible band (400–760 nm), but then ascended gradually in the short NIR and NIR long wave bands (780–1300 nm). Then the curves formed a high reflectivity platform until it began to decline after 2100 nm.

Table 3. Soil reflectivity values and SOC% at different bands under Oak trees.

Samples	SOC%	Ref. at 410nm	Ref. at 570nm	Ref. at 660nm	Ref. at 849nm	Ref. at 1543nm	Ref. at 2187nm
A1	2.1	6.5	17	19	26	37.5	33.5
A2	2.37	6	15	17	24.5	35	31
A3	4.66	6	15	18.5	24	31	26.5
A4	5.1	7	16.5	19	25	30.5	25.5
A5	5.25	6	15	19.5	24	32	24.5
A6	4.98	6	15	17.5	23	30	26
A7	1.47	7	16.5	21	25.5	33	31
A8	2.15	8	17.5	22	28	36.5	33
Average	3.51	6.562	15.938	19.188	25	33.188	28.875

The results show that the reflectivity values of soil under Oak trees in the IR region (849, 1543, 2187nm) were almost more than that at the visible portion (410, 570, 660nm). It ranged between 25-33% for the IR with an average of 29.02%, while it was between 6.56-19.188% for the visible part with an average of 13.89%. The band 660 nm shows relatively high reflectivity values compared with the blue and green bands which meant it was sensitive to the OM. In table-3 it is clear that the sample A8 has the highest reflectivity value among all the samples in all bands because it has low SOC (2.15%), low soil moisture (4.50%) and high content of $CaCo_3$ (23.11%). Fang and Zhao, (2018) found that the high CaCo3% in soil decreases its reflectivity, which is due to that the carbonates have many absorption bands within the VNIR domain, caused by overtones and mixtures of elementary vibrations of the CO_3^{-2} ion.

Sample A6 (table-3) has the lowest reflectivity among the other samples in all bands which is due to the high amount of SOC (4.98%), high soil moisture (6.26%), low $CaCo_3$ (7.56%) and dark color (Bonett et al, 2016).

Table-4 shows soil reflectivity values and SOC% for each of the 410, 570, 660, 849, 1543 and 2187nm bands under Pine trees. In the IR region, they almost were more than that of the visible portion. It was between 33.68 to 41.62% for the IR with an average of 36.68%, while it ranged between 7.5 to 19.625% for the visible part with an average of 17.25%. Christy, (2008) found that the most significant spectrum part for assessing SOC was in the NIR between 920–1718 nm.

Table 4. Soil reflectivity values and SOC% at different bands under Pine trees

Samples	SOC%	Ref. at 410nm	Ref. at 570nm	Ref. at 660nm	Ref. at 849nm	Ref.at 1543nm	Ref.at 2187nm
A11	1.91	7	17.5	21.5	40	40	36
A12	1.43	7.7	25	30.5	37.5	51	45
A13	3.23	7	19.5	23.5	26	46	36
A14	4.29	10	15	27.5	25.5	30	32
A15	3.5	4	12.5	19.5	30	33	26.5
A16	3.5	4	22.5	17.5	35	42	29
A17	3.78	8.5	23	27	37.5	42	32.5
A18	3.09	11.8	22	30	38	49	41
Average	3.0913	7.5	19.625	24.625	33.688	41.625	34.75

In table-4, it is clear that sample A12 has the highest reflectivity value among all bands. This is due to the low SOC (1.43%), high amount of $CaCo_3$ (33.61%), and light soil texture (sandy loam). Soil reflectance is relatively high for loamy sand and sandy soils that have more than 70% sand content and has a high amount of quartz in the sand fraction, which increased the intensity of spectral reflectance (White et al. 1997). On the other hand, sample A14 has the lowest reflectivity value among all bands which is due to the high amount of SOC (4.29%), low content of CaCo3 (8.404%) and the soil texture was sandy clay loam. Soil reflectance decreased when clay content dominated from phyllosilicates increased (Palacios-Orueta and Ustin 1998).

Comparing the reflectivity values in tab-3 and tab-4, it was evident that soil reflectivity percentage under Pine trees in all bands was higher than that under Oak trees. This means that the spectral reflectance of soils increased when soil attributes decrease particularly its OM content (Mitran et al. 2015; Chaturvedi and Melkania.2013).

3.3 Regression curves between SOC and soil reflectivity:

For Oak trees, table-5 shows that the P-value at 95.0% confidence level for the bands 570, 1543 and 2187nm were less than 0.05 (0.0460, 0.0011 and 0.0003 alternatively. This means that there is a significant relationship between the variables in these bands. The R^2 values were 58.2%, 89.9% and 93.9% at the green and IR bands, respectively. Also, it is obvious that R^2 shows a moderately strong relationship in each of the IR bands 1543 and 2187nm, they were 89.9% and 93.9%, respectively. The strongest relationship was at band 2187nm. Conforti et al. (2018) found that R^2 for SOC under forest soil in Calabria Region, southern Italy was 84%; Šestak et al (2018) found that R^2 was 75% in the Western Pannonia subregion of Croatia and 83% based on the results of Luce et al. (2014) and Feyziyev et al. (2016).

Table 5. P-value of the different bands under Oak and Pine trees

Tree type	Band (nm)	R^2	P	Relation ship	The model
oak	410	40.33		Non-sig	O.C% Oak = 11.9557 - 1.33429*410nm
	570	58.21	0.0460	sig	O.C% Oak = 23.1005- 1.20883*570nm
	660	48.00	0.0845	Non-sig	O.C% Oak = 18.4929 - 0.76*660nm
	849	54.34	0.0587	Non-sig	O.C% Oak = 21.1162 - 0.713333 *849nm
	1543	89.88	0.0011	sig	O.C% Oak = 19.2507 - 0.465139*1543nm
	2187	93.92	0.0003	Sig	O.C% Oak = 16.5681 - 0.370026*2187nm
Pine	410	3.04	0.7081	Non-sig	O.C% Pine = 2.45798 + 0.0718597*410 nm
	570	33.54	0.1730	Non-sig	O.C% Pine = 5.52133 - 0.113472*570 nm
	660	14.46	0.4000	Non-sig	O.C% Pine = 4.94672 - 0.0672765*660 nm
	849	54.25	0.0590	Non-sig	O.C% Pine = 7.05428 - 0.122543*849 nm
	1543	58.30	0.0458	sig	O.C% Pine = 6.90557 - 0.0870955*1543 nm
	2187	45.78	0.0946	Non-sig	O.C% Pine = 6.34953 - 0.0842713*2187 nm

Non-sig: Non-significant, sig: significant, P= P-value at 95.0% confidence level

Results also depicted that P-value for the 410, 660 and 849nm bands was more than 0.05 (0.1254, 0.0845 and 0.0587, respectively). In addition to that, the Pine trees P-value results were more than 0.05 for the bands 410, 570, 660, 849 and 2187 (0.781, 0.1730, 0.4000, 0.0590 and 0.0946). This means that means there is a Non-significant relationship between the variables in these bands. The R^2 values were 3%, 33.5 %, 14.5%, 54.3% and 45.9 %. McCoy, (2005) discovered that in the spectral range of 490–560 nm, soil reflectivity will be less where a higher presence of SOM recorded. The only band that showed a P-value less than 0.05 was the 1543nm band, it was 0.0458. This means that there is a significant relationship between the variables in this band. R^2 for this band was 58.3%, which shows a moderately strong relationship.

3.4 Non-linear Models between SOC and soil reflectivity:

Table- 6 shows the non-leaner models under Oak trees for the band 1543nm. The most suitable model is the Double reciprocal because it has the lowest RSS value (0.0399) and R2 is 92.91:

O.C %Oak= 1/ (1.77512 48.3392/1543nm)

In addition to that, the most suitable model for the band 2187nm was the Square Root-X because it has the lowest RSS value (0.963) and R^2 was 93.9:

O.C%Oak=29.5418-4.38911*sqrt (2187nm)

Also, the non-leaner model under Oak trees that was suitable for the band 570nm was the Square-Y Logarithmic X because it has the lowest RSS value (7.397) and R^2 was 59.55:

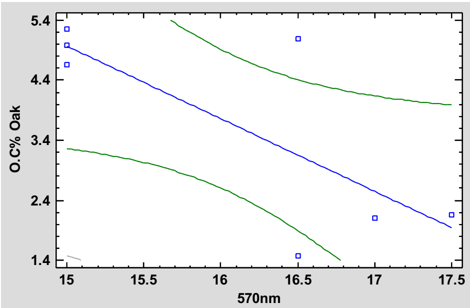
O.C % Oak = sqrt (391.054 - 135.183*ln (570nm).

Table 6. Non-linear models for 1543nm band under Oak trees

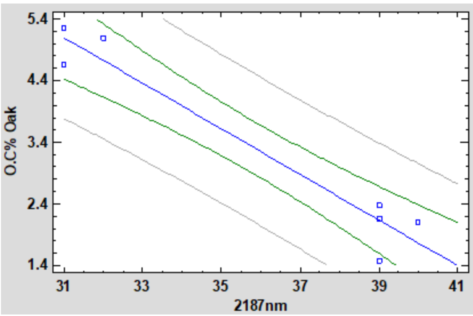
No	Model type	R^2	RSS	Ster	Iny	Equation
1	Exp	91.97	1.6267	0.1365	5.82	O.C % Oak = exp(5.82988 - 0.137664*1543nm)
2	Ly SqX	92.02	1.5128	0.1361	3.52	O.C % Oak = exp(3.52765-0.00204292*1543nm^2)
3	SqrtYSqX	90.99	1.3695	0.1327	3.98	O.C % Oak = (3.98442 - 0.00186355*1543nm^2)^2
4	Drec	92.91	3.4841	0.0399	1.77	O.C % Oak = 1/(1.77512 - 48.3392/1543nm)
5	Mu	91.77	1.7642	0.1383	17.41	O.C % Oak = exp(17.4144 - 4.61709*ln(1543nm))
6	LY SqrtX	91.89	1.6926	0.1373	10.44	O.C % Oak = exp(10.4438 - 1.59542*sqrt(1543nm))
7	DSqrt	90.91	1.4588	0.1333	10.29	O.C % Oak = (10.2957 - 1.45574*sqrt(1543nm))^2

Exp= Exponential Ly SqX = Logarithmic Y Square X SqrtYSqX = Square root-Y Square -X Interception with yaxis Drec= Double reciprocal Mu=Multiplicative LY sqrtx=Log-Y Square root-X Dsqrt=Double Square root

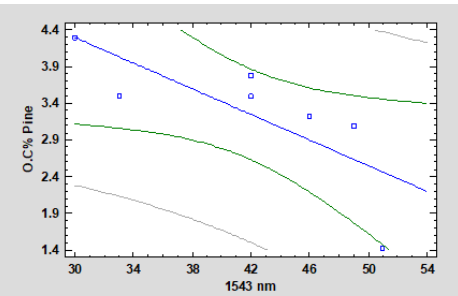
Finally, the non-leaner model under Pine trees for the band 1543 nm was the Double squared because it has the lowest RSS value (1.664) and R^2 is 69.7: OC % Pine= sqrt (23.2119-0.00659001 *1543nm^2).



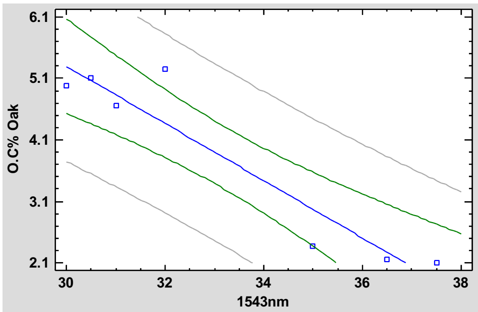
A-at 570nm under Oak



B- at 1543nm under Oak



C-at 1543nm under Pine



D- at 2187nm under Oak

Figure 4. the best curves that fit the relationship under Oak & Pine trees

3.5 The percentage of SOC in bare soil

Table -7 shows the SOC% of the bare soil samples of both outside and inside of the forest. It is clear that the percent of OC in bare soil were lower when compared with those of soil samples under the canopy of each of the three trees. This is because that the main source of organic materials in the forest soil results from the vegetation that is deposited on the soil as litter and it is partially dispersed into the soil surface (Klein and Dutrow 2000; Santa and Tarazona 2001). Also if we compared SOC% in the inside and the outside bare soil, the 1st one has higher OC than that of the later which is due to the effect of the tree residuals and their decomposition in the inside forest areas. In addition to that, the values of SOC% in Oak trees were higher in both outside and inside samples (1.91 and 1.43), than Pine trees (1.53 and 1.07), as Vahel, (2013) found the amount of OM inside the forest of Oak and Pine in Zawita and Sowratok areas ranged from (0.09 to 5.83%). (Hajar and Salar, 2015) reported that the SOC% in Oak forest ranged from (2.35 to 3.36 %) in Brifka village.

Table 7. SOC% values in bare soils and under different trees canopy

Trees species	SOC% 0f Bare soil (Inside)	SOC% of Bare Soil (Outside)	Mean SOC% under tree canopies
Oak	1.91	1.43	3.51
Pine	1.53	1.07	3.09

4. CONCLUSIONS

According to the current study's results, it can be concluded that the ASD FieldSpec 3 Spectroradiometer as a quite efficient and un-destructive tool can be used for SOC estimation under Oak and pine trees especially at the IR spectrum. The typical band that can be used for estimating SOC under both tree types was the 1543nm.

The R^2 showed a moderately strong relationship between the variables under Oak and pine trees. They were 89.88 and 58.3 alternatively with low standard error (0.0399, 0.0185) which indicates that the predicted values are close to the real values. Besides that, under Oak trees results indicated that other bands show high R^2 between the variables. These bands were 570 and 2187 nm, the R^2 values were 58.21 and 93.92 alternatively. Generally speaking, IR is more is preferred in estimating SOC under both trees, and this coincides with that found by Wetzel, (1983), Epema et al, (2003), Christy, (2008) and Liu et al, (2016).

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