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Asritha VP
PhD. Scholar. Dept. SSAC, VNMKV, Parbhani, Maharashtra, India

Dr. VD Patil
Ex. DI & Dean, F/A, VNMKV, Parbhani, Maharashtra, India

Corresponding Author:
Asritha VP
PhD. Scholar. Dept. SSAC, VNMKV, Parbhani, Maharashtra, India

Spectral behaviour of yellow soil of Rajasthan under various levels of organic matter

Asritha VP and Dr. VD Patil

Abstract
This investigation on spectral behaviour of yellow soil of Rajasthan under various levels of organic matter was conducted in the laboratory of Department of Soil Science and Agriculture Chemistry, VNMKV, Parbhani in 2018. One and half kilogram of yellow soil (S3) was mixed with six levels of vermicompost *viz.* V_0: No vermicompost, V_1:100 gm vermicompost, V_2: 250 gm vermicompost, V_3: 500 gm vermicompost, V_4: 1 kg vermicompost and V_5: 1.5 kg vermicompost making total 6 treatment combinations to create different levels of organic matter and colour shades. These different combinations were exposed for spectral reflectance studies and observations were taken by SVC GER 1500 Spectro radiometer. The readings (% reflectance) were taken for corresponding wavelengths (nm) of Red and NIR bands. It was noticed that with increase in vermicompost to yellow soil there was decrease in reflectance. It is found that S3T1 and S3T2 *i.e.* yellow soil 1.5 kg + 100 gm VC and yellow soil 1.5 kg + 250 gm VC showed higher reflectance at all wavelengths than S3T3, S3T4 and S1T5 (*i.e.* addition of 500 gm, 1 kg and 1.5 kg of vermicompost, respectively). While addition of lower amount of vermicompost *i.e.* 100 gm, 200 gm and 500 gm yellow soil depicted higher reflectance. Yellow soil showed maximum Red reflectance at 658 to 660 nm band and NIR reflectance at 858 to 860 nm.

Keywords: Spectral reflectance, black soil, organic matter, red reflectance, NIR reflectance

Introduction

The colour of the soil is closely related to its organic matter content, with darker soils being higher in organic matter, which indicates the strong relationship between soil organic matter content and it's visible light reflectance. Although there are a lot of inversion methods used to get the organic matter content from soil reflectance, all of the methods subject to certain limitation to some extent and display huge error when applying in different soil categories. To date, there is no versatile model which is fit for all over the world. The waveband selection for different study area is also diverse. Even though by using the application potential of hyper spectral remote sensing technique in monitoring soil organic matter content in the visible and near infrared spectrum, we can detect those spectral characteristics which are sensitive to organic matter content and establish corresponding inversion model. Organic matter correlated highly with reflectance in the 0.5- 1.2 µm range (Mathews *et al.*, 1973) [4]. Spectral reflectance is negatively correlated with soil organic matter content and the reciprocal of reflectance is inefficient for its detection. Three unique spectral signatures representative of various stages of litter decomposition are present in the soil.

Methodology

Collection of soil sample

The soil used for the six treatments was yellowish in color and sandy loam (68.92% sand, 32.33% silt and 10.07% clay) in texture. Taxonomically this sierozems group of desert soils coming under Typic Camborthids (Battacharyya *et al.*, 2013) [1]. One and half kilogram of soil was collected from Jobner, Rajasthan (26º58'32.9"N, 75º22'46.9"E) on 08.12.2016.

Processing of soil sample

The soil sample was ground and sieved through 2 mm sieve to avoid the shading of aggregates effects during it's exposure to the radiation. The soil sample was taken in to analysis for quantifying the physico- chemical parameters. Yellow soil showed alkaline nature (pH 7.5) and electrical conductivity was high. This soil was very low in organic carbon content but high in inorganic content (Table 1).

They processed and mixed accordingly to make various combinations of black soil and organic matter levels (Table 2). Five bands from Red and NIR regions of electromagnetic spectra were selected and recorded the spectral reflectance data of each combination of black soil and organic matter levels (Table 3).

Table 1: Physico-chemical properties of soil

Type of soil	pH	EC(dSm^{-1})	Carbon status		
			OC (%)	IC (%)	TOC (%)
Yellow soil	7.5	0.578	0.16	0.53	0.69

Table 2: Proportion of soil and vermicompost (VC) combinations

Symbol used	Combinations
S3	Yellow soil
S3T1	1.5 kg yellow soil+100 g VC
S3T2	1.5 kg yellow soil+250 g VC
S3T3	1.5 kg yellow soil+500 g VC
S3T4	1.5 kg yellow soil+1 kg VC
S3T5	1.5 kg yellow soil+1.5 kg VC
S3T6	1.5 kg yellow soil

Table 3: List of Red and NIR bands selected

Sr. No	Bands selected	Wavelength (nm)
Visible (Red) bands		
1	B1	650 nm - 652 nm
2	B2	652 nm - 654 nm
3	B3	654 nm - 656 nm
4	B4	656 nm - 658 nm
5	B5	658 nm - 660 nm
NIR bands		
6	B6	850 nm - 852 nm
7	B7	852 nm - 854 nm
8	B8	854 nm - 856 nm
9	B9	856 nm - 858 nm
10	B10	858 nm - 860 nm

Spectral observations
SVC GER 1500 Spectroradiometer was used for collecting the data of spectral reflectance in the Visible and Near Infra Red (NIR) regions of electromagnetic radiation. Inside the dark room, a set arranged with SVC GER 1500 Spectroradiometer was used to take the spectral observations of different soil samples collected, where ordinary lamps of 60 W from both sides were used as the light sources falling upon the object. Barium sulphate plate was used as reference for each radiance measurement of objetcs.

Instruments used for collection of spectral data
SVC GER 1500 Spectroradiometer is a self-contained instrument which integrates the spectroradiometer with an internal CPU and battery so that measurements can be done by using only one hand. This instrument is connected with a wireless bluetooth to a PDA (Personal Digital Assistant) where data can be viewed quickly. The measurable spectral range of this instrument is 350 nm to 1050 nm, with 512 spectral channels, 1.5 nm bandwidth and 3.2 nm resolution.

Results and Discussion
Spectral reflectance of vermicompost (dry and moist) in Red and NIR bands
Spectral reflectance of dry and moist vermicompost was measured under the five selected bands from Red and NIR regions of EMR. Figure 1 shows the nature of reflectance of vermicompost under dry and moist condition of vermicompost. The reflectance of dry and moist vermicompost over 350 to 1050 nm wavelength range showed that from 350 to 550 nm and from 900 to 1050 nm, the differences between dry and moist did not show any differences rather they are merged. However there was difference in reflectance due to dry and moist condition of vermicompost between 550 to 850 nm.

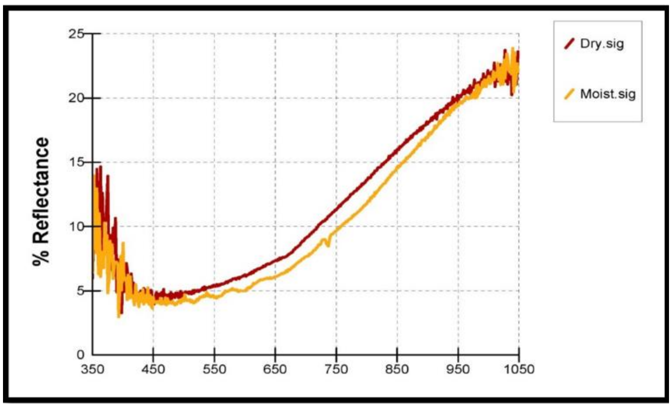

Fig 1: Reflectance of vermicompost at dry and moist conditions

It was noticed that the spectral reflectance of vermicompost changes with moisture content. Under high moisture content (wet condition) the spectral reflectance was at lower magnitude as compared in dry condition of vermicompost. Table 4 shows the mean Red reflection (7.4% for dry and 6.2% for moist) and mean NIR reflection (16.2% for dry and 14.8% for moist) for vermicompost. Daughtry (2001) [2] studied over this and found the similar results. Maximum mean Red reflectance of 6.8% and NIR reflection of 15.5%. We found 658-660 nm as the best Red wavelength range and 858- 860 nm as the best NIR wavelength range which showed maximum spectral reflection. These findings matches to Huete and Escadafal (1991) [3] who noted that the soils rich in organic matter frequently had the maximum reflectance curves between 500 nm and 1300 nm.

Table 4: Spectral reflectance of vermicompost (dry and moist) in Red and NIR bands

Sr. No	Red bands	Red reflectance		Mean	NIR bands	NIR reflectance		Mean
		Dry	Moist			Dry	Moist	
1	650 -652	0.073	0.061	0.067	850- 852	0.160	0.146	0.153
2	652 -654	0.074	0.061	0.068	852- 854	0.161	0.146	0.154
3	654 -656	0.074	0.062	0.068	854- 856	0.162	0.147	0.155
4	656-658	0.074	0.062	0.068	856- 858	0.162	0.149	0.156
5	658-660	0.075	0.063	0.069	858- 860	0.164	0.150	0.157
Mean		0.074	0.062	0.068	Mean	0.162	0.148	0.155

(reflectance mentioned here = value X 1/100)

Spectral reflectance of yellow soil under various levels of organic matter
The spectral behaviour of yellow coloured soil is very distinct and clear. With increase in vermicompost level there was increase in reflectance, and as observed in Figure 2 which depicts the spectral behaviour of yellow soil against the wavelength 350 nm to 1050 nm. It is noticed that up to 450 nm wavelength, there was more noise and reflectance was intermingled. However after 450 nm the reflectance was increased continuously up to 1050 nm. However the difference was clear between 450 to 950 nm. Further, in general it was noticed that with increase in vermicompost to yellow soil there was decrease in reflectance. It is clear in the

figure that S3T1 and S3T2 *i.e.* yellow soil 1.5 kg + 100 gm VC and yellow soil 1.5 kg + 250 gm VC showed higher reflectance at all wavelengths than S3T3, S3T4 and S3T5 (*i.e.* addition of 500 gm, 1kg and 1.5 kg of vermicompost, respectively). However the only yellow soil showed intermediate reflectance which shows irractic behaviour.

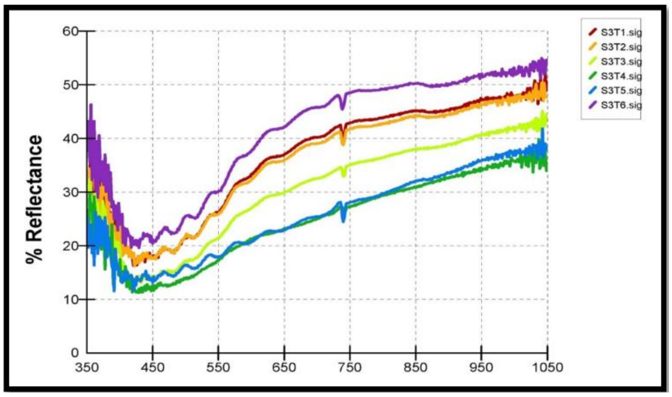

Fig 2: Reflectance of yellow soil under various levels of organic matter

(a) Spectral reflectance of yellow soil under various levels of organic matter in selected Red bands

From the values of reflectance obtained for five selected bands of red region (Table 5), it is observed a maximum reflection (43.1%) for the treatment of yellow soil alone. When the addition of organic matter happens, it is cleared that the reflectance property tends to be decreased. Among the treatments, yellow soil which had combination with 100 g vermicompost showed maximum reflectance (37.8%) and treatment of yellow soil with 1.5 kg vermicompost showed minimum reflectance (23.4%). Daughtry (2001) [2] in his work on soil spectral reflectance, noticed a similar trend.

Table 5: Spectral reflectance of yellow soil under various levels of organic matter in Red bands

Sr. No	Red bands (nm)	Corrected red reflectance						Mean
		S1T1	S1T2	S1T3	S1T4	S1T5	S1T6	
1	650 -652	0.371	0.360	0.300	0.230	0.232	0.422	0.319
2	652 -654	0.373	0.362	0.301	0.231	0.233	0.424	0.321
3	654 -656	0.375	0.364	0.303	0.233	0.234	0.428	0.323
4	656-658	0.375	0.365	0.303	0.234	0.234	0.429	0.323
5	658-660	0.378	0.367	0.305	0.235	0.234	0.431	0.325
Mean		0.374	0.364	0.302	0.233	0.234	0.427	0.322

(reflectance mentioned here = value X 1/100 and (S3T1;1.5 kg yellow soil:100 g VC, S3T2;1.5 kg yellow soil:250 g VC, S3T3;1.5 kg yellow soil:500 g VC, S3T4;1.5 kg yellow soil:1 kg VC, S3T5;1.5 kg yellow soil: 1.5 kg VC, S3T6;1.5 kg yellow soil only)

(b) Spectral reflectance of yellow soil under various levels of organic matter in selected NIR bands

From the values of reflectance obtained for five selected bands of NIR region (Table 6), it is observed a maximum reflection (50.3%) for the treatment of yellow soil alone. When the addition of organic matter happens, it is cleared that the reflectance property tends to be decreased. Among the treatments, yellow soil which had combination with 100 g vermicompost showed maximum reflectance (45.2%) and treatment of yellow soil with 1.5 kg vermicompost showed minimum reflectance (31.3%). Daughtry (2001) [2] also noticed a similar trend in his work.

Table 6: Spectral reflectance of yellow soil under various levels of organic matter in NIR bands

Sr. No	Red bands (nm)	Corrected red reflectance						Mean
		S1T1	S1T2	S1T3	S1T4	S1T5	S1T6	
1	850- 852	0.452	0.443	0.381	0.321	0.310	0.503	0.402
2	852- 854	0.451	0.441	0.381	0.321	0.311	0.502	0.401
3	854- 856	0.450	0.443	0.381	0.322	0.311	0.502	0.402
4	856- 858	0.452	0.442	0.382	0.323	0.312	0.502	0.402
5	858- 860	0.452	0.443	0.383	0.324	0.313	0.503	0.403
Mean		0.451	0.442	0.382	0.322	0.311	0.502	0.402

(reflectance mentioned here = value X 1/100 and (S3T1;1.5 kg yellow soil:100 g VC, S3T2;1.5 kg yellow soil:250 g VC, S3T3;1.5 kg yellow soil:500 g VC, S3T4;1.5 kg yellow soil:1 kg VC, S3T5;1.5 kg yellow soil: 1.5 kg VC, S3T6;1.5 kg yellow soil only)

From these figures it was inferred that base colour of soil dominates the spectral reflectance. Even if there was increase in organic matter level to the extent of 1:1 proportion. It is also cleared that, eventhough the shape of graph remains same for different combinations, as the organic matter increases, the widening of spectral curves happening in between same combination of vermicompost with different type of soil. It is confirmed that mineralogical makeup of soil influence the spectral behaviour of yellow soil at a great extent. Further yellow coloured soil has more amount of quartz and to some extent limonite, thus soils shows less complexity as compared to other soils. The composition of organic matter with respect to humic acid, fluvic acid and humin content which have also impact on spectral behaviour of this soils.

Conclusions

- With increase in vermicompost addition to soil there was decrease in reflectance inspite of soil type.
- Spectral property of soil is also influenced by the mineralogical makeup of that soil.
- 658- 660 nm in Red region and 858- 860 nm NIR region showed maximum reflectance for black and red soils.
- Reflectance data can be used to distinguish between different coloured soils.

Way Forward

- The detailed study with hyperspectral bands between 650 nm to 660 in Red region and 858- 860 nm NIR region will focus light on the signatures of these soils and organic matter.

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