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Spectral behaviour of red soil of Maharashtra under various levels of organic matter

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Abstract
This study on spectral behaviour of red soil of Maharashtra 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 red soil (S2) 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 red soil there was decrease in reflectance. It is found that S2T1 and S2T2 *i.e.* red soil 1.5 kg + 100 gm VC and red soil 1.5 kg + 250 gm VC showed higher reflectance at all wavelengths than S2T3, S2T4 and S2T5 (*i.e.* addition of 500 gm, 1kg and 1.5 kg of vermicompost, respectively). Red soil made two clear cut zones of reflectance. 1.5 kg red soil with 1 kg and 1.5 kg vermicompost recorded minimum reflectance. While addition of lower amount of vermicompost *i.e.* 100, 200 and 500 gm depicted higher reflectance from wavelength 550 to 850 nm. Red 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
Induction of scientific tools and techniques like Remote Sensing (RS) are essential for holistic analysis of whole gamut of resources and quick retrieval of the data. Among all the techniques remote sensing has emerged as a very useful tool for mapping and monitoring of various natural resources. In general remote sensing is defined as the science and art of obtaining information about an object, area or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area and phenomenon in the investigation (Lillesand and Kiefer, 1994) [6]. In the remote sensing systems, spectral reflectance studies operate in the wavelength regions in which reflected energy is predominant. The reflectance character of earth surface or plants is quantified by measuring the portion of incident energy that undergone reflection later. This is a function of wavelength which is called spectral reflectance and it is expressed in percentage. A graph of spectral reflectance of an object as a function of characteristic wavelength is termed as spectral reflectance curve. The configuration of spectral reflectance curve gives us an insight into the spectral characteristic of an object and has strong influence on the choice of wavelength region in which the remote sensing data need to be acquired for a particular application. Studies has shown that some features of interest cannot be spectrally separated. Thus to utilize remote sensing data effectively, one must know and understand the spectral characteristic of the particular feature under investigation and what are all the factors affect these characteristics.

The possibility to identify the spectral variations, normally linked to specific absorption phenomena, makes the reflectance spectroscopy an important tool in the study of soil composition in the laboratory, field or through satellite images (Dematte *et al.*, 2004) [4]. Soil reflectance data can be acquired in the laboratory or in the field and from both sky and orbit. Unlike in the laboratory soil reflectance measurements which are done under controlled conditions, reflectance measurements are encumbered by problems such as variation in the viewing angle, illumination changes, soil roughness and exact ground position *etc.* in the case of field reflectance measurements. The wide spectral range found by different workers to assess organic matter content suggested that organic matter is important factor which affect across the entire spectral region. It plays a major role with respect to many chemical and physical processes in the soil environment, and has a strong significance on soil reflectance characteristics (Ben-Dore, 2001) [1].

Methodology

Collection of different coloured soils

The red color soil used for the six treatments belongs to Pangari series, which is a member of fine loamy skeletal, mixed isohyperthermic family of Typic Haplustepts (Challa *et al.*, 2008) [2]. This soil was sandy clay loam (53.23% sand, 26.12 % silt and 20.63 % clay) in texture. One and half kilogram of red soil were collected from Ratnagiri, Maharashtra (17º00'04.1"N, 73º31'53.1"E) on 16.11.2016.

Processing of soil samples

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. Red soil showed acidic nature (6.3) and ectrical conductivity was very low. This soil was very high in organic carbon content (Table 1). They processed and mixed accordingly to make various combinations of red 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 red 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 (%)
Red soil	6.3	0.120	1.20	0.41	1.60

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

Symbol used	Combinations
S2	Red soil
S2T1	1.5 kg red soil+100 g VC
S2T2	1.5 kg red soil+250 g VC
S2T3	1.5 kg red soil+500 g VC
S2T4	1.5 kg red soil+1 kg VC
S2T5	1.5 kg red soil+1.5 kg VC
S2T6	1.5 kg red 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

This 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.

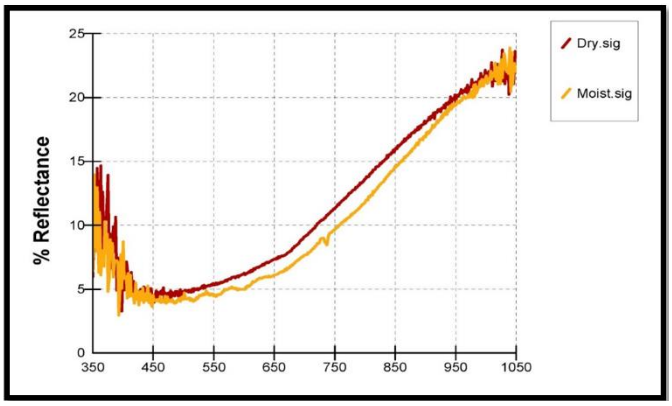

Fig 1: Reflectance of vermicompost at dry and moist conditions

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) [3] 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) [5] 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 red soil under various levels of organic matter

The data presented in Figure 2 in respect of red soil made two clear cut zones of reflectance. 1.5 kg red soil with 1 kg and 1.5 kg vermicompost recorded minimum reflectance. While addition of lower amount of vermicompost *i.e.* 100, 200 and 500 gm depicted higher reflectance from wavelength 550 to 850 nm. Even in this wavelength ranges differences are widen and distinct.

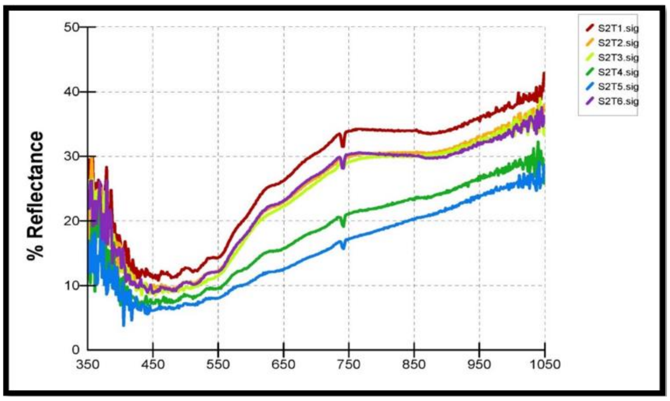

Fig 2: Reflectance of red soil under various levels of organic matter

(a) Spectral reflectance of red 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 (27.1%) for the treatment of red soil alone. When the addition of organic matter happens, it is cleared that the reflectance property tends to be decreased. Among the treatments, red soil which had combination with 100 g vermicompost showed maximum reflectance (23.8%) and treatment of red soil with 1.5 kg vermicompost showed minimum reflectance (12.9%). Daughtry (2001) [3] also noticed a similar behaviour of reflectance with organic matter in soil.

Table 5: Spectral reflectance of red 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	0.232	0.230	0.223	0.157	0.126	0.263	0.205
2	652 -654	0.233	0.231	0.225	0.158	0.126	0.265	0.206
3	654 -656	0.235	0.234	0.227	0.160	0.127	0.267	0.208
4	656-658	0.236	0.235	0.227	0.161	0.128	0.268	0.209
5	658-660	0.238	0.237	0.229	0.163	0.129	0.271	0.211
Mean		0.235	0.233	0.233	0.160	0.127	0.267	0.208

(reflectance mentioned here = value X 1/100 and (S2T1;1.5 kg red soil:100 g VC, S2T2;1.5 kg red soil:250 g VC, S2T3;1.5 kg red soil:500 g VC, S2T4;1.5 kg red soil:1 kg VC, S2T5;1.5 kg red soil: 1.5 kg VC, S2T6;1.5 kg red soil only)

(b) Spectral reflectance of red 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 (34 %) for the treatment of red soil alone. When the addition of organic matter happens, it is cleared that the reflectance property tends to be decreased. Among the treatments, red soil which had combination with 100 g vermicompost showed maximum reflectance (30.6%) and treatment of red soil with 1.5 kg vermicompost showed minimum reflectance (20.5%). Daughtry (2001) [3] also observed similar trend of reflectance with organic matter.

Table 6: Spectral reflectance of red 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	0.305	0.300	0.300	0.234	0.203	0.337	0.281
2	852- 854	0.306	0.301	0.300	0.235	0.205	0.339	0.281
3	854- 856	0.305	0.300	0.299	0.235	0.204	0.338	0.280
4	856- 858	0.305	0.300	0.300	0.236	0.205	0.338	0.281
5	858- 860	0.306	0.301	0.300	0.236	0.205	0.340	0.281
Mean		0.305	0.300	0.300	0.235	0.204	0.338	0.281

(reflectance mentioned here = value X 1/100 and (S2T1;1.5 kg red soil:100 g VC, S2T2;1.5 kg red soil:250 g VC, S2T3;1.5 kg red soil:500 g VC, S2T4;1.5 kg red soil:1 kg VC, S2T5;1.5 kg red soil: 1.5 kg VC, S2T6;1.5 kg red soil only)

These results might be because of mineralogical makeup of soil. As we know that red coloured soil has more haematic, magnetic, pyrite type of mineralogical makeup, which is comparatively less complex than 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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