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

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Abstract
An investigation on spectral behaviour of black 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 black soil (S1) 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 black soil there was decrease in reflectance. It is found that S1T1 and S1T2 *i.e.* black soil 1.5 kg + 100 gm VC and black soil 1.5 kg + 250 gm VC showed higher reflectance at all wavelengths than S1T3, S1T4 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 black soil depicted higher reflectance. Black 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 natural resources sectors are immensely important to India's economy. Optimal exploitation of the resources (both renewable and non-renewable) with proper enriching mechanism calls for cutting across the narrow confines of sectoral approaches and taking a holistic view of the region. Induction of scientific tools and techniques like Remote Sensing (RS), Geographical Information System (GIS) and Global Positioning System (GPS) 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. Remote sensing measures Electro Magnetic Energy (EME) from the sun or emitted by the sensor itself (microwave sensor) which is reflected, scattered or emitted by different surface features on the earth. Detection and measurement of these spectral signatures enable identification of the surface features by remote sensing satellites. The remote sensing field brings information obtained from interaction of electromagnetic radiation with matter into the region visible to human eye and provides a spatial overview of even invisible data (Ben-Dore, 2001) [1].

The soil spectral reflectance signatures result from the presence or absence, as well as the position and shape of specific absorption features of it's constituents. Absorption is brought about by various chemical or physical phenomena such as intermolecular vibrations and electronic processes in atoms. Electromagnetic energy is either emitted or absorbed when an atom or molecule changes from one characteristic energy level to another. Regarding the spectral reflectance behaviour of soil, the factors that influence soil reflectance act over less specified spectral bands which are soil colour, moisture content, soil texture, surface roughness, presence of iron oxide and organic matter content. Thus the soil spectral behaviour is determined by the cumulative property resulting from the intrinsic spectral behaviour of the heterogenic combinations of mineral and organic materials and their humidity (Stoner and Baumgardner, 1981) [4].

Methodology

Collection of soil sample

The soil used for the six treatments was black in colour and clay (55% clay) in texture. Taxonomically it is classified as fine smectitic calcareous isohyperthermic Typic Haplustert. One and half kilogram of soil was collected from Parbhani, Maharashtra (19º14’56.5”N, 76º47’19.2”E) on 13.10.2016.

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. Black soil showed alkaline nature (pH 7.6) and ectrical conductivity was very low. This soil was medium in organic carbon 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 (%)
Black soil	7.6	0.110	0.55	0.48	1.03

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

Symbol used	Combinations
S1	Black soil
S1T1	1.5 kg blacksoil+100 g VC
S1T2	1.5 kg black soil+250 g VC
S1T3	1.5 kg black soil+500 g VC
S1T4	1.5 kg black soil+1 kg VC
S1T5	1.5 kg black soil+1.5 kg VC
S1T6	1.5 kg black 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.

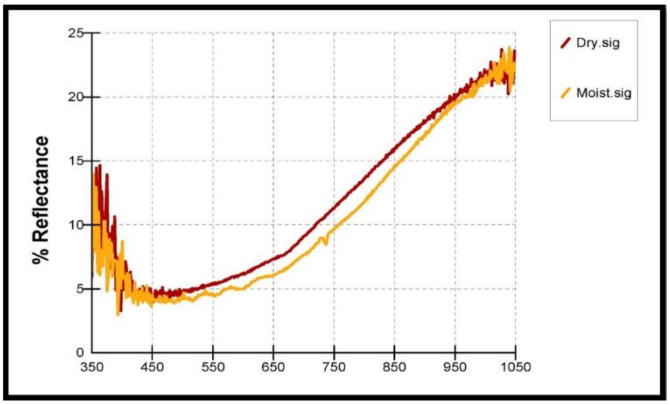

Fig 1: Reflectance of vermicompost at dry and moist conditions

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 black soil under various levels of organic matter

Figure 2 depicts the spectral behaviour of black 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 black soil there was decrease in reflectance. It is clear in the figure that S1T1 and S1T2 *i.e.* black soil 1.5 kg + 100 gm VC and black soil 1.5 kg + 250 gm VC showed higher reflectance at all wavelengths than S1T3, S1T4 and S1T5 (*i.e.* addition of 500 gm, 1kg and 1.5 kg of vermicompost, respectively). However the only black soil showed intermediate reflectance which shows irractic behaviour.

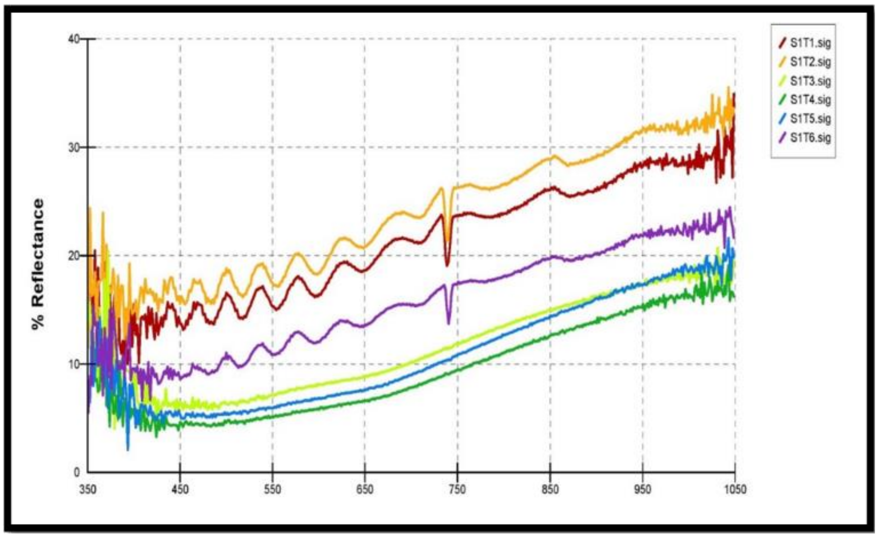

Fig 2: Reflectance of black soil under various levels of organic matter

(a) Spectral reflectance of black 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 (21.7%) for the treatment of black soil alone. When the addition of organic matter happens, it is cleared that the reflectance property tends to be decreased. Among the treatments, black soil which had combination with 100 g vermicompost showed maximum reflectance (19.5%) and treatment of black soil with 1.5 kg vermicompost showed minimum reflectance (6.8%). These findings shows similarities with Daughtry (2001) [2] who observed that the soil samples with high organic matter content showed lower spectral reflectance.

Table 5: Spectral reflectance of black 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	0.187	0.136	0.088	0.076	0.066	0.208	0.127
2	652 -654	0.188	0.137	0.089	0.077	0.066	0.211	0.128
3	654 -656	0.190	0.138	0.089	0.077	0.067	0.212	0.129
4	656-658	0.192	0.139	0.090	0.078	0.068	0.214	0.130
5	658-660	0.195	0.141	0.090	0.078	0.068	0.217	0.132
Mean		0.190	0.138	0.089	0.077	0.066	0.212	0.129

(reflectance mentioned here = value X 1/100 and S1T1;1.5 kg black soil:100 g VC, S1T2;1.5 kg black soil:250 g VC, S1T3;1.5 kg black soil:500 g VC, S1T4;1.5 kg black soil:1 kg VC, S1T5;1.5 kg black soil: 1.5 kg VC, S1T6;1.5 kg black soil only)

(b) Spectral reflectance of black 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 (29.1%) for the treatment of black soil alone. When the addition of organic matter happens, it is cleared that the reflectance property tends to be decreased. Among the treatments, black soil which had combination with 100 g vermicompost showed maximum reflectance (26.3%) and treatment of black soil with 1.5 kg vermicompost showed minimum reflectance (12.9%). Daughtry (2001) [2] also noticed similar trend of spectral reflectance with addition of organic matter.

Table 6: Spectral reflectance of black 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	0.262	0.198	0.150	0.144	0.127	0.289	0.195
2	852- 854	0.259	0.199	0.150	0.144	0.127	0.291	0.195
3	854- 856	0.262	0.199	0.151	0.145	0.127	0.290	0.196
4	856- 858	0.261	0.198	0.151	0.146	0.128	0.291	0.196
5	858- 860	0.263	0.199	0.152	0.147	0.129	0.291	0.197
Mean		0.261	0.199	0.151	0.145	0.128	0.290	0.196

(reflectance mentioned here = value X 1/100 and S1T1;1.5 kg black soil:100 g VC, S1T2;1.5 kg black soil:250 g VC, S1T3;1.5 kg black soil:500 g VC, S1T4;1.5 kg black soil:1 kg VC, S1T5;1.5 kg black soil: 1.5 kg VC, S1T6;1.5 kg black soil only)

From the above results it is confirmed that mineralogical makeup of soil influence the spectral behaviour of black soil at a great extent. It is shown that black soils are more complex in their mineralogical assembledge 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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