SPECTRAL RESPONSE FOR DIFFERENT SOILS UNDER VARYING MOISTURE CONDITIONS

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ABSTRACT

Remote sensing is now in a strong position to provide meaningful spatial data for use in soil science investigations. In the last 10 years, advancements in remote sensing techniques and technologies have given rise to a wealth of exciting new research findings in soil-related disciplines. The use of very high spectral and spatial resolution remote sensing tools in soil mapping is becoming increasingly useful to reduce times and expenses, that are typical of conventional field surveys and of laboratory analysis. Modern satellite- or air-borne hyperspectral imaging systems, working in the VNIR and SWIR spectral ranges, provide high-resolution reflectance spectra, characterized by hundreds of narrow, contiguous spectral bands, thus allowing identification and mapping of a wide range of surface materials. The theoretical basis for measuring the soil moisture is based on the large contrast between the dielectric properties of liquid water and dry soil. In the present study, measurements of reflectance of different types of soils were acquired in a laboratory for three different soils at various moisture contents. Soil moisture content had strong influence on spectral reflectance. The same type of reflectance depressions are observed in all the graphs at the different wave lengths such as 650, 750 and 900 nm and the maximum reflectance is different for different soil. The results of this study help to quantify the type of soil and the soil moisture content in the sample by observing the reflectance of the spectral curve.

INTRODUCTION

Remote sensing technology has been successfully used in studying the various aspects of soils in spatial and temporal domain. The data obtainable from the sensors placed in a satellite or aircraft or ground level could be interpreted as a function of soil properties. Therefore, spectral reflectance of soils plays an important role in extracting information on different types of soils and land degradation. The techniques make use of the data obtained from different regions of electromagnetic spectrum viz., visible, infrared, thermal and microwave regions.

A good number of studies carried over nearly three decades testifies the role of remote sensing in soil related studies. The interpretation techniques have also under gone change over a period of time on par with satellite spatial and spectral resolutions. In this paper the application of geospatial technology in the study of the spectral reflectance’s of soils, soil moisture along with important issues and prospects are discussed.

Understanding the spectral reflectance properties of the soils is a fundamental to many applications of remote sensing in soils. The soil reflectance data can be acquired in the laboratory or in the field and from air/space. In the laboratory the soil reflectance measurements are made under controlled conditions, which may enable to understand the relationship between the physical and chemical properties of soil and soil reflectance. In the field, reflectance measurements are made with the help of the portable field spectrometers/ radiometers. Field soil spectroscopy will help in rapid point to point measurement of soil properties. In case of soil reflectance from air/space, the soil reflectance values can be obtained over a large area and reflectance can be studied in spatial domain. But the factors like low signal to noise ratio and atmospheric attenuations have a critical effect on these measurements.

Besides this the thermal infrared regions (3-5 μm and 8-12 μm) to provide the diagnostic information about the soils. Spectrometers, radiometers and polarimeters provide quantitative measurement of reflected energy from soil and have found applications in studying the various aspects of soils.

REVIEW LITERATURE

Soil moisture is an important factor across a range of environmental processes, including plant growth, biogeochemistry, erosion, and land atmosphere heat and water exchange (e.g., Wigneron et al., 1998). Surface soil moisture plays a key role to understand the exchange of water and heat energy between the land surface and the atmosphere through evaporation, to evaluate soil traffic ability (Idso et.al , 1975), to characterize plant health (Muller and De´ camps, 200)or soil texture features like soil organic carbon or clay contents. Giridhar et al 2014 developed the spectral signatures of the different crops by using the spectroradiometer which helps in the differentiation of the different types of crop based on the spectral reflectance or the spectral library. Nevertheless, the quality of the retrieved soil moisture is highly dependent on the surface roughness (Nocita et al 2013, Wang et al 1997). Timely and accurate estimates of soil moisture are therefore highly desirable for understanding and modeling these processes. Spectral data on the selected cultivars to be collected using spectroradiometer. All the spectral measurements are to be collected during 1100–1400 hr noon time to avoid the impact of illumination changes on the spectral responses Spectral data to be recorded as reflectance values and then imported into a spreadsheet for further analysis (Sowmya and Giridhar 2014) Remote sensing approaches have primarily focused on microwave wavelengths, where moisture exerts strong control over soil dielectric properties, where measurements are not impeded by clouds or darkness (Njoku and Entekhabi, 1996). Moisture also greatly influences the reflection of shortwave radiation from soil surfaces in the VNIR (400–1100 nm) and SWIR (1100–2500 nm) regions of the spectrum (Bowers and Hanks, 1965;).

However, quantification of moisture using these wavelengths remains difficult because of significant variability from other soil chemical and physical properties, such as organic matter and mineralogy, well as vegetation cover (Asner, 1998; Ben-Dor et al., 1999). On the other side, hyperspectral imagery has demonstrated its potential to retrieve the soil moisture but its performance depends on the soil color and texture, the presence of organic material and crusts [7–10]. Further, the penetration depth in the optical domain is significantly lower and can only allow us to quantify the uppermost layer in a soil column. The familiar darkening of soil upon wetting is because of a change in the real part of the refractive index (n) of the immersion medium from air ($n= 1$) to water ($n= 1.33$) (Twomey et al., 1986). This decreases the contrast between soil particles ($n \approx 1.5$) and their surrounding medium, resulting in an increase in the average degree of forward scattering and, thus, an increased probability of absorption before reemerging from the medium (Bryant et al. 2003).

The reflectance of the soil differs at different soil moisture contents by the study on red soils in the laboratory conditions (Giridhar et.al 2016). Numerous studies have investigated the relationships between wet and dry soil reflectance, noting an overall decrease in reflectance upon wetting (Baum gardner et al., 1985; Bowers and Hanks, 1965; Twomey et al., 1986). Fewer studies have addressed soil reflectance at intermediate moisture levels although partially wet conditions are more likely than complete saturation in natural soils (Idso et al. (1975) provided empirical evidence that soil albedo decreases linearly with reflectance, but subsequent studies have challenged this view.

PROCEDURE

An understanding of spectral signatures is essential in the understanding and interpretation of a remotely sensed image. Different materials are discriminated by wavelength-dependent absorptions, and these images of reflected solar energy are known as spectral signatures. The property that is used to quantify these spectral signatures is called spectral reflectance. This is a ratio of the reflected energy to incident energy as a function of wavelength (Smith, 2001b). The graph of the spectral reflectance of an object as a function of wavelength is termed the spectral reflectance curve (Lillesand and Kiefer, 1999).

The configuration of the spectral reflectance curves is important in the determination of the wavelength region(s) in which remote sensing data is acquired as the spectral reflectance curves give insight into the spectral characteristics of an object (Lillesand and Kiefer, 1999). Spectral signatures obtained from multispectral images are discrete compared to the contiguous signatures obtained from hyperspectral images. Contiguous spectral signatures allow for detailed analysis through the detection of surface materials and their abundances, as well as inferences of biological and chemical processes.

Note that, in the visible (400-700nm), the shape of the curve does not change greatly, corresponding to the perception that wet soil is darker, but essentially the same color as dry soil. In fact, there are spectral changes in the visible, but they are relatively subtle . The gross change in amplitude is largely true through the near infrared as well. In the short wave infrared, however, there are significant changes in the reflectance spectra that are directly associated with the increased water content that are either masked by the water absorption or minimized by the presence of water. It is apparent that, if field spectra or remotely sensed spectra of soils are to be used to evaluate soil properties, it will be necessary to account for the spectral effects resulting from the presence of water in the soil

Reflectance measurements were acquired in a laboratory setting using a range of 350–1050 nm SVC HR 512i spectrometer with a 4° FOV lens, with a resolution of ≤ 3.5 nm FWHM @ 700 nm with an integration speed of 10-1000 ms. the total no of bands covered by the instrument is 512 bands. A reflectance measurement takes the scan of a reference (white plate) and calculates the ratio of the target scan to that reference the spectral measurements are taken using the laser point of the instrument. First the white plate reference is taken for the calibration o f the instrument. The disturbed soil samples like the sand, red soil, black soil are taken to the laboratory and the spectral measurements are collected for the dry samples and the water is added to the samples to maintain the same moisture contents in all the samples using the soil moisture meter and then the spectral reflectance is collected for the soil samples at the same moisture concentration.

Some of the factors effecting soil reflectance are moisture content, soil texture (proportion of sand, silt, and clay), surface roughness, presence of iron oxide and organic matter content. These factors are complex, variable, and interrelated. For example, the presence of moisture in soil decreases its reflectance. As with soil, this effect is greatest in the water absorption bands at 450, 550and 650 nm. On the other hand, similar absorption characteristics are displayed by the soil at 0% soil moisture content.

The reflectance curves of the different soils at 0% soil moisture content is shown in figure 1 where the maximum reflectance can be seen at 550 nm and the maximum reflectance of sandy soil is about 160.8%, and of black soil is 130% and the red soil has the low reflectance of about 30%. The reflectance curve for moisture content 4.5% is as shown in figure 2 shows the least reflectance at the 550 nm wave length which is highly important and differentiating factor for differentiating the wetted soils. Soil moisture content is strongly related to the soil texture. For example, coarse, sandy soils are usually well drained, resulting in low moisture content and relatively high reflectance. On the other hand, poorly drained fine textured soils generally have lower reflectance. In the absence of water, however, the soil itself exhibits the reverse tendency i.e., coarse textured soils appear darker than fine textured soils.

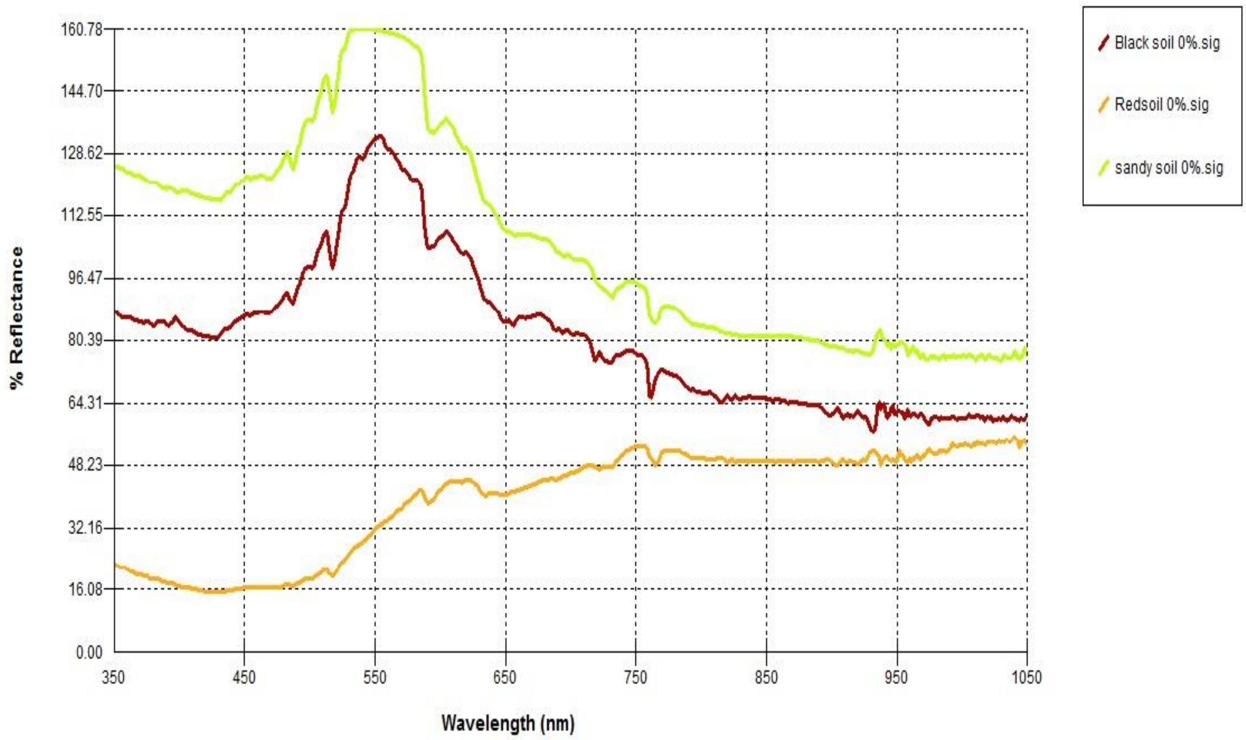

Figure 1: Reflectance curves of the Black, Red and Sandy soil at 0% moisture content.

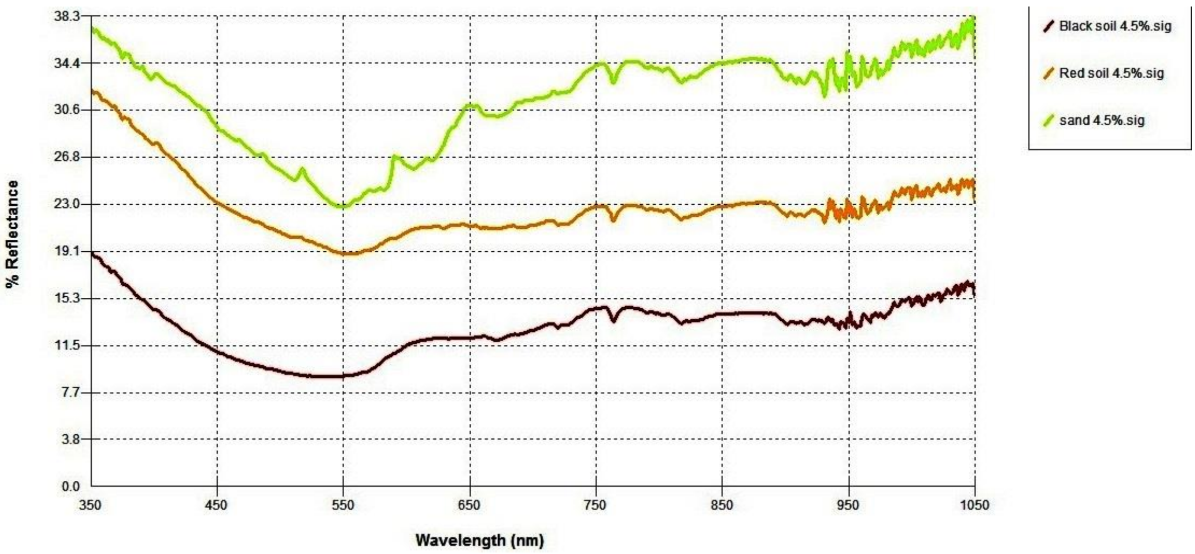

Figure 2: Reflectance curves of the Black, Red and Sandy soil at 4.5% moisture content.

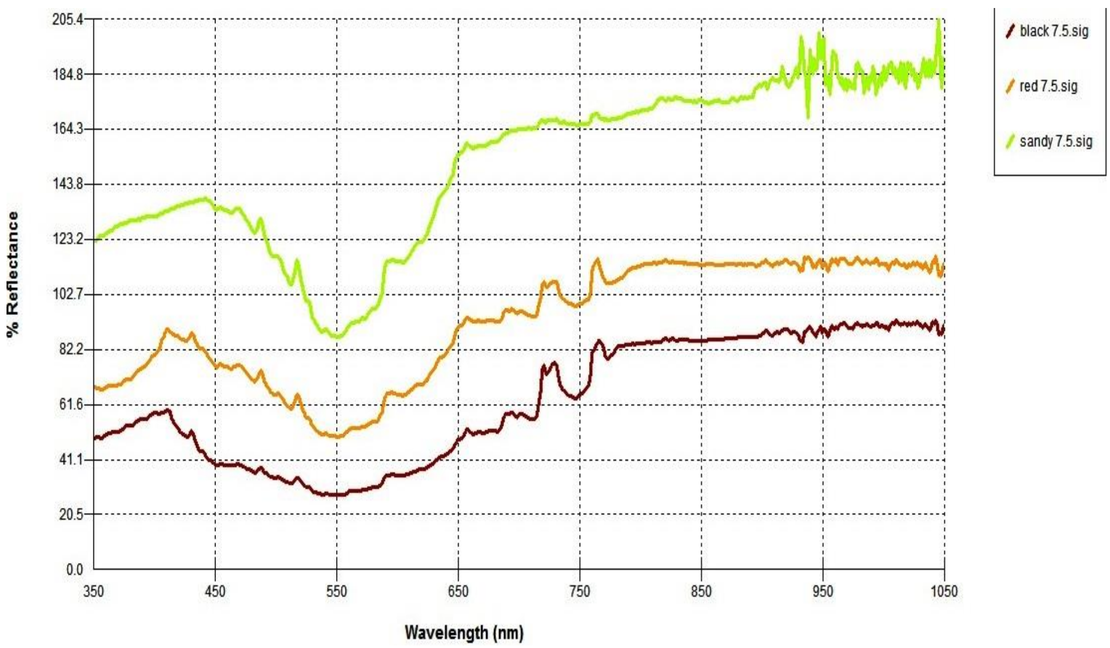

Figure 3: Reflectance curves of the Black, Red and Sandy soil at 7.5% moisture content.

CONCLUSIONS

At 550 nm wave length the maximum reflectance of the soils at the zero moisture content is observed for the three soils: i.e. red , black and sandy soils, at which the minimum reflectance is also seen at the same wave length for the same soils at 4.5 % and 7.5% soil moisture content. And the same type of reflectance depressions can be observed in both the graphs at the different wave lengths like the 650, 750 and 900 nm. The reflectance % also differs for the different soils at different soil moisture contents. The red soil at different moistures like 0%, 4.5%, 7.5% has the different reflectance % as 20%, 32%, 65% respectively. The black soil at different moistures like 0%, 4.5%, 7.5% has the different reflectance % as 95%, 20%, 50% respectively The sandy soil at different moistures like 0%, 4.5%, 7.5% has the different reflectance % as 128%, 37%, 123% respectively. So by observing the maximum reflectance changes at the 450nm to 650 nm and the dips near 750nm the moisture content of the soils can be identified as the reflectance will differ for different soils at different soil moisture contents.

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