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Analysis of Soil using Spectral Signatures

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***Abstract* - Soil contains organic matter, clay and particles of rock. The composition of soil varies physically as well as chemically which is important for plant growth. The traditional techniques to measure soil contents are time consuming while remote sensing provides efficient techniques for mapping these contents. The visible infrared, near infrared and short wave infra red bands of electromagnetic spectrum are used to study the soil without destructing its properties. In this paper we present the study of soil spectral signatures. The study of soil is carried out using spectral signatures obtained by using ASD field spectrometer. The association between the spectral data and the soil contents is carried out. The soil samples were collected from Shendra and Chikhalthana in Aurangabad district Maharashtra state (India). Principal component analysis is applied to these spectra for classification purpose.** .

***Keywords:*--- Spectral signature, soil nutrients, soil classification, principal component analysis.**

I. INTRODUCTION

Good information of soil nutrients is important in agriculture for the growth of crops. According to the author characteristics of soil can be chemical, biological, mineralogical and physical [1]. Research in [2] says that the use of traditional chemical methods are precise but are time consuming and costly. Thus they fail to meet the modern agricultural needs. Remote sensing provides quick and environmental friendly techniques to assess soil attributes. Hyper spectral remote sensing gives detail information of soil spectral characteristics to monitor soil nutrients. The surface properties and chemical elements of soil can provide important information of organic matter present in soil, quality of soil, moisture content in soil, salinity, soil texture etc. Spectral imaging provides a way to map and measure certain soil properties. In near infrared reflectance analysis (NIRA), Near Infrared (0.4-1.0μm) region of the electromagnetic spectra was used. Also the VIS-NIR (Visible near infrared) and SWIR (short wave IR) region were suitable for analysis of soil. For the optimal prediction of soil constituents about 350-700 bands were required. Using this, the inter correlation of soil features between featureless constituents of soil and constituents with features was allowed [3]. As studied, VIS region contains the information of minerals in soil like iron oxides, clay minerals, carbonates, soil organic matter, vegetation yield and water content, soil roughness [4].

As stated by the authors, spectral data is a high dimensional data. To reduce this high dimensionality and compress into limited variables principal component analysis was implemented on the spectral regions. Regression analysis was later applied to predict the mapping between data and principal components [5]. Euclidean distance was calculated to describe similarities and dissimilarities between soil samples [6].

II. SPECTRAL PROFILE OF SOIL

As studied from [6], the visible near infrared and short wave infrared region absorbed features are overtone or combined in infrared region of the electromagnetic spectrum.

The soil properties were distributed in the following way in the VIS - IR – SWIR region of electromagnetic spectrum:

1. VIS (400-700 nm) range – Soil Color
2. Broad and shallow bands near 500-700nm – Iron oxides, oxy hydroxides, hydroxides
3. Narrow bands near 1400-1900 nm – hydroxyl and water molecules
4. Beyond 2000 nm – Clay minerals, organic constituents, carbonates, salt minerals

Organic carbon, clays and carbonates are important constituents of soil. Their spectral sub regions are defined as follows:

Table1. : Spectral sub regions

Soil Content	Spectral Sub region
Organic carbon	350 – 1100 nm
Calcium carbonate	2280 – 2390 nm
Clay	2170 – 2290 nm

Other absorptions by the soil constituents occur throughout the 350 – 2500 nm range but they are difficult to recognize as they represent weaker tones of soil.

Since spectral reflectance of soil is different for different bands and these bands are mapped to specific content in soil, soil reflectance was used effectively for identifying the contents of soil.

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Thus, it can be concluded from [7] that visible and near infrared region gives an alternative to conventional laboratory soil analysis.

III. DATA PREPARATION

The study area selected is located at two different sites from the Marathwada region of Maharashtra state in India. The sites were Shendra and Chikhalthana.

The soil samples were collected from the surface of the earth. The experiments were done to collect spectral data of soil with the help of ASD Field spec Pro: Analytical Spectral device in the range of 350 – 2500 nm wavelengths. The soil material was air dried and sieved with a 2mm mesh. The reflectance of soil samples was measured with ASD field spectrometer in the laboratory. Each soil sample was scanned 20 times in the range of 350 – 2500 nm wavelengths and the average of 20 scans was calculated. This resulted in reducing spectral noise. The soil profile is shown (Figure 1 and 2) in the form of a spectral curve.

IV. PRINCIPAL COMPONENT ANALYSIS

The study by Nereu Augusto Streck et al [8] says the reflectance measured using the Field spec Pro device is used to find the quantities of various soil nutrients. According to Kamolchanok Panishkan et al, one of the feature extraction methods for data representation where a set transformed in uncorrelated features is generated is Principal Component Analysis. It is a multivariate analysis technique is also known as Eigenvector analysis. PCA reduces the number of variables by eliminating the relations among input variables and developing a set of new variables that are linear functions of the original variables. This newly formed set retains the properties of the original variables, provided that the number of new variables does not exceed the original ones [9].

Study says that PCA was applied for the reduction of dimension and variability in spectral reflectance. When the PCA method was applied to the spectral signature curves (Reflectance curves), it gave a small set of base spectra along with the principal components associated with each sample of reflectance curve to reduce noise, decrease redundancy and compress it.

The important use of PCA is to compress data with the help of correlation existing between different variables measured. According to the study, PCA distinguishes between various soil data collection areas and gives the exact region of source material. Principal component one (PC1) correlates the intensity of spectral reflectance samples and Principal component two (PC2) correlates with the slope between the visible and infrared samples. PCA group's similarity in soils derived from identical parent material. The major soil constituents like minerals, organic matter were related as well as prediction and analysis of soil constituents was achieved. To reduce the dimension of information and variability in spectral data, PCA is applied.

As Gore et al [10] says, when the PCA method was applied to the spectral signature curves (Reflectance curves), it gave a small set of base spectra along with the principal components associated with each sample of reflectance curve to reduce noise, decrease redundancy and compress it.

V. EXPERIMENTAL RESULTS AND DISCUSSION

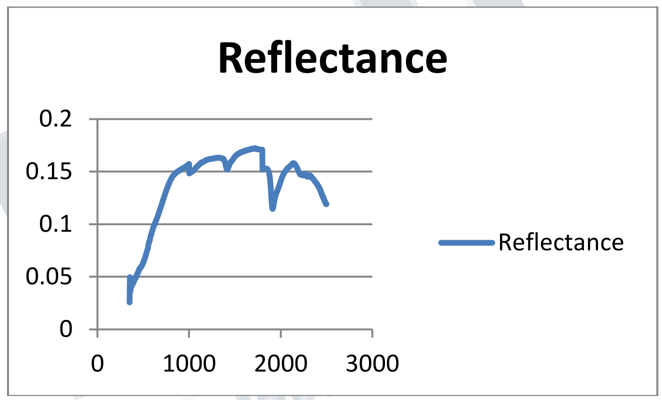

Figure 1: Soil spectral signature (Shendra)

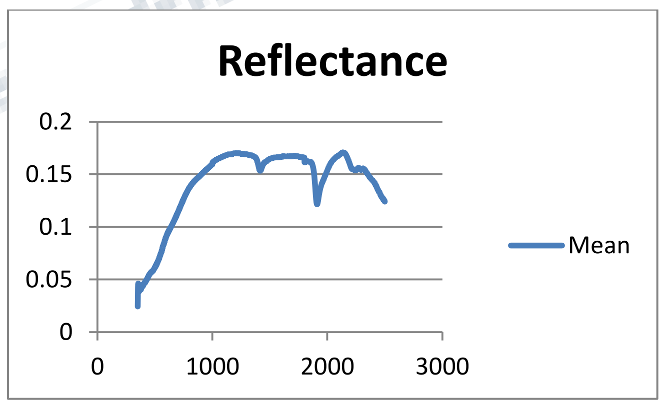

Figure 2: Soil spectral signature (Chikhalthana)

The input spectral curves are shown in fig 3a and 4a for Shendra region and Chikhalthana region respectively. The results after applying principal component analysis are shown in figure 3b and figure 4b for the two regions. The wavelengths are clustered according to similarity. In 3b the

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clusters are formed according to the contents present in the soil.

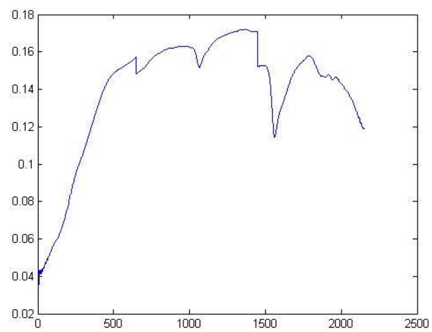

Figure 3a: Input Spectral Signature for Shendra region

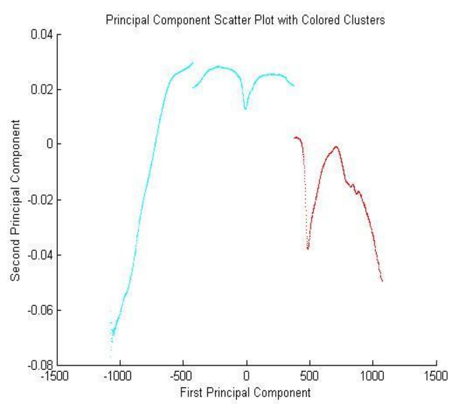

Figure 3b: PCA output for Shendra region

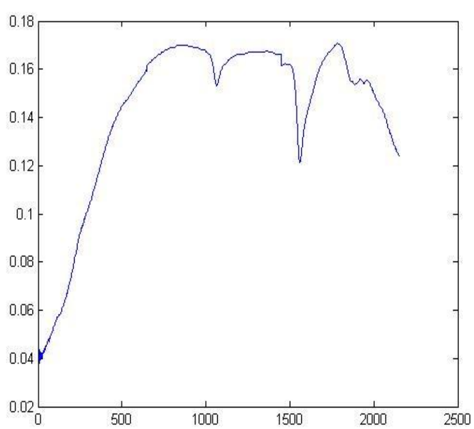

Figure 4a: Input Spectral Signature for Chikhalthana region

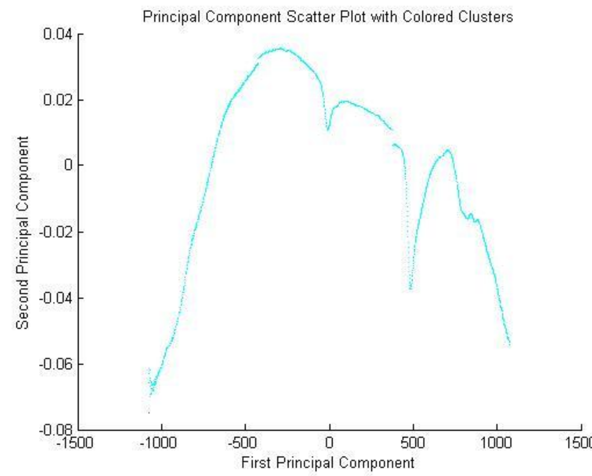

Figure 4b: PCA output for Shendra region

While in 4b the clusters show similar properties throughout the curve. The contents are clustered in same group. PCA has compressed the data with the help of correlation in variables measured. The input and output curves show that PCA has reduced the noise. It has grouped similarity in soils in identical material.

VI. CONCLUSION

VIS-NIR, SWIR band imaging spectroscopy of electromagnetic spectrum can provide complete information of various contents of soil and their characteristics. The quantitative aspects of soil like soil mineralogy, fertility, soil organic matter, moisture can be mapped faster with less cost and without causing harm to soil. The spectral library supports the classification soils using PCA. PCA forms the clusters of soils with similar parent material.

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