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Evaluation of Soil Physical/Chemical Parameters for Agriculture Production in Vaijapur Taluka Using VNIR-SWIR Reflectance Spectroscopy

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Abstract**—** Soil is a precious resource of the environment to survival and humanistic welfare .From the mixture of minerals, organic matter and living organism components soil is formed. Soil Physical, Chemical and Biological characteristics plays a very significant role in agricultural field. Accelerated low cost and predictable assessment of soil quality under agricultural management is necessary to accomplish convenient observation of the effects of various management practices on soil conditions to avoid soil degradation and ensure feasible soil productivity and also soil security. The objective of this study is to find soil Physical and Chemical parameter contents from top surface (0-20cm) of agricultural soil in Vaijapur taluka. We measure raw spectral reflectance of all soil samples .and also use 1st and 2nd Derivatives techniques for pre-processing spectral data. Mostly soil texture of Vaijapur taluka comes under the clay loam. In this study we predicting soil properties with particular sensitive band such as soil water(1400 nm, 1900 nm, 2200 nm),pH (1477nm,1932nm and 2200 nm),Sand(1900 nm),Silt(2000 nm),Clay(2200 nm) and for Soil Organic Matter(750-1000nm) for better crop production in Vaijapur taluka using Field Spec4 Spectroradiometer between 350-2500 nm wavelength. It is a rapid, non-destructive, and cost-effective and time consuming tool for evaluating the soil parameters. According to R-square and RMSE values the PLSR model gives better results to achieve these objectives and here we also suggest crops which is suitable for soil in Vaijapur taluka.

Keywords**—**Spectroradiometer , VNIR-SWIR , PLSR

I. INTRODUCTION

According to the Soil Science Society of America Soil is the unconsolidated mineral or organic material on the immediate surface of the earth that serves as a natural medium for the growth of land plants. It is needed to extent the soil fertility and specify deficiencies that need to be remedied. Soil is classified in terms of their properties such as Physical (Texture (Sand, Silt ,Clay),Structure, Density, Consistency and Colour), Chemical (Cation Exchange Capacity(CEC),pH, Minerals ,Organic Matter and Biological(Biota, Flora, Fauna microorganisms) [1]. Soil characteristics assessment has abundant applications for agricultural management. As we know Soil is a composite system whose development and working are elaborate and it is crucial to fully perceive .To form relationship between soil specific component and soil Chemical and Physical properties there are various traditional soil diagnostics techniques are used. Historically, by using laboratory analysis we understand the soil system and estimation of its quality and functions .But preserving soil for future generations and make more efficient use of it we need to develop further estimation techniques for better understanding of soil as a complete system and resources. There are different domains provides various soil monitoring tools for improve agriculture productivity. One of them is Remote Sensing. Its techniques in soil studies started in the 1960's .Creation of spectral signature database of object is the basic need of it. It consist of Point Spectroscopy and Imaging Spectroscopy [2]. In the present research work spectral measurement of soil carried out between 350-2500 nm. The objective of the study were (1) to study the soil physical/chemical parameters using VNIR-SWIR Reflectance Spectroscopy. (2) For pre-treatment of soil spectra Savitzky–Golay 1st and 2nd derivatives is used.(3) For prediction of soil moisture, pH, sand, silt and clay ,the PLSR model is used. The section first contains introduction related to study and also previous work. Section second consist of data acquisition, materials and methodology .In section third contains experimental analysis with pre-processing. Section fourth incorporate the results and in section fifth highlights the conclusion.

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II. RELATED WORK

In recent years, visible near infrared and shortwave infrared spectroscopy has develop into a mostly essential analytical technique. Reflectance spectroscopy divides in visible near infrared having wavelength (VNIR: 400-1100nm) and Shortwave Infrared (SWIR: 1100-2500nm) wavelength for soil reflectance. The visible part of the electromagnetic radiation (visible: 400-700nm) contains blue (400-500nm), green (500-600nm) and red (600-70nm) wavelength [3]. It is useful in different stratum like it investigate an extensive range of samples from liquid, solid and gas .This technology is based on illustrating the interaction between electromagnetic radiation and material [4] .Reflectance spectroscopy provides an equivalent techniques to physical and chemical laboratory soil analysis for assessment of an enormous range of key soil properties [5]. Soil water content or moisture is a substantial relationship between the exchange of water and energy at the soil atmosphere interface. It can also signify the carbon status in the soil because soil water content has converse interrelationship with soil carbon [6]. Soil Organic Matter is an ingredient of soil solid-phase matter and serves as a reserve for many essential nutrients called “Nutrient Bank for Plant” and its loss is closely linked with the decline of soil fertility, soil productivity and agricultural sustainable development [7]. Soil texture is an important land environmental variable because it show a key aspect in soil degradation and water transport processes, governing soil quality and its productivity .Soil pH effected on management and productivity of soil [8].

III. METHODOLOGY

III.A Study Area

The selected study area Vaijapur is a city and a municipal council in Aurangabad district. Maharashtra, India which is geographically located at 19.92°N latitude and 74.73°E longitude which comes under the minimal rainfall region. Mostly black and red type of soil is present in this area [9]. In month June ,July, September and October 2017,35 soil samples were collected during 10:00 am to 6:00 pm. Distance between two sample was 1-2 km .At each site 5 soil samples with approximately 1 kg of surface soils was obtained (0-20 cm) and we also used Global Position System to record the corresponding Geographical Coordinates. These fresh soil samples were packed in air tight zip lock plastic bags for restore moisture and also it is labelled & taken to the spectral measurement.

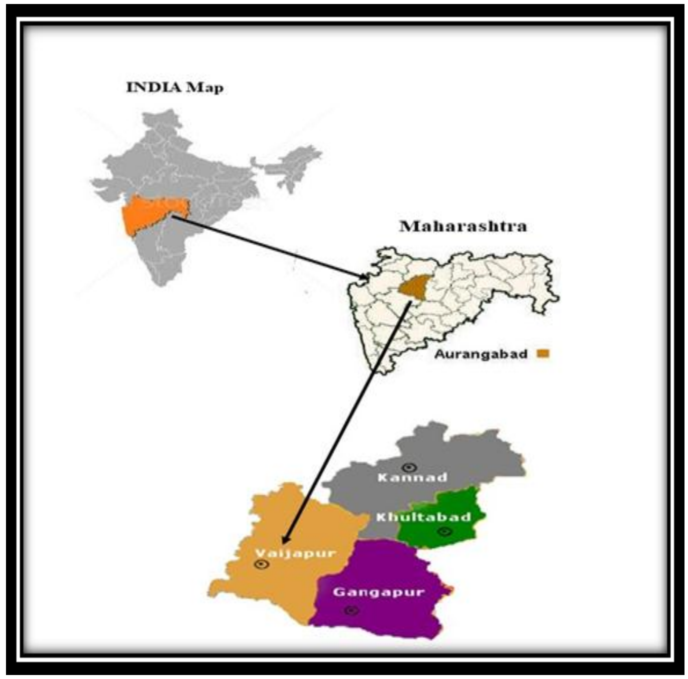

Fig .01.The Geographical Location Map of the Study Area

III-B Spectral Signature Acquisition

The soil samples were taken for spectral measurement in dark room using Analytical spectral Devices (ASD) Field Spec4 Spectroradiometer for obtaining the reflectance spectra of soil. The ASD Spectroradiometer provides the reflectance spectra at VNIR–SWIR region having wavelength range from 350-2500nm [10] [11] [12]. The total of 10 spectra of each sample was recorded to minimize the noise produced by the instrument for obtaining the final spectra. We got 350 soil spectra’s for 35 samples for creation of database. The RS3 spectral acquisition software was used to collect soil spectral measurements and its file extension is .asd .We also used Global Position System to record the corresponding Geographical Coordinates.

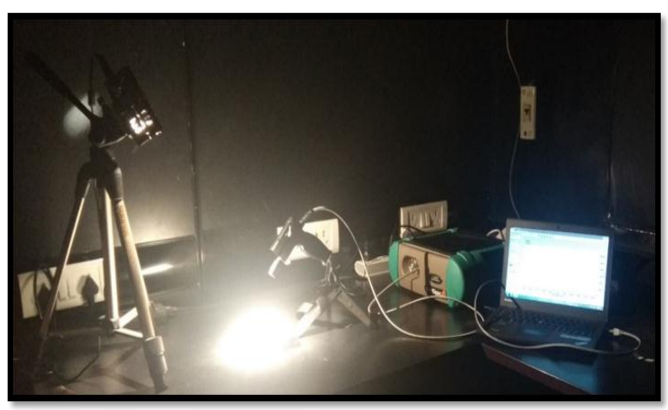

Fig.02. Field spec4 Spectroradiometer setup for Soil Spectral measurement.

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IV . SPECTRAL PARAMETER ANALYSIS

Spectroradiometer is a Non Imaging Technology which is used in agriculture to predict soil physical and chemical parameters. It consist of RS3 data acquisition and Viewspec4 pro software for pre-processing .The spectral signatures of soil recorded by RS3 software is transformed into ASCII format with the help of Viewspec4 pro software .The soil spectral parameter estimation is executed for six spectral signatures. The wavelength bands for Soil Moisture(1400 nm ,1900nm and 2200 nm),Soil Organic Matter(750-1000nm),pH(1477nm ,1932nm and 2200nm),Sand(1900nm),Silt(2000nm) and for Clay(2200nm) [13].The fig 03 shows the Mean Spectral Signatures of all Soil Specimens. All Descriptive Statistics of Soil parameters is calculated which is shown in Table 01.

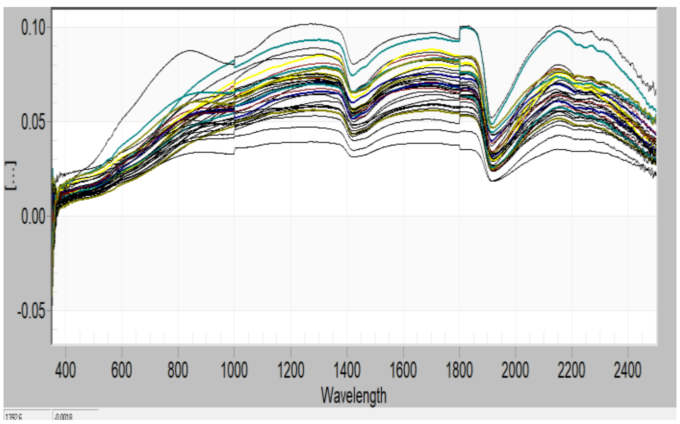
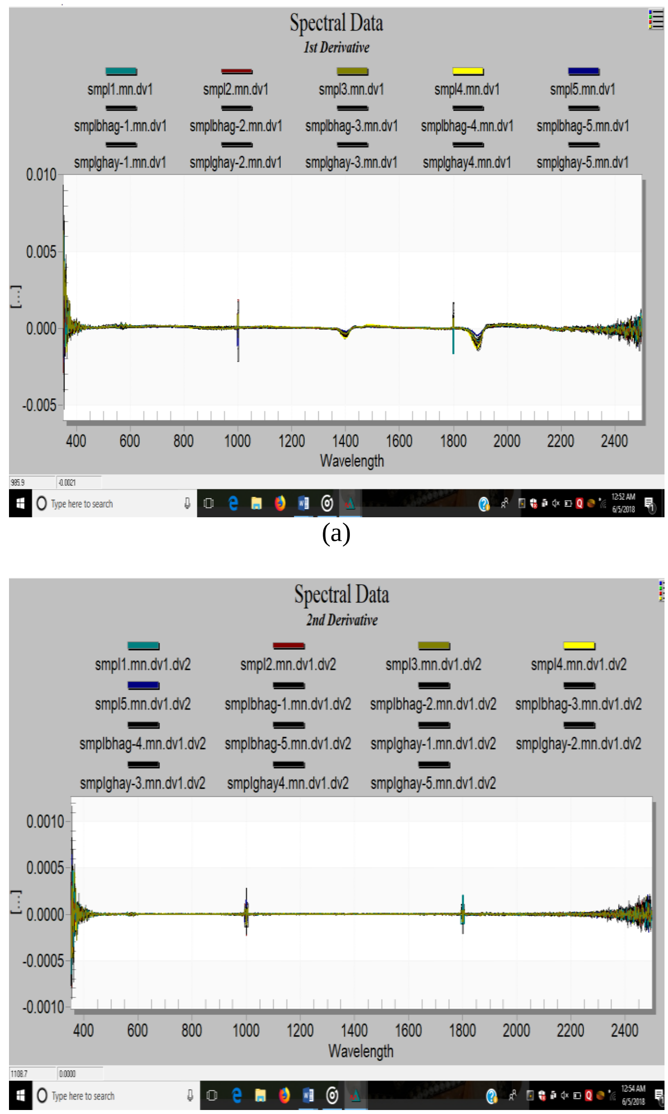


Fig.03. Mean Spectral signatures of all soil samples in Vaijapur Taluka

IV.A. PREPROCESSING

Derivatives (1st and 2nd) this transformation try to precise for baseline effects in spectra for the purpose of creating robust calibration models for soil parameter estimation. The 1st derivative (Der1) of a spectrum is a measure of the slope of the spectral curve at every point. Since the slope of the curve is not affected by baseline offsets in the spectrum, the 1st derivative is a very effective method for removing baseline offsets. Nonetheless, peaks in raw spectra usually become zero-crossing points in 1st derivative spectra, which can be difficult to interpret. This pre-processing technique gives good result for our study region.

The 2nd derivative (Der2) is a measure of the change in the slope of the curve. In addition to ignoring the offset, it is not affected by any linear slope that may exist in the data, and is therefore a very effective method for removing both the baseline offset and slope from a spectrum. For all that , peaks in raw spectra usually change sign and turn to negative peaks [14] .The below Fig 05 shown the 2nd Derivative for all soil samples.



(b)

Fig.04. (a ,b) 1st&2nd Derivatives of all soil samples

IV.B. STATISTICAL ANALYSIS

According to Statistical Analysis and given below graph here we see in our study area the Content of Sand and silt has present in less amount whereas Water, Soil Organic Matter ,pH and Clay contents are present in higher amount .The table 01. Shows the Descriptive statistics for all soil samples in Vaijapur taluka. It consist of Minimum, Maximum, Median, Mean, Standard Deviation,1stQu and 3rd Qu. Fig 05 represent graphical presentation of all soil physical and chemical parameters in Vaijapur taluka. In that we see the sample no .18 gives higher results for all soil parameters [15].

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Table 01: Statistics of Soil Moisture, Soil Organic Matter, and pH, Sand, Silt and Clay

Statistical Operation	Water	pH	Sand	Silt	Clay	SOM
Min	0.029	0.032	0.020	0.024	0.034	0.032
Max	0.164	0.178	0.121	0.146	0.196	0.167
Median	0.052	0.057	0.037	0.042	0.062	0.052
Mean	0.055	0.061	0.039	0.046	0.065	0.053
Std.Dev	0.021	0.022	0.016	0.019	0.025	0.021
1st Qu	0.048	0.052	0.030	0.036	0.054	0.045
3rd Qu	0.058	0.064	0.042	0.051	0.070	0.055

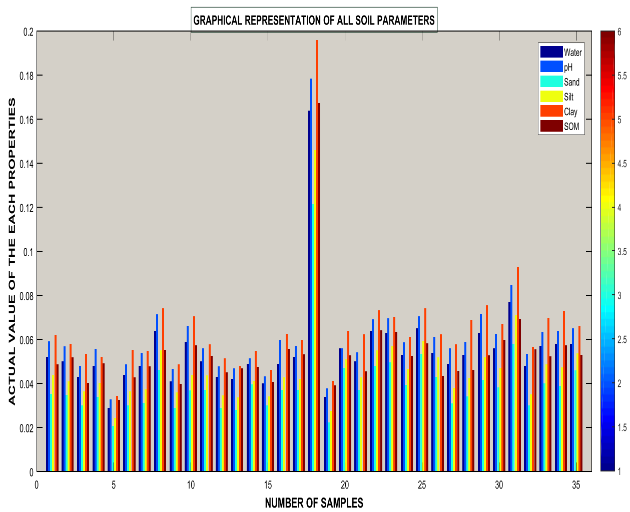
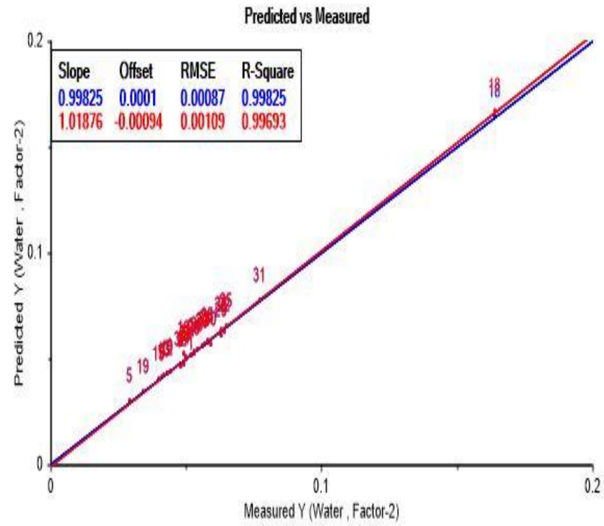


Fig .05.Graphical Representation of Soil Parameters

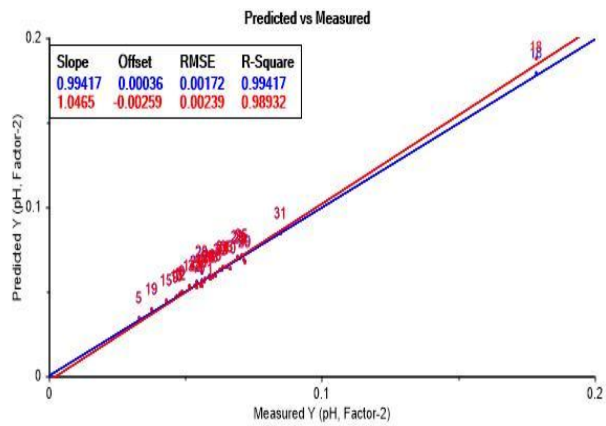
V. RESULTS

Partial Least Square Regression PLS was developed in the 1960's by Herman Wold as an econometric technique, but some of its most avid proponents (including Wolds's son Svante) are chemical engineers and Chemometricians [16-19]. PLSR is a most popular modelling technique and it is mostly used for quantitative spectral analysis. PLSR is used to construct predictive models when there are many predictor variables that are extremely collinear. This technique is mostly related Principal Component Regression (PCR). By fitting this regression model, some PLSR factors that explain most of the variation in both prediction and response [20][21][22][23] .In general ,the PLSR was used to improve the analysis accuracy of spectral data.

According to results obtained from statistical analysis related to Water, pH, Sand, Silt ,Clay and SOM contents and spectral data of either calibration or validation data set in agricultural soil from Vaijapur region. The predicted vs Measured scatter graph with factor 2 shows higher determination coefficient and lower Root Mean Square Error values in fig. 06 (a-f).



(a)



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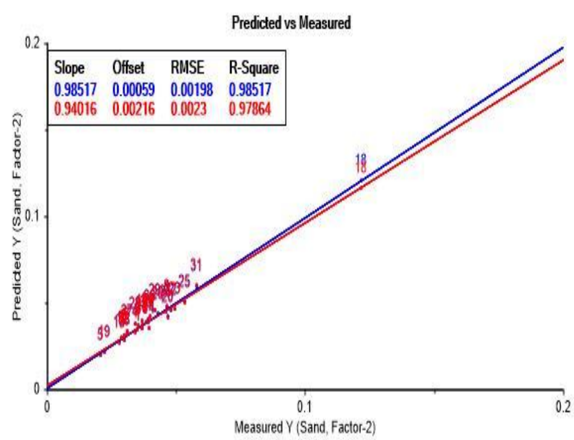

(c)

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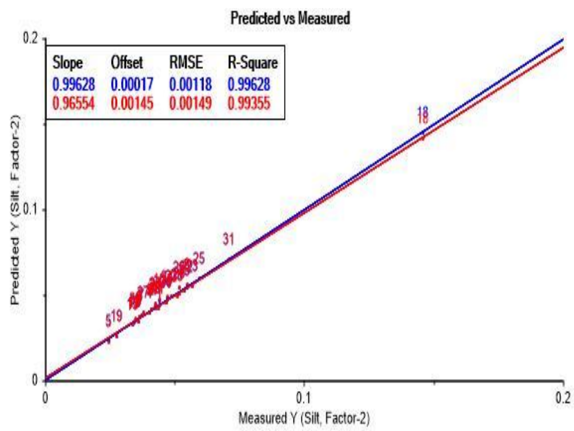
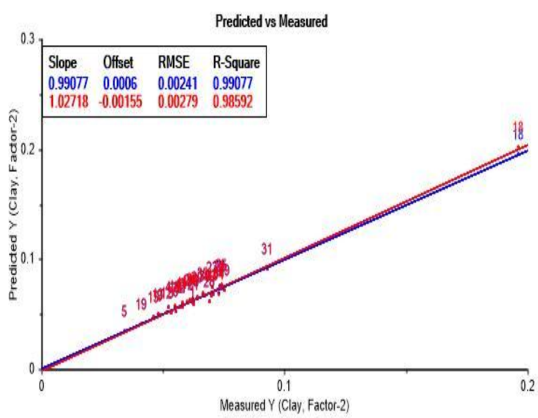
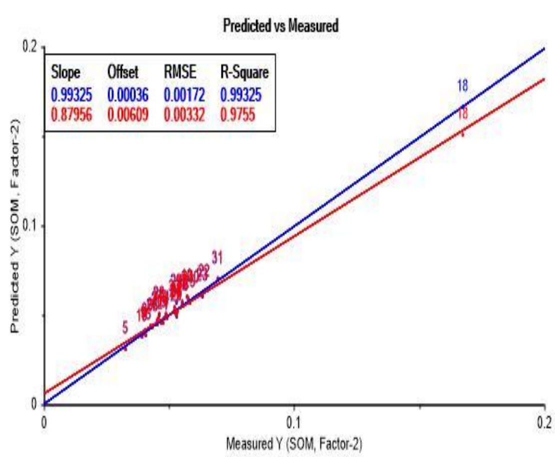


(d)



(e)



(f)

Fig. 06.Regression plots of the Measured versus Predicted Soil Physical and Chemical parameters obtained via the PLSR model for all 35 soil samples from Vaijapur Taluka :(a)Water(b)pH(c)Sand(d)Silt(e)Clay(f)SOM

VI. CONCLUSION

This study assessed the effectiveness of VNIR-SWIR spectroscopy and its techniques for rapid and inexpensive non-destructive determination of soil physical and chemical parameters.

The findings of this paper demonstrated that :

1) The 1st Derivative pre-processing technique gives good result for our study area.

2) According to statistical results in our study area mostly clay-loam texture of soil is found.

3) PLSR analysis showed that of all soil parameters ,the best prediction models obtained for Water(R-square=0.998RMSE=0.00087,R-square=0.996 RMSE=0.00109) pH(R-square=0.994 RMSE=0.00172,R-square=0.989RMSE=0.00239)Sand(R-square=0.985 RMSE=0.00198,R-square=0.978 RMSE=0.0023),Silt(R-square=0.996 RMSE=0.00118,R square=0.993 RMSE=0.00149)Clay(R-square=0.990 RMSE=0.0021,R-square=0.985 RMSE=0.00279)SOM(R-square=0.993 RMSE=0.00172,R-sqaure=0.975 RMSE=0.00609)for calibration and validation data set. And the given estimated model gives good results for our study area according to slope value which is nearby 1. The soil physical and chemical parameters plays very important role to increase agriculture sector. According to our descriptive statistics and PLSR results regarding to study area Vaijapur taluka we estimated that this soil is good for Wheat, Cotton, and Sugarcane and Sweetcorn crop production.

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