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Prediction of Salt in Soil by PLS Regression Using Hyperspectral Laboratory Data

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***Abstract*—** the intent of this paper is prediction of the salt content in agriculture soil. Soil salinity is a process which affects the quality of soil and reduces the agriculture production. The soil salt content adversely affects the soil physical property including soil water content. The Visible and Near-Infrared Reflectance Spectroscopy provides improved estimation of soil salinity as fast approach to the characterization of soil salt content with spectral resolution of 350-2500 nm. The Partial Least Square Regression Method (PLSR) is frequently used to determine Soil Salt Content (SSC) obtains from the spectral data. The Result shows that the 550nm, 850 nm, 1430nm, 1918nm, 2052nm wavelength which are sensitive to salt content and model based on Partial Least Square Regression PLSR can only make approximate predictions for First Derivative RMSE (Root Mean Square Error) = 0.0282-0.0365, R2 (Coefficient of Determination) = 0.9313-0.9051 and for Continuum Remove RMSE (Root Mean Square Error) = 0.0280-0.0386, R2 (Coefficient of Determination) = 0.9313-0.8939.

Keywords— *Spectral Data, Visible-NIR, Soil Salt Content (SSC), Partial Least Square Regression (PLSR).*

I. INTRODUCTION

Soil salinization is most common form of land degradation and environmental hazards mostly in arid and semiarid region are caused by deposition of water soluble salt on soil surface which leads to decrease soil fertility and reduce the crop yield and agriculture production. Currently in India proportion of salt affected soils in irrigated land is 27%, there are few studies shown that soil salinity can be identified by soil reflectance or salinity spectral indices using PLSR, and also can be detected using high resolution spectroscopy [1, 5].

Salt content from 2gm/kg is no saline soil and 4gm/kg is moderately saline soil and up to the 8 to 12g/kg is saline soil. Spectral reflectance gives the better and accurate analysis level. The spectral data ranges in visible region (400-700nm) allows us fast and effective tool for mapping soil salinity recently grown [6, 10]

Visible and Near-Infrared reflectance spectroscopy range (350-2500nm) has been an effective and alternative to traditional laboratory chemical analysis, Vis-NIR spectroscopy is an analytical method based on the multivariate statistical models such as Principal Component Regression (PCR), Artificial Neural Network (ANN) and several data mining technique such as Regression Tree etc. but the Partial Least Square Regression method is the commonly used to determine SSC from spectroscopic data. This paper is based on working of reflectance spectroscopy in the Visible-NIR region to prediction of soil salt contents [11, 15].

II. MATERIALS AND METHOD

A. Study Area

Aurangabad City has been chosen for study of soils longitude and Latitude (19˚54'N and 75˚ 18'E) from 30 soil samples were collected from farming land of various fields within the University Campus area of Dr. Babasaheb Ambedkar Marathwada University, longitude and latitude (19.9027° N, 75.3105° E), Aurangabad state of Maharashtra, India.

B. Soil samples analysis

The collected samples were crushed air-dried and made sieved before taking measurements. Then, reflectance spectra of the samples was measured in the laboratory in the Vis-NIR (350-2500 nm) range, with a spectral resolution of 3 nm (from 350 to 1000 nm) to 10nm (from 1000 to 2500nm) using a FieldSpec4 Spectroradiometer [. A high-intensity contact probe with a built-in light source (6.5 halogen lamp) was used. The light source having height 44.6 cm, height of Gun is 5 cm, both were placed at a distance of 40 cm from each other. The spectral readings of all soil samples were taken on 22/01/2018 in Lab [16].

C. *Spectral measurements*

Before, taking spectral measurement of soil samples, standardized White Spectralon panel with 100% reflectance for optimizing signals, accuracy and detecting response was used. Each sample was scanned 10 times within 180˚ rotation. These 10 readings were then averaged into one spectrum per sample. To eliminate the noise at the edges, the spectrum was reduced to 400nm-2450nm, and also the splice correction was applied on spectra. For taking spectral measurement, RS3 Spectral Acquisition Software (ASD Inc.) has been used [17, 20].Methodology

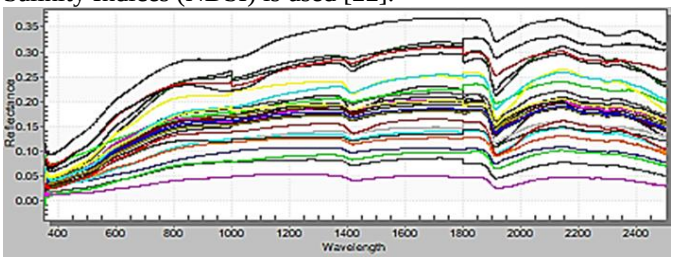
D. *Pre-processing transformation*

Three types of spectra were used to develop the model i.e. simple Reflectance spectra, First Derivative and Continuum Remove smoothened with by splice corrections. The first derivative is used to remove base line from spectra and increase absorption features to extract the information from near infrared range. For Continuum Remove we used convex hull in ViewSpecPro software it is useful to minimize difference in brightness and to enhance the absorption spectra's [21].

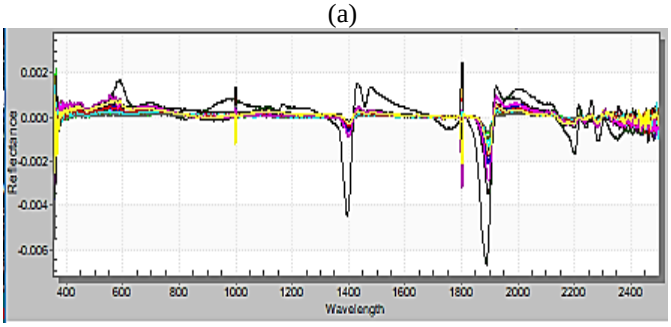
III. DATA ANALYSIS

A. *Spectral Data*

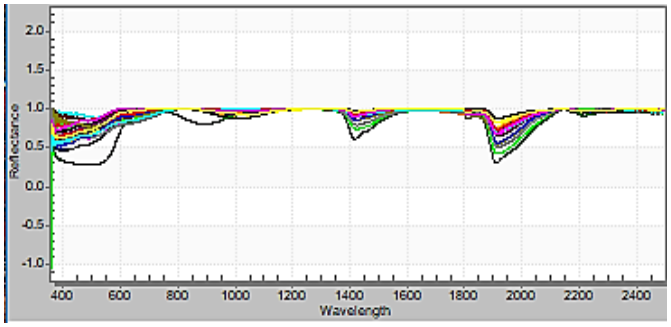
To estimate the salt contents in soil a Normalized Difference Salinity Indices (NDSI) is used [22].



(a)



(b)



(c)

Figure.1: (a) Mean spectra of original Reflectance of 30 soils sample, (b) First Derivative reflectance of 30 soils Sample and (c) Continuum removes absorbance of 30 soils sample.

The analysis is performed by using (Math Work8.0) MATLAB 2013a software [23].

B. *Partial Least Square Regression*

PLSR is popular regression method would often use to spectral analysis and algorithm uses multivariate correlate predictor (X) and response of soil salt property (Y). The equations are as follows [24].

$$R^2 = \sum_{i=1}^{N} \frac{(\hat{y} - \bar{y})^2}{(y - \bar{y})^2}$$

$$RMSE = \sqrt{\sum_{i=1}^{N} \frac{(\hat{y} - y)^2}{N}}$$

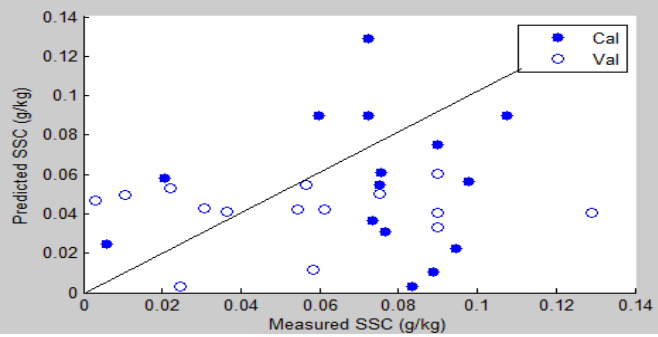
Where,
$\hat{y}$ is the predicted value,
y is the observed value,
$\bar{y}$ is the mean of observed values,
N is the number of sample data,
SD is the standard deviation of the observed values

C. *Prediction Accuracy*

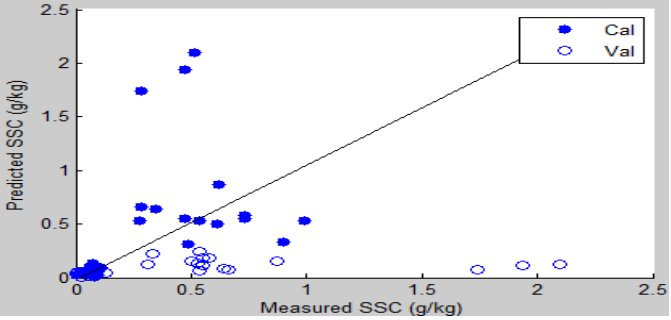
The soil samples were divided into calibration and validation data set. The prediction accuracy of the model for the calibration and validation data sets have been evaluated through the parameter such as R2 (Coefficient of determination), and RMSE (Root Mean Square Error) and RPD (Ratio of Prediction to Deviation) [25].

IV. RESULTS AND DISCUSSION

The mean Visible-NIR spectral data of 30 samples same as other studies Figure 1 (a) Enhancement in the peak was generally seen in the First Derivative of reflectance of all samples spectra as shown in figure1 (b), the absorbance shows in continuum remove Figure 1(c).



(a)



(b)

Figure.2 Plots of the Measured versus Predicted SS contents obtained by using Global PLSR models (a) First Derivative Spectra and (b) Continuum Remove Spectra.

Above figure shows the performance of PLSR model that plots the measured and predicted salt concentrations using PLSR analysis for the calibration and validation data sets, respectively. The R2 values in the validation set are higher and RMSE values are lower than the corresponding values in the calibration set.

The contents of salt in all the soil samples are shown below Table 1, the soil which contains low amount of salt is non-saline soil and it is based on the absorbance, Normal Soil Salinity Index are used to measures the salt content but the NDSI performs well to predict the soil salt content.

Table-1 Salt Contents within the Soil Samples

Sample Number	Salt Contents g/kg
1	2.60
2	2.89
3	2.26
4	2.73
5	2.58
6	2.84
7	2.38
8	2.78
9	2.87
10	3.36
11	2.55
12	2.86
13	3.08
14	3.02
15	2.75
16	2.96
17	2.77
18	2.31
19	3.22
20	2.55
21	2.55
22	2.89
23	2.59
24	2.87
25	2.92
26	2.14
27	2.96
28	2.91
29	3.06
30	2.98

V. CONCLUSION

After the analysis of the spectral data, we got 550nm, 850nm, 1430nm, 1918nm, 2052nm wavelength are highly sensitive to salt content. Global PLSR regression model are used to analyze the salt content within the soil samples. The performance of the model showed with the help of RMSE and R2 values. The samples used from different areas of fields which showed that the calibrations are similar. The soil with low salt content is non-saline soil and good for agriculture.

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