Mapping of Soil Organic Matter (SOM) using Hyperspectral Imaging and Non-imaging Data – A Review

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***Abstract*— Soil has healthy microbial population, and then the indication of the soil is rich in Soil Organic Matter (SOM). It is very beneficial for farmers to improve the production of crops. The detection and mapping of Soil Organic Matter from soil is vital task to enhance the quality of soil. An achievement of objectives and goal of ASD Fieldspec4 Spectroradiometer (350-2500nm) is preferred with less effort and time with more accuracy.**

In this paper we focus on the methods and techniques i.e. Partial Least Square Regression (PLSR) and Artificial Neural Network (ANN) modelling for mapping of Soil Organic Matter. For use of soil and evaluation purpose the mapping of soil organic matter is noble importance which is directly related to food production. This study uses Vis-NIR spectroscopy to assess and map the soil organic matter content from soil.

Keywords*— *ANN, ASD Fieldspec4 Spectroradiometer, PLSR, Soil Organic Matter, Vis-NIR spectroscopy.

I. INTRODUCTION

The Soil Organic Matter (SOM) consists of the residues of plant and animals in various stages of decay, substances synthesized by soil organisms and cells and tissues of soil organisms. The dead roots, root exudates, litter, leaf drop, the bodies of soil animals such as insects and worms as well as the living microorganisms such as roots, micorrhizae and bacteria are the primary sources of organic material inputs. An essential and dynamic variable in terrestrial ecosystem is the Soil Organic Matter (SOM).

Organic matter serves as a reservoir of nutrients and water in the soil, aids in reducing compaction and surface crusting and increases water infiltration into the soil. To provide a meaningful spatial data for use in investigations of various types of soils the remote sensing techniques plays a vital role [1]. Traditionally, the information of Soil Organic Matter has mainly been obtained through field soil sampling and laboratory analyses, such methods are highly accurate but because they are costly and labor-intensive [2,3], and it cannot be used for rapid monitoring of Soil Organic Matter during soil degradation processes.

If soil contains higher organic matter level then there are some advantages:

1. It reduces nutrient leaching losses.
2. It promotes aggregation of soil particles
3. It helps in soil water infiltration
4. It improves water holding capacity
5. It reduces the potential for runoff and erosion as well
6. Allows favorable soil temperatures
7. It improve plant root growth
8. Gives healthy microbial populations
9. It moderate pH ranges.

The soil organic matter is somewhat difficult to measure, so that laboratories mostly try to detect, estimate and report the soil organic carbon [4]. In soil organic matter there are 58% organic carbon exists.

To improve the productivity of soil, all micronutrients in the soil must be exist in proper content [5]. As the soil organic matter is beneficial for plant root growth, to improve water holding capacity and to reduce nutrient leaching losses the farmer must have the proper knowledge about the soil organic matter content present in the soil, which will be helpful to them to improve the soil physical, chemical and biological properties which is useful to gain the production of crop.

The color of different type of soil and the soil organic matter is strongly associated to each other. From studies, we can say that the darker soils have large number of organic contents which shows bonding between the soil organic matter and visible reflectance [6].

To analyze the soil and their contents, there are field soil sampling and laboratory analysis technique which is time consuming [7]. From past four decades, soil Vis-NIR technology is used by researchers, which is helpful for digital soil mapping and soil resource surveys. The ASD Fieldspec4

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Spectroradiometer (350-2500nm) plays a vital role in detection and assessment of soil organic matter from soil.

For mapping of soil organic matter from soil, the development of Hyperspectral sensors, spectral features can be mapped. However, Artificial Neural Network (ANN) predictive modeling techniques was used by number of researchers to predict spatial variation of surface soil properties using air-borne as well as space borne Hyperspectral remote sensing data. The digital soil mapping techniques can be used to improve the accuracy, consistency and speed where soil survey information is produced.

This paper describes related work in section II; section III defines the different methods. Some observations obtained in previous studies is described in section IV.

II. Related Work

The Visible (400-700nm) and Near-Infrared (700-2500nm) spectroscopy technique allows more accurate and faster access of information of soil based on quantitative as well as qualitative basis. As a result, Vis-NIR reflectance spectroscopy is very beneficial choice to estimate contents from different types of soil.

In Sudheer Kumar Tiwari research suggested that, for all the three data sets i.e. image, field and lab scale, the combination of ANN predictive modeling technique and Hyperspectral data gives more accurate results, which indicates that they could be used for prediction of soil organic carbon content mapping.

Amol D. Vibhute demonstrated the assessment of soil organic matter contents from VNIR reflectance spectroscopy by using thirty soil samples. The result concluded that, the combination of SG-FDT method was correct for feature extraction of soil organic matter. The more soil samples give more accurate results, so that furthermore, by using seventy four soil specimens for study, it gives the result that, by using VNIR hyperspectral Diffuse Reflectance Spectroscopy datasets the soil attributes can be easily detected.

Martin Wiesmeier evaluates Digital Soil Mapping (DSM), in which combination of Random Forest (RF) and Classification and Regression Trees (CART) shows good results for the prediction of properties of soils [8].

Zuo Luo research, they showed that the detection of very low or narrow soil organic matter and its quantitative mapping using field spectrometer and hyperspectral remote sensing is possible [9].

Mervin St. Luce demonstrated the determination of soil organic matter on Black, Orthic Black and Dark Brown Chernozemic soils from western Canada which gives results that VNIRS plays vital role which is cost-efficient, rapid as well as non-destructive for assessment of soil organic matter quality [10].

III. Methods

Soil organic matter is an organic matter component of soil. There are some techniques and methods to detect the soil organic matter from soil.

a. Partial Least Square Regression (PLSR):

PLSR is a statistical method in which the predicted variables and the observable variables are projecting to a new space to find a linear regression model.

To find fundamental relations between two matrices(X and Y) we can use PLSR method. To model covariance structure in X and Y matrices the PLSR is a latent variable approach.

b. Artificial Neural Network algorithm (ANN):

The ANN modelling is mostly similar to the working of human brains. To solve complex problems it gives the method to characterize the synthetic neurons.

The ANN is mostly useful –

- To know the impact of variation (increasing or decreasing) of our dataset.

- To understand the cases in which the model correctly fits.

- To show how particular model shows good results than other.

IV. Observations

Sudheer Kumar Tiwari conducted the multivariate predictive modelling technique – Artificial Neural Network (ANN) using Hyperion image, field and laboratory scale data for mapping of soil organic carbon from soil.

Amol D. Vibhute shows that, the ASD Fieldspec4 Spectroradiometer gives better results to detect the organic matter contents without perilous chemicals. Also for smoothing process of spectra the Savitzky-Golay (SG) method used with First-Derivative Transformation (FDT) and Partial Least Square Regression (PLSR) method gives superior outcome. The study using 30 soil samples shows that, best spectral channels for extraction of soil organic matter content are 441,517,527,648 and 1000nm.

V. Conclusion

Assessment and mapping of soil organic matter in soil is more essential process to know the quality of soil. From the previous researches and studies we can conclude that, to analyze soil organic matter from soil instead of laboratory analysis, if we use the Vis-NIR spectroscopy technique then we can get fast and better results.

To detect the quality of soil, we can use different techniques such as SG-FDT, SG-SDT with the Partial Least Square Regression methods and for mapping ANN modelling technique mostly used. If we analyze & map the soil organic matter from different type of soil, then it will be helpful for farmers to increase their crop production.

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REFERENCES

[1] Sudheer Kumar Tiwari, Sudip Kumar Saha, Suresh Kumar, "Prediction Modeling and Mapping of Soil Carbon Content Using Artificial Neural Network, Hyperspectral Satellite Data and Field Spectroscopy", Advances in Remote Sensing, 4, 63-72, 2015.

[2] Amol D. Vibhute, Rajesh K. Dhumal, Ajay Nagne, Rupali Surase, Amarsinh Varpe, Sandeep Gaikwad, "Assessment of Soil Organic Matter through Hyperspectral Remote Sensing Data (VNIR Spectroscopy) using PLSR Method", IEEE ,978-1-5386-2989-5/17,2017.

[3] Amol D. Vibhute , Karbhari V. Kale, Suresh C. Mehrotra, Rajesh K. Dhumal and Ajay D. Nagne, "Determination of soil physicochemical attributes in farming sites through visible, near-infrared diffuse reflectance spectroscopy and PLSR modeling" , Springer, 7:26, 2018.

[4] Dr. Ratnadeep R. Deshmukh, Dnyaneshwar D. Karale, "Estimation of Soil Organic Carbon Content using Visible Near Infrared Reflectance Spectroscopy".

[5] Ashwini Dilip Padmanabhi, Dr. Ratnadeep R. Deshmukh, "Hyperspectral Analysis of Soil Total Nitrogen using PLSR Method: A Review", Research India Publications, Volume 12, Number 2,pp. 357-364, 2017.

[6] Ting He , Jing Wang , Zongjian Lin & Ye Cheng, "Spectral features of soil organic matter", Taylor & Francis, Geo-spatial Information Science 12(1):33-40, Volume 12, Issue 1, March 2009.

[7] Xing-Xing Qiao, Chao Wang, Mei-Chen Feng, Wu-De Yang, Guang-Wei Ding, Hui Sun, Zhuo-Ya Liang & Chao-Chao Shi, "Hyperspectral estimation of soil organic matter based on different spectral preprocessing techniques", Taylor & Francis, VOL. 50, NO. 3, 156–163, 2017.

[8] Martin Wiesmeier, Frauke Barthold, Benjamin Blank, Ingrid Kögel-Knabner, "Digital mapping of soil organic matter stocks using Random Forest modeling in a semi-arid steppe ecosystem", Springer Science+Business Media ,Plant Soil, 340:7–24, 2010.

[9] Zhuo Luo, Liu Yaolin, Wu Jian, Wang Jing, "quantitative mapping of soil organic material using field spectrometer and Hyperspectral remote sensing", The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. Vol. XXXVII, pp. 901-906, 2008.

[10] Mervin St. Luce, Noura Ziadi, Bernie J. Zebarth, Cynthia A. Grant, Gaetan F. Tremblay, Edward G. Gregorich, "Rapid determination of soil organic matter quality indicators using visible near infrared reflectance spectroscopy", ELSEVIER, Geoderma 232–234, 449–458, 2014.

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