International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2454-9150 Special Issue - NCCT - 2018

Analysis of Chlorophyll in Plant Species Leaves using Hyperspectral Remote Sensing Data

Amarsinh B.Varpe, Karbhari V. Kale, Amol D.Vibhute, Rupali R. Surase, Ajay D. Nagne

Geospatial Technology Research Laboratory, Department of Computer Science & I.T, Dr. Babasaheb Ambedkar Marathwada University Aurangabad, Maharashtra, India.

varpeamarsinh@gmail.com

Abstract - An identification of plant species is essential for many applications such as plant species classification along with its current status and yield estimation. In the present paper, we have investigated the analysis of chlorophyll content of three different types of plants with healthy & dry leaves (Synygium Cumini, Adhatola Zeylanica and Azadirachta Indica) using values of the spectral indices. The variations Chlorophyll a, Chlorophyll b and Carotenoid content of healthy and dry leaves of plant based on spectral indices were determined. The statistical analysis has been done through open source software based on python. The hyperspectral data was acquired of plants healthy and dry using ASD devices. The computed healthy leaves values of the pigment specific simple ratio (PSSRc) were found to be the highest value i.e. (5.200) and corresponding value for dry leaves was (3.810). It was possible to estimate content of chlorophyll in plants using the hyperspectral data.

Keywords — Plant Species, Spectral Signature, Spectral Features, Vegetation Indices, Plant Species Classification, Hyperspectral Datasets.

I. INTRODUCTION

Hyperspectral remote sensing is a powerful tool for determination of chlorophyll content in plant leaves. The objective of the present study is to identify biophysical and biochemical parameters of plant leaves using various vegetation indices (VIs) from spectral signature. Spectral reflectance signatures represent the relationships between electromagnetic radiation (EMR) and the physical and chemical properties of the object of interest. They are the fundamental means of data representation and analysis in all forms of passive reflected sunlight remote sensing [1]. Recent sensors for spectral reflectance measurements allow the discrimination of a large number of wavelength bands resulting in a high spectral resolution. Methods have to be developed systematically to extract information of plant leaves using spectral bands [2].

The light energy to be converted into chemical energy by photosynthesis is first taken up by plant pigments, primarily related to green pigments cholorophyll.The absorption of light in the plants leaves causes energized state [3], [4].

In the present study, we have reported information regarding identification of plants leaves using various vegetation indices the spectral bands. We have selected the six types of chlorophyll content index viz PSSRa, PSSRb, PSSRc, PSNDa, PSNDb, and PSNDc. The paper consists of four sections. The studied area, hyperspectral datasets and applied methods are explained in section two. Experimental results with its discussion were explained in section three. Section four shows the conclusion of the study area.

II. THE STUDIED REGION

The geographical location of the study area is $19^0$54'3.7944 N latitude and $75^0$21'8.9208 E longitude of Aurangabad (MS) Maharashtra, India. Annual average rainfall of study area is 940 mm with 25^0 C to 37^0 C annual temperature.

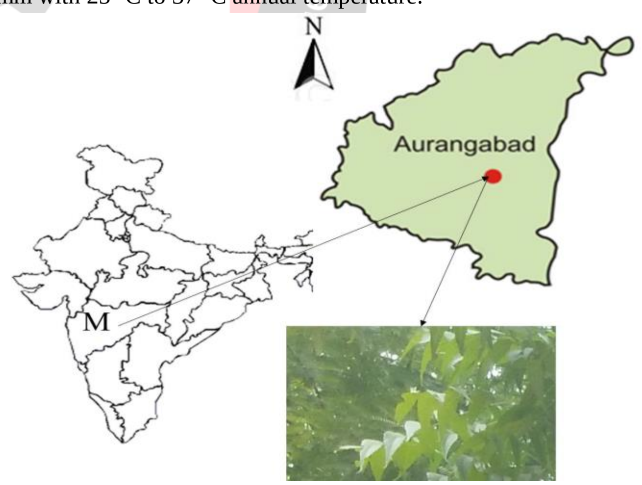

Figure.1 Location of study area

The plant species samples of three types were collected from the botanical garden of Dr.B.A.M.University on 21 March 2016.These three types of plants were (*Synygium Cumini*, *Adhatola Zeylanica and Azadirachta Indica*) ten samples of each variety have been collected and considered to be of healthy and dry type. These samples were also dried in the laboratory for our study [5], [6].

III. MATERIALS AND METHODS

A. *Hyperspectral Datasets*

The ASD Field Spec 4 Spectroradiometer was used to acquire spectral signature of the samples. The wavelength of the ASD instrument is 350-2500 nm. The spectral resolution of ASD is 3 nm to 10 nm for 350-1000 nm and 1000-2500 nm with sampling interval 1.4nm and 2nm for each range respectively. White reference panel was used for optimization and calibration of device to achieve absolute reflectance in lab conditions before samples recording [7]. The ASD instrument provides halogen lamp with 75w. It was used to record the plant samples by zenith angle of 60^0 from the distance of 45 cm above the samples. The field of view (FOV) was 8 degree and fiber-optic cable was set as of nadir where plant samples were 15 cm long. The Petri dish with a 2 cm thickness and 20 cm diameter was used for acquiring the reflectance spectra of plant samples. Each sample was recorded by ten times for receiving spectra and then averaged as a pure spectrum. The RS3 (Version 6.3) inbuilt software was used for recording the reflectance spectra of leaves.

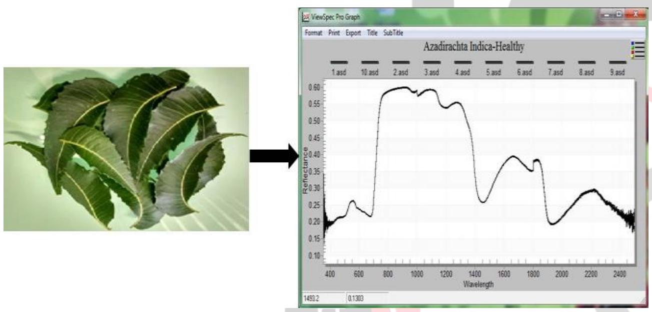

Figure.2 Azadirachta Indica ten healthy leaves

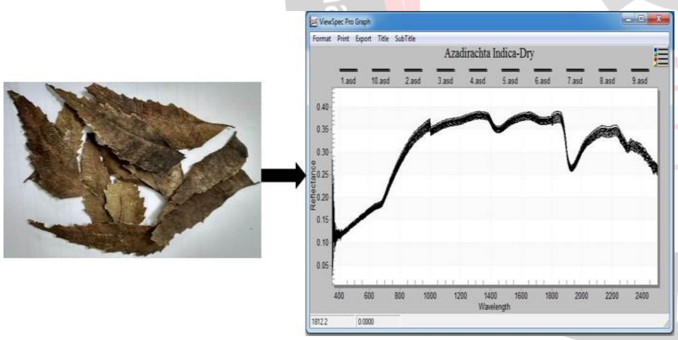

Figure.3 Azadirachta Indica ten dry leaves

The Fig.2 and 3 show one example of spectral signatures acquired from the ASD field spec 4 spectroradiometer for healthy and dry leaves respectively [8], [9], [10].

B. *Spectral Vegetation Indices (SVIs)*

SVI's have been amplitude from strongly spectral data which are closely correlated to specific plant parameters e.g. plant species chlorophyll a, chlorophyll b and carotenoid. SVI are widely applied in hyperspectral remote sensing data for the identification and evaluation of plant species pigment. The calculated SVI are summarized in Table.1 and 2 which are related to photosynthesis pigment content of plant species from literature.

C. *Spectral Indices for Evaluation*

The hyperspectral indices used in this study are listed in Table.3 in which six indices were considered for the current study. The following algorithms were used.

1. Pigment specific normalized difference (PSND):

The indices may provide a measure of the depth of the pigment absorption features in leaves spectra relative to the highly reflective near infrared. Appling these indices to the present data set we find that strong exponential relations exist between Chl a, Chl b and Cars.

The formulation of indices Eq.1, 2 and 3 uses chlorophyll content for four different wavelengths such as 470 nm, 635 nm, 680 nm and 800 nm.

$$PSNDa = (R_{800}-R_{680}) / (R_{800}+R_{680}) \quad (1)$$
$$PSNDb = (R_{800}-R_{635}) / (R_{800}+R_{635}) \quad (2)$$
$$PSNDc = (R_{800}-R_{470}) / (R_{800}+R_{470}) \quad (3)$$

2. Pigment specific simple ratio (PSSR):

The basis of this approach was to develop a simple index for each pigment of interest, using a similar structure to that of the simple ratio vegetation index which itself is a measure of the overall depth of the chlorophyll absorption feature. Each index uses a near infrared band 800 nm which can be considered to minimize the effects of radiation interactions at leaf surface and internal structures in the mesophyll. The wavebands 680, 635 and 470 nm were chosen on the basis of the absorption maxima of Chl a, Chl b and Cars, respectively, which are least affected by convolution.

Pigment specific simple ratio index is well examined method for chlorophyll identify the leaves by Eq.4, 5 and 6.

$$PSSRa = (R_{800}) / (R_{680}) \quad (4)$$
$$PSSRb = (R_{800}) / (R_{635}) \quad (5)$$
$$PSSRc = (R_{800}) / (R_{470}) \quad (6)$$

Where, R is reflectance at the wavelength denoted by the subscripts.

Table.3 Vegetation Spectral Indices used in this study

Spectral Index	Equation	Indicator	Reference
Pigment specific normalized difference	PSNDa= $(R_{800}-R_{680})/(R_{800}+R_{680})$	Chlorophyll a	Blackburn(1998a) [11]
	PSNDb= $(R_{800}-R_{635})/(R_{800}+R_{635})$	Chlorophyll b	
	PSNDc= $(R_{800}-R_{470})/(R_{800}+R_{470})$	Carotenoid	
Pigment Specific simple ratio	PSSRa= $(R_{800})/(R_{680})$	Chlorophyll a	Blackburn(1998a [11]
	PSSRb= $(R_{800})/(R_{635})$	Chlorophyll b	
	PSSRc= $(R_{800})/(R_{470})$	Carotenoid	

IV. RESULTS AND DISCUSSIONS

In our study, we have used six types of SVIs which were computed by using open source software from spectral signature acquired with the ASD spectrometer. These indices were computed for all 10 samples correspond to three different types of plants. These samples were dried in the laboratory by keeping then at a dry place for ten days. The spectra were also acquired for these dry samples and the indices were also computed.

The Table.4 shows the values of SVI's indices along with corresponding average and standard deviations for three different types of plants with healthy and dry conditions. The following salient features may be observed from the Table,

1. The values of the PSSRa, PSSRb, and PSSRc are the largest among all other indices. The chlorophyll contents are more sensitive to the indices.
2. The computed healthy leaves values of the pigment specific simple ratio (PSSRc) was found to be the highest value i.e. (5.200) and corresponding value for dry leaves was (3.810).
3. The indices for SC, AZ and AI are very much different. These plants can be identified easily of the basis of these indices.
4. The vegetable indices for dry plants are significantly less than corresponding values of healthy plants.

V. CONCLUSION AND FUTURE SCOPE

The plant species were evaluated from hyperspectral non-imaging datasets using spectral indices. The spectral indices are useful in plant species evaluation with suitable results. The present study has investigated the use of spectral indices with plant reflectance spectra to identify the chlorophyll content. It is concluded that, spectral indices are the better way to analyze the hyperspectral non-imaging datasets based on narrow bands.

The present study can be used for plant leaves chlorophyll content within time which has useful applications in agriculture.

ACKNOWLEDGMENT

Authors would like to acknowledge technical supports under UGC SAP (II) DRS Phase-II, DST-FIST and NISA to Department of Computer Science & IT, Dr. Babasaheb Ambedkar Marathwada University, Aurangabad, Maharashtra, India and also thanks for financial assistance under UGC-BSR research fellowship for this work.

REFERENCES

[1] K. Pfitzner, A. Bollhöfer, G. Carr, "A Standard Design for Collecting Vegetation Reference Spectra: Implementation and Implications for Data Sharing", spatial science, vol.52, pp.1-3, 2006.

[2] Karla Muller, Ulf bottcher, Henning Kage, "Analysis of vegetation indices derived from hyperspectral reflection measurements for estimating crop canopy parameters of oilseed rape", Biosystems Engineering, pp.172-182, 2008.

[3] Eugene I. Rabinowitch, Govindjee, "The role of Chorophyll in Photosynthesis", pp.4-7, 1965.

[4] Rajesh K. Dhumal, Amol D. Vibhute, Ajay D. Nagne, Yogesh D. Rajendra, Karbhari V. Kale and Suresh C.Mehrotra, "Advances in Classification of Crops using Remote Sensing Data", Cloud Publications, International Journal of Advanced Remote Sensing and GIS, Volume 4, Issue 1, Article ID Tech-483 ISSN 2320 – 0243, pp.1410-1418, 2015.

[5] Amarsinh B Varpe, Yogesh D Rajendra, Amol D Vibhute, Sandeep V Gaikwad, KV Kale, "Identification of plant species using non-imaging hyperspectral data", (MAMI) Man and Machine Interfacing, International Conference, IEEE, pp.1-4, 2015.

[6] Amol D.Vibhute, K.V.Kale, Rajesh Dhumal, S.C.Mehrotra, "Soil type classification and mapping using hyperspectral remote sensing data", (MAMI) Man and Machine Interfacing, International conference IEEE, pp.1-4, 2015.

[7] Penuelas J., Baret F., and Filella I., "Semi empirical indices to assess carotenoids/ chlorphyll a ratio from leaf spectral reflectance", photosynthetica, pp.221-230, 1995.

[8] Chappelle E.W., Kim M.S. and Mcmurtrey J.E., "Ratio analysis of reflectance spectra (RARS) an algorithm for the remote estimation of the concentrations of chlorophyll A, chlorophyll b and the carotenoids in soybean leaves", Remote sensing of environment, pp.239-247, 1992

[9] Yachao Wang, Gang Wu, "Plant Species Identification Based on Independent Component Analysis for Hyperspectral Data", Journal of Software, vol.9,No.6, June 2014.

[10] Sims D.A and Gamon J.A, "Relationship between leaf pigment content and spectral reflectance across a wide range of species, leaf structures and developmental stages", Remote Sensing of Environment, pp.337-354, 2002.

[11] Blackburn G.A, "Quantifying chlorophylls and carotenoids at leaf and canopy scale an evalution of some hyperspectral approaches", Remote Sensing of Environment, pp.657-675, 1998a.

Table.1 Various SVI for healthy plant species

Number of Sample	1	2	3	4	5	6	7	8	9	10
PSNDa	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
PSNDb	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31
PSNDc	0.31	0.33	0.33	0.33	0.33	0.33	0.35	0.33	0.33	0.33
PSSRa	4.57	4.58	4.61	4.6	4.65	4.67	4.63	4.67	4.68	4.63
PSSRb	4.35	4.32	4.3	4.29	4.29	4.67	4.32	4.67	4.32	4.31
PSSRc	5.22	5.23	5.21	5.2	5.22	5.22	5.17	5.22	5.17	5.22

Table.2 Various SVI for dry plant species

Number of Sample	1	2	3	4	5	6	7	8	9	10
PSNDa	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.33	0.33	0.33
PSNDb	0.32	0.32	0.32	0.32	0.32	0.32	0.31	0.31	0.31	0.31
PSNDc	0.38	0.38	0.38	0.38	0.38	0.38	0.37	0.37	0.37	0.37
PSSRa	2.73	2.75	2.73	2.73	2.75	2.75	2.75	2.74	2.74	2.74
PSSRb	2.47	2.47	2.47	2.47	2.47	2.47	2.47	2.46	2.46	2.46
PSSRc	3.54	3.54	3.54	3.56	3.54	3.56	3.56	3.53	3.53	3.53

Table.4 Statistices of Narrowband Spectral Indices

Plants	**Synygium Cumini (SC)**				**Adhatola Zeylanica (AZ)**				**Azadirachta Indica (AI)**			
Category	Healthy		Dry		Healthy		Dry		Healthy		Dry	
Index	Avg	STD	Avg	STD	Avg	STD	Avg	STD	Avg	STD	Avg	STD
PSNDa	0.33	0.031	0.23	0.004	0.55	0.006	0.12	0.025	0.43	0.011	0.18	0.016
PSNDb	0.31	0.005	0.25	0.004	0.55	0.007	0.12	0.005	0.42	0.004	0.17	0.013
PSNDc	0.37	0.009	0.33	0.004	0.55	0.006	0.23	0.007	0.43	0.005	0.05	0.009
PSSRa	4.63	0.04	2.74	0.008	3.37	0.013	2.28	0.041	2.71	0.006	1.5	0.009
PSSRb	4.38	0.151	2.46	0.004	3.17	0.01	2.28	0.02	2.56	0.005	1.5	0.018
PSSRc	5.2	0.021	3.55	0.01	3.32	0.018	3.81	0.027	2.74	0.01	1.9	0.217

