Development of spectral library of mangrove native species of the Muthupet lagoon, Tamil Nadu, India using field spectroscopic instrument

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In the recent trends, the spectro-radiometer technique has proved its significance in the development of spectral library of earth’s surface materials to support the hyperspectral image interpretation and analysis. To enhance the efficiency of hyperspectral image classification, acquisition of spectral signature must be carried out. A practical study was carried out on Muthupet mangrove forest, Tamil Nadu, India. According to remote sensing data, the selected study shows as contiguous lagoon, and Avicennia marina (95% occupancy) is the majority community of the study area followed by Acanthus ilicifolius, and Aegiceras corniculatum. It is the first attempt to develop the spectral library for mangrove true species, and mangrove associates for the Muthupet lagoon, Tamil Nadu, India. With detailed field visits, by using the analytic spectral device (ASD), the spectral library built for prominent 6 true mangrove species such as Acanthus ilicifolius, Aegiceras corniculatum, Avicennia marina, Excoecaria agallocha, Rhizophora apiculata and Rhizophora mucronata) in connection to that 5 mangrove associates Salicornia brachiata, Sesuvium portulacastrum, Suaeda martina, Suaeda monoica, and Azims tetracantha. The reflectance and absorption of each species was observed, and built a spectral library of mangroves species, It is found that Acanthus ilicifolius provides high reflectance than others. This spectral library can be useful for mangroves species identification using hyperspectral data.

[Keywords: Avicennia marina, Field spectro-radiometer, First derivative of reflectance, Mangrove associates, Mangrove species]

Introduction

The Mangrove forests are salt-tolerant vegetation community of woody hydrophytes. It originates from tropical and subtropical zone of ecosystem, which covers various features such as estuaries, lagoons, creeks and mudflats, creeks. The forests are dense with spreading trees since each species has different roots structure such as knee roots, pneumatophores and stilt roots. The remote sensing is the most important foundation of spatial consequence of the earth’s surface. The hyperspectral remote sensing system is unique and provides the fine spectral resolution of objects in many narrow bands, it can be able to measure the quantitative information over vegetation with physicochemical status. The spectral measurement using hyperspectral sensor is helpful in classifying the materials in ecosystem characteristics. The effects of environmental processes and trouble on the spatio-temporal distribution of vegetation communities are significant aspects, and concern organizations are responsible to protect the natural zone level. Many authors made use of reference spectral libraries for mineral mapping. This idea can be inspired recently for the mapping of vegetation using in situ reflectance measurements.

The species identification using multispectral bands is not good enough due to absence of much absorption information for various crops. The better-quality spectral discrimination scheme is not available, therefore suitable technique is required in classifying similar class on the data either using training data extracted from the image or spectral library. Many spectral libraries (soil, water, vegetation are available for user), those are supporting for visual interpretation and upgraded-in to current commercial software. However, existing spectral library did not have some reference spectra for mangrove species. To develop the reference spectral library for mangrove species, an extensive field work was carried out and incorporated with unknown mangrove species. It has been observed that taking measurements on land is uncomfortable and difficult to use electronic equipment in lagoon. The measurement of leaf reflectance in 531 nm can vary within minutes after shifting dark to full light in field conditions without detachment. Collection of
mangrove leaves from the forest is a common practice for spectral measurements as filed access is very complicated. The spectro-radiometer is a special kind of optical instrument, which is designed for general purpose, and very useful in many application, particularly for remote sensing application. It acquires the spectra from blue-green-red, infrared and short wave infrared portion and used for various application. Various studies conducted for hyperspectral measurement for vegetation species identification. The analytical spectral device consists of more than 2000 channel with a range of 3.5–2.5 µm. The non imaging field instrument capable of providing more than 100 individual bands, and provided contiguous information about the earth surface. It acquires good spectral radiance from field, and retrieves the absolute reflectance of earth’s surface targets. In ancient years, the field spectro-radiometers exploited to study about colour vision. Currently two types of spectro-radiometer available in the market are (1) small, light devices that are designed to operate in the visible near infrared with considerable signal-to-noise ratio and (2) larger, heavier devices which are responsive to the visible, infrared, near infrared, and shortwave infrared of spectrum. A ground based investigation is being carried out by acquiring the spectral profile from the ASD in fresh leaf scale. To enhance the hyperspectral data classification, a reference spectral library is needed, but the available spectral library like United states geological survey (USGS) does not have the own unique library for native mangroves species. The main task of article is to develop a spectral library for mangrove species and mangrove associates from non imaging instrument.

Materials and Methods

Study area

The Tamil Nadu shoreline is located on the southeast coast of Indian peninsula, and it is about 1,076 km long. The Cauvery delta is located in the region of Tamil Nadu state in southern India. It covers the lower reaches of Cauvery and its delta. The delta regions covers the Muthupet lagoon area (Latitude: 10°18’13” to 10°20’71” N and Longitude: 79°30’90” to 79°34’87” E; Figure 1) along the coastal zone of the Bay of Bengal and Palk strait, is selected for mangrove spectral library generation. The stream drained by the tributaries of the Cauvery river such as the Paminiyar, Koraiyar, Kandankurichanar, Kilathangiyar and Marakkakoraiyar. This forest receives freshwater mostly through the northeast monsoon season from October to November.

The area of Muthupet mangrove wetland is about 12,000 ha, and it is divided into six reserve forests. It consists of two large lagoons, which are contiguous and about 1,700 ha in area. The botanical survey reviewed that there are total 8 numbers of true mangrove species present in the Muthupet mangroves. Among them three species namely: Ceriops decandra, Rhizophora apiculata and Rhizophora mucronata were reintroduced recently. The current status of this study area is that there were degraded of mangroves, and only six mangrove species available. The Mangrove associates such as Suaeda maritima, Suaeda monica and Salicornia brachiata are also found in the in landward margin wetlands.

The mangrove leaves were picked and packed with plastic covers and arranged for measurement of optical properties of leaves. The spectral acquisition can be done across narrow bands in the region of 3.5–10 µm, 10–1.83 µm and 1.83–2.50 µm. The laboratory spectra data carried out for the 6 true mangroves species and 5 Mangrove associate during July 29, 2018. Before collecting all the species, authors frequently visited the Muthupet mangrove forest, and observation is made about the leaves structure and root of each species, location and abundance of mangrove species and associates. The following observations are made during field visit. The distribution of species is shown in Figure 2. 1) Seaward zone occupied by Avicennia marina as dominant, followed by Aegiceras corniculatum; 2) The mid zone is mixing of Avicennia marina with small patches of Rhizophora apiculata, and Rhizophora mucronata and 3) The terrestrial zone is occupied by Souada zone with small patches of Prosopis juliflora.

The field photographs which exhibit the canopy status of mangrove as shown in Figure 3. The Spectral library is developed for all the healthy mangrove species. The view Spec used to build the spectral profile of those species.

The view spec tool is also permits the larger number of files and visualize graphically. It has provision such as Log 1/R (1/T), 1st Derivative, 2nd Derivative and Lambda Integration. The GARMIN GPS Etrex-10 used to collect the location of each species as shown in Table 1. The specification of GPS is 1000 way points, and 50 routes. The First derivative
Fig. 1 — Location of study area

Table 1 — List of mangrove true species and its associates collected from Muthupet mangrove forest

<table>
<thead>
<tr>
<th>S. No</th>
<th>Coordinates</th>
<th>Name of true mangrove species</th>
<th>Name of true mangrove associate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>N 10° 21’ 15.53&quot;</td>
<td>E 79° 31’ 51.28”</td>
<td>Avicennia marina</td>
</tr>
<tr>
<td>2</td>
<td>N 10° 21’ 15.23&quot;</td>
<td>E 79° 31’ 51.38”</td>
<td>Aegiceras corniculatum</td>
</tr>
<tr>
<td>3</td>
<td>N 10° 21’ 09.89&quot;</td>
<td>E 79° 32’ 11.61&quot;</td>
<td>Rhizophora mucronata</td>
</tr>
<tr>
<td>4</td>
<td>N 10°’ 21’ 09.81&quot;</td>
<td>E 79° 31’ 39.61”</td>
<td>Excoeceria agallocha</td>
</tr>
<tr>
<td>5</td>
<td>N 10° 21’ 14.08”</td>
<td>E 79° 32’ 05.44”</td>
<td>Acanthus ilicifolius</td>
</tr>
<tr>
<td>6</td>
<td>N 10° 21’ 11.28”</td>
<td>E 79° 21’ 28.38”</td>
<td>Rhizophora apiculenta</td>
</tr>
<tr>
<td>7</td>
<td>N 10° 21’ 20.56”</td>
<td>E 79° 31’ 51.09”</td>
<td>Suadea Martima</td>
</tr>
<tr>
<td>8</td>
<td>N 10° 21’ 16.54”</td>
<td>E 79° 31’ 49.22”</td>
<td>Salicornia brachiata</td>
</tr>
<tr>
<td>9</td>
<td>N 10° 19’ 22.57”</td>
<td>E 79° 32’ 24.42”</td>
<td>Sesuvium portulaccustrum</td>
</tr>
<tr>
<td>10</td>
<td>N 10° 19’ 23.06”</td>
<td>E 79° 32’ 24.37”</td>
<td>Azhima tetracantha</td>
</tr>
<tr>
<td>11</td>
<td>N 10° 19’ 23.04”</td>
<td>E 79° 32’ 24.32”</td>
<td>Suadea monoica</td>
</tr>
</tbody>
</table>
of the reflectance of mangrove species can be built through view Spec tool. Finally, the spectral signatures were exported in the Environmental visualization (ENVI 4.7) software for building of the library. In this study, all the spectral signatures imported into the spectral library tool, and extract the signatures curves for the mangroves and its associates. The flow chart for over all methodology is show in Figure 4. The Physio-chemical parameter of true mangrove species, and mangrove associates are shown in Figure 5 and 6 respectively. *Rhizophora apiculata* and *Rhizophora mucronata* have introduced recently by the Tamilnadu forest department, the leaves of those *Rhizophoracy* family are very thicker and dark green in color.
Results and Discussion

The spectral library was generated for True mangrove species and its associates. The absorption of each species as mentioned in Table 2. Among the mangrove species, the *Excoecaria agallocha* has the high reflectance peak, i.e. 82% at 1086 nm across very near infrared of electromagnetic spectrum, the reflectance is maximum between 672 nm and 1273 nm wavelength of infrared spectrum. Red edge for the *Avecennia marina* is originated at the 672 nm. The reflectance is maximum 33% at 548 nm. The maximum absorption occurs at 1.43 µm and the reflectance is very low at Short wave infrared region i.e. 17% of reflectance at 1672 nm. *Acanthus ilicifolius* has maximum reflectance at 1070 nm in the near infrared regions; however, reflectance is peak at 552 nm of green wave length. Absorption peak is taking place at the wavelength of 1432 nm. The *Aegiceras corniculatum* has high reflectance in 550, moreover the reflectance is high between the wavelengths of 701 nm to 1263 nm of near infrared of EMR, the absorption peak at the wavelength of 1430 nm of near infra-red. Both *Rhizophora apiculata* and *Rhizophora mucronata* almost behave identical at visible, near Infra red, and short wavelength infrared region. The *Rhizophora apiculata* met maximum peak at the wavelength of 1078 nm of infrared of electromagnetic spectrum. Similarly

![Fig. 4 — Flow chart for methodology](image)

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Species name</th>
<th>Absorption (nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><em>Avicennia marina</em></td>
<td>400, 500, 950, 1100, 1400, 1900</td>
</tr>
<tr>
<td>2</td>
<td><em>Aegiceras corniculatum</em></td>
<td>401, 505, 955, 1101, 1401, 1900</td>
</tr>
<tr>
<td>3</td>
<td><em>Rhizophora apiculata</em></td>
<td>400, 500, 949, 1102, 1400, 1900</td>
</tr>
<tr>
<td>4</td>
<td><em>Rhizophora mucronata</em></td>
<td>400, 499, 950, 1100, 1400, 1900</td>
</tr>
<tr>
<td>5</td>
<td><em>Excoecaria agallocha</em></td>
<td>400, 498, 951, 1100, 1399, 1900</td>
</tr>
<tr>
<td>6</td>
<td><em>Acanthus ilicifolius</em></td>
<td>402, 500, 950, 1100, 1400, 1900</td>
</tr>
</tbody>
</table>
Rhizophora mucronata has maximum reflectance at 548 nm of visible spectrum, and attained maximum reflectance peak of 75% at the wavelength of 1075 nm of near infrared regions, since presence of water absorption bands, the reflectance is very low, and the absorption peak at 1432 nm of short wavelength infrared of the EMR. The Avicennia marina is dominant occupancy in the study area, which exhibit maximum reflectance about 72% at 1088 nm in NIR. The reflectance is high between the wavelength of 679 nm to 1268 nm, and reflectance 27% in 555 nm of visible spectrum of EMR, the absorption is peak at 1434 nm of SWIR. Among the mangrove associates, Sensuvium portulacastrum provides maximum peak
at NIR, followed by *Suada zones*, *Salicornia brachiata*, and *Salvadoraceae*. Despite mangrove associates are not salt tolerant, most of patches are found to be degraded condition and it is continue to support to mangroves true species, the plot of reflectance of all species as shown in Figure 7. First derivative of reflectance of those mangrove species is shown in Figure 8, which is provided the peak reflectance and absorption details across wavelength. To understand the reflectance of each species, the offset has been set (Figure 9). When compared to existing spectral library, the reflectance of mangrove species can vary with respect to environmental condition, generally mangroves are distributed in the coastal zone, since there is lack of fresh water, hyper salinity and degraded conditions, and the reflectance is almost low when compared to reflectance of crops in various portion of EMR. The *Prosopis juliflora* provides high reflectance than the mangroves.
Conclusion

In this article, The spectral library generation for mangroves is carried out, which is highly required for a spectral matching techniques, existing spectral library like USGS does not provide the spectra library for mangrove species since canopy structure is very much depend on natural parameter like salinity, and soil condition of zone, in advancement of hyperspectral technology, it is first attempted to develop the spectral library for true mangrove species and its associate in Muthupet mangrove forest. 25 numbers of samples are utilized to collect the reflectance of true species. The spectral library built for prominent 8 true mangrove species. (Acanthus ilicifolius, Aegiceras corniculatum, Avicennia marina, Excoecaria agallocha, Rhizophora apiculata and Rhizophora mucronata) in connection to that 5 mangrove associates (Salicornia brachiata, Sesuvium portulacastrum, Suaeda martima, Suaeda monoica, Azims tetracantha). The near infra red portion of EMR plays vital role for the mangroves species rather than the short wave infrared region. Among the mangroves species, Excoecaria agallocha has high reflectance across very near-infra red of electromagnetic spectrum i.e. 82 % of reflectance at 1086 nm and the reflectance is maximum between 672 nm and 1273 nm wavelength of infrared spectrum. The Avicennia marina is dominant occupancy in the study area, which exhibit the maximum reflectance about 72 % at 1088 nm in NIR. The Aegiceras corniculatum provides high reflectance between the wavelengths of 701 nm to 1263 nm of Near Infrared of EMR. Acanthus ilicifolius has maximum reflectance at 1070 nm in the NIR, the Rhizophora apiculata and Rhizophora mucronata almost behave identical at visible, near infra red, and short wavelength infrared region. In connection to that among the mangrove associates, Sesuvium portulacastrum provided maximum peak at NIR, followed by Suaeda zones, Salicornia brachiata, and Salvadoraceae. Thus, the spectral library was built for all the mangrove species. The reflectance and absorption of each species was observed. Among the mangroves species, the Acanthus ilicifolius provides high reflectance. Finally this spectral library can be useful for spectral matching techniques in Hyperspectral approach, and image classification can be improved with higher accuracy.

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Conflicts of Interest

The authors declare no conflict of interest.

Author Contributions

AS collected the data, designed the method of study and wrote the major part of articles. SS visualized the method and wrote part of the manuscript and also performed the revision and NR prepared the method for spectral data collection and visualized the revision.

References


