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Spectral reflectance properties of mangrove species of the Muthupettai mangrove environment, Tamil Nadu

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Abstract: *In the Muthupettai mangrove environment, spectral properties of six mangrove species viz. Avicennia marina, Aegiceras corniculatum, Excoecaria agallocha, Acanthus ilicifolius, Suaeda monoica and S. maritima was studied using Multi band Ground Truth Radiometer (Model–041). The study found that the chlorophyll concentration of different mangrove leaves varies between 0.05 and 0.36 mg g^{-1}, registering the minimum in S. maritima and maximum in E. agallocha. Interestingly species with higher chlorophyll concentration showed lower reflectance values alteast in the spectral bands 1 and 2. E. agallocha registered 0.36 mg g^{-1} of chlorophyll while it recorded only 2.18 and 2.43% reflectance where as S. maritima recorded 3.16 and 3.27% of reflectance in bands 1 and 2. This indicates chlorophyll concentration is one of major factors responsible in determining the reflectance pattern of the pant communities. The spectral properties of mangroves were largely differed with that of the water and soil samples collected from the same locations, these results favour the utilization of remotely sensed data for depicting various water and soil quality parameters from that of mangrove species in the mangrove environment. This study also found that the difference in reflectance of mangroves at canopy level is not only influenced by the chlorophyll content of species but also by the prevailing environmental condition and background reflectance of soil and water as well*

Key words: *Spectral reflectance, Mangroves, Chlorophyll content*
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Introduction

Identification, delineation and classification of various environmental features through remote sensing data visually or with the help of computers require an understanding of their spectral response in different parts of the electro magnetic spectrum. The spectral reflectance properties of coastal surface play an important role in the interpretation and analysis of coastal water features of the marine environment. Further, the remote sensing techniques can be fully used if we have a thorough knowledge in spectral responses of the materials and objects existing in the marine surface. It is because these spectral responses form the basis for the characterisation of materials and objects.

For classification of remote sensing data collected over Indian coastal areas and local environmental conditions, reliable ground-truth data are required. But, there is a scarcity of spectral reflectance ground-truth data for coastal and marine surfaces in the Indian region. So, it is important to have prior knowledge and understanding about the absorption and reflectance characteristics of various marine environmental features and the parameters that influence them, in order to interpret remotely sensed data more meaningfully and accurately (Sinha, 1986). Moreover, study of spectral signatures provides with the choice of selecting the spectral bands or bandwidths for differentiating various environmental features and to select the type of sensor best suitable for specific application.

Though, there are innumerable studies on spectral properties of various objects, such studies are very limited in the mangrove environment. Krishnamoorthy *et al.* (1997) and Ajithkumar *et al.* (1998, 1999) have carried out such studies in the Pitchavaram and Muthupettai mangrove environment. However there are few studies attempted to study the reflectance pattern of the mangroves using satellite data. Blasco and Aizpuru (2002) have reported that the entire spectral reflectance pattern of the mangroves is induced by chlorophyll concentration. SAC (2003) attempted to establish set of standard reflectance characters for distinguishing major mangrove communities of India. Thangaradjou *et al.* (2007) and Shah and Anjali Bahuguna (2007) have emphasized the need of hyper spectral signatures to distinguish mangrove and other marine communities at species level.

Though there are certain literatures attempted to study the reflectance of mangroves using satellite data, still observations on spectral properties of the mangrove biota are not enough due to difficulties in using airborne systems to study the mangrove canopy reflectance. Hence, the present study was undertaken to find out the reflectance pattern of the dominant mangroves species of the Muthupet mangrove forests, using multiband ground truth radiometer and the results will help to distinguish mangrove communities from the other features like water and sediment based on reflectance.

Materials and Methods

Study area: Muthupettai mangrove forest (Lat. 10° 25' N; Long. 79° 39' E) lying along the southeast coast of India, is located on the

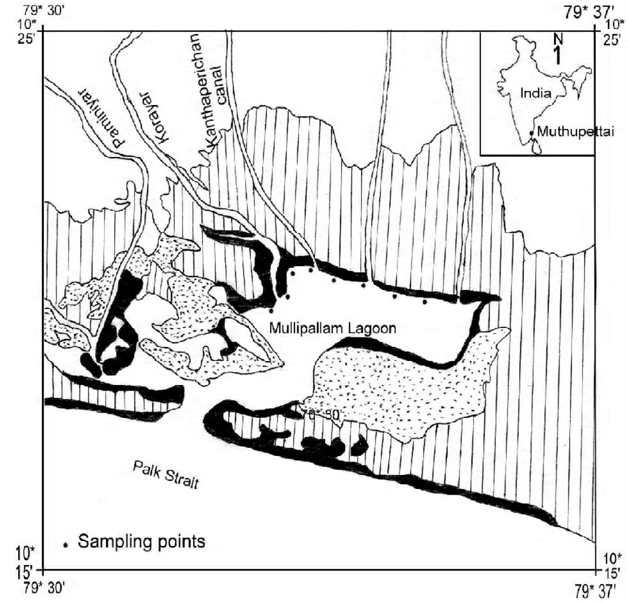

Fig. 1: Map showing the study area

southern part of the Kaveri deltaic region (Fig. 1). It spreads to an area of about 6800 ha. The mangrove remains homogenic with the dominant occurrence of *Avicennia marina*

Spectral reflectance: Spectral reflectance measurements of six mangrove species *viz., Avicennia marina, Aegiceras corniculatum, Excoecaria agallocha, Acanthus ilicifolius, Suaeda monoica* and *S. maritima* of the Muthupet mangrove environment were carried out during June 1997 using the multi-band ground truth radiometer of landsat thematic mapper (TM) and Indian remote sensing satellite (IRS) bands by following the method described by Krishnamoorthy *et al.* (1997). The multi band ground truth radiometer (GTR), model-041, manufactured by Optomech Engineers Pvt. Ltd., Balanagar, Hyderabed in technical collaboration with the Space Application Centre, ISRO, Ahemedabad was used in this study to measure the *in situ* spectral reflectance of various objects. The GTR measures the reflected radiation in a series of discrete spectral bands rather than over a continuous spectral range. It has 11 spectral bands in the wave length range of 450-900 nm wavelength, out of which the first four (bands 1-4) are compatible with Landsat-TM, the next four (bands 5-8) are compatible with IRS and the last three (bands 9-11) are compatible with SPOT. For the present study spectral bands of IRS have alone are taken for discussion.

The details of various filters supplied in GTR are given in (Table 1). The optical head and digital display panel units are the two subsystems of the instrument. The field of view of the optical head is $15^o \pm 1/2^o$. It received the radiation reflected by the surface or object being sensed at a selected spectral band, which is the measure of the spectral radiance of the surface. This output is measured in watts per sq cm per steradian and micrometer (W/cm^2-s-ms μm). The range of output recorded by the digital panel meter is from $0.01x10^{-5}$ to $19.99x10^{-2}$ W/cm^2-Sr- μm). This instrument can work under ambient temperature from 5 to 45^{o}C and at a RH of 30 to 90% with a sensitivity of better than 3% of the solar reflectance.

Reflectance standard measurements (using barium sulphate plate) were recorded immediately before and after the spectral measurements were taken from mangrove canopy. Reflectance were recorded for all the six species in eight different locations and averaged. In this experiment, the effect of sun elevation on the reflectance of the panel was not considered. However, the reflectance measurements were made between 11 AM to 1 PM to minimize the effect of sun elevation angel variations. Reflectance from the barium sulphate plate was estimated to use as reference for the calculation of percentage. The percentage of reflectance was calculated by the formula -

$$\text{\% Reflectance} = \frac{\text{Reflectance radiation from the object}}{\text{Incident radiation}} \times 100$$

Chlorophyll analysis: Leaves of all the six mangrove species were collected for chlorophyll analysis. Chlorophyll content of the mangrove leaf was estimated by Method given by Arnon (1949).

Results and Discussion

The spectral behaviour of water and sediments of the Muthupettai mangrove environment have been clearly discussed in our earlier papers (Ajithkumar *et al.,* 1998, 1999). Mangrove species present in the same locations from where the water and sediment analysis was made also subjected for reflectance studies and the results were compared with water and sediment reflectance properties.

The spectral reflectance study on mangrove plants showed variations in the amplitude of radiances between different mangrove plant species and also within the same species occurring in different locations during the same period of observation, as advocated by Sato *et al.* (1992). Spectral reflectance of vegetation canopy would vary with varying wave lengths and the knowledge on the properties of individual leaf is inevitable to understand why a canopy reflects more at certain wavelengths than others. Report of Curran (1985) stating that pigmentation, canopy structure and leaf morphology have an effect on the reflectance, absorbance and transmittance is worth mentioning here. A comparison of spectral reflectances of different mangrove plant species will provide some useful information with regard to the variation in the intensity of reflectance and to correlate with various related parameters of mangrove vegetation.

Six species *viz. Avicennia marina, Excoecaria agallocha, Aegiceras corniculatum, Acanthus ilicifolius, Suaeda monoica* and *S. maritima* were selected for the spectral reflectance study. All the mangrove species investigated showed similar pattern of reflecatance with varying reflectance intensities at different bands. But the study has not found any uniform difference in all the bands among all the species.

Table - 1: Details of filters supplied in GTR

GTR Band number	Satellite	CWL[a] (nm)	Bw[b] (nm)	Range (nm)
1	LANDSAT-TM	485	70	450-520
2	LANDSAT-TM	560	80	520-560
3	LANDSAT-TM	660	60	630-690
4	LANDSAT-TM	830	140	760-900
5	IRS	485	70	450-520
6	IRS	555	70	520-590
7	IRS	650	60	620-680
8	IRS	815	90	710-860
9	SPOT	545	90	500-590
10	SPOT	645	70	610-680
11	SPOT	840	100	790-890

Source: GTR manual, published by Optomech Engineers Pvt. Ltd., Hyderabad, CWL[a] = Central wave length BW [b] = Band width

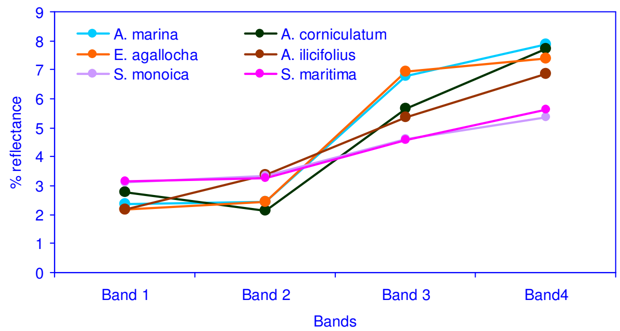

Fig. 2: Spectral reflectance of different mangrove plants

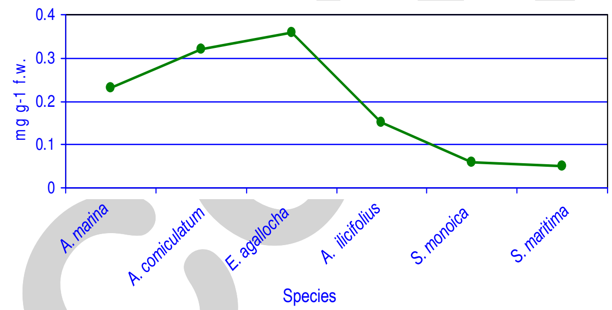

Fig. 3: Chlorophyll content of different mangrove plant species

From the measurements, reflectance percentage was calculated for each wavelength and the reflectance curves were drawn for each species (Fig. 2). Among the six species, *A. marina* showed higher reflectance and *S. monoica* showed the lowest reflectance. In general, a decrease in reflectance could be observed in bands 1 and 2 but there was a steady increase in reflectance from band 3. This indicates the utilization of light by the plant communities in these ranges (450-520 and 520-590 nm wave length). This could be witnessed by the relation between higher chlorophyll concentration and higher utilization of light intensity *eg., E. agallocha* and *A. corniculatum* have recorded higher chlorophyll concentration and interestingly both the species registered lower reflectance in the bands 1 and 2 and higher reflectance in bands 3 and 4. This is also well supported by the findings of the Blasco and Aizpuru (2002) who has reported that the entire spectral reflectance pattern of the mangroves is induced by chlorophyll concentration and by humidity gradient in soil related to tidal level.

Among the six plant species studied, chlorophyll content was more in *E. agallocha* followed by *A. corniculatum* and *A. marina* (Fig. 3), but the reflectance was higher in *A. marina*. This is again proves the relationship between chlorophyll concentration and utilization of light by plants, however the present study could not found any significant correlation between the chlorophyll concentration and reflectance. From this it is quit understandable that, the variation in reflectance of mangrove plant species is not only due to the chlorophyll content of the leaf alone but also due to the environmental conditions, plants health *etc.* The local environmental conditions like pollution and salinity would influence the spectral reflectance properties of mangrove plants. He has studied the spectral reflectance of *A. marina* from Ennore, Pitchavaram and Madavamedu. *A. marina* in Pitchavaram showed higher reflectance but the reflectance in Ennore (polluted) and Madavamedu (less saline) was markedly lower. Blasco and Aizpuru (2002) also reported that in addition to chlorophyll concentration humidity gradient in soil related to tidal level is also influencing the reflectance pattern of mangrove communities.

From the study it is also clear that the multi spectral bands are not good enough in distinguishing mangroves at species level, as the reflectance data indicates overlapping at several locations among the species. *A. ilicifolius* and *A. corniculatum* have showed overlapping at band 3 while *A. ilicifolius* overlaps with *S. maritime* at band 2. However, a combination of all the bands could help in distinguishing mangroves at generic level or at community level as opined by SAC (2003). To avoid such confusions in distinguishing mangroves at species level Thangaradjou *et al.* (2007) and Shah and Bahuguna (2007) have emphasized the need of hyper spectral data.

At canopy level, reflectance spectra depend not only on the optical properties of leaves but also on the background reflection of water and sediment. Spectral reflectance of different types of water features of the mangrove environment showed characteristic behaviour and significant difference in different wavelengths (Ajithkumar *et al.,* 1998) like wise spectral reflectance of sediments of the Muthupet mangrove environment also showed characteristic behaviour and significant differences (Bowers and Hanks, 1965; Cipra *et al., 1971;* Ajithkumar *et al.,* 1999) at different locations. These difference in reflectance could be attributed to the spatio-temporal changes in physico-chemical properties of water and changes in mineralogical composition, texture and moisture content of the soils and also presence of heavy metals in the sediments (Peerzada and Rohoza, 1989). Spectral properties of mangrove plants vary spatially and also probably temporally at canopy level and it is not only influenced by the chlorophyll content of species but also the prevailing environmental condition and background reflectance of soil and water. Precise estimation of such difference in spectral reflectance properties of water, soil and mangrove species through remote sensing will be highly useful in the effective management of mangrove environment. From the present study on spectral reflectance of mangrove water, soil and plant, it can be concluded that difference in the spectral properties of water from the mangrove environment (soil and canopy) can be used to differentiate the various features like water, mudflats, saline lands, vegetations of the mangrove environment.

Acknowledgments

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