INTERNATIONAL JOURNAL OF PLANT, ANIMAL AND ENVIRONMENTAL SCIENCES
IJPAES
VOLUME-2, ISSUE-4, OCT-DEC-2012 ISSN 2231-4490

Coden : IJPAES www.ijpaes.com

Received: 10th August-2012 *Revised: 13th August -2012* *Accepted: 19th August -2012*

Research article

ANALYSIS OF MANGROVE VEGETATION OF DIVISEEMA REGION, KRISHNA DISTRICT, ANDHRA PRADESH

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ABSTRACT: Mangrove Ecosystems play an important role in preventing cyclones and tsunamis at estuaries from entering into interior land and in the economic development of local inhabitants. Mangrove plants have special adaptations such as stilt roots, viviparous germination, salt-excreting leaves, breathing roots, knee roots by which these plants survive in water logged anaerobic saline soils. The study of mangrove ecosystems in the deltaic region of Krishna river, particularly in Diviseema region is very less and hence taken up. Selection of the main field stations, the study of various representative quadrats of sub-field stations and the study of mangrove species are made. The Frequencies, IVI, MIV and SI and CD of the mangrove species in the study area are determined and analysed.

Key Words: Mangrove Ecosystem, Vegetation analysis, Important Value Index, Maturity Index Values, Similarity Index and Coefficient Difference.

Abbreviations: IVI - Important Value Index; MIV - Maturity Index Values; SI-Similarity Index; CD - Coefficient Difference.

INTRODUCTION

Mangrove plants are specialized to tolerate high salinity, tidal extremes, and high fluctuations in wind, temperature and muddy anaerobic soil with the development of some adaptive morphological characteristics. No other groups of terrestrial plants survive well under such conditions. A muddy substratum of varying depth and consistency is the necessary phytogeographical condition for their growth.

The aim of the investigation is to study the distribution of mangroves, estimate their ecological status based on Frequency, IVI, MIV, SI and CD of mangrove vegetation.

Study Area

Krishna delta is situated between 15°.40' N and 16°.55'N latitude and 80°.0' and 82°.23' E longitudes. It is bound in the north by Diviseema (Krishna district), in the east by Bay of Bengal, in the west by Repalle (Guntur district) and in the south by Nizampatnam (Guntur district).
Mangroves in Diviseema area lie between latitude 15° 15' - 15° 55'N latitude and 80° 45' - 81° 00' E longitude. The northern distributary of Krishna river drains in this area near Hamsaladeevi.
Previous studies were concentrated at Nizampatnam, Kothapalem of Guntur district. Recently the present authors analysed the Mangrove vegetation of Machilipatnam region [1].
The present study is carried out to identify the mangrove vegetation distributed in the deltaic region of Diviseema area, which is surrounded by northern distributary, Gollamothupaya & Nadimaru distributary of Krishna river and the rest of Krishna river, which are present near Nagayalanka in Krishna district, Andhra Pradesh. Previous studies were concentrated at Nizampatnam, Kothapalem of Guntur district.
The area at which the Bay of Bengal takes a geographical "U" turn has a very high tidal impact. Hence the field stations Sorlagondi, Nachugunta, Yelichetladibba are frequently affected by cyclonic storms in Krishna district. So they are considered to be interesting field stations for mangrove study and hence included in the study area. The three villages are Reserve Forests**.** This region is selected from the revenue district of Krishna.

There is a northern distrubutary of Krishna river at Puligadda, 60 km downstream from Vijayawada and it empties into the sea at Hamsaladeevi. There are two more distributaries of Krishna river at Gollamothupaya and Nadimeru, which are about 25 km down stream from Avanigadda and flow northward to join the sea at Sorlagondi and Nachugunta respectively. The rest of main Krishna River continues southwards to join the sea at Yelichetladibba. Mangroves are mainly prevalent around tidal creeks, channels, lagoons, tidal flats and mud flats of the three distributaries.

Deltaic region of Diviseema area is surrounded by northern distributary, Gollamothupaya & Nadimeru distributaries and the rest of Krishna river, which are present near Nagayalanka in Krishna district (map: Figure – 1). The deltaic system is divided into three field stations viz., 'Sorlagondi' between Northern and Gollamothupaya distributaries, 'Nachugunta' between Gollamothupaya & Nadimeru and 'Yelichetladibba' between Nadimeru & Krishna river. The Krishna river after Nadimeru bifurcates the Krishna and Guntur districts. All these areas are selected from the revenue district of Krishna.

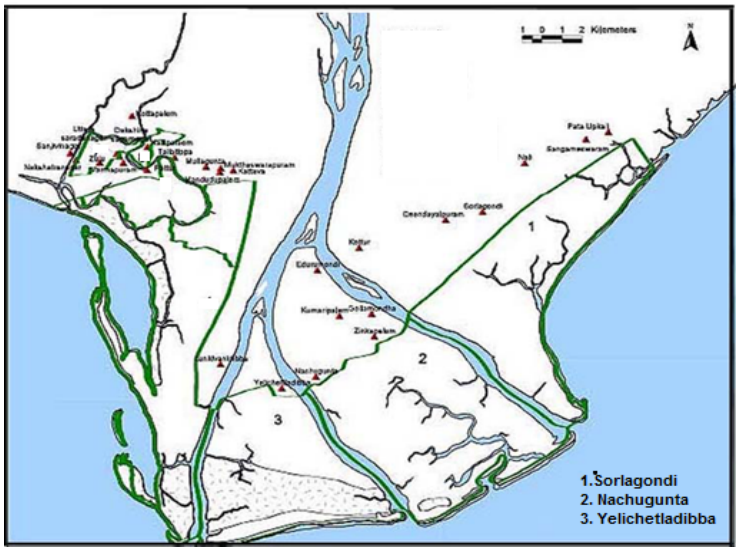

Figure 1: Map showing the Mangrove Vegetation in Diviseema Region

Mangrove vegetation is a fragile ecosystem. Krishna mangroves are changing rapidly due to natural calamities, deforestation, aquaculture, over-exploitation, absence of proper management, conservation etc. Mangrove vegetation is a natural protector from natural threats like cyclones, tsunamis etc. The cyclone in 1977 and the tsunami in 2004, which devastated Diviseema and Machilipatnam regions respectively, are examples of natural threats. It is proved that mangroves act as natural protectors to control the cyclonic winds and tsunami waves, with densely populated mangrove vegetation [2]. Therefore, a detailed study of Krishna mangroves is very important.

The Krishna deltaic region is in tropical humid climate, with hot summers and moderate winters. Maximum temperature varies from 23^0 C to 33^0 C and the minimum value ranges between 19^0 C to 23^0 C during a year. This region gets annual rainfall due to the southwest monsoon. The average normal rainfall in the district is 110 cm, as obtained from the data collected in 2012.

MATERIALS & METHODS

The main field stations are in the arena of Diviseema. The vicinity of northern distributary of Krishna river, along with other criteria like vegetation structure, inundation frequency and the extent of human interference are taken into account while selecting a main field station. The above criteria have also been selected [3] to visualize the factors responsible for the degradation of mangrove belts.

Several field visits in various seasons have been made to study the mangrove distribution pattern, frequency and species abundance, which, in turn, are used to determine the ecological status of the mangrove vegetation.
Line transects of varying widths and quadrats from 4 m x 4 m to 10 m x 10 m are laid on either side of the creeks and data from each one are recorded from ten such transects / quadrats. Plant materials collected during sampling are identified with the help of the standard herbaria of the Botanical Survey of India and Gamble Volumes of the Department of Botany, Nagarjuna University, Guntur.

Various parameters like Frequency, Relative Frequency etc. are calculated by the using formulae (1) and (2),

$$\text{Frequency} = \frac{\text{No of occurrences of a species}}{\text{Total no of site samples taken}} \text{ X } 100 \quad (1)$$

$$\text{Relative Frequency} = \frac{\text{No of occurrences of particular species}}{\text{Total no of occurrences of all the species}} \text{ X } 100 \quad (2)$$

The values of relative frequency are calibrated on a 10-point scale to assign a status to the species in each region. Four distinct groups are derived from this 10-point scale and each group in each region is designated as follows:
7 – 10 Very Frequent; 5 – 7 Frequent; 3 – 5 Less Frequent; < 3 Rare

The abundance and density represent the numerical strength of species in the community [4]. Abundance is described as the number of individuals occurring in a quadrat per sampling unit and density as the number of individuals per sampling unit. Abundance and density were calculated using the formulae (3) (4) (5) and (6),

$$\text{Abundance (A)} = \frac{\text{Total number of individuals}}{\text{Number of Sampling units of occrance}} \text{ X } 100 \quad (3)$$

$$\text{Relative Abundance} = \frac{\text{Abundance of a particular species}}{\text{Sum of the abundances of all species}} \text{ X } 100 \quad (4)$$

$$\text{Density} = \frac{\text{Total no of individuals of a species in all quadrats}}{\text{Total no of quadrats sampled}} \text{ X } 100 \quad (5)$$

$$\text{Relative density} = \frac{\text{Density of a particular species}}{\text{Sum of the densities of all species}} \text{ X } 100 \quad (6)$$

Importance Value Index (IVI)

The concept of 'Important Value Index (IVI)' has been developed for expressing the dominance and ecological success of any species, with a single value [4]. This index utilizes three characteristics, viz. relative frequency, relative density and relative abundance. The three characteristics are computed using frequency, density and abundance for all the species falling in all the transects using formula (7),

IVI = Relative *frequency + Relative abundance + Relative density* (7)

MIV, SI, CD are used to assess the maturity, similarity, diversity, respectively, of mangrove vegetation among various field stations [5].

Maturity Index Value (MIV)

The degree of maturity of a plant community is established based on the percent frequency of all species in the sites of study regions divided by the number of species occurred. This is MIV. Sampling is done by selecting 10 quadrats at each site and the frequency of each species is calculated, before calculating the percentage frequency. The Maturity Index Values are compared among different sites and it is inferred that the one nearer to 100 is highly matured in the community over others as suggested [6]. The formulae for MIV is given in (8),

$$\text{MIV} = \frac{\text{Frequency of all species}}{\text{No of species studied}} \text{ x } 100 \quad (8)$$

Similarity Index (SI) and Coefficient Difference (CD)

Expression of similarity of species and community coefficients indicate the degree of homogeneity of vegetation which reflects habitat status. The SI is calculated by using the formula (9) given by [7].

$$S = \frac{2W}{(a+b)} \times 100 \quad (9)$$

where S = Similarity index between the sites being compared
W = Sum of the species
a = Total number of species in site number one
b = Total number of species in site number two

The degree of similarity is determined among the sites as percentage of resemblance and categorised into highest, medium, lowest and no similarity. The corresponding CD values are obtained by subtracting the percentage similarity from 100. The formulae for CD is given in (10),

$$C.D = 100 - S \quad (10)$$

RESULTS & DISCUSSION

Floral Composition

In this region mangrove vegetation consisting of 20 genera and 26 species of 16 families has been recorded as 16 trees, 5 shrubs and 5 herbs (Table – 1).

Habitat-wise distribution of mangroves in the three field stations of this Region is shown in the Figure **– 2.**

Table 1: Systematic Position of the species present in the Mangrove Region of the Study area

S.No	Family	Name of the Species	Vernacular name	Habitat
1	Myrsinaceae	*Aegiceras corniculatum*(L.)	Guggilam	Tree
2	Avicenniaceae	*Avicennia alba*	Gudammada	Tree
3	Avicenniaceae	*Avicennia marina* (Forsk.)	Tellamada	Tree
4	Avicenniaceae	*Avicennia officinalis* (L.)	Nallamada	Tree
5	Rhizophoraceae	*Bruguiera cylindrical* (L.)	Uradu	Tree
6	Rhizophoraceae	*Bruguiera gymnorrhiza* (L.)	Thoddu ponna	Tree
7	Rhizophoraceae	*Ceriops decandra* (Griff.)	Calhasu / Thogara	Tree
8	Euphorbiaceae	*Excoecaria agallocha* (L.)	Tilla	Tree
9	Combretaceae	*Lumnitzera racemosa*	Thanduga	Tree
10	Rhizophoraceae	*Rhizophora apiculata*	Ponna	Tree
11	Rhizophoraceae	*Rhizophora mucronata*	Uppu Ponna	Tree
12	Meliaceae	*Xylocarpus granatum*	Senuga	Tree
13	Sonneratiaceae	*Sonneratia apetala*	Pedda kalinga	Tree
14	Acanthaceae	*Acanthus ilicifolius* (L.)	Allchi	Shrub
15	Plumbaginaceae	*Aegialitis rotundifolia* Roxb.	gadara	Tree
16	Verbenaceae	*Clerodendrum inerme* (L.)	Pisingi	Tree
17	Convolvulaceae	*Cuscuta reflexa* Roxb.	savarapu kada	Herb
18	Fabaceae	*Dalbergia spinosa* Roxb.	Chillangi	Shrub
19	Fabaceae	*Derris heterophylla*	silasila/ Nalla Theega	Shrub
20	Malvaceae	*Hibiscus tiliaceus* (L.)	attaka nara	Shrub
21	Poaceae	*Porterasia coarctata* Roxb.	Yellu gaddi	Herb
22	Amaranthaceae	*Pupalia lappacea* (L.)	yerra uttareni	Herb
23	Salvadoraceae	*Salvadora persica* (L.)	Gunnangi	Tree
24	Chenopodiaceae	*Suaeda fruticosa* (L.)	Elakura	Shrub
25	Chenopodiaceae	*Suaeda maritima* (L.)	Elakura	Herb
26	Chenopodiaceae	*Suaeda monoica* Forsk.	Elakura	Herb

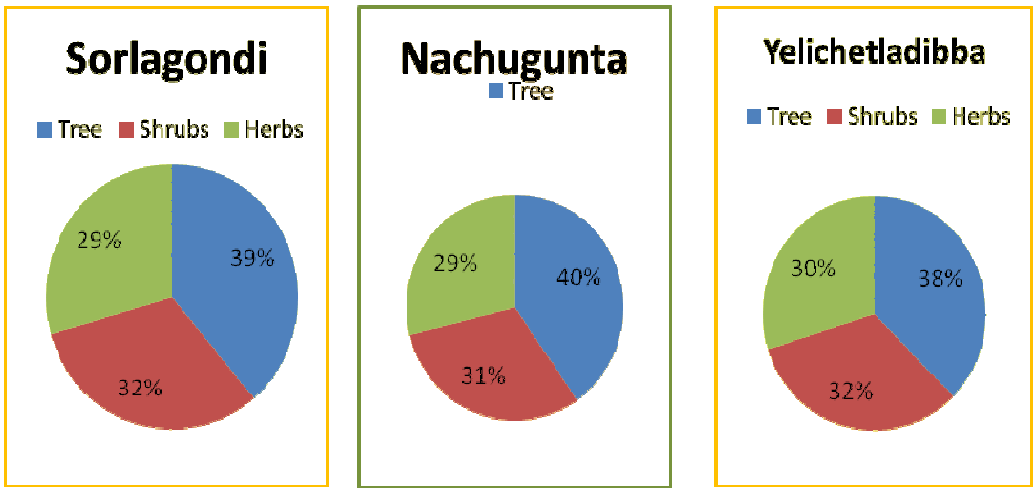

Figure 2: Habitat-wise distribution of Mangroves in study region

The mangrove vegetation of Diviseema has been broadly classified into three main categories. They, alongwith their composition of species and distribution pattern, are mentioned below.

1. The interior group of mangrove vegetation, which mainly consists of species of Avicenniaceae, Rhizophoraceae and Euphorbiaceae.

2. The mangrove vegetation of central area, which mainly consists of species of Sonneratiaceae, Combretaceae and Myrsinaceae.

3. Mangrove vegetation spread at peripheral or marginal areas, which consists of species of Acanthaceae, Verbenaceae, Chenopodiaceae, Fabeceae and Poaceae.

Important Value Index

Species dominance is calculated based on the Important Value Index
In Sorlagondi the highest IVI value is 23.73 for *Avicennia marina* and *Avicennia officinalis* followed by 14.84 for *Rhizophora apiculata*, *Acanthus ilicifolius* and then by *Bruguiera cylindrica*, *Bruguiera gymnorrihiza*, *Clerodendrum innema*, *Porterasia coarctata* with a value of 12.59. In Sorlagondi also the dominant species are *Avicennia marina* and *Avicennia officinalis.* The details are shown in Table 2.

In Nachugunta the highest IVI value is 20.24 for *Avicennia marina and Avicennia officinalis followed by 15.16 for Bruguiera gymnorrihiza, Excoecaria agallocha, Rhizophora apiculata* which is further followed by *Aegiceras corniculatum, Bruguiera cylindrica, Rhizophora mucronata, Sonneratia apetala, Acanthus ilicifolius, Suaeda* maritima with a value of 12.62. In this village also the dominant species are Avicennia marina and Avicennia officinalis and for details refer Table 2.

In Yelichetladibba the highest IVI value is 24.35 for Avicennia *marina* and *Avicennia officinalis.* The next dominant species *Suaeda maritima* have an IVI value of 19.82. Suaeda fruticosa having a value of 16.10 is the next dominant species. The dominant species in Yelichetladibba are again *Avicennia marina* and *Avicennia officinalis* and for details refer Table 2.
From the results of species composition and IVI values it is obvious that the family Avicenniaceae is the single largest family in Diviseema region followed by Euphorbiaceae, shown in Figure 3. Similar results are reported for Godavari delta [8].

Table 2: Species dominance based on the IVI values present in Diviseema Region

S.No.	Name of the Plant Species	Important Value Index		
		Sorlagondi	Nachugunta	Yelichetladibba
1	*Aegiceras corniculatum*	8.08	12.62	9.61
2	*Avicennia alba*	10.33	11.19	9.61
3	*Avicennia marina*	23.73	20.24	24.35
4	*Avicennia officinalis*	23.73	20.24	24.35
5	*Bruguiera cylindrical*	12.59	12.62	9.61
6	*Bruguiera gymnorrhiza*	12.59	15.16	15.30
7	*Ceriops decandra*	10.33	9.52	9.61
8	*Excoecaria agallocha*	10.33	15.16	15.30
9	*Lumnitzera racemosa*	10.33	9.52	9.61
10	*Rhizophora apiculata*	14.84	15.16	15.30
11	*Rhizophora mucronata*	10.33	12.62	9.61
12	*Xylocarpus granatum*	8.08	9.52	9.61
13	*Sonneratia apetala*	10.33	12.62	2.56
14	*Acanthus ilicifolius*	14.84	12.62	15.30
15	*Aegialitis rotundifolia*	10.33	9.52	0.00
16	*Clerodendrum inerme*	12.59	9.52	9.61
17	*Cuscuta reflexa Roxb.*	8.08	9.52	15.30
18	*Dalbergia spinosa Roxb.*	8.08	6.43	9.61
19	*Derris heterophylla*	10.33	9.52	9.61
20	*Hibiscus tiliaceus*	8.08	6.43	0.00
21	*Porterasia coarctata Roxb.*	12.59	9.52	9.61
22	*Pupalia lappacea*	10.33	9.52	0.00
23	*Salvadora persica*	8.08	9.52	15.30
24	*Suaeda fruticosa*	10.33	9.52	16.10
25	*Suaeda maritima*	10.33	12.62	19.82
26	*Suaeda monoica*	10.33	9.52	15.30

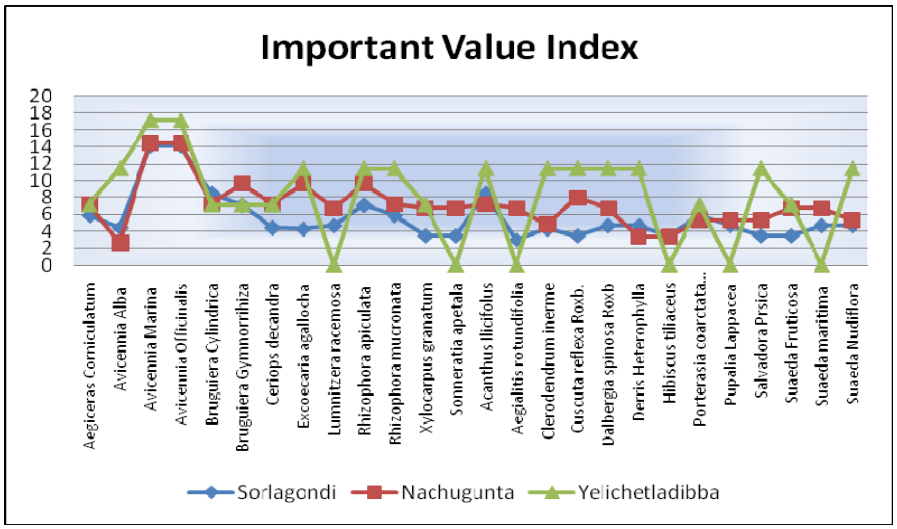

Figure 3: Distribution of Mangroves in Diviseema region based in IVI values

Maturity Index Value

The Maturity Index Values of the field stations in this Region i.e. 61.54 of Sorlagondi, 76.92 of Nachugunta and 69.57 of Yelichetladibba show that there is the densest mangrove vegetation at a place (Nachugunta in the present case), where there is a maximum frequency of inundation. The maximum frequency of inundation is due to the geographical "U" curve at that place. Further, it can be inferred that places where there is less frequency of inundation, have less dense mangrove vegetation.

Maximum Index Values (MIV) of mangrove species at different field stations in Diviseema region show that Nachugunta is highly matured in the mangrove community (its MIV value being 76.92, which is nearest to 100). This is because Nachugunta of Diviseema has highly favourable conditions both geographically and environmentally for the matured growth of mangroves. There is a maximum inundation of tidal water in this field station, when compared with other field stations, for geomarphological reasons. Moreover, the soil is highly sandy-clayey in this station when compared with the others. The details are given in Table 3 & Figure 4.

Table 3: Maturity Index Values (MIV) of Mangrove at different field stations

S.No.	Name of the Plant Species	Frequency %		
		Sorlagondi	**Nachugunta**	**Yelichetladibba**
1	*Aegiceras corniculatum*	40.00	100.00	50.00
2	*Avicennia alba*	60.00	33.33	50.00
3	*Avicennia marina*	100.00	100.00	100.00
4	*Avicennia officinalis*	100.00	100.00	100.00
5	*Bruguiera cylindrical*	80.00	100.00	50.00
6	*Bruguiera gymnorrhiza*	80.00	100.00	100.00
7	*Ceriops decandra*	60.00	66.67	50.00
8	*Excoecaria agallocha*	60.00	100.00	100.00
9	*Lumnitzera racemosa*	60.00	66.67	50.00
10	*Rhizophora apiculata*	100.00	100.00	100.00
11	*Rhizophora mucronata*	60.00	100.00	50.00
12	*Xylocarpus granatum*	40.00	66.67	50.00
13	*Sonneratia apetala*	60.00	100.00	0.00
14	*Acanthus ilicifolius*	100.00	100.00	100.00
15	*Aegialitis rotundifolia*	60.00	66.67	0.00
16	*Clerodendrum inerme*	80.00	66.67	50.00
17	*Cuscuta reflexa Roxb.*	40.00	66.67	100.00
18	*Dalbergia spinosa Roxb.*	40.00	33.33	50.00
19	*Derris heterophylla*	60.00	66.67	50.00
20	*Hibiscus tiliaceus*	40.00	33.33	0.00
21	*Porterasia coarctata Roxb.*	80.00	66.67	50.00
22	*Pupalia lappacea*	60.00	66.67	0.00
23	*Salvadora persica*	40.00	66.67	100.00
24	*Suaeda fruticosa*	60.00	66.67	50.00
25	*Suaeda maritima*	60.00	100.00	100.00
26	*Suaeda monoica*	60.00	66.67	100.00
	Total	1680.00	2000.00	1600.00
	MIV	**64.62**	**76.92**	**61.54**

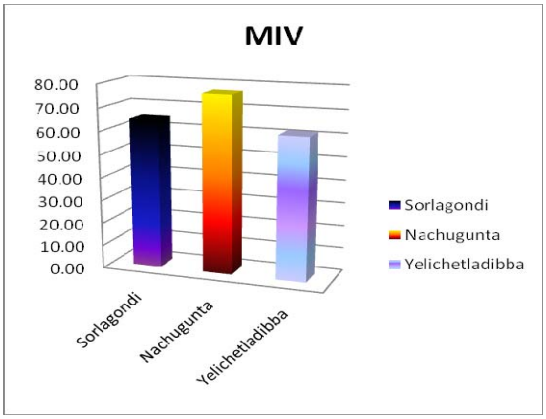

Figure 4: Station-wise Maturity Index Values (MIV) of Mangrove vegetation

Similarity Index

Similarity Index for each station is calculated to know the extent of homogeneity of vegetation. Depending on the extent of homogeneity, the regions are categorised as given below:

80 to 100% - highest resemblance, 60 to 80% - medium resemblance

40 to 60% - least resemblance, 0 to 40% - no resemblance

Majority of the sampling sites showed medium resemblances with regard to species diversity with similarity indices ranging from 78.95 between sites1&9 to 60.47 between the sites 7&9. Highest resemblance ranging from 88.37 between the sites 1&7 to 80.95 between the sites 3&8. The lowest resemblances ranging from 59.26 between the sites 2&5 to 48.28 between the sites 4&5. The elaborate and summarized details are given in Tables 4 and 5 respectively.

Table 4: Similarity Index (SI) of Mangroves at different field stations of the Study area

Site No	1	2	3	4	5	6	7	8	9	10
1		64.71	75.00	72.22	58.06	62.86	88.37	75.00	78.95	68.57
2			55.56	62.50	59.26	64.52	71.79	77.78	58.82	70.97
3				63.16	54.55	70.27	84.44	80.95	75.00	70.27
4					48.28	66.67	78.05	73.68	61.11	54.55
5						71.43	66.67	66.67	64.52	71.43
6							75.00	64.86	74.29	75.00
7								84.44	60.47	75.00
8									55.00	70.27
9										62.86

Table 5: Summarization of Similarity Index (SI) of Mangroves at different field stations with categorization.

Sub Field Stations	1&7	3&8	1&9	7&9	2&5	4&5
SI Value	88.37	80.95	78.95	60.47	59.26	48.28
Category	Highest Resemblance		Medium resemblance		Least Resemblance	

Highest similarity indices between the sites, in the present study, might be due to formation of common species into dense thickets, lining the network of canals and mud flats. Medium and lowest similarity in between the sites could be due to the occurrence of mixed type of species such as Acanthus ilicifolius, Avicennia alba, Dalbergia spinosa, Suaeda nudiflora and S. monoica. The sustainability of mangrove ecosystems in these sites of low and medium SI is due to the soil enriched with nutrient organic matter and the vast distribution of pelagic communities is due to mangrove ecosystems. Lower similarity in occurrence of plant communities towards marginal areas and high similarity in the central areas seem to be not an uncommon phenomenon in the Krishna delta. The higher similarity values for plant communities in interior and central areas are due to higher organic carbon content of the soil whereas marginal areas promoted less diversed plant growth due to high variations and low organic carbon content of the soil. The results are in accordance with the observation [9] for Godavari delta.

Coefficient Difference

The highest coefficient difference of 51.72 is recorded between sub field stations 5&4 while the least coefficient difference value of 11.63 is obtained between sub field stations 7&1. Other sub-field stations show coefficient difference ranging from 21.05 to 45.45 is shown in Table 6.

Table 6: Coefficient difference of Mangrove at different field stations

Site No	1	2	3	4	5	6	7	8	9
1									
2	35.29								
3	25.00	44.44							
4	27.78	37.50	36.84						
5	41.94	40.74	45.45	51.72					
6	37.14	35.48	29.73	33.33	28.57				
7	11.63	28.21	15.56	21.95	33.33	25.00			
8	25.00	22.22	19.05	26.32	33.33	35.14	15.56		
9	21.05	41.18	25.00	38.89	35.48	25.71	39.53	45.00	
10	31.43	29.03	29.73	45.45	28.57	25.00	25.00	29.73	37.14

It is worth noting here that *Aegialitis rotundifolia* (Gadara) is the species which occurs in Krishna delta only but not found in Godavari Delta. Further it was reported that *Aegialitis rotundifolia* was found in the mangrove forests of Sunderbans and Mahanadi [10].

CONCLUSION

From the results of the present study the family Avicenniaceae is the single largest family in Diviseema region followed by Euphorbiaceae**.** It is found that Nachugunta in this region is highly matured in the mangrove community. Highest similarity indices between the sites, in the present study is attributed to the formation of common species into dense thickets. Similar results are observed in Godavari delta.

ACKNOWLEDGEMENTS

Authors are thankful to Sri. J.Krishna Sumanth, Assistant Professor in Mathematics, DMS SVH College of Engineering, Machilipatnam for his help in statistical calculations and interpretations.

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