Publications
ANALYSIS OF MANGROVE VEGETATION OF MACHILIPATNAM COASTAL 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 Machilipatnam coastal 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, Important Value Index (IVI), Maturity Index Values (MIV) and Similarity Index (SI) and Coefficient Difference (CD) of the mangrove species in the study area are determined.

Key Words: Mangrove Ecosystem, Vegetation analysis, Important Value Index (IVI), Maturity Index Values (MIV), Similarity Index (SI) and Coefficient Difference (CD).

1. 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 present study is carried out to identify the mangrove vegetation distributed in and around Machilipatnam. The port at Gilakaladindi near Machilipatnam is going to be expanded and hence the present study is carried out to identify the mangrove patches present in Gilakaladindi and its nearby villages Pedapatnam, Polatitippa and Pallethummalapalem(P.T.Palem).

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The objectives of the investigation are to study the distribution of mangroves, estimate their ecological status based on Frequency, Important Value Index (IVI), Maturity Index, Similarity Index and Coefficient Difference of mangroves vegetation.

2. Study Area

Machilipatnam is between 16°10’N to 16.17°N latitudes and 81°09’E to 81.13°E longitudes on the southeast coast of India and in the east corner of Andhra Pradesh. Mangroves in this area lie between latitude 16° 0’ - 16° 15’N latitude and 81° 10’ - 81° 15’ E longitude. The northern distributary of Krishna river drains in this area near Hamsaladeevi.

Machilipatnam sea coast is receiving a stream called Upputeru from Kolleru region at Pedapatnam. So, Pedapatnam is a riverine based mangrove region. The other field stations viz. Gilakaladindi, Polatitippa and Pallethummalapalem of the region are the mangrove areas receiving sea water by tidal effect. Hence these field stations gain significance in the study of mangroves. The Mangrove Vegetation is shown in Figure 1.

![Image](image.png)

Figure 1: Map showing the Mangrove Vegetation in Machilipatnam Region

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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 (Banerjee, 1998). 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. The hottest months are April, May and June, when the average highest temperature is 33$^\circ$ C. The coldest month is January, when the highest temperature is 23$^\circ$ C. Maximum temperature varies from 23$^\circ$ C to 33$^\circ$ C and the minimum value ranges between 19$^\circ$ C to 23$^\circ$ C during a year. Machilipatnam gets annual rainfall due to the southwest monsoon. The average normal rainfall in the district is 110 cm, as obtained from the data collected from June 2008 to June 2011.

3. Materials & Methods

The main field stations are in the arena of Machilipatnam. The starting point 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 (according to Smith, 1992) to visualize the factors responsible for the degradation of mangrove belts.

Several field visits 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 quadrates 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),

\[
\text{Frequency} = \frac{\text{No of occurrences of a species}}{\text{Total no of site samples taken}} \times 100
\]
Relative Frequency = \( \frac{\text{No of occurrences of particular species}}{\text{Total no of occurrences of all the species}} \times 100 \) \( (2) \)

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 (Mishra, 1968). Abundance is described as the number of individuals occurring per sampling unit and density as the number of individuals per sampling unit. Abundance and density were calculated using the formulae \( (3) \) \( (4) \) \( (5) \)

\[
\begin{align*}
\text{Abundance (A)} & = \frac{\text{Total number of individuals}}{\text{Number of sampling units of occurrence}} \times 100 \quad (3) \\
\text{Relative Abundance} & = \frac{\text{Abundance of a particular species}}{\text{Sum of the abundances of all species}} \times 100 \quad (4) \\
\text{Density} & = \frac{\text{Total no of individuals of a species in all quadrats}}{\text{Total no of quadrats sampled}} \times 100 \quad (5) \\
\text{Relative density} & = \frac{\text{Density of a particular species}}{\text{Sum of the densities of all species}} \times 100 \quad (6)
\end{align*}
\]

3.1 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, (Mishra, 1968). 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 \( (7) \)

\[
\text{IVI} = \text{Relative frequency} + \text{Relative abundance} + \text{Relative density} \quad (7)
\]

Maturity Index Value (MIV), Similarity Index (SI), Coefficient Difference (CD) are used to assess the maturity, similarity, diversity of mangrove vegetation among various field stations (Philips 1959).

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3.2 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 and divided by the number of species occurrence this is Maturity Index Value (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 by Pichi-Sermolli (1948). The formulae for MIV is given in (8).

\[ MIV = \frac{\text{Frequency of all species}}{\text{No of species studied}} \times 100 \]  
(8)

3.3 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 Similarity Index (SI) is calculated by using the formula (9) given by Oosting (1956).

\[ S = \frac{2ab}{(a+b)} \times 100 \]  
(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 Coefficient Difference (CD) values are obtained by subtracting the percentage similarity from 100. The formulae for CD is given in (10).

\[ \text{C.D} = 100 - S \]  
(10)

4. Results & Discussion

4.1 Floral Composition

Mangrove vegetation in the study area consisting of 12 genera and 17 species of 11 families has been recorded as 12 trees, 2 shrubs and 3 herbs. The details are given in Table 1.
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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       | Guggilam        | Tree    |
| 2     | Avicenniaceae     | Avicennia alba               | Gudammada       | Tree    |
| 3     | Avicenniaceae     | Avicennia marina             | Tellamada       | Tree    |
| 4     | Avicenniaceae     | Avicennia officinalis        | Nallamada       | Tree    |
| 5     | Rhizophoraceae    | Bruguiera cylindrica         | Uradu           | Tree    |
| 6     | Rhizophoraceae    | Bruguiera gymnorrhiza        | Thoddu ponna    | Tree    |
| 7     | Euphorbiaceae     | Excoecaria agallocha         | Tilla           | Tree    |
| 8     | Combretaceae      | Lumnitzera racemosa          | Thanduga        | Tree    |
| 9     | Rhizophoraceae    | Rhizophora apiculata         | Ponna           | Tree    |
| 10    | Rhizophoraceae    | Rhizophora mucronata         | Uppu Ponna      | Tree    |
| 11    | Sonneratiaceae    | Sonneratia apetala          | Pedda kalinga   | Tree    |
| 12    | Acanthaceae       | Acanthus Ilicifolius         | Alchi           | Shrub   |
| 13    | Plumbaginaceae    | Aegialitis rotundifolia      | gadara          | Tree    |
| 14    | Convolvulaceae    | Cuscuta reflexa Roxb.        | savarapu kada   | Herb    |
| 15    | Fabaceae          | Dalbergia spinosa Roxb.      | Chillangi       | Shrub   |
| 16    | Chenopodiaceae    | Suaeda maritima              | Elakura         | Herb    |
| 17    | Chenopodiaceae    | Suaeda monoica               | Elakura         | Herb    |
Habitat-wise distribution of mangroves in the four field stations of the study area is shown in the Figure 2.

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

The mangrove vegetation of Machilipatnam sea coast has been broadly classified into three main categories. They, along with 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.

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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, Fabaceae and Poaceae.

4.2 Important Value Index

Species dominance is calculated based on the Important Value Index (IVI).

In Pedapatnam the highest IVI value is 30.61 for *Avicennia marina* and *Avicennia officinalis*, followed by 22.91 for *Excoecaria agallocha* and 19.05 for *Aegiceras corniculatum*, *Bruguiera gymnorrhiza*, *Rhizophora apeculat* and *Sonneratia apetala*. The details are shown in Table 2.

| S.No | Name of the Plant Species | Pedapatnam | Gilakaladindi | Polatitappa | P.T.Palem |
|------|---------------------------|-------------|---------------|-------------|-----------|
| 1    | *Aegiceras corniculatum*   | 19.05       | 20.71         | 21.95       | 21.23     |
| 2    | *Avicennia alba*           | 20.74       | 15.48         | 18.26       | 17.62     |
| 3    | *Avicennia marina*         | 30.61       | 32.86         | 29.17       | 28.36     |
| 4    | *Avicennia officinalis*    | 30.61       | 32.86         | 29.17       | 24.79     |
| 5    | *Bruguiera cylindrica*     | 14.43       | 20.71         | 13.84       | 17.67     |
| 6    | *Bruguiera gymnorrhiza*    | 19.05       | 15.48         | 13.84       | 21.23     |
| 7    | *Excoecaria agallocha*     | 22.91       | 20.71         | 21.95       | 17.67     |
| 8    | *Lumnitzera racemosa*      | 14.43       | 10.24         | 13.84       | 13.42     |
| 9    | *Rhizophora apiculata*     | 19.05       | 10.24         | 18.34       | 17.67     |
| 10   | *Rhizophora mucronata*     | 14.43       | 15.48         | 18.34       | 13.42     |
| 11   | *Sonneratia apetala*       | 19.05       | 20.71         | 18.34       | 17.67     |
| 12   | *Acanthus ilicifolius*     | 14.43       | 15.48         | 13.84       | 17.67     |
| 13   | *Aegialitis rotundifolia*  | 9.80        | 15.48         | 13.84       | 17.80     |
| 14   | *Cuscuta reflexa Roxb.*    | 14.43       | 15.48         | 13.84       | 13.42     |
| 15   | *Dalbergia spinosa Roxb.*  | 14.43       | 10.24         | 9.34        | 13.42     |
| 16   | *Suaeda maritima*          | 14.43       | 15.48         | 18.26       | 17.80     |
| 17   | *Suaeda monoica*           | 14.43       | 17.62         | 18.26       | 13.42     |

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In Gilakaladindi the highest IVI value is 32.86 for *Avicennia marina* and *Avicennia officinalis*, followed by 20.71 for *Aegiceras corniculatum*, *Bruguiera cylindrica*, *Excoecaria agallocha*, *Sonneratia apetala* and 17.62 for *Suaeda monoica*, for details refer Table 2.

In Polatitippa the highest IVI value is 29.17 for *Avicennia marina* and *Avicennia officinalis*, followed by *Aegiceras corniculatum* and *Excoecaria agallocha* with 21.95 and by *Rhizophora apiculata*, *Sonneratia apetala* and *Rhizophora mucronata* with a value of 18.34, for details refer Table 2.

In Pallethummalapalem(P.T.Palem) the highest IVI value is 28.36 for *Avicennia marina* and followed by 24.79 for *Avicennia officinalis*, *Aegiceras corniculatum* and by *Bruguiera gymnorrhiza* with an IVI value of 21.23, 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 Machilipatnam region followed by *Euphorbiaceae*, shown in Figure 3. Similar results are reported for Godavari delta (Blasco, 1971& Brahmaji Rao, 1998).

![Important Value Index](image)

**Figure 3:** Distribution of Mangroves in Machilipatnam region based in IVI values

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4.3 Maturity Index Value

Maturity index values of the field stations i.e. 78.43 of Pedapatnam, 68.63 of Gilakaladindi, 78.43 of Polatitippa and 84.31 of Pallethummalapalem show that there is the densest mangrove vegetation at a place (Pallethummalapalem in the present case), where there is a maximum frequency of inundation. 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 Machilipatnam region show that Pallethummalapalem is highly matured in the mangrove community (its MIV value being 84.31, which is nearest to 100). This is because Pallethummalapalem of Machilipatnam 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 geomorphological 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 % | Pedapatnam | Gilakaladindi | Polatitippa | P.T.Palem |
|-------|---------------------------|-------------|------------|--------------|-------------|-----------|
| 1     | Aegiceras corniculatum     | 100.00      | 100.00     | 100.00       | 100.00      | 100.00    |
| 2     | Avicennia alba             | 66.67       | 33.33      | 66.67        | 66.67       |           |
| 3     | Avicennia marina           | 100.00      | 100.00     | 100.00       | 100.00      | 100.00    |
| 4     | Avicennia officinalis      | 100.00      | 100.00     | 100.00       | 100.00      | 100.00    |
| 5     | Bruguiera cylindrica       | 66.67       | 100.00     | 66.67        | 100.00      |           |
| 6     | Bruguiera gymnorhiza       | 100.00      | 66.67      | 66.67        | 66.67       |           |
| 7     | Excoecaria agallocha       | 100.00      | 100.00     | 100.00       | 100.00      |           |
| 8     | Lumnitzera racemosa        | 66.67       | 33.33      | 66.67        | 66.67       |           |
| 9     | Rhizophora apiculata       | 100.00      | 33.33      | 100.00       | 100.00      |           |
| 10    | Rhizophora mucronata       | 66.67       | 66.67      | 100.00       | 66.67       |           |
| 11    | Sonneratia apetala         | 100.00      | 100.00     | 100.00       | 100.00      |           |
| 12    | Acanthus ilicifolius       | 66.67       | 66.67      | 66.67        | 66.67       |           |
| 13    | Aegialitis rotundifolia    | 33.33       | 66.67      | 66.67        | 66.67       |           |
| 14    | Cuscuta reflexa Roxb.      | 66.67       | 66.67      | 66.67        | 66.67       |           |
| 15    | Dalbergia spinosa Roxb.    | 66.67       | 33.33      | 33.33        | 66.67       |           |
| 16    | Suaeda maritima            | 66.67       | 66.67      | 66.67        | 66.67       |           |
| 17    | Suaeda monoica             | 66.67       | 33.33      | 66.67        | 66.67       |           |
| **Total** |                           | **1333.33** | **1166.67** | **1333.33** | **1433.33** |           |
| **MIV** |                           | **78.43**   | **68.63**  | **78.43**    | **84.31**   |           |

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4.4 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 80.00, between sites 9&12 to 60.87 between sites 1&3 and 7&9. Similarly the highest resemblance ranging from 100 between the sites 2&8 to 81.48 between the sites 5&7 and 7&11 is observed in some sites. The lowest resemblances from 60 between the sites 4&9 to 57.14 between the sites 1&6 and 3&4. There is no resemblance (34.48) between the sites 3& 5. The elaborate and summarized details are given in Tables 4 and 5 respectively.
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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    | 11    | 12    |
|---------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1       | 74.07 | 60.87 | 88.89 | 76.92 | 57.14 | 95.24 | 74.07 | 63.64 | 83.33 | 76.92 | 69.57 |
| 2       | 86.67 | 64.00 | 96.97 | 78.57 | 78.57 | 100.00| 82.76 | 90.32 | 96.97 | 86.67 |
| 3       |       | 57.14 | 34.48 | 66.67 | 58.33 | 86.67 | 96.00 | 74.07 | 82.76 | 92.31 |
| 4       | 66.67 | 84.21 | 94.74 | 64.00 | 60.00 | 72.73 | 66.67 | 66.67 |
| 5       |       | 74.07 | 81.48 | 96.97 | 78.57 | 93.33 | 93.75 |       | 82.76 |
| 6       |       |       | 63.64 | 78.57 | 78.26 | 72.00 | 74.07 |       | 83.33 |
| 7       |       | 78.57 | 60.87 | 88.00 | 81.48 |       |       |       |       |
| 8       |       |       | 82.76 | 90.32 | 96.97 |       |       |       |       |
| 9       |       |       |       | 76.92 | 78.57 |       |       |       |       |
| 10      |       |       |       |       | 86.67 |       |       |       |       |
| 11      |       |       |       |       |       |       |       |       |       |

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

| Sub Field Stations | 2&8 | 5&7 | 7&11 | 9&12 | 1&3 | 7&9 | 4&9 | 1&6 | 3&4 | 3&5 |
|--------------------|-----|-----|------|------|-----|-----|-----|-----|-----|-----|
| SI Value           | 100 | 81.48 | 80 | 60.87 | 60 | 57.14 | 34.48 |
| Category           | Highest resemblance | Medium resemblance | Least resemblance | No 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 diversified plant growth due to high variations and low organic carbon content of the soil. The results are in accordance with the observation made by Murty and Rao (1980) for Godavari delta.

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4.5 Coefficient Difference

The highest coefficient difference of 65.52 is recorded between sub field stations 5&3 while the least coefficient difference value of 0.00 is obtained between the sub field stations 8&2. Other field stations show coefficient difference ranging from 3.03 to 42.86 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    | 10   | 11   |
|---------|------|------|------|------|------|------|------|------|------|------|------|
| 1       |      |      |      |      |      |      |      |      |      |      |      |
| 2       | 25.93|      |      |      |      |      |      |      |      |      |      |
| 3       | 39.13| 13.33|      |      |      |      |      |      |      |      |      |
| 4       | 11.11| 36.00| 42.86|      |      |      |      |      |      |      |      |
| 5       | 23.08| 3.03 | 65.52| 33.33|      |      |      |      |      |      |      |
| 6       | 42.86| 21.43| 33.33| 15.79| 25.93|      |      |      |      |      |      |
| 7       | 4.76 | 21.43| 41.67| 5.26 | 18.52| 36.36|      |      |      |      |      |
| 8       | 25.93| 0.00 | 13.33| 36.00| 3.03 | 21.43| 21.43|      |      |      |      |
| 9       | 36.36| 17.24| 4.00 | 40.00| 21.43| 21.74| 39.13| 17.24|      |      |      |
| 10      | 16.67| 9.68 | 25.93| 27.27| 6.67 | 28.00| 12.00| 9.68 | 23.08|      |      |
| 11      | 23.08| 3.03 | 17.24| 33.33| 6.25 | 25.93| 18.52| 3.03 | 21.43| 13.33|      |
| 12      | 30.43| 13.33| 7.69 | 33.33| 17.24| 16.67| 33.33| 13.33| 20.00| 25.93| 17.24|

5. Conclusions

From the results of the present study the family Avicenniaceae is the single largest family in Machilipatnam region followed by Euphorbiaceae. It is found that Pallethummalapalem 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 reported for Godavari delta.

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