



## Diversity of Mangroves in Udupi District of Karnataka State, India

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### Abstract

The mangrove diversity was studied in two estuaries of Udupi taluk [Udyavara river estuarine complex (U) and Swarna – Sita and Kodi estuarine complex (S)] and one estuary of Kundapura taluk [Chakra Haladi and Kollur Estuarine river complex (C)] of Udupi district of Karnataka State. The study showed comparatively more mangrove diversity in Udyavara river estuarine complex (U) than in Swarna – Sita and Kodi estuarine complex (S) and Chakra Haladi and Kollur Estuarine river complex (C). In Chakra Haladi and Kollur Estuarine river complex (C) area, a few species were found comparatively more dominant than the other species and in other two study areas, the mangrove species were found more or less evenly distributed.

**Keywords:** Mangrove, estuary, diversity.

### Introduction

Karnataka state is situated between 11° 31' and 18° 45' N lat. and 74° 12' and 78° 40' E long. and lies in the West-Central part of the peninsular India. More than one dozen rivers originating from the Western Ghats open into the Arabian Sea along the Karnataka coast, rendering the inshore waters rich in nutrients and planktons. Netravati, Gurupur, Gangoli, Sitanadi, Aghanasini, Kali and Sharavati are the important rivers in this area. The estuaries formed by these rivers are important from the ecological and biological points of view. The mangroves are typically growing in standing water or saturated soil. Hence the ecological role of precipitation is different in mangrove ecosystems than in most of the terrestrial ecosystems. Precipitation influences the salinity more than water availability. Substrates vary, even though many are coral or volcanic in origin<sup>1,2</sup>.

Strong influences of salinity, water logging, and anoxia are responsible for physical and biological similarities in substrate conditions<sup>3,4</sup>. The heavy metals and phosphorous fractionation, geochemistry and textural aspects of sediments in a tropical mangrove ecosystem have been studied and the organic matter concentration was found to range from 1.5 to 13.4%. It is controlled by the particle size of the sediments. Abundance of greater surface area of fine particles, high organic matter content and flocculation process are responsible for enhanced concentrations of heavy metals in the surface sediments<sup>5,6</sup>. Mangrove zonation along the Indian coast has been described fairly well and conceptualized emphasizing the fact that mangroves are the products of an estuarine whole<sup>7,8</sup>. Physico-chemical parameters of different mangrove waters have been studied more specifically at the eastern and western sides of the Sunderban mangroves and the soils were found basically similar on both the sides, except in conductivity, soil texture and NPK

ratio. *Avicennia* species and *Acanthus ilicifolius* dominate in the western side islands and *Aegiceras majus* in the eastern side islands. *Ceriops-Phoenix* association occurs in elevated land areas and *Excoecaria* species and *Ceriops decandra* exist over the entire forest of the Sunderbans<sup>9</sup>. On a large land mass or within a group of islands, mangrove plant species diversity tends to increase with precipitation and the area of the watershed and found to decrease with increasing latitude<sup>10</sup>.

Distribution of the mangrove species in the eastern and western sides of the Sunderban mangroves is however, different. Mangrove ecosystems support a relatively low diversity of the dominant higher plants with thirty to forty species in the most diverse sites and only one or a few in many places<sup>11,12</sup>.

**Study Area:** In Dakshina Kannada and Udupi Districts of Karnataka state, ten main rivers join the Arabian Sea. These are i. Nethravathi, ii. Gurupur, iii. Udyavar, iv. Shambhavi, v. Pavanje, vi. Sita-Swarna, vii. Haladi, viii. Chakra, ix. Kollur and x. Baindur river. The sea board is very much influenced by tidal rivers, 'hole' and backwater creeks. The principal estuaries of the sea board are the Netravati – Gurupur estuary, the Mulki – Pavanje estuary, the Udyavara – Pangala estuary, the Swarna – Sita – Kodi estuary, the Chakra – Haladi – Kollur estuary, the Baindur hole estuary and the Shiroor hole estuary of Dakshina Kannada and Udupi Districts. In the present study, only three estuaries from Udupi District are selected. The study area are represented in figure 1, 2 and 3.

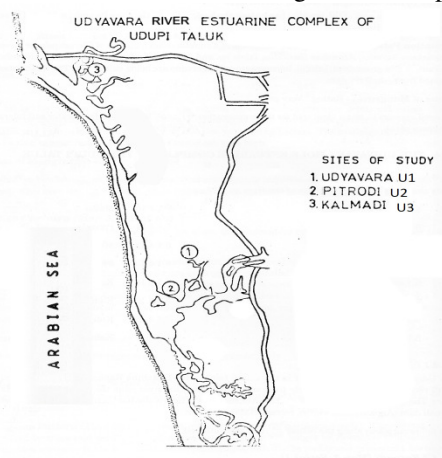
### Material and Methods

The study area is selected in two Taluks of Udupi District namely Udupi and Kundapur 13°06' 20.86''N to 13° 12.52''N and 74° 47' 13.12'' to 74° 37' 43.31''E. respectively. Each study area is divided in to three sampling stations. 50x20 m

Belt transects is used for mangrove sampling. Transects are laid randomly. 90 and 60 transects are laid in study area. Their occurrence and height are noted. The specimens are collected during flowering season of each species. The mangroves present in transects are identified using standard key books. Dried specimens are then mounted on herbarium sheets of standard size 29x42 cm using synthetic glue and the woody part of the specimen is stitched using white coloured thread. Flowers are preserved in alcohol and are studied under compound microscope for detailed morphology. The specimens like stilt roots, vivipary, pneumatophores are preserved using 70% alcohol. Standard methods for collection and preservation are used<sup>3</sup>. The soil samples are also collected from each sampling station and are analysed. Shannon-Wiener's diversity is used to calculate the variation in mangrove species diversity of the study area using the formula,

$$H' = -\sum_i P_i \log_e (P_i)$$

Where 's' is the number of species, and 'Pi' is the proportion of the total number of individuals consisting of the 'i<sup>th</sup>' species.



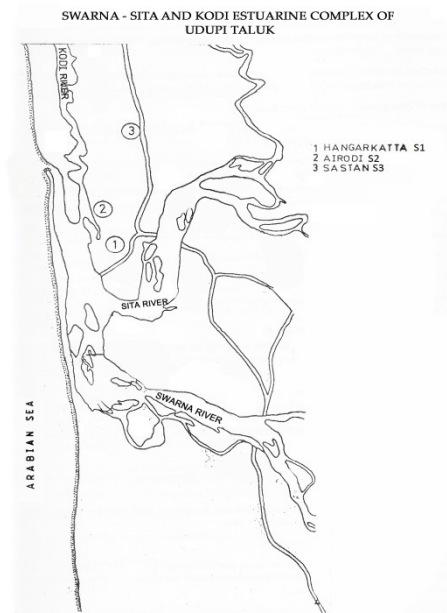
**Figure-1**  
 Udyavara river estuarine complex (U)

## Results and Discussion

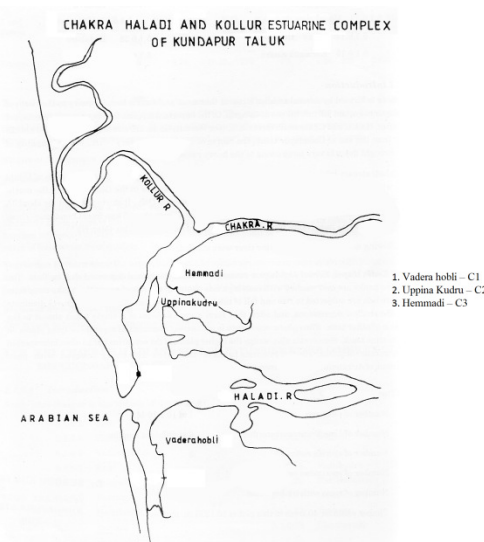
The soil of U1 is clayey loam in texture under the vegetal cover with a mild acidic pH. Here the organic carbon is high, Potassium is medium and the available Phosphorus is low. The available micronutrients such as Zinc, Copper, Manganese and Boron are above adequate and the Iron content is high<sup>5</sup>.

The soil of U2 is clayey loam in texture under the vegetal cover, with a slightly acidic pH. Here also the organic carbon is high, Potassium is medium and the available Phosphorus is low. The available micronutrients such as Zinc, Copper, Manganese and Boron are found high<sup>5</sup>.

The soil of U3 is clayey loam in texture, with a slightly acidic pH. The organic carbon is high, Potassium is medium and the available Phosphorus is low<sup>5</sup>.



**Figure-2**  
 Swarna – Sita and Kodi estuarine complex (S)



**Figure-3**  
 Chakra Haladi and Kollur Estuarine river complex (C)

The soil of S1 is clayey loam in texture under the vegetal cover. The pH is weakly acidic. The organic carbon is very high. The available Phosphorous and Potassium are very low. The available micronutrients such as Zinc, Copper, Manganese and Boron are found above adequate<sup>5</sup>.

The soil of S2 is clayey loam in texture under the vegetal cover. The pH is acidic. The organic carbon is very high; the available Phosphorous and Potassium are very low. The available micronutrients such as Zinc, Copper, Manganese and Boron are above adequate. The Iron content is very high<sup>5</sup>.

The soil of S3 is clayey loam in texture and the pH is acidic. The organic carbon is very high, the available Phosphorous and Potassium are very low. The available micronutrients such as Zinc, Copper, Manganese and Boron are reported above adequate. The Iron content is very high<sup>5</sup>.

The soil of C1 is clayey loam in texture under the vegetal cover Potassium are medium and the pH is acidic. The organic carbon is very high, the available Phosphorous and Potassium are very low. The available micronutrients such as Zinc, Copper, Manganese and Boron are above adequate. The Iron content is very high<sup>5</sup>.

The soil of C2 is clayey loam in texture under the vegetal cover and the pH is mildly acidic. The organic carbon is very high, the available phosphorous and potassium are medium. The available micronutrients such as zinc, copper, manganese and boron are above adequate. The Iron content is very high<sup>5</sup>.

The soil of C3 is clayey loam in texture under the vegetal cover. The pH is weakly acidic. The organic carbon is very high; the available Phosphorous and Potassium are very high. The available micronutrients such as Zinc, Copper, Manganese and Boron are above adequate. The Iron content is very high<sup>5</sup>.

In Udyavara river estuarine complex (U), the three study areas show the distribution of mangrove plants as shown in table 2. In this estuarine region, among the three study areas, *Acanthus ilicifolius* is found more dominant followed by *Acrostichum aureum* and *Excoecaria agallocha*. Simpson Index for Udyavara river estuarine complex (U) is 0.8129, Shannon Diversity Index is 1.842 and Pielou's evenness value is 0.6308.

**Table-1**  
 The study area with sampling sites

Udyavara river estuarine complex (U)	Swarna – Sita and Kodi estuarine complex (S)	Chakra Haladi and Kollur Estuarine river complex (C)
Udyavara – U1	Hangarkatta – S1	Vadera hobli – C1
Pitrodi – U2	Airodi – S2	Uppina Kudru – C2
Kalmadi – U3	Sastan – S3	Hemmadi – C3

In Swarna – Sita and Kodi estuarine complex (S), the three study areas show the distribution of mangrove plants as shown in table 2. In this estuarine region, in the three study areas, *Acanthus ilicifolius* is found more dominant followed by *Rhizophora mucronata* and *Sonneratia caseolaris*. Simpson Index for Swarna – Sita and Kodi estuarine complex (S) is 0.7129, Shannon Diversity Index is 1.417 and Pielou's evenness values is 0.5158.

In Chakra Haladi and Kollur Estuarine river complex (C), the three study areas show the distribution of mangrove plants as shown in table 2. In this estuarine region, in the three study areas, *Acrostichum aureum* is found more dominant followed by *Acanthus ilicifolius* and *Rhizophora mucronata*. Simpson Index for Swarna – Sita and Kodi estuarine complex (S) is

0.7081, Shannon Diversity Index is 1.365 and Pielou's evenness value is 0.3915.

**Table-2**  
 Distribution of mangrove trees in river estuarine complex of Udupi District

Sl. No.	Taxa	No. of Trees/plants		
		U	S	C
1	<i>Acanthus ilicifolius</i>	+	+	+
2	<i>Acrostichum aureum</i>	+	+	+
3	<i>Aegiceras corniculatum</i>	+	+	+
4	<i>Avicennia alba</i>	+	+	+
5	<i>Avicennia officinalis</i>	+	+	-
6	<i>Bruguiera gymnorrhiza</i>	+	-	+
6	<i>Excoecaria agallocha</i>	+	-	+
8	<i>Kandelia candel</i>	+	-	+
9	<i>Rhizophora mucronata</i>	+	+	+
10	<i>Sonneratia alba</i>	+	+	+
11	<i>Sonneratia caseolaris</i>	-	+	+

The Shannon Diversity Index of the three study areas did not show much variation. Hence diversity is less. However the Shannon Diversity Index value of Udyavara river estuarine complex (U) is slightly more than the Shannon Diversity Index values of Swarna – Sita and Kodi estuarine complex (S) and Chakra Haladi and Kollur Estuarine river complex (C). So mangrove diversity is comparatively more in Udyavara river estuarine complex (U) than in the other two study areas. The Pielou's evenness value of Chakra Haladi and Kollur Estuarine river complex (C) shows that a few species are more dominant than the other species and in other two study areas, the mangrove species are more or less evenly distributed.

In the present study in Udupi District, thirteen species of mangroves have been recorded. Out of these, eleven are true mangroves and the remaining two are found associated with the true mangroves. Among true mangroves, *Rhizophora mucronata* is found as a dominant tree species. The remaining tree species are *Avicennia alba*, *Aegiceras corniculatum*, *Sonneratia alba*, *Excoecaria agallocha*, *Bruguiera gymnorrhiza*, *Kandelia candel*, *Sonneratia caseolaris* and *Avicennia officinalis*. One mangrove shrub species namely *Acanthus ilicifolius* and one mangrove fern namely *Acrostichum aureum* are reported from the present study area. The results are represented in the (table 3). Two species namely *Clerodendrum inerme* and *Cyperus malaccensis* are found associated with the true mangrove plants in the study area.

The mangrove plants have great potential to adapt for the changes in climate (precipitation and temperature), the rise in sea levels and to the incidence of solar ultraviolet-β radiation. The same has been observed with most of the species studied in Udupi District. *Avicennia officinalis* shows a short flowering period beginning from January to March and fruiting from August to September. *Acanthus ilicifolius* is a common shrub often found associated with *Clerodendrum* or *Acrostichum aureum*<sup>1,2</sup>.

**Table-3**  
**Mangrove plants present in Udupi district,**  
**(Entire study area)**

Sl. No.	Taxa	Family
1	<i>Acanthus ilicifolius</i>	Acanthaceae
2	<i>Acrostichum aureum</i>	Pteridaceae.
3	<i>Aegiceras corniculatum</i>	Myrsinaceae
4	<i>Avicennia alba</i>	Avicenniaceae
5	<i>Avicennia officinalis</i>	Avicenniaceae
6	<i>Bruguiera gymnorhiza</i>	Rhizophoraceae
7	<i>Excoecaria agallocha</i>	Euphorbiaceae
8	<i>Kandelia candel</i>	Rhizophoraceae
9	<i>Rhizophora mucronata</i>	Rhizophoraceae
10	<i>Sonneratia alba</i>	Sonneratiaceae
11	<i>Sonneratia caseolaris</i>	Sonneratiaceae

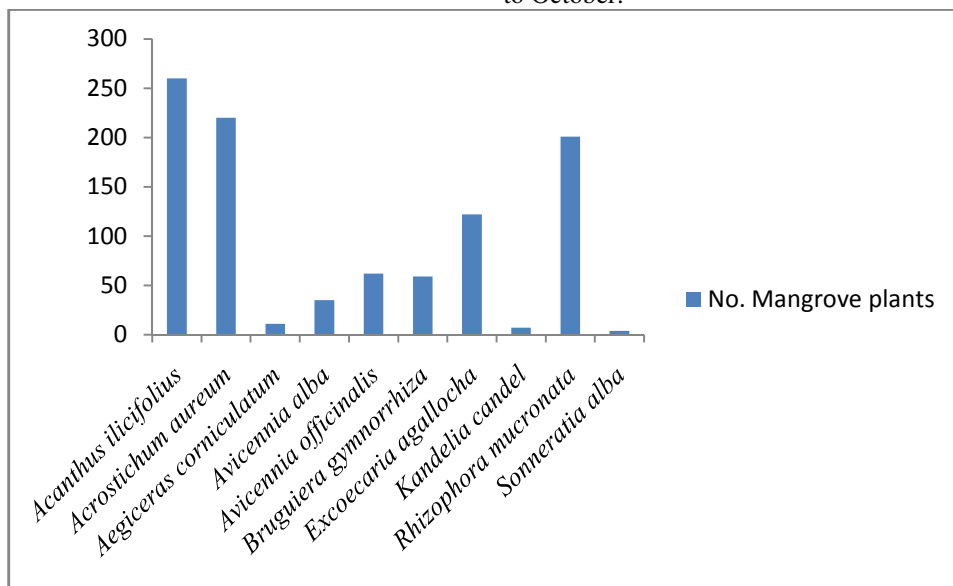
The lagoon banks facing the riverine stream have *Avicennia alba* and *Sonneratia alba* formation. Gradually they were replaced by *Clerodendrum inerme* and *Acanthus ilicifolius*. The next stage in succession is the invasion of *Acrostichum aureum*, which is a salt tolerant fresh water fern. In the present study in Udupi district, *Acanthus ilicifolius* and *Acrostichum aureum* are found dominant. The tree species observed is *Rhizophora mucronata*. The plants have peculiar adaptations like support roots, breathing roots, knee roots, viviparous germination, salt-excreting leaves etc. by which the plants are well-adapted to water-logged, anaerobic saline soils of coastal environment<sup>3-5</sup>.

The organic matter concentration ranges from 1.5 to 13.4% and it depends on the particle size of the sediments. Increased concentrations of heavy metals in the surfacial sediments are due to the abundance of greater surface area of fine particles, high organic matter content and flocculation process<sup>6,7</sup>. In

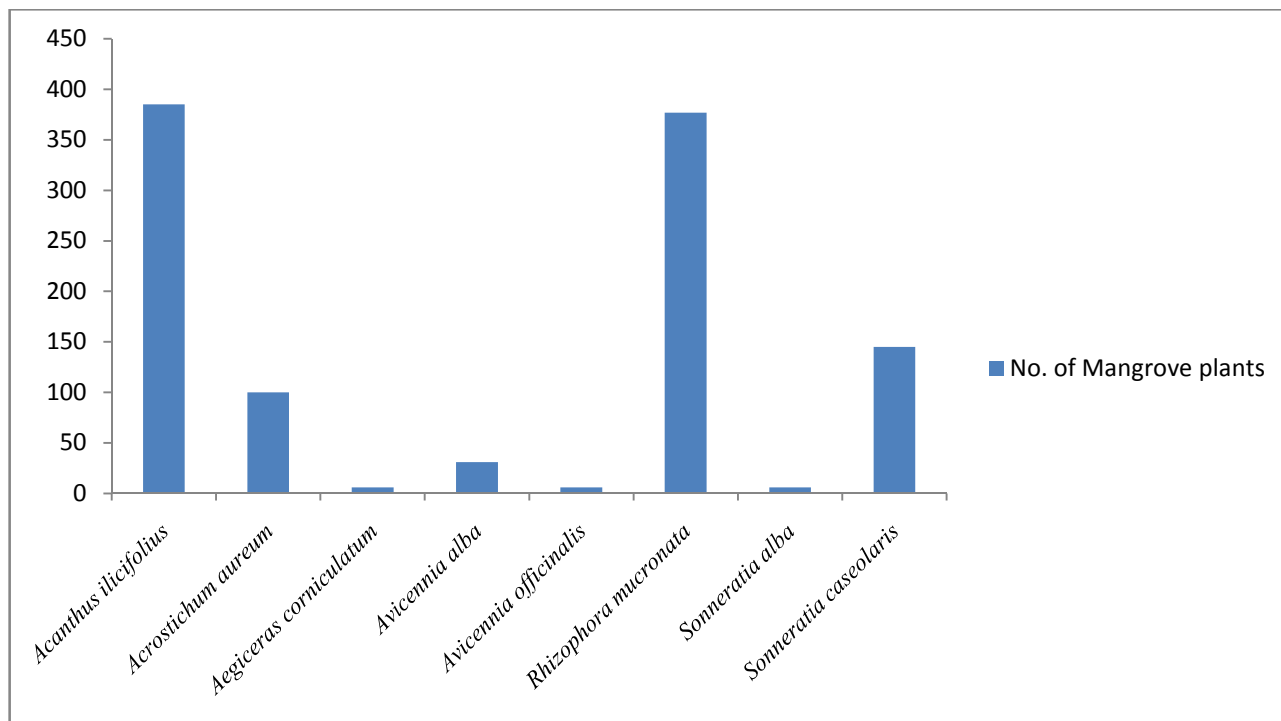
Udupi, the soil is acidic in nature and rich in macro and micro nutrients and organic carbon. The heavy metal traces were absent thus showing less impact on pollution.

Mangroves are important for stabilising loose soil and detritus. They also act as a filter for land runoffs and a bulwark against sea erosion. They protect the hinter land from tidal surges, cyclonic storms and high velocity winds<sup>8,9</sup>. The same properties could be attributed to the mangroves of the present study area. However artificial barrier is becoming a necessity in order to prevent the adverse effects of the rage of the sea.

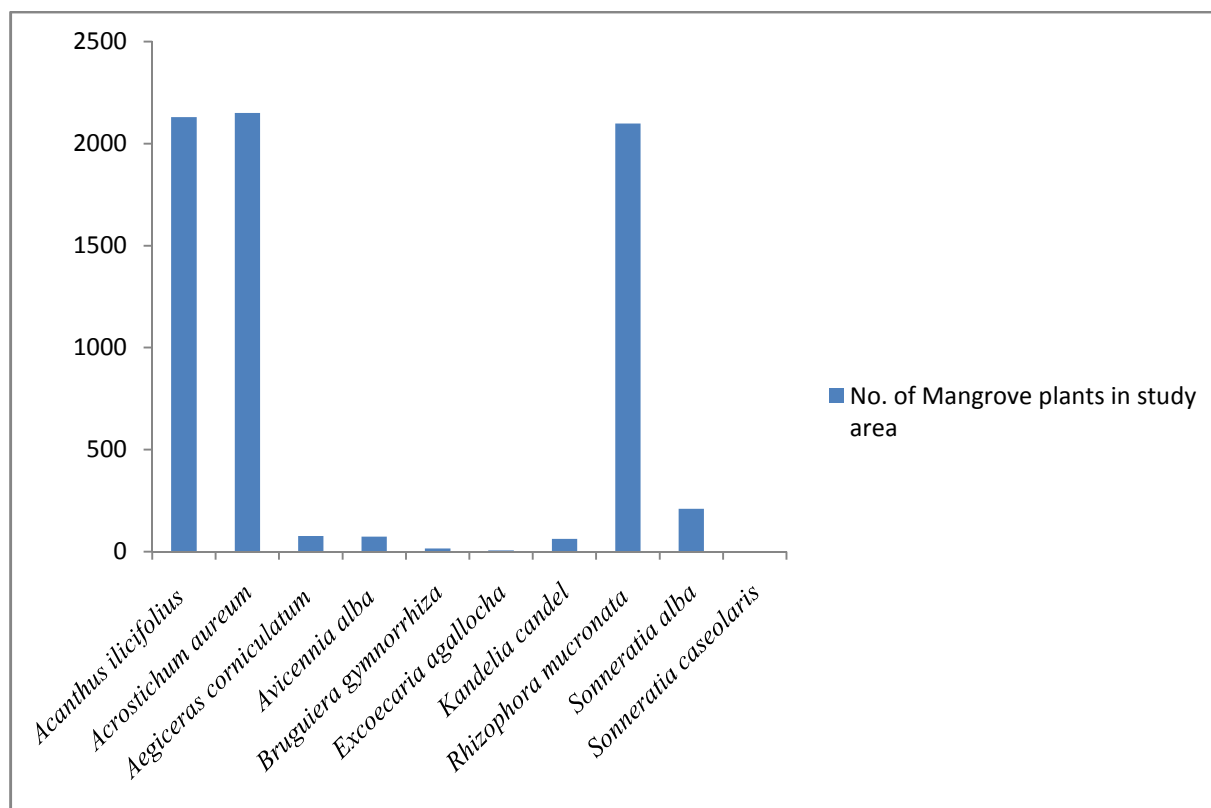
In Udupi District, even though large area is covered by the mangrove vegetation, only eleven species of true mangroves are present (table 3 and figure 4 ,5, 6 and 7). Mangrove ecosystems support a relatively low diversity of the dominant higher plants with thirty to forty species in the most diverse sites and only a few species in many places reported that the western side islands of Sundarbans were dominated by *Avicennia* species and *Acanthus ilicifolius* and the eastern side of Sundarbans by *Aegiceras majus*<sup>10,11</sup>. In our observation *Bruguiera gymnorhiza* and *Kandelia candel* are found to flower from January to December with fruiting time from April to September and April to January respectively. *Sonneratia alba*, *Excoecaria agallocha* and *Sonneratia caseolaris* flowered from February to July and fruited during August to February, June to January and July to January respectively. *Aegiceras corniculatum* flowered from March to December and fruited during July to February. *Acanthus ilicifolius* flowered from April to December and fruited during July to February. *Avicennia alba* and *Avicennia officinalis* flowered from June to September and fruited during August to February and September to March respectively. In *Rhizophora mucronata* flowering and fruiting season is simultaneous and is from July to October.



**Figure-4**  
**Distribution of Mangrove plants in study area of Udyavara river estuarine complex (U)**

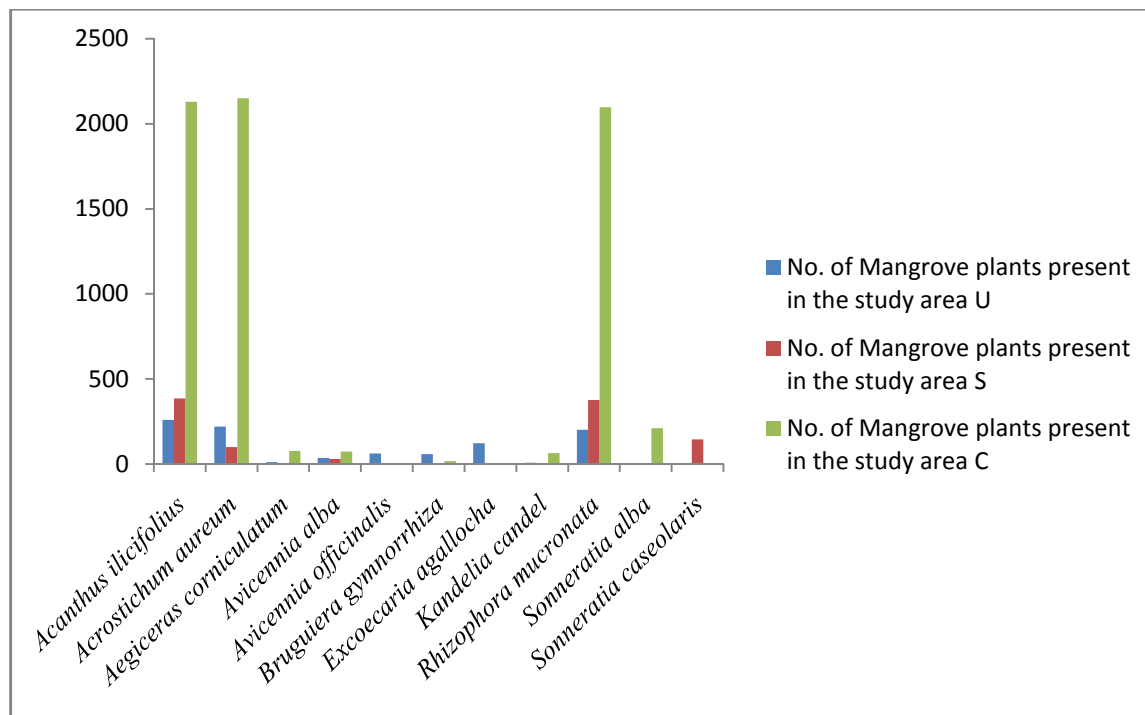


**Figure-5**  
 Distribution of Mangrove plants in study area of Swarna– Sita and Kodi estuarine complex(S)



**Figure-6**  
 Distribution of Mangrove plants in study area of Chakra Haladi and Kollur Estuarine river complex (C)





**Figure-7**  
**Distribution of Mangrove plants in study area of Udupi District**

## Conclusion

In the present study of biodiversity of mangrove plants of Udupi district of Karnataka state (India), nine areas were selected, three areas each from Udyavara river estuarine complex of Udupi Taluk(U), Swarna – Sita and Kodi of Udupi Taluk(S) and Chakra Haladi and Kollur estuarine river complex of Kundapur Taluk (C) of Udupi District. During the study period, plant specimens were collected from the above mentioned nine study areas and they were identified and preserved. Eleven species of mangrove plants have been reported in the present study areas (table 3 and figure 4, 5, 6 and 7). Among these, nine are tree species and one is a shrub and the other one is a Pteridophyte (Fern). In the present study, three study areas did not show much variation in the diversity. However, among the three study areas, diversity has been found comparatively more in Udyavara river estuarine complex (U) than the other two study areas. In Chakra Haladi and Kollur Estuarine river complex (C), a few species were found more dominant over the other species. The mangrove species were found more or less evenly distributed. Due to lack of awareness, here the mangrove vegetation has been disturbed by anthropogenic activities. Hence this mangrove vegetation needs suitable conservation methods for their future survival.

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