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## Research Article

# INVENTORY ON THE DIVERSITY AND DISTRIBUTION OF MANGROVES FROM THE COASTAL ECOSYSTEMS OF KERALA STATE, INDIA

**\*Neethu G Pillai and Harilal C.C**

Department of Botany, University of Calicut, Malappuram District, Kerala, India-673 635

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### ABSTRACT

Consolidation of data pertaining to the extent and diversity of mangroves is a pre requisite for the selection of strategies for the conservation of existing and the introduction of newer population. In this direction, the present study has been carried out to assess the extent and diversity of mangroves confining to 10 districts of Kerala by consistent field visits, Google imageries, toposheets and GPS. The present survey estimated the total extent of mangroves in Kerala to be 19.531 km<sup>2</sup>. It has also been highlighted that out of 10 districts studied, Kannur occupied highest mangrove cover (38.22 %), followed by Ernakulam (31.5%), Kozhikode (6.18 %), Kasaragod (5.65 %), Alleppey (5.32 %), Kottayam (5.04 %), Kollam (2.71 %), Thrissur (2.08 %), Malappuram (1.88 %) and Trivandrum (1.41%). Diversity studies revealed the existence of 15 true mangrove species falling under 9 genera and 6 families. The study concluded that, though there is technical increases in the extent of mangroves, most of the major mangrove growing areas are under drastic pressure. Since the survival of this eco system is inevitable for ensuring coastal balance, intensive and extensive conservation and ecosystem reinstatement programmes should be undertaken without delay.

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## INTRODUCTION

The mangroves are intertidal plant formations of tropics and subtropics, which are adapted to grow in the saline environments. They are unique in their location, structure and function. These are comparatively one of the well-studied ecosystems throughout the world and have been received attention of researchers from different fields of science.

Mangroves are mainly found between the Tropic of Cancer and the Tropic of Capricorn, covering majority of the tropical and subtropical coastlines, worldwide (Saenger, 2002). Recent reports on the distribution of mangroves reveal that they are found in 105 nations globally (Hamilton and Casey, 2016), in which Indian mangroves are one of the major forests of the South East Asia. In India, the total area of mangroves is estimated to be 6,740 km<sup>2</sup> (MoEF, 1987), which is about 7% of the world's mangrove area.

Mangroves of Kerala are highly fragmented and confined mostly to the estuaries of major rivers, lagoons, backwaters and creeks along the coastal belt. Mohanan (1997) estimated that, mangroves in Kerala coast are less than 50 km<sup>2</sup>, existing in discrete and isolated patches with a total of 32 mangrove species. It has also been reported that the extent of mangroves of Kerala is 2502 ha, of which 1189 ha belongs to the State and

1313 ha under private ownership (Vidyasagaran and Madhusoodanan, 2014).

In the last two decades, mangrove populations have witnessed annual loss between 0.16 and 0.39% globally due to various anthropogenic activities (Hamilton and Casey, 2016). It has been reported that Kerala coast once supported about 700 sq.km of mangroves and presently it has been dwindled to a considerable extent. Mangrove ecosystems are receiving increasing attention in Kerala, but still lack updated information on their diversity and extent for deriving strategic plans for conservation / afforestation. The present study has been carried out to assess the extent and diversity of mangrove ecosystems in the heterogeneous environments of Kerala with a view to conserve their existing habitats from further degradation.

## MATERIALS AND METHODS

Extensive literature survey has been carried out to have an idea about their habitats, together with their extent and diversity in the coastal environments of Kerala. Accordingly field visits were carried out to these mangrove habitats confining to 10 districts of Kerala. The mangrove patches distributed along various districts under study were categorized into homogeneous and heterogeneous types. The assemblage of true

\*Corresponding author: **Neethu G Pillai**

Department of Botany, University of Calicut, Malappuram District, Kerala, India-673 635

mangrove species along with their associates in a particular area were grouped as homogeneous, while patches of true mangroves along with mangrove associates and other vegetation were categorized as heterogeneous types. The regions occupied by mangroves were surveyed using a GPS and the areas occupied by such mangroves were worked out using toposheets and Google imageries. Both homogenous and heterogeneous patches were separately measured to find out the total extent in square kilo meters. Plant specimens were collected from different locations and their identification was carried out following standard mangrove identification manual (Banerjee *et al.*, 1989) and also with the help of experts. Representative specimens were preserved

## RESULTS

### Extent of mangroves in Kerala

The district wise extent of mangroves in square kilo meters and their percentage to the total mangrove cover of the State is depicted in Table 1.

**Table 1** Extent of mangroves along different districts of Kerala

Sl. No:	District	Current Mangrove Extent (km <sup>2</sup> )			Existing %
		Homogeneous	Heterogeneous	Total	
1	Trivandrum	0.151	0.124	0.275	1.41
2	Kollam	0.271	0.209	0.530	2.71
3	Alleppey	0.487	0.551	1.038	5.32
4	Kottayam	0.565	0.420	0.985	5.04
5	Ernakulam	2.674	4.269	6.153	31.50
6	Thrissur	0.331	0.076	0.407	2.08
7	Malappuram	0.329	0.038	0.367	1.88
8	Kozhikkode	1.044	0.164	1.207	6.18
9	Kannur	6.029	1.435	7.465	38.22
10	Kasaragod	1.033	0.071	1.104	5.65
Total				19.531	

Data pertaining to the present status of mangroves in the 10 districts of Kerala revealed that, Trivandrum district occupy 0.275 km<sup>2</sup> (1.41%), which is inclusive of 0.151 km<sup>2</sup> of homogeneous and 0.124 km<sup>2</sup> heterogeneous population. Of the 9 locations studied, Akkulam - Veli region occupied the largest mangrove area (0.126 km<sup>2</sup>) whereas, Vizhinjam has been noticed for least mangrove population (0.0002 km<sup>2</sup>).

Mangrove areas of 0.530 km<sup>2</sup> (2.71%), inclusive of 0.2711 km<sup>2</sup> of mangrove patches and 0.2087 km<sup>2</sup> of mixed patches are reported in Kollam district. Here, the highest mangrove area is reported from the Shakhikulangara region (0.226 km<sup>2</sup>) and the lowest area from Oachira (0.008 km<sup>2</sup>).

The extent of mangrove areas in Alleppey district was estimated to be 1.038 km<sup>2</sup> (5.32%) with 0.487 km<sup>2</sup> of homogenous and 0.551 km<sup>2</sup> of heterogeneous mangrove patches. Eramalloor and Perumpally have been noticed as the areas with higher and lower mangrove patches with 0.286 km<sup>2</sup> and 0.0001 km<sup>2</sup>, respectively. Similarly, Kottayam district occupied 0.985 km<sup>2</sup> (5.04%) of mangrove areas with 0.565 km<sup>2</sup> of homogeneous and 0.420 km<sup>2</sup> of heterogeneous population. Among the 14 locations studied, Kumarakom has occupied maximum area with 0.308 km<sup>2</sup> and Keezhukunnu with a lowest area of 0.007 km<sup>2</sup>.

Ernakulam district has been noticed to occupy 6.153 km<sup>2</sup> (31.50%) of mangrove areas, which are inclusive of 2.67 km<sup>2</sup> of homogeneous and 4.27 km<sup>2</sup> of heterogeneous patches. Puthuvypin occupied the largest stretch (1.02 km<sup>2</sup>), while

Kandakkadavu reported the smallest (0.0005 km<sup>2</sup>). A total of 0.407 km<sup>2</sup> (2.08%) mangrove forest has been identified from Thrissur district, including 0.332 km<sup>2</sup> homogeneous and 0.076 km<sup>2</sup> heterogeneous patches. Among different locations studied, Chettuvai reported the largest area (0.095 km<sup>2</sup>) and Chanda Nagar reported the smallest patch with 0.001 km<sup>2</sup>.

A total area of 0.367 km<sup>2</sup> (1.88%) mangrove habitats has been reported from the district of Malappuram. The homogeneous and heterogeneous patches reported were 0.329 km<sup>2</sup> and 0.038 km<sup>2</sup> respectively. Out of 17 locations studied, Kadalundi-Vallikkunnu region is reported for higher extent (0.104 km<sup>2</sup>) and Thavalakulam for the lowest (0.004 km<sup>2</sup>). The district of Kozhikkode has been noticed for a total of 1.207 km<sup>2</sup> (6.18%) mangrove forests including both homogeneous (1.044 km<sup>2</sup>) and heterogeneous (0.164 km<sup>2</sup>) patches. Mangrove areas of Sarovaram bio park, Kottooli occupied the largest area (0.171 km<sup>2</sup>) and Azhchavattam region occupied the smallest patch within the district.

Kannur district showed the existence of a total of 7.465 km<sup>2</sup> (38.22%) mangrove cover, which is inclusive of 6.029 km<sup>2</sup> homogeneous and 1.435 km<sup>2</sup> heterogeneous patch. Among the numerous healthy patches, Kunhimangalam possesses the highest area of 0.286 km<sup>2</sup> and Chalil with least area of 0.001 km<sup>2</sup>. Kasaragod district occupies a total area of 1.104 km<sup>2</sup> (5.65%) of mangroves, with both homogeneous (1.033 km<sup>2</sup>) and heterogeneous (0.071 km<sup>2</sup>) patches. Kumbala has been reported for holding largest area of mangroves (0.445 km<sup>2</sup>) and Udumbumthala for a smallest patch with a size of 0.0004 km<sup>2</sup>.

The present survey estimated the total extent of mangroves in Kerala as 19.531 km<sup>2</sup>. It has also been highlighted that out of 10 districts studied, Kannur district occupied highest mangrove cover with 7.465 km<sup>2</sup> which is coming around 38.22 % of the total extent within the state. This is followed by Ernakulam district with 6.153 km<sup>2</sup> (31.5%), Kozhikkode (6.18 %), Kasaragod (5.65 %), Alleppey (5.32 %), Kottayam (5.04 %), Kollam (2.71 %), Thrissur (2.08 %), Malappuram (1.88 %) and the minimum extent has been reported from Trivandrum district with 0.275 km<sup>2</sup> (1.41%).

Upon comparing the results of the present study with that of Basha (1991), an increasing mangrove cover of about 2.821 km<sup>2</sup> within the last 25 years is noted. As observed in Table 2, most of the districts are reported with increase in the total mangrove area.

**Table 2** Mangrove cover changes in km<sup>2</sup>

District	Current extent (2016) km <sup>2</sup>	Basha (1991) km <sup>2</sup>	Changes between 1991 – 2016 (25 years) km <sup>2</sup>
Trivandrum	0.275	0.23	+0.045
Kollam	0.530	0.58	-0.050
Alleppey	1.038	0.90	+0.138
Kottayam	0.985	0.80	+0.185
Ernakulam	6.153	2.60	+3.553
Thrissur	0.407	0.21	+0.197
Malappuram	0.367	0.12	+0.247
Kozhikkode	1.207	2.93	-1.723
Kannur	7.465	7.55	-0.085
Kasaragod	1.104	0.79	+0.314
Total	19.531	16.71	+2.821

‘+’ indicates increasing trend and ‘-’ indicates decreasing trend

Trivandrum (0.045 km<sup>2</sup>), Alleppey (0.138 km<sup>2</sup>), Kottayam (0.185 km<sup>2</sup>), Ernakulam (3.553 km<sup>2</sup>), Thrissur (0.197 km<sup>2</sup>),

Malappuram (0.247 km<sup>2</sup>) and Kasaragod (0.314 km<sup>2</sup>) districts have been reported for increase in the total mangrove cover during last 25 years. The districts with decline in total mangrove cover during last 25 years were Kollam (0.050 km<sup>2</sup>), Kozhikode (1.723 km<sup>2</sup>) and Kannur (0.085 km<sup>2</sup>).

The study reveals that the mangroves in these districts have shrunken considerably to few patches, mainly in Dharmadam, Nadakkavu, Edakkad, Pappinisseri, Valapattanam, Muzhappilangad, Kunhimangalam, Pazhayangadi, Kavvayi, Thalassery, Ezhimala and Mahe of Kannur district, Kotti, Koduvally, Vadakara, Kallai and Kadalundi of Kozhikkode district and Asraamam of Kollam district. The year wise declines in the total mangrove cover of these districts are 0.002 km<sup>2</sup>/yr, 0.069 km<sup>2</sup>/yr and 0.003 km<sup>2</sup>/yr respectively. High extent of degradation in the total mangrove cover has been noticed in Kozhikkode district. The year wise mangrove declining rate of Kozhikkode district is alarming, indicating the fact that if the destruction proceeds in the same manner, the remaining mangrove patches will be degraded within the next 20 years.

### Diversity of mangroves in Kerala

Attempts were also carried out to study the diversity of true mangrove species in Kerala. The results revealed that, Trivandrum district was under possession of 10 true mangrove species, which include *Aegiceras corniculatum*, *Avicennia officinalis*, *Bruguiera cylindrica*, *B. gymnorhiza*, *Excoecaria agallocha*, *E. indica*, *Lumnitzera racemosa*, *Rhizophora apiculata*, *R. mucronata* and *Sonneratia caseolaris*.

Kollam district was reported with maximum species diversity of 14 true mangrove species. Species such as *Aegiceras corniculatum*, *Avicennia marina*, *A. officinalis*, *B. sexangula*, *Excoecaria agallocha*, *E. indica*, *Kandelia candel*, *Lumnitzera racemosa*, *Rhizophora apiculata*, *R. mucronata* and *Sonneratia caseolaris* were noted to have scattered distribution in the district.

Alleppey district is reported with 10 mangrove species which include *Aegiceras corniculatum*, *Avicennia marina*, *A. officinalis*, *Bruguiera cylindrica*, *B. gymnorhiza*, *Excoecaria agallocha*, *Kandelia candel*, *Rhizophora apiculata*, *R. mucronata* and *Sonneratia caseolaris*. 7 true mangrove species such as *Avicennia marina*, *A. officinalis*, *B. sexangula*, *Excoecaria agallocha*, *Rhizophora apiculata*, *R. mucronata* and *S. caseolaris* are sparsely distributed along different locations of Kottayam district.

True mangrove species such as *Aegiceras corniculatum*, *Avicennia marina*, *A. officinalis*, *Bruguiera cylindrica*, *B. gymnorhiza*, *Excoecaria agallocha*, *Kandelia candel*, *Rhizophora apiculata*, *R. mucronata*, *Sonneratia alba* and *S. caseolaris* were the 11 species distributed in the Ernakulam district. Thrissur district is characterized by 7 mangrove species such as *Aegiceras corniculatum*, *Avicennia officinalis*, *Bruguiera cylindrica*, *Excoecaria agallocha*, *Kandelia candel*, *Rhizophora apiculata* and *R. mucronata*.

Malappuram district has been reported with 10 mangrove species such as *Aegiceras corniculatum*, *Avicennia marina*, *A. officinalis*, *Bruguiera cylindrica*, *B. sexangula*, *Excoecaria agallocha*, *Kandelia candel*, *Rhizophora mucronata*, *Sonneratia alba* and *S. caseolaris*. Kozhikkode district was also

with 10 true mangrove species such as *Aegiceras corniculatum*, *Avicennia marina*, *A. officinalis*, *Bruguiera cylindrica*, *Excoecaria agallocha*, *Kandelia candel*, *Rhizophora apiculata*, *R. mucronata*, *Sonneratia alba* and *S. caseolaris*.

Kannur has been reported for a maximum of 12 true mangrove species, which include *Aegiceras corniculatum*, *Avicennia marina*, *A. officinalis*, *Bruguiera cylindrica*, *B. sexangula*, *Excoecaria agallocha*, *Kandelia candel*, *Lumnitzera racemosa*, *Rhizophora apiculata*, *R. mucronata*, *Sonneratia alba* and *S. caseolaris*. Kasaragod was reported with 10 true mangrove species such as *Aegiceras corniculatum*, *Avicennia marina*, *A. officinalis*, *Bruguiera cylindrica*, *Excoecaria agallocha*, *Kandelia candel*, *Rhizophora apiculata*, *R. mucronata*, *Sonneratia alba* and *S. caseolaris*.

Consolidation of the above observation revealed the existence of 15 true mangrove species falling under 9 genera and 6 families in the state of Kerala. The details regarding their scientific name, vernacular name (Malayalam), family and recent IUCN status are depicted in Table 3.

**Table 3** True mangrove species of Kerala identified in the present study

Sl. No	Scientific Name	Vernacular Name (Malayalam)	Family	IUCN Category
1.	<i>Aegiceras corniculatum</i> (L.) Blanco	Pookandal	Myrsinaceae	LC
2.	<i>Avicennia marina</i> (Forssk.) Vierh.	Cheru uppatti	Avicenniaceae	LC
3.	<i>Avicennia officinalis</i> L.	Uppatti, Uppootti	Avicenniaceae	LC
4.	<i>Bruguiera cylindrica</i> (L.) Blume	Kuttikandal	Rhizophoraceae	LC
5.	<i>Bruguiera gymnorhiza</i> (L.) Savi.	Penakandal	Rhizophoraceae	LC
6.	<i>Bruguiera sexangula</i> (Lour.) Poir.	Swarnakandal	Rhizophoraceae	LC
7.	<i>Ceriops tagal</i> (Pers.) C. B. Rob.	Manjakandal	Rhizophoraceae	LC
8.	<i>Excoecaria agallocha</i> L.	Kannampotti, Kammatti	Euphorbiaceae	LC
9.	<i>Excoecaria indica</i> L.	Kandal	Euphorbiaceae	DD
10.	<i>Kandelia candel</i> (L.) Druce	Ezhuthanikandal, Nallakandal	Rhizophoraceae	LC
11.	<i>Lumnitzera racemosa</i> Willd.	Kadakandal	Combretaceae	LC
12.	<i>Rhizophora apiculata</i> Blume	Vallikandal, Peekandal	Rhizophoraceae	LC
13.	<i>Rhizophora mucronata</i> Lam.	Pranthakandal	Rhizophoraceae	LC
14.	<i>Sonneratia alba</i> Sm.	Nakshathrakandal	Sonneratiaceae	LC
15.	<i>Sonneratia caseolaris</i> (L.) Engl.	Chakkarakandal	Sonneratiaceae	LC

- IUCN Red list of threatened species version 2017-2 ([www.iucnredlist.org](http://www.iucnredlist.org))
- LC – Least Concern (A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for critically endangered, endangered, vulnerable or near threatened. Widespread and abundant taxa are included in this category).
- DD – Data Deficient (Appropriate data on abundance and distribution are lacking).

Inquiries on the true mangrove species of Kerala revealed that, the state is endowed with 15 True mangrove species as a whole. They are *Aegiceras corniculatum*, *Avicennia marina*, *Avicennia officinalis*, *Bruguiera cylindrica*, *B. gymnorhiza*, *B. sexangula*, *Ceriops tagal*, *Excoecaria agallocha*, *E. indica*, *Kandelia candel*, *Lumnitzera racemosa*, *Rhizophora apiculata*, *R. mucronata*, *Sonneratia alba* and *S. caseolaris* belonging to the families Myrsinaceae, Avicenniaceae, Euphorbiaceae, Rhizophoraceae, Combretaceae and Sonneraceae. Among different families reported, Rhizophoraceae possesses the maximum number of species (7) followed by Avicenniaceae (2 species), Euphorbiaceae (2 species), Sonneraceae (2

species), Combretaceae (1 species) and Myrsinaceae (1 species). 14 mangrove species reported in this study are coming under Least Concern (LC) Category of IUCN. The species *Excoecaria indica* is coming under the Data deficient category.

The study revealed that, even though the existing mangrove areas are highly localized, the species diversity of these mangroves confining to the coast of Kerala is comparatively high.

## DISCUSSION

The present study evaluated the extent and diversity of mangroves along different districts of Kerala state. Comparison of the results with earlier authentic reports was carried out to assess the extent of changes during different period of time. The possible reasons for the increase / decrease in extent and diversity have also been discussed.

### *Extent of mangroves in Kerala*

The present study reports a total of 0.275 km<sup>2</sup> area of mangroves in Trivandrum district. Mohanan (1997) reported a total of 15 ha of mangrove population, whereas Vidyasagan and Madhusoodanan (2014) reported the existence of 0.28 km<sup>2</sup>. A significant increase in area has been noticed in the district compared to 1997. However, comparing the present data with latest reports (2014), a slight decrease in area has been noticed. The total area of mangrove cover currently existing in the districts of Kollam, Alleppey and Kottayam are 0.530 km<sup>2</sup>, 1.038 km<sup>2</sup> and 0.985 km<sup>2</sup> respectively. Basha (1991) reported 0.58 km<sup>2</sup> of mangrove patch in Kollam district, 0.90 km<sup>2</sup> in Alleppey and 0.80 km<sup>2</sup> in Kottayam district. Upon comparing with previous reports, a noticeable decline along the coastal plains of Kollam district has been noticed and a significant increase had happened to the total area of mangrove patches in Kottayam district.

In the present study Ernakulam and Malappuram districts have been noticed to occupy 6.153 km<sup>2</sup> and 0.367 km<sup>2</sup> of mangrove areas respectively. In 2014, Vidyasagan and Madhusoodanan reported an extent of 6 km<sup>2</sup> from Ernakulam and 0.26 km<sup>2</sup> from Malappuram district. Upon comparing with the earlier reports it can be stated that, the total area of mangrove patches within the districts has grown further to show an increase of 0.153 km<sup>2</sup> and 0.10 km<sup>2</sup> respectively. As Ernakulam is a fast developing district of the state, significant attention has been given for the conservation of its mangroves. Increased awareness on the importance of mangrove among people, especially those who live along the coastal region have contributed to the prevention of cutting of mangrove trees for developmental / recreational purposes. Also the interventions of some of the non-governmental organization have resulted in the establishment of local bodies to conserve and restore mangrove ecosystems.

The total mangrove area reported in Thrissur district is 0.407 km<sup>2</sup>. Kurien *et al.* (1994) reported the existence of 0.41 km<sup>2</sup> of mangroves in Thrissur district. A total of 0.30 km<sup>2</sup> were reported by Vidyasagan and Madhusoodanan in 2014. Thus upon comparing with reports of 1994, no significant change has been noticed in the total area of mangroves, whereas a marginal increase has been noticed as compared to the data published in 2014.

The present study reports 1.207 km<sup>2</sup> and 1.104 km<sup>2</sup> areas of total mangroves in the districts of Kozhikode and Kasaragod. Mohanan in 1997 reported 2.0 km<sup>2</sup> and 0.50 km<sup>2</sup> of mangroves in Kozhikode and Kasaragod districts respectively. Upon comparing the data with previous reports, it can be stated that the mangrove cover of the district has considerably increased to a certain extent. This might be due to the intense afforestation activities carried out by both governmental and non-governmental agencies.

In the present study, Kannur district showed the existence of a total of 7.465 km<sup>2</sup> mangrove cover. Vaiga and Sincy (2016) reported 7.55 km<sup>2</sup> of mangrove forest from Kannur district. Upon comparing the present estimate with the recent report (2016), the total mangrove cover of the district has been dwindled by around 0.1 km<sup>2</sup>. Land clearance for the construction of new sea ports, extension of existing sea ports and establishment of industrial units near the coast has also contributed to the depletion of mangrove cover in the district. Upon comparing the results of the present study with an authentic report of Basha (1991), an increasing mangrove cover of about 2.821 km<sup>2</sup> in the state of Kerala, within the last 25 years is noted. This increase might be due to an increase in awareness on the importance of mangroves among public. Also there were contributions from the part of governmental and nongovernmental organizations in the area of mangrove introduction. The incidence of Asian tsunami in 2004 and Hurricane Katrina in 2005 have also contributed towards the enhanced awareness on mangroves as their contribution in preventing coastal erosion and subsequent inundation was significant.

### *Diversity of mangroves in Kerala*

In Trivandrum district, the present study reports 10 true mangrove species. The number of species was found to be the same as reported by Mini *et al.* (2014). However, Thomas (1962) and Vidyasagan and Madhusoodanan (2014) reported 5 and 4 species of true mangroves respectively from the district. Upon comparing with earlier reports, the present study reported considerably higher number of mangrove species from the district.

The present result indicated an increase in the number of true mangrove species in Kollam district (14 species) as against 12 species reported by Vijayan *et al.* (2015). In Alleppey district, the current statistics indicated the existence of 10 species. Sunil (2000), Vidyasagan and Madhusoodanan (2014) and Mini *et al.* (2014) have reported 12 true mangrove species from the district of Alleppey. Comparison of the present result with these reports indicated a decline in the number of true mangrove species.

The total number of mangrove species reported in the present study from Kottayam district is 7. There is a marginal decline in the species of mangroves as compared to the report of Mini *et al.* (2014) from Kottayam district, whereas, compared to the reports with 5 species of true mangroves by Vidyasagan and Madhusoodanan (2014), the present study described a higher number.

Present study reported 11 mangrove species from Ernakulam and 7 from Thrissur districts. Upon comparing with the reports of Mini *et al.* (2014), the present study noted a lesser number of

true mangrove species from Ernakulam district. However, the study reported higher number of true species as compared to the reports of Sunilkumar (1993) and Vidyasagaran and Madhusoodanan (2014). Considerable decline in the total number of true mangrove species has been noticed as compared to the reports (11 species) of Mini *et al.* (2014) from Thrissur district.

Malappuram and Kozhikode districts have been reported with 10 true mangrove species each. Radhakrishnan *et al.* (2006), Vidyasagaran and Madhusoodanan (2014) and Mini *et al.* (2014) reported 2, 8 and 9 species of true mangrove species from Malappuram district. As compared to all these reports, the present study reported a higher number of species. Radhakrishnan *et al.* (2006) reported 7 and Vidyasagaran and Madhusoodanan (2014) reported 9 species of true mangroves from the district of Kozhikode. The present result indicated that the species diversity confining to the district has increased.

The present study reported 12 and 10 true mangrove species from Kannur and Kasaragod districts respectively. Radhakrishnan *et al.* (2006) and Vidyasagaran *et al.* (2014) reported 7 and 11 species of true mangrove species from Kannur district. The present result revealed a higher number of species as compared to these reports and is similar to the reports of Mini *et al.* (2014).

The study described similar number of species as compared to the reports of Vidyasagaran and Madhusoodanan (2014) from Kasaragod district. However, as compared to the reports by Mini *et al.* (2014) with 12 species, the species diversity of the district has presently decreased.

Various reasons have been identified during the present investigation on the extent and diversity of mangroves in Kerala, and that can be summarized as follows. Invasion of mangrove areas by human population is one of the main reasons, in which most of the mangrove areas has been removed either partially or completely for various developmental purposes. Unscientific developmental activities like construction of concrete walls and other retaining structures around the mangrove areas or filling/ reclamation of these areas hinder the entry of tidal water into the mangrove areas and hamper its expansion. Over exploitation of mangrove resources like cutting of mangroves for fire wood, cattle feed, etc. by the local people also damaged this fragile ecosystem. Removal of mud from the banks of backwaters by local people for household purposes together with plantation activities has also been noticed as factors leading to threat on mangroves. Waste disposal also affected the mangroves to a large extent. The policies framed by the government to encourage tourism and other recreational activities in the coastal environments have also contributed adversely to the conservation of mangroves and other marine biodiversity. Above all, lack of awareness among the public regarding the importance of mangroves is a major problem associated with mangrove conservation and protection. Ezhimala- Kunhimangalam region is highly affected with fishing related activities, sand mining, coir retting etc. Valapattanam mangroves are pressurized by pollution from wastes like slaughter house, domestic sewage, carcasses of animals, reclamation and coconut husk retting. Encroachment and unscientific construction activities are the main reasons of destruction in Chetwai and Ashtamudi

mangroves. Mangalavanam mangroves are stressed by land encroachment, pollution due to dumping of cement bags and other wastes. Cutting of mangrove trees for fuel wood and other construction activities, draining and filling of the areas are threats at Puthuvypin region.

Since the survival of this eco system is inevitable for ensuring coastal balance, intensive and extensive conservation and ecosystem reinstatement programmes should be undertaken without delay.

## CONCLUSION

Though there is a technical increase in the extent of mangroves, most of the major mangrove growing areas are under drastic pressure. Significant measures have to be adopted for protecting / uplifting the mangrove habitats of Kerala. Special enforcement cell should be placed to take legal actions through the departments concerned for mangrove area protection. Identification of private owned mangrove areas through field surveys and their acquisition by the government has to be carried out for better protection. The developmental activities that are harmful to mangrove population should be subjected to regular examination by a joint committee involving panchayath authorities, local people representatives and scientists. Creation of awareness regarding the importance of mangroves and mangrove habitats need to be given top priority. Since the survival of this eco system is very important for the well-being of all coupled flora and fauna, intensive and extensive conservation and ecosystem reinstatement programmes should be undertaken without delay. Conservation of these worth preserving pieces of nature's gift is highly insistent, because tomorrow may be too late.

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