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On mangroves and mangrove associates of Puthuvypin of Ernakulam district of Kerala (South India)

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Abstract
Puthuvypeen is an upcoming major Industrial area in Kochi in the Indian state of Kerala. Given its close proximity to the Kochi city and to the international sea route Puthuvypeen has attracted many investment projects in the near past. Further, of late, Government of Kerala decided to set up a mega Oceanarium project together with a Marine Biological Research Centre at Puthuvypeen with the objective of imparting awareness on the marine resources of the Arabian Sea. Though the development projects contribute to advancements in the social and economic fronts and overall growth of the region, they may also bring in adverse effects on the environmental quality, if adequate precautions are not taken to prevent them. A comprehensive database on the baseline environmental characteristics is a pre- requisite for an integrated assessment of environmental impacts, if any, with respect to pre-construction, construction and post-construction phases of the projects. The present study which forms part of a larger integrated study was meant to collect information on mangroves and mangrove associates of the area with a view to act as a baseline data for future studies on the impact of the projects on the aquatic environment. 11 species of true mangroves and 32 species of mangrove associates were found to occur in the study area. The various bio diversity threats to mangroves and mangrove associates in the area were also identified and discussed in the paper.

Keywords: mangroves, mangrove associates, puthuvypin, kochi

Introduction

Puthuvypeen (also called puthu vype) is an upcoming major Industrial area in Kochi in the Indian state of Kerala [1]. It is a western suburb of Kochi City and is a part of Vypin Island which is 24 km long and 2.6 km wide. Vypin island has a total area of 87.85 km^2 [2]. The island is situated on the western side of Ernakulam District with Kodungallur Strait on the North, Cochin backwaters and Cochin Port on the South, River Periyar and Kochi city on the East and Arabian Sea on the West. The island is connected to the city by three bridges known as "Goshree" Bridges. The ecology of Vypeen Island is unique, endowed with large canals extending over 50 km and a network of small canals emerging there from [3]. The population of Vypeen is estimated at more than 2 lakh, with one among the highest density of population in the world.

Given its close proximity to the Kochi city and to the international sea route Puthuvypeen has attracted huge investment projects in the near past like the Liquefied Natural Gas (LNG) Terminal, Bunkering Terminal, Single Buoy Mooring, Ship Repair Complex, to name a few [4]. It is perhaps one of the fastest growing industrial areas in the state of Kerala. Puthuvype Beach, though a less visited beach at present is also one of the very beautiful beaches which is expected to be developed for tourism and the local administration is making a lot of efforts to promote this place as a highly sought after tourist destination.

Recently Government of Kerala decided to set up a mega Oceanarium project together with a Marine Biological Research Centre at Puthuvypeen with the objective of imparting awareness on the marine resources of the Arabian Sea. The Oceanarium development project, proposed at Puthuvypeen forms the country's first such initiative. It has been conceived as an 'infotainment' facility serving the dual objective of information and entertainment. The proposed development site for the Oceanarium project, spread over an area of 50 acres (Block No.10, Survey. No 238), is located in Puthuvypeen Village of Kochi Taluk in Ernakulam District of Kerala.

Though the development projects (fig.1) contribute to advancement in the social and economic fronts and overall growth of the region, they may also bring in adverse effects on the environmental quality, if adequate precautions are not taken. When stress in such projects is laid on providing benefits to the stakeholders, quality of the project environment is invariably overlooked. This, as felt in many instances, may result into severe landscape changes, degradation of land, water and soil quality, loss of vegetation and habitats, endangered fauna, imbalances in ecosystems, socio-economic and cultural instability, among many other undesirable repercussions. It will ultimately lead to a stressed ecosystem that does not contain the full complement of species and interrelationships that would normally prevail. Therefore, there is a pertinent need to carefully evaluate the prevailing environmental conditions of the development area and surroundings prior to the implementation of the development projects. A comprehensive database on the baseline environmental characteristics is a pre- requisite for an integrated assessment of environmental impacts, if any, with respect to pre-construction, construction and post-construction phases of the various projects. Though studies exist on mangroves of various areas in and around Cochin backwaters and in other parts of the state of Kerala [5-15], no studies are known to exist exclusively on the mangroves of the study area. The present study which forms part of a larger integrated

study was meant to make an inventory of mangroves and mangrove associates which are among the most dynamic but fragile ecosystems of intertidal zone, with a view to act as a baseline data for future studies on the impact of the projects on them. The present paper also attempts to identify the bio diversity threats to mangroves and mangrove associates in the area.

Fig 1: Sites of various development projects

2. Materials and Methods

Information on the mangroves of Puthuvypin was collected through field studies during March 2013 to October 2013. The area covering the proposed site of the Oceanarium and its surroundings within a radius of 10 km was covered under the study (fig. 2). The area covered under the present study has been located at the geographical coordinates of 09º 58' N latitudes and 76º 23' E longitudes (Survey of India Topographic sheets No. 58B/4, 58B/8, 58C/1 and 58C/5).

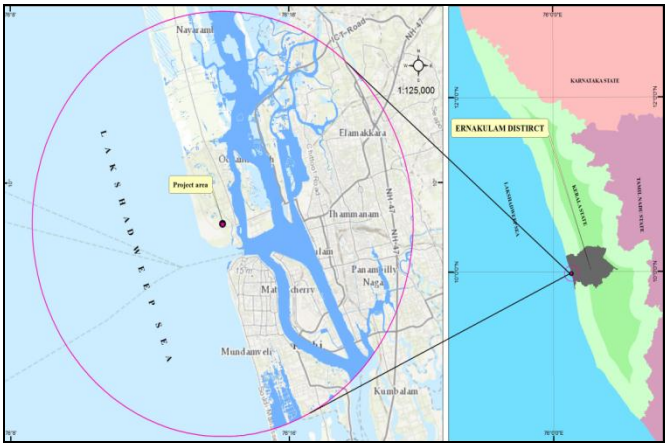

Fig 2: Study area

For the estimation of density and percentage of species composition of mangroves, 10 random stations each of 25 m^2 area (5 x 5 m) lying within the mangrove area were selected with the help of a GPS and the species wise number of mangrove plants in each station was noted down. The number of mangrove plants in each station divided by the area of the station (25 m^2) gave the density of mangroves viz., the number of mangrove plants per square metre in the station. The total number of mangrove plants in all the stations put together divided by the total area of the. Stations (250 m^2) gave the density of mangroves in the study area. The percentage species composition was computed as the number of plants belonging to a particular species divided by the total number of plants which was multiplied by 100.

3. Results and Discussion

The mangroves in puthuvypin are mainly located towards the north of the development site. The mangrove cover of the area could be categorized into three, viz. moderately dense, interspersed with settlements and degraded ones. Of these, the major category is the one interspersed with habitations/settlements. The area houses 11 species of true mangroves belonging to four families (table 1) and 32 species of mangrove associates belonging to 18 families (table 2).

Table 1: True mangrove species found in Puthuvypin

S. No.	Scientific name	Vernacular name (Malayalam)	Family
1	*Avicennia marina* (Forsk) Vierh.	Cheru uppatti	Acanthaceae
2	*Avicennia officinalis* L.	Uppatti, Upootti	Acanthaceae
3	*Bruguiera cylindrica* Blume	Kuttikandal	Rhizophoracea
4	*Bruguiera gymnorrhiza* (L.) Savigny	Penakandal	Rhizophoraceae
5	*Bruguiera sexangula* (Lour.) Poir	Swarnakandal	Rhizophoraceae
6	*Excoecaria agallocha* L.	Kommatti, Kannampotti	Euphorbiaceae
7	*Rhizophora apiculata* Blume	Vallikkandal, Naikandal	Rhizophoraceae
8	*Rhizophora mucronata* Lam.	Pranthankandal	Rhizophoraceae
9	*Sonneratia alba* J. Smith	Nakshthrakandal	Sonneratiaceae
10	*Sonneratia caseolaris* (L.)	Chakkarakandal, Blathikandal	Sonneratiaceae
11	*Acanthus ilicifolius* (L.) Engl.	Chakkaramullu, Chulli, Chullikandal	Acanthaceae

Table 2: Mangrove associates found in Puthuvypin

S. No.	Scientific name	Vernacular name (Malayalam)	Family
1	*Acrostichum aureum* L.	Machithol, chavithol, Thavikkad	Pteridaceae
2	*Annona glabra* L.	Kadalatha	Annonaceae
3	*Bacopa monnieri* (L.) Pennell	Brahmi	Plantaginaceae
4	*Dalbergia candenatensis* (Dennst.)	Kulayeeti	Fabaceae
5	*Derris scandens* (Roxb.) Benth.	Ponnan valli	Fabaceae
6	*Derris trifoliata* Lour	Ponnuvalli	Fabaceae
7	*Diplachne fusca* (L.) P. Beauv.	Chamappullu	Poaceae
8	*Dolichandrone spathacea* (L.f.) Schum.	Neerpongu	Bignoniaceae
9	*Fimbristylis cymosa* R. Br.	Vayalpotta	Cyperaceae
10	*Fimbristylis ferruginea* (L.) Vahl	Puzhapotta	Cyperaceae
11	*Fimbristylis polytrichoides* (Retz.) Vahl	Padappanpotta	Cyperaceae
12	*Hibiscus tiliaceus* L.	Thaliparuthi	Malvaceae
13	*Ipomea campanulata* L	Manivalli	Convolvulaceae
14	*Ipomea pes-caprae* (L.) R.Br.	Chuvanna adambu	Convolvulaceae
15	*Ipomea violacea* L.		Convolvulaceae
16	*Cyperus javanicus* Houtt.	Valeera	Cyperaceae
17	*Morinda citrifolia* L.	Manjanathi	Rubiaceae
18	*Paspalum distichum* L.	Kulavarangu	Poaceae
19	*Phragmites karka* (Retz.) Trin. Ex Steud.	Nannana	Poaceae
20	*Millettia pinnata* (L.) Panigrahi	Pongu	Fabaceae
21	*Premna serratifolia* L.	Kozhiyappa,Munja	Verbenaceae
22	*Sauropus bacciformis* (L.) Airy Shaw	Nilam- thengu	Euphorbiaceae
23	*Schoenoplectus littoralis* (Schard.) Palla	Urunipotta	Cyperaceae
24	*Sesbania bispinosa* (Jacq.) W.F. Wight	Kilannu	Fabaceae
25	*Sesuvium portulacastrum* (L.) L.	Smabar cheera	Aizoaceae
26	*Sphenoclea zeylanica* Gaertn	Pongathi	Sphenocleaceae
27	*Sporobolus virginicus* (L.) Kunth		Poaceae
28	*Thespesia populnea* (L.) Sol. Ex Corr. Corr.	Poovarasu, Cheelanthi	Malvaceae
29	*Typha angustifolia* L.	Aanappullu	Typhaceae
30	*Wedelia chinensis* Merr	Manjakkayyonni	Asteraceae
31	*Clerodendrum inerme* (L.) Gaertn.	Neernochi, Puzhamulla, Cheruchinna	Lamiaceae
32	*Crinum viviparum* (Lam) Ansari& Nair	Polathali	Liliaceae

The density of mangroves in different stations is presented in fig. 3. The average density of mangroves in the study area was found to be 0.67 plant per m^2. The percentage species composition of the mangroves in the area is provided in fig.4.

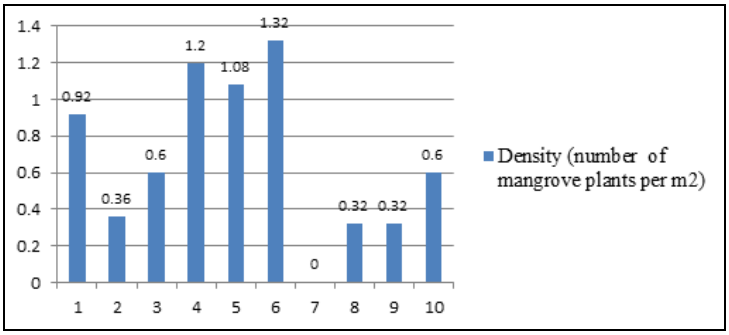

Fig 3: Density of mangroves (number of plants per m^2) in different stations in the study area (stations on x axis).

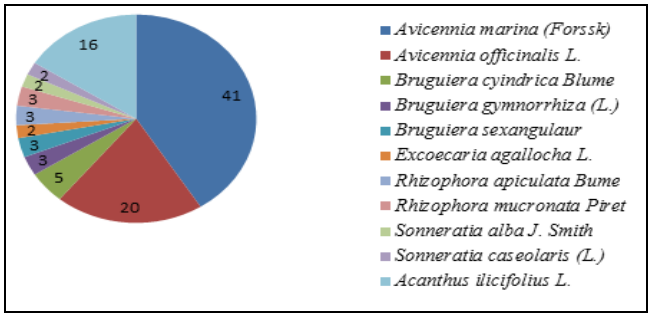

Fig 4: Species composition (percentage) of mangroves in the study area.

Mangroves of Kerala are less complex in terms of tidal creek networks compared to the dense complex networks of mangrove ecosystems along the east coast of the country [16]. The species diversity of mangrove vegetation in Kerala is considered to be high. No studies are known to exist exclusively on the mangroves of the study area which would have facilitated a direct comparison with the results of the present study. However studies do exist on mangroves of various areas in and around Cochin backwaters and in other parts of the state of Kerala. From the Cochin estuary, the occurrence of *Acanthus ilicifolius*, *Avicennia alba*, *Rhizophora sp.* and *Bruguiera sp.* in small numbers was reported by

Kurien [5]. Ramachandran *et al.* [6, 7] after a very detailed survey along the entire Kerala coast reported 39 mangroves and mangrove associated species. These authors observed that mangroves of Kerala were degraded and grew in isolated patches. Banerjee *et al* [8] reported 32 species under 24 genera of 19 families from Kerala. However, Basha [9] could observe only 27 species under 21 genera of 17 families. Unni [10] and Khaleel [11] reported 18 true mangrove species and 23 associates from the state. Anupama and Sivadasan [12] reported only 15 true mangroves. But the mangrove associates were nearly three times, i.e. 49 in number belonging to nine genera and seven families. Madhusoodhanan and Vidyasagar [13] found 15 species of true mangroves but could locate only 33 associates in the state. Recently Mini *et al*. [14] reported 24 species of mangroves and 98 species of mangrove associates in Kerala. Vidyasagaran and Madhusoodanan [15] observed that except few areas, most of the mangroves in Kerala are in an irreversible process of degradation. According to these authors the mangroves had been degraded due to construction of a number of barrages for irrigation purposes, clear felling and lack of fresh water supply, lack of tidal flushing of the degraded areas, release of pollutants from various domestic and industrial sources, changes in water quality, Illegal sand mining etc. the study also revealed that *Excoecaria indica, Lumnitzera racemosa and Ceriops taga*l are the most threatened species. In the present study 11 species of true mangroves were found to occur in the study area. The number of mangrove associates noted was 32. It indicates that a sizeable portion of the mangrove species reported from other parts of the state is available in the study area.

Mangroves of the coastal belts assume utmost conservation significance for its unique biodiversity content and multifarious ecological services. The mangroves are constituted by an assortment of medium trees and shrubs that are adapted to grow in saline coastal sediment habitats. The massive root system of mangroves is efficient at dissipating wave energy [17]. The mangrove swamps protect the coastal areas from erosion and storm surge, especially during hurricanes and tsunamis [18]. A substantial part of the study area is occupied by inland water bodies with network channels, mainly associated with the Vembanad Lake. The area and surroundings are prone to sea water incursion during high tides. The flow of lagoon water into the sea and inward flow of saline sea water due to tidal action cause movement of sediments, which results in the formation of mud flats and tidal flats. The mangroves thrive in the area due to the prevailing estuarine environment, in which the fresh water and saline water intercalations occur due to tidal influence.

Apart from the other ecosystem services, mangroves play very important roles in sustenance of fishery resources. They act as feeding, breeding and hiding place for a number of marine organisms including the commercially important shrimps, crabs and fishes. Mangroves also act as nursery grounds for many fin fishes and shell fishes. They also play very important role in contributing to the primary productivity of the aquatic environment. Hence, loss of mangroves will cause direct and indirect repercussions which are ecologically and economically significant. Despite their benefits, mangrove forests in Kerala have experienced extensive deforestation over the last few decades due to increased demand for commodities. This phenomenon is likely to persist, given the continued increase in population and urbanization.

There were many studies in the past to systematically quantify the conversion of mangroves to different land use types in Kerala and identify the key drivers of mangrove deforestation over the last decade [10, 19]. While there are encouraging signs of a slowdown in mangrove deforestation, it is important to note that mangrove loss in Kerala still remains substantial. This not only results in negative impacts on the mangrove diversity, but also undermines the ecosystem services that mangrove forests provide, such as carbon storage.

The demographic and socio-economic indicators of the state reflect a situation of mounting pressure on natural resources [19]. These factors alone or in combination have resulted in destruction in various degrees. It may be pointed here that the density of human population in Kerala has increased from 819 (in 2001) to 859 per km^2 (in 2011) [20]. The state showed 15 per cent GDP growth during 2012 and leads in social development indices in the country [20]. These forces naturally result in urbanization and consequent development pressures, which cause severe toll in the quantity and quality of natural resources. Ernakulam district in Kerala particularly witnessed massive destruction of mangroves for various development projects in the last couple of decades [19]. The destruction of mangroves was mostly for alternate development activities such as national projects, residential and commercial complexes, shrimp/fish ponds, roads and railway lines. Earlier, 90 per cent of mangroves in Kerala were destroyed either for paddy cultivation, coconut orchard or for land reclamation [21].

The increased demographic pressure along with industrial needs has resulted in large scale reclamation of many productive wetlands like paddy fields and the marshy tracts along the coastal line. Mangrove vegetation along the coastal regions of the state especially in the riverside had been cleared from early period for agriculture and human settlements and currently the vestiges of mangrove bushes are seen along the coast [19].

Mangroves in Ernakulam district are mostly seen along the Cochin backwaters under the strong influence of Vembanad Lake. Being the commercial hub of the state, major developmental activities in Ernakulam are concentrated along the backwaters. The mangroves along the Cochin backwaters are increasingly subjected to large scale destruction for different developmental projects. More than 100 hectares of the Government's land was cleared for the establishment of LNG Petronet Terminal. Mangroves were also cleared for the construction of roads and bridges while implementing Goshree Island development project in Ernakulam [19].

Mangroves have also vanished due to illegal cutting of mangrove trees for fuel wood, over grazing for fodder, fish and shrimp culture, indiscriminate encroachment of land for developmental activities, conversion of mangrove lands into coconut plantations and sand mining. The change in the land use pattern has led to the degradation of wetlands including mangroves. Apart from the erratic and insufficient runoff to the coastal area, excessive sand mining from the river bed has heavily threatened the very existence of the unique mangrove ecosystem [22]. One of the reasons for the large scale land filling in the coastal areas and other water bodies in Kerala is the absence of clear cut boundary line. More than 80 per cent of the mangroves are owned by the private people and the absence of marked boundary in the marshy mangrove area aggravates the reclamation activity. When water recedes in the summer months exposing the mud flats the reclamation is

easy. The mangrove flora which has high natural regenerative capacity has remained stunted in many pockets in the coastal area. This is primarily due to pollution from urban and rural areas. The mangrove depletion in the state has reached to the extent that the functional role of the mangrove ecosystem in both hydrological and biotic terms has been narrowed down. Many wetlands are over loaded with heavy metals, other toxic substances, plastics and other degradable and non-degradable substances. In many places eutrophication has inhibited the growth of the biota in the natural habitat.

The land holding and ownership of mangroves are the significant factors in utilization, conservation and management of mangroves. More than 85 per cent of mangrove area in Kerala is under the private holdings/ownership [10, 19, 23, 24]. The mangroves under public ownership have been largely converted for developmental activities like ICTT, Vallarpadam, expansion of Cochin Port Trust and LNG, Petronet, Puthuvypeen. The mangroves in private lands are also under threat. Because of the surging land prices, the private owners, especially in urban areas prefer to clear off the mangroves to fetch better price in the land market.

Increase in temperature, CO_2 emission, storm surges and sea level rise are the principal threats to mangroves in the long run. Conversion of mangrove wetlands leads to reduction in biodiversity and contributes to changes in carbon cycle [25]. Mangroves are considered as nature's best system for combating global warming because of their high capacity for carbon sequestration and role as a nutrient sink. The global climate change and resultant sea level rise threaten the natural withstanding ability of mangroves especially island mangroves. The life and livelihood of coastal population is at risk owing to the sea level rise and increased incidence of storm surges. The greenhouse effect on the impact of hydrological cycle may cause increasing scarcity of fresh water in the coastal region. Climate induced changes are likely to affect livelihood options of the coastal people of Kerala [26]. In depth long term studies from different regions of the world are needed to get more precise conclusions. Ellison and Studdart [27] reported that mangrove habitats are the first to be directly affected from global climate change owing to the location at the interface of sea. The grave impact of sea level rise on mangrove community was reported from Southeast Asian countries [28]. The increased sea level rise may drastically impact mangrove habitats by altering the hydrological features and related processes. The vertical rise of water column due to sea level rise would result in water logging and destruction of mangroves and associate fauna such as bivalves, crabs and juvenile fishes [29]. The highly erosive and dynamic nature as well as sea variations indicates high vulnerability of the Kerala coast to sea level rise. Sea erosion and inundations would destroy the traditional paddy fields and shrimp and fish farms and have negative impact on the coastal population of the state. The impact of climate change is often experienced slowly and the awareness level among the people is rather limited. Drying of mangroves during summer months were observed and large scale destruction of mangrove seedlings owing to prolonged water stagnation. With the reduced annual rainfall in the last few years, the period of fresh water availability has reduced and hence mangrove seedlings remain in the saline water for longer period resulting in large scale destruction. The salt water intrusion to the rivers and backwaters usually take place in November–December. Of late the intrusion has advanced to early September. This may cause adverse effects on mangrove vegetation. However scientific validation is needed in this aspect.

One of the aims of any management option of natural resources is biodiversity conservation and enhancement [30]. The Sunderban mangroves were the first scientifically managed mangroves in the world [31]. In Kerala, an effective management strategy for mangroves is to be evolved in view of the rising pressure on land resources. An effective management plan to protect the biodiversity together with safeguarding the needs of mangrove dependent local communities is proposed.

4. Conclusion

The present study was to make an inventory of mangroves and mangrove associates of Puthuvypin, an upcoming major Industrial area in Kochi in the Indian state of Kerala. In the study 11 species of true mangroves were found to occur. They are *Avicennia marina* (41%), *A. officinalis* (20%), *Acanthus ilicifolius* (16%), *Bruguiera cyindrica* (5%), *B. gymnorrhiza* (3%), *B. sexangula* (3%), *Rhizophora. apicuata* (3%), *R. mucronata* (3%), *Sonneratia alba* (2%), *S. caseolaris* (2%) *and Excoecaria agallocha* (2%). The density of mangrove growth was found to be 0.67 plant per m^2. In addition, 32 species of mangrove associates were also found to occur in the study area. The results of the present study would serve as a baseline data for future studies on the impact of various development projects implemented in Puthuvypin on the mangrove ecosystem. In the paper an attempt was also made to identify the key drivers of mangrove deforestation in Kerala.

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