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# Is Sand Bar Formation a Major Threat to Mangrove Ecosystems?

**P. K. Syamjith[1], N. Ramani[2]**

[1]Research Scholar, Division of Acarology, Department of Zoology, University of Calicut, Kerala-673635, India

[2]Professor, Division of Acarology, Department of Zoology, University of Calicut, Kerala-673635, India

**Abstract:** ***Mangroves are the most fragile ecosystems in the intertidal zones of tropical and subtropical areas, supporting a rich diversity of flora and fauna on regional and global scales. Mangrove ecosystems are prone to die back owing to diverse climatic and anthropogenic effects. The present study is focused on the various climatic and anthropogenic effects experienced by the Kadalundi-Vallikkunnu community reserve mangrove (11°07'33.'76" N and 75°49'49.40" E), located in North Kerala, India. This site forms the State's first community reserve, lying very close to the Arabian Sea and being home to various migratory birds. Results of field observations and Google Earth image analysis in the above mangrove ecosystem revealed remarkable changes in the land cover, owing to the formation of sand bars, along the edges of the river mouth. The sand bar formation at the site has resulted in the massive die-back of the mangrove vegetation, especially that of Avicennia marina. Apart from these, dumping of waste materials in the site, often completely masking the mangrove vegetation also severely affected the growth of A. marina. During the summer season, owing to heavy infestation by a Lepidopteran caterpillar, the plant was found susceptible to canopy defoliation also. The findings made during the present study recall the urgent measures to be adopted from the authorities to ensure community participation for restoration of the community reserve.***

**Keywords:** Mangroves, sand bar, Avicennia marina, community reserve, dieback

## 1. Introduction

Mangroves are unique wetland ecosystems found in the inter-tidal areas of the tropical and subtropical countries, which foster by sheltering a rich diversity of flora and fauna including endangered species (Robertson and Duke 1990; Sathirathai and Barbier, 2001) and thus serve as 'Nature's nurseries' (Siddappa, 2013) . These ecosystems play vital roles to support the livelihood of human beings (Bhatt *et al*, 2013) for a variety of reasons, including agriculture, aquaculture, forestry, shoreline protection and from soil erosion (Hogarth, 1999). This ecosystem protects the shores from other coastal hazards like, storm, flooding and even from the 2004 Indian ocean Tsunami (Kathiresan and Rajendran, 2005; Danielsen *et al*, 2005), hurricane (USGS report, 1997). The mangrove trees, roots and canopy serve as habitat for various plants like algae and many invertebrates and vertebrates (Nagelkerken *et al*, 2008). Moreover, the mangrove litter serves as ingredients for nutrient cycle release, especially inputs, organic carbon in mangrove sediments (Alongi *et al*., 1993; Alongi, 1998;) and their balance of aerobic and anaerobic microbial processes (Kristensen *et al*., 2008). As per the estimates of the Forest Survey of India (FSI, 1987), the mangrove areas in India extend for 4662.56 Sq Km, and Kerala has 700 sq kms (Ramachandran and Mohananan, 1987). However, the mangrove ecosystem of Kerala is now reduced to 17 Sq Kms. (KFRI, 2009), owing to various anthropogenic and climatic effects. A reduced mangrove area would challenge/ threat the human life, reduce coastal water quality, biodiversity and eliminate fish and crustacean breeding grounds. Sand bars are submerged ridges of detritus sediments commonly found near river mouths (Jayappa and Narayana,2009).The formation of sand bars is a more complex process (Tanaka, 2005) representing important morphological features of natural beaches (Gallagher *et al*., 1998;). In the present study, an attempt was made to focus on the impact of sand bar and other man –made activities at the Kadalundi- Vallikkunnu community reserve, North Kerala India.

## 2. Material and Methods

### 2.1 Study Site

The study site, viz. Kadalundi-Vallikkunnu community reserve represents the State's first community reserve (11°07'33.76″ N and 75°49'49.40″ E) (Sreedevi Chitharanjan, 2011). It is a coastal area lying very close to the Arabian sea and serve as a home for various migratory birds found distributed in Kozhikode and Malappuram districts of North Kerala (west coast), India. (Figure1).

### 2.2 Floristic Analysis

All the true and associate mangrove plants were collected and made into herbarium and identified with the expertise of the faculties of Department of Botany, University of Calicut.

### 2.3 Google Earth Pro (GEP) digital image Processing and Analysis

The available satellite images of the study site at different time intervals (2002-2014) were recorded by using Google Earth Pro 7.1 (GEP) software. The images were set at (latitude 11°07'38.'64" N and longitude 75°49'50.23" E). The images were not enhanced during the analysis. The aerial photographs of the study site Eye alt, at 2334 ft were used to demarcate the evolutionary changes in land forms, especially on the sand bar formation. The entire analysis of the study area was performed on a scene-by- scene basis. The measurements of the area of sand bar were performed using the GEP polygonal tool.

### 2.4 Field photography

Frequent field visits were made during the period from 2007 to 2014. All the relevant photographs were taken to record the data on changes in land cover and mangrove vegetation.


**Figure 1**: Location of the study area ((Red spot) in Kadalundi- Vallikkunnu community reserve, Kerala, India.

## 3. Results

### 3.1 Floristics

In the present study, three species of true mangrove plants . Five species of mangrove associates and two grass plants could be recorded (Table.1 and Figure 2 A-I). The dominant plant species recognized in the site was *Avicennia mariana* followed by *Acanthus ilicifolius* .

### 3.2 Damage to the mangrove ecosystem observed from the Google Earth Pro- image analysis

A comparison of the study site based on the images acquired at different time scales, revealed no significant change in the land cover during the period of 2002 to 2004 (Figs. 3A &B). The changes which occurred in the area leading to the formation of sand bars as small patches were visible in the year 2010 (Fig. 3C), and the patches measured about 3871 Sq m. Later, these patches were found extending towards the area of mangrove vegetation, and formed as a complete sand bar, measuring about 4317 Sq m. (Figs. 3D &G). On progressive observation, the area of sand bar was found to extend more, covering an area of 6986 Sq m. during 2011 (Fig. 3E) and this area formed a substratum for the growth of the grass species, Mariscus javanicus and the climber, Ipomea pes- caprae (Fig. 3H). During the time scale of 2011 to 2014, the area of sand bar on that site was found to decrease to about 4961Sq m. However, instances of formation of new bars were visible in adjacent areas, especially along the river banks (Fig. 3F).

### 3.3 Field Photography / Change Analysis

As evidenced from the GEP image, an approximate distance of 56 meters of sand bar was found shifted towards the terrestrial mangrove area (Figs.4A &B).As shown in Fig.4F, the formation of a new area of sand bars measuring 1332Sq m was observed on the edges (between latitude 11°07'36.'96" N, longitude 75°49'53.28" E and 11°07'38.'11" N and longitude 75°49'54.70" E) of Kadalundi river (Figs.4C&D). The complete destruction of *A.marina* was observed at this site.

**Table 1:** Flora of mangrove vegetation.

| *Sl.No* | *Species Name* | *Type* | *Family* |
|---|---|---|---|
| 1 | *Acanthus ilicifolius* L. | TM | Acanthaceae |
| 2 | *Avicennia marina* (Forsk.) Vierh. | TM | Avicenniaceae |
| 3 | *Rhizophora mucronata* Poir. | TM | Rhizophoraceae |
| 4 | *Clerodendrum inerme* (L.) Gaertn. | MA | Verbenaceae |
| 5 | *Caesalpinia crista* L. | MA | Caesalpiniacae |
| 6 | *Derris trifoliata* Lour. | MA | Fabaceae |
| 7 | *Ipomea pes- caprae* (L.) R.Br. | MA | Convolvulaceae |
| 8 | *Mariscus javanicus* Houtt.) Merr & Metcalf. | - | Cyperaceae |
| 9 | *Pennisetum pedicellatum* Trin. | - | Poaceae |

TM- True Mangrove, MA- Mangrove Associate


**Figure 2**. **A**- *Avicennia marina*, **B**- *Acanthus ilicifolius*, **C**- *Rhizophora mucronata*, **D**- *Clerodendrum inerme*, **E**- *Caesalpinia crista* ,F- *Ipomea pes- caprae* ,**G**- *Derris trifoliata* ,**H**- *Mariscus javanicus*, **I**- *Pennisetum pedicellatum*.

Breathing roots, or pneumatophores of *A.marina* were found buried in the sediment, and the proposals were found settled down on the sandbar sediment (Fig.4E). It was also noted that most of the pneumatophores of *A. Marina* was exposed, leading to dieback of vegetation (Figs.4F & G). Simultaneously, defoliation of the plants was also observed owing to the feeding activity of a lepidopteran caterpillar, which devoured the fresh leaves of *A. marina* (Fig.4 H), during the summer seasons. Added to the above, several anthropogenic activities like waste dumping over mangrove vegetation (Fig. 4 I), coir retting in adjacent areas, etc. were also observed at the site.

## 4. Discussion

The mangrove swamps have high great environmental significance owing to their vital roles in soil formation, shoreline stabilization, and helping in the interaction of detritivores with dead plant materials (Julie *et al.*, 2013). Analysis of time scaled image data made during the present study revealed the characteristic formation of sand bars during the period from 2002 to 2014. The formation of small patches of sand bars was found appeared, between 2002 and 2010. The results of the present study enabled to make a general observation on the change in topography and

hydrology of mangrove ecosystem, which might be considered as a major cause of mangrove plant death. Topographic features around the mangrove vegetation is an important factor affecting destruction of mangroves (Yanagisawa *et al*.,2009).The tidal flow and sea waves in mangrove ecosystems mutually contribute their roles in material exchange, soil aeration and replenishing of nutrients in mangrove ecosystem (Bhosale, 2013). The sand bar formation limits the flow of water in and out to the mangrove swamps. It also reduces the mangrove zonation with respect to the mangrove species. They will in turn affect the river mouth topography (Tanaka *et al*., 2005), and removal of plants by scouring (Rominger *et al*., 2010).

Results of field surveys made at Kadalundi indicated a mass destruction of the true mangrove plant, *A. marina* along the river basin. The seeds and seedlings of the plant were found settled on the sand bars, without getting flooded away by the tidal currents. The sediment accretion and soil erosion would determine propagule dispersion and their establishment with respect to spacio-temporal changes in mangrove ecosystems(Clarke *et al*., 2001). However, excessive accretion would cover and suffocate the seedlings (Thi *et al*., 2014). Results of time scale dependent comparison studies showed that mangrove dieback occurred at the river mouth, along with the migration of the sandbar. This supports the recent findings of Thi *et al* (2014) who confirmed huge loss of mangroves at the East Sea and Gulf of Thailand sides of Mui Ca Mau, based on remote sensing data analysis.


**Figure 3:** Google Earth Pro (**GEP**) - **A & B**- Image showing non- occurrence of Sandbar at study site. **C**- Formation of sand bars as small patches (Arrow head) **D**- Development of sand bar during the year 2010.**E**- Expansion of sand bar ,**F**- Sandbar shift,**G**- close –up of Sandbar, **H**- Establishment of *Mariscus javanicus* (grass plant) and *Ipomea Ipomea pes- caprae* (climber) on sand bar.


**Figure 4.** Google Earth Pro (GEP)- Image **A- C** shows migration and the formation of a new sand bar (Yellow arrow). **D**- Very close view of the newly formed Sand bar along the riverside - (Arrow head) **E &F** - Pneumatophore burial by the deposition of sediment and settle down of *Avicennia* propagules (Black arrow), **G**- Massive dieback of *A. marina* ,**H**-Feeding of Lepidopteran caterpillar on fresh leaves of *A. marina* **I**- waste dumping near mangrove plants.

(Heavy deposition of sediments on mangrove pneumatophores leading to their destruction was observed frequently, in the study site, which would lead to killing of mature mangrove plants ( Ellison, 1998). Generally, mangrove pneumatophores grow vertically upwards and with their tips exposed in air, thereby playing significant role in ventilation mechanism, for the survival in anaerobic soil (Purnobasuki and Suzuki, 2005). However, sand bar formation was found to hinder the entry of floods to the pneumatophores and the sand grains would obstruct the lenticels, thereby affecting the passage of air through the pneumatophores, gradually leading to the dieback of mangrove vegetation. Further, destruction of the mangrove canopy by a lepidopteran defoliator was also observed in the study site, which would aggrieve the die back of mangrove plants. Mangrove ecosystems of Kerala are under the threat of various kinds of destructive insects, including the lepidopterans (JainJ and Louis ,2001). A combination of all

these natural cum anthropogenic activities may lead to complete elimination of mangrove vegetation from the Kadalundi -Vallikkunnu mangrove ecosystem, which is the first declared Community Reserve of Kerala.

## 5. Conclusion

Mangrove afforestation is a key factor in the establishment of a nutrient –rich estuarine biotopes. Nowadays, mangroves are prone to various climatic and anthropogenic activities. An indigenous effort and mechanism for restoration in this Community reserve is the need of the hour. Awareness should be created among the scientific and public sectors, with more priority to the local people, on the protective, productive, ecological and environmental values of mangroves. This information would invite the attention of concerned authorities for making pertinent planning and decisions in the future to ensure protection of the mangrove ecosystems left behind.

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## Author Profile

**Syamjith P.K,** has completed M.Sc degree in Entomology from University of Calicut, Kerala in the year 2009. Recipient of Rajiv Gandhi National Fellowship from University Grants Commission (UGC), New Delhi, India for the year 2011-2016. Currently doing Ph.D in Acarology.

**Dr. N. Ramani** received Ph.D from University of Calicut, Kerala, India. She is working as a Professor in the Division of Acarology, Dept. of Zoology, University of Calicut. **Current Research Interest:** Biosystematic studies on oribatid mites, plant mites, predatory mites, studies on role of oribatid mites in biodegradation, elucidation of biocontrol efficacy of predatory mites. 28 years of teaching & 32 years of research experience in entomology and acarology. **Honors / Awards received**: ‘ Special Recognition Award’ instituted by the Organizing Committee, International Symposium cum Workshop in Acarology, Bidhan Chandra Krishi Viswa Vidyalaya, West Bengal in April, 2010 for the endeavors and contributions made towards the progress in Acarology in India, Rashtriya Gaurav Award presented by the India-International Friendship Society, New Delhi for outstanding contributions. Guided 8 Ph.D. students (7 ongoing Ph.D. programs), 11 M. Phil. & 20 M.Sc. students to work on various plant mites/soil mites/predatory mites / ticks. Author / editor of 2 books & about 115 research publications in International / National journals/proceedings.