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Mangroves: an Underestimated Ecosystem?

Mangrove is a type of tree / shrub / fern / palm, generally found in the estuarine margins or in the intertidal zones of coastal areas or wetlands, and are regularly inundated by tidal water. They are halophyte in nature and can tolerate salt content to a great extent. This ecosystem aids in sustaining the livelihood in the coastal areas by several means such as by providing food, fodder, fuel, timber, *etc.* Some of the mangrove species have medicinal properties and are used against many ailments. They also ensure water security by protecting intrusion of saltwater into aquifers or freshwater. Mangrove forest acts as a habitat for various organisms and hence conserves biodiversity. Their entangled root system acts as a filter and collects debris between them thereby preventing it from washing away into the water body. It removes toxic heavy metals from the water *via* phytoremediation and most importantly it sequesters carbon from the atmosphere leading to the reduction in global warming and ultimately climate change. Mangrove ecosystem acts as a shield against natural catastrophe such as tsunami, floods, storm and cyclone. Regardless of its several advantages, its indiscriminate use for various economic activities has jeopardized this ecosystem. Every year this ecosystem has been declining at a rate of 2 per cent. The realization of the problems arising from the lack of such ecosystem has led to the development of several strategies emphasizing on its preservation and restoration.

INTRODUCTION

The word mangrove has been derived from a combination of two different words *i.e.,* 'mangue' from Portuguese and 'grove' from English which means community of trees (Roy *et al.,* 2009). Mangrove is a type of tree / shrub / fern / palm, longer than one metre in height, grows above mean sea level and are usually found in the estuarine

margins or the intertidal zones of coastal areas or wetlands (Duke, 1992). They are also known as tidal forest and are located at the brim of land and sea, regularly inundated by tidal water.

CLASSIFICATION OF MANGROVES

Broadly, mangroves are classified into two groups.

- True mangroves
- Mangrove associates (Hogarth, 2015)

True mangroves have features like high salt tolerance, well-developed aerial roots and are found towards or near to the shoreline. Examples of true mangroves are red mangrove (*Rhizophora mangle*), black mangrove (*Avicennia germinans*) and white mangrove (*Laguncularia racemosa*). However, mangrove associates are glycophytes in nature and they cannot tolerate high salt levels. They do not have aerial roots and are found on the landward side. An example of a mangrove associate is buttonwood mangrove.

CHARACTERISTICS OF MANGROVES

Mangroves are mostly found in tropical and sub-tropical areas and have a unique feature of interlinkage between terrestrial, marine and freshwater ecosystem (Roy *et al.,* 2009). Some of the species can withstand temperature of up to 5°C, high salinity, high tide, strong wind and anaerobic condition, but cannot tolerate frost (Tomlinson, 1986). The optimum condition required for their satisfactory growth is warm and humid climate and regular influx of freshwater that brings along fertile nutrients. They are highly productive wetland ecosystem with a net primary productivity of 2.5 g C m^{-2} day^{-1} (Thomas *et al.,* 2018). Mangroves are halophytes in nature and they can tolerate salt level to a great extent. They evade the harmful effect of excess salt concentration by three important mechanisms *viz.,* prohibition, collection and discharge. They prohibit salt uptake by means of ultra-filters present in their roots and this type of mechanism is found in *Rhizophora* species. However, some of the species such as *Avicennia marina* discharges the salt through specialized salt glands present in their leaves (Dschida *et al.,* 1992). Species like *Lumnitzera racemosa* and *Exoecaria agallocha* collects excess salt in their vacuoles. They have well-developed aerial roots that assist in physical stability or anchorage in the soft and unstable mud and also aids in its survival under anaerobic / anoxic condition by supplying oxygen to the underground root parts (Srikanth *et al.,* 2015). There are different types of aerial roots found in different mangrove species *viz.,* prop root, knee root, pneumatophores (pencil root and cone root), buttress root, spreading root, *etc.* Gaseous exchange in mangrove is also facilitated by lenticels (breathing pores) present in its roots and modified branches by means of aerenchyma. Mangroves are viviparous in nature. They produce seeds and these seeds germinate in the mother tree itself. Once the young plants are ready to develop roots, they falloff from the mother tree and then establishes itself in the mud. Some falls near the parent tree while some are carried to a distant place along with the flow of water. They consist of waxy and succulent leaves that help in storage of freshwater and also minimize evaporation loss.

DIVERSITY OF MANGROVES

It is believed that mangrove has been originated in the Indo-Malaysian region (Sarkar, 2017). Giri *et al.* (2011) reported that the largest extent of mangroves is found in Asia (42%) followed by Africa (20%), North and Central America (15%), Oceania (12%) and South America (11%). Among the Asian countries, Indonesia contributes about 60 per cent followed by Malaysia (10%), Myanmar (10%), Bangladesh (8%), India (7%) and Philippines (5%). India inhabits a total of 62 mangrove species shared among 52 genus and 36 families and consist of only 3.2 per cent of global mangrove forest (Kathiresan, 2018). Indian mangrove habitats are distributed mainly in three zones: (i) East Coast, (ii) West Coast, and (iii) Andaman and Nicobar Islands including Lakshadweep (Mandal and Naskar, 2008). Sundarbans occupy 43 per cent of total mangrove cover in India. However, Sundarbans in India (30%) and Bangladesh (60%) combined is the largest contiguous mangrove forest (Spalding *et al.,* 2010), and it is the only mangrove forest in the world colonized with the Royal Bengal Tigers (*Panthera tigris tigris*).

IMPORTANCE OF MANGROVES

Mangrove forests are important both ecologically and economically. They support coastal livelihoods worldwide. They acts as a habitat for various living organisms such as fish, birds, reptiles, *etc.* (Ellison, 2008) and conserves biodiversity. Mangroves provide food, fodder, timber and firewood. Some of the species are even used as medicines against several ailments. They also ensure water security for coastal livelihoods by protecting intrusion of saltwater into freshwater or aquifers. The entangled root system of

mangroves acts as a filter and collects debris between them thereby preventing it from washing off into the water body. Their root system also traps silt and reduces the chance of soil erosion. They remove toxic heavy metals from the water *via* phytoremediation and also absorb excess nitrates and phosphates released into the water body, thereby prevents eutrophication. Mangroves sequester a large amount of carbon from the atmosphere resulting in reduced greenhouse gas emission in to the atmosphere and thus slow down the rate of global warming and climate change. They also protect the coastal areas against the violent natural catastrophes such as tsunami, storms, floods and cyclone due to their entangled root system. Mangroves are also considered sacred and there is a temple in Chidambaram of Tamil Nadu, known as Thillai Nataraja Temple exclusively for mangroves where *Excoecaria agallocha* (blinding tree) has been worshipped from the past seventeen centuries (Kathiresan, 2018).

MANGROVES AS CARBON SINK

Mangrove forest can store carbon for a long period of time, if kept undisturbed. They are the only 'blue carbon' forest of the ocean sometimes called as coastal woodland or oceanic rainforest or tidal forest (Kathiresan, 2018). They store carbon in three different locations *i.e.,* aboveground in the form of plant biomass, belowground in their roots and a large amount ranging from 50-99 per cent is also stored in the soil (IUCN, n.d.). Alongi (2014) observed that on an average, mangrove ecosystem can sequester 174 g C m^{-2} $year^{-1}$ which is much higher than other coastal ecosystems such as salt marshes, sea grasses, estuaries and shelves and also it is 2-4 times greater than the carbon sequestered by tropical forests.

MANGROVES AGAINST NATURAL DISASTER

Mangrove forest can reduce the severity of natural calamities such as tsunami, floods, cyclone and storm. The mangrove ecosystem is considered as an effective bio-shield that acts as a natural sea defense. When a super-cyclone struck Odisha during October 1999, the mangrove forest helped in reducing the impact of this cyclone that killed almost 10,000 people and made 7.5 million homeless, which otherwise would have been more dangerous. Also, during the disastrous tsunami of 26 December 2004, areas in Pichavaram and Muthupet as well as Cuddalore district of Tamil Nadu state with dense mangrove cover recorded fewer human casualties and property damage compared to areas without mangroves (Padma, 2004; Danielson *et al.,* 2005). They not only dissipated the wave energy but also trapped people and prevented them from washing out into the deadly sea (EJF, 2006). Similarly, in Andhra Pradesh many people escaped from the dangerous tsunami by taking shelter in the mangrove of Coringa wildlife sanctuary and hence they survived (WWF, 2005).

THREATS TO MANGROVES

Even though they play an important role in protecting human as well as biodiversity, these unique mangrove habitats of India has been facing various threats due to its indiscriminate utilization for various economic activities such as fodder, firewood and timber for building material, alcohol, paper, charcoal, *etc.* (Upadhyay *et al.,* 2002). Apart from these, conversion of mangrove ecosystem for aquaculture and agriculture, construction of ports and harbours, extension of human inhabitation, urbanization, industrialization, climate change and chemical pollution are major issues that affect mangrove ecosystem (Naskar, 2004). Large quantities of plastics were observed in the mangrove areas of Kerala, Karnataka and Maharashtra (CMFRI, 2017). A study by Valiela *et al.* (2001) estimated that 38 per cent of mangrove loss may be attributable to shrimp farm development followed by forest use (26%), fish aquaculture (14%), diversion of freshwater (11%), land reclamation (5%), herbicides (3%) and others (3%). It was reported that after the catastrophic tsunami in 2004, 97 per cent of mangroves were destroyed in the Nicobar region of Andaman and Nicobar Islands (Ghosh, 2018). According to FSI (2009), they noted a decline in mangrove cover in the Andaman and Nicobar Islands by 20 km^2 due to the "after effects of tsunami." The mangrove cover in 2007 was recorded as 615 km^2 while in 2005 it was 635 km^2. The force of the tsunami uprooted a huge number of trees and the submerged condition impeded soil respiration resulting in wilting of mangrove trees within two months of submergence. Similarly, Sundarbans is also facing a great threat of drowning due to tectonic subsidence. Mangrove forest is declining rapidly at a rate of 2 per cent each year (IUCN, n.d.). Between 2000 and 2015, depletion of mangrove forest has resulted in the release of 122 million tonnes of carbon in the atmosphere (Erickson-Davis, 2018).

CONSERVATION STRATEGIES

Awareness programme, proper management plan, legal measures, strict rules and regulations, emphasizing research on mangrove ecosystems, involving local people in mangrove protection and restoration, afforestation, proper monitoring and surveys and consistent allocation of funds for its protection and development are some of the important strategies to conserve this vulnerable ecosystem (Ashokkumar & Irfan, 2018). Eco-tourism is an alternate option that may revive these unique ecosystems and at the same time it will help in educating the people about its significance and generate some economic returns also.

CONCLUSION

Mangrove provides several environmental goods and services besides having high ecological, economical and religious values. Utilization of mangroves for various economic activities and conversion of the mangrove ecosystem for other developmental purpose has resulted in dramatic reduction of mangrove forests with negative impact on the environment and economy. Mangrove preservation and restoration can be a novel measure for effective mitigation of global warming and climate change. The future of mangroves in India needs effective management plan and its execution with strong participation from the local people.

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