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Impact of Anthropogenic Pollution on Mangrove Biodiversity: A Review

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Abstract

Mangrove ecosystem is a very exclusive ecosystem on the Earth. Mangrove forests, still abundant in South and Southeast Asia, are amongst the world's most fragile ecosystems and continue to disappear under the increased threat of climate change and human interventions, which is under menace due to anthropogenic activities such as habitat loss, aquaculture development over harvesting and increase of pollution load. Researchers from all over the world agree on the fact that the existence of mangroves forests is under great risk due to fragmentation of the habitats. In this review paper, status of mangrove habitat loss, the role of mangrove to act as a sink of pollutants and carbon capture (carbon sequestration), accumulation and biomagnifications of heavy metals is discussed. Emphasis has been given to understand the effect of heavy metals, organic and inorganic pollutants on the mangroves and the natural ability of this ecosystem to tolerate the pollution load. Lastly some of the measures that can be undertaken are also discussed.

Keywords: *Mangrove Biodiversity; Carbon-Sequestration; Pollution Sink; Mangrove Deforestation*

Introduction

Mangrove forests are amongst the world's most fragile ecosystems. Mangroves are coastal forests found in sheltered estuaries and along river banks. The term "mangrove" describes both the ecosystem and the plant families that have developed particular adaptations to live in this tidal environment [1]. Its comprehensive role, including the interactive relationship with the bordering habitat and sheltering diverse species, has made it a treasured storehouse of the nature particularly production of fish and shellfish. Mangroves are one of the most industrious ecosystems that enrich coastal waters, yield commercial forest products, protect coastlines, and even support coastal fisheries and store- house of numerous endangered faunas [2, 3]. Estuaries are regions of enhanced biogeochemical activity and impart important ecosystem services along with supporting complex food webs [4]. Mangroves act as a delicate link between marine and fresh water ecosystems, pollution sink and source of nutrient flux into marine ecosystem. But, one is bound to be surprised to know that such a natural fighter against pollution is constantly being affected by the rising level of pollution. The aim of the review paper is to find out how this unique ecosystem, even if being adversely affected by pollution, still sustains the influential balance of the ecosystem and plays a key role in nutrient cycling in coastal and estuarine ecosystem.

Mangroves—A Unique Ecosystem with Rich Species Diversity

Basically Mangroves are woody halophytic plants, which exist in the conditions of high salinity; extreme tides strong winds, high temperatures and muddy-anaerobic soils. The halophytic adaptations of mangroves, such as vivipery ,support roots negatively geotropic breathing roots (*i.e.*, pneumatophores), sclerophyllous leaves with salt excre-tion glands and sunken stomata, stilt root and root but tress are all indicative of the evolutionary selection to persist in muddy, brackish coastal environment on physi- ologically dry soil. Mangroves are salt tolerant species and can take up water despite of high osmotic potential of soil water and even if the salt is absorbed, it is excreted through the salt glands in the leaves. Mangrove ecosystems can be used as indicators of coastal change or sea-level rise. These ecosystems are so specialized that any minor variation in their hydrological or tidal regimes causes noticeable mortality [10].

Loss of Mangrove Ecosystem

Unfortunately this unique ecosystem is itself being violently harmed by the progress of civilization. The existence of mangroves forests is under great risk due to fragmentation of the habitats. Moreover, ecosystem services offered by the mangroves are likely to be lost completely within the next few years. Globally, mangroves are disappearing at an alarming rate of 1 to

2% per year, faster than the adjacent coral reefs or tropical rainforests. Asia has the largest mangrove area in the world, with highest biodiversity of more than 50 species of true mangroves. In Asia, Sundarbans is the world's largest contiguous mangrove patch covering an area of 10,000 kms. The trans-boundary forest of Sundarbans is spread over two countries, of which 60% is in Bangladesh and 40% in India. The mangroves of Sundarban essentially host a number of critically endangered fauna including the royal Bengal tiger .This mangrove ecosystem is affected by numerous cyclonic storms [12]. Asian mangroves as a whole is affected by anthropogenic disturbances like intensive logging, land conversion to promote paddy cultivation and aquaculture and pollution [5]. According to the estimate, since last few years' loss of mangrove has been observed in Asia which was mainly due to intense deforestation activities [6]. So in current scenario the need of the hour is to conserve this fragile ecosystem. Though mangrove ecosystem is an important focus for conservation biologists, environmentalists but the growth of public consciousness to conserve mangrove ecosystem still remains as the burning question [7].Deforestation led by increasing demand for land and climate change events such as rise of sea level and reduction in freshwater flow are considered as major players behind the continuous annihilation of mangroves; however, climate change events may impact to only 10–15% reduction of mangrove habitats in distant future, whereas the immediate threat comes from uncontrolled exploitation and deforestation . The consequent impacts of such losses resulted in serious concern amongst conservationists and exposed the coastal communities to a further increased threat of climate change and hydro meteorological disasters.

Mangrove Soil and Water-Act as a Pollution Sink

Like all other green species, Mangrove has got definite role against the pollution. It has natural ability to act as a sink of anthropogenic and industrial pollutants. It can also arrest and bring about bioremediation of certain pollutants (like fluoride) in local environment. It not only acts as a sink or transfers the pollutants but also oxidizes the metals present in the sediment by exuding oxygen into the anoxic soil through aerial roots. Mangrove wetlands are used for low cost waste disposal site. Rise in industrialization and uncontrolled anthropogenic pressure on mangrove patches has been increase in recent years, however, mangroves ecosystem adapted themselves by acting as natural pollution sink.

High Absorptive Capacity of Mangrove Sediment

Mangrove ecosystem retains toxic metals and stops it from infiltrating into the marine ecosystems. Different mangrove forest areas across the world have varying level of pollution load.

Biotransformation and Bioaccumulation

The contaminant accumulation in sediments and bioaccumulation pathway on mangrove ecosystem elucidate the fate and effects of trace metals released from anthropogenic sources in the mangrove ecosystem [8, 12]. Out of 60 mangrove species, 33 species are used for toxicity test [9, 12]. There is a trend of change in mangrove biodiversity in different parts of the globe. Most of the investigation is revolving around the bioaccumulation potential of different mangroves, which reveals that *Avicinnea* sp is one of the most tolerant species in respect to heavy metals, amongst mangroves. In Indian scenario there is a clear increase of *A. marina* in different mangrove patches. Thus one can derive at this point that pollution factor can also be a potential reason for their dominance. So more pollutants would mean proliferation of only pollution tolerant mangroves to flourish and ecosensitive species would be replaced, and henceforth would result in deterioration of mangrove biodiversity.

Mangroves as major Carbon sinks

Carbon emission is the major cause for climate change and global warming. There is a 36% raise in global CO2 emission in the recent past and it shows a steady mean increase from 357 ppmv (parts per million by volume [10, 11]. Mangroves act as an effective carbon sink [11, and 12] and sequester higher amount of CO2 (than any other non-mangrove forest types). Mangroves are most carbon-rich forests in the tropics and well known for high carbon assimilation and flux rates. While, comparing the carbon storage capacity of mangroves ecosystem with other ecosystems, mangroves has superiority and could be act as effective carbon sink.

Conclusion

Protection and conservation of mangrove ecosystem in the developing countries should be given priority. Along with the above factors, chemical pollution, particularly accumulation and bio-transformation of toxic metals could be a significant factor for reduction of mangrove biodiversity. Balanced Economic Development and Tran-boundary Cooperation Economic development in coastal areas needs to be done in a sustainable way with proper care of the mangroves. Although provisions of environmental impact assessment for developmental activities are prevalent in almost all the South and Southeast Asian countries, their significance is constantly challenged against the economical and developmental priorities. Special emphasis is therefore required for careful selection of developmental sites. Also, compensatory aforestation should be promoted for developmental activities in mangrove areas. Finally, regional cooperation for trans-boundary ecosystem management needs to be enhanced. Out of the six

mangrove habitats in the Indo-Malayan ecozone, five are shared by two or more nations. Therefore, regional cooperation for joint action plan, joint monitoring program for ecosystem health assessment, and transboundary environmental management form crucial management issues. Presently, some formal initiatives are in place in Sundarban mangroves between India and Bangladesh; however, given the extent of mangrove extent of Indo-Malayan ecoregion, it is highly recommended for a regional platform to share different management experiences, opportunities, and challenges.

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