# Salinity rise in Indian mangroves – a looming danger for coastal biodiversity

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*India has a long coastal line of over 7500 km supporting vast habitats such as lagoons, backwaters, estuaries, coral reefs and mangrove swamps. Among them, the mangrove ecosystem commands the highest importance because of its biological productivity and specialized diversity. After coral reefs, mangrove forests have the highest productivity among the coastal wetlands. With regard to biodiversity, mangroves support a unique group of fungi, microbes, plants and higher animal species including several species of migratory water birds. Such unique wetlands are in peril due to increasing salinity in recent times especially after the tsunami of 2004. It is time to control the increasing salinity, failing which the Indian subcontinent stands to lose its unique coastal biodiversity which, in turn, might affect the marine food web of the entire tropical region.*

Mangrove forests are important wetlands along tropical and subtropical coasts, providing environmental sustainability, ecological security and economic prosperity[1]. Several reports have emphasized that mangroves are one of the world's richest storehouses of biological and genetic diversity[2–5]. In a broad sense, this ecosystem harbours unique and endemic species of plants and animals; moreover 90% of all marine organisms spend some portion of their life cycle within the mangrove ecosystem[6]. Ironically such precious ecosystems are among the world's most threatened biomes[7]. Tam and Wong[8] and Balasubramanian[4] emphasized that conservation of mangroves for better habitat quality and biodiversity is always needed, especially in south and southeast Asian countries.

Along India's long coastal line of over 7500 km are diverse habitats such as lagoons, backwaters, estuaries, coral reefs and mangrove swamps. The country's coastal ecosystem is also known for its significant diversity of flora and fauna. Mangrove ecosystem commands the highest importance because of its biological productivity and specialized diversity[9]. After coral reefs, the mangrove forest has the highest productivity among coastal wetlands[10]. With regard to biodiversity, the tidal forest supports a unique group of fungi, microbes, plants and animal species such as crustaceans, molluscs, fishes, water birds and a number of endangered mammals like the fruit bat, the dolphin and the Bengal tiger[5]. In a wide spectrum, Indian mangrove harbours 3985 biological species that include 919 (23%) floral species and 3066 (77%) faunal species. No other country in the world supports so many species in the mangrove ecosystem[3]. Interestingly, most of the species are endemic to mangroves. In addition, it is an important nursery ground for several marine shrimps, crabs and fishes of this subcontinent[11]. Moreover, Indian mangroves provide a range of important environmental and socio-economic values such as protecting shores from wind, wave and water currents, inhibiting the effects of natural calamities such as cyclone and tsunami and preventing soil erosion and siltation, defending coral reefs and sea grass, and offering direct economic benefits through the production of large quantities of prawn, fish, medicinal plants as well as supplying wood and other forest products[3,5,12]. Due to these characteristic features, the mangrove is considered as an important component of the Indian coastal system.

Such an important ecosystem is under severe pressure in recent years due to the increasing level of salinity. The vital role of salinity in wetland habitats has been well established in several studies, especially in various saline habitats such as estuaries, swamps and lagoons[13–15]. Obviously, the degree of salinity fluctuation varies among the Indian mangroves. For instance, salinity in the Pichavaram mangroves of Tamil Nadu, Southern India ranges between 0.6‰ and 36.2‰ (ref. 16) whereas in the Muthupet mangroves (Tamil Nadu), the range is 5–47‰ (ref. 17). In the Sundarbans mangroves of West Bengal, salinity ranges from 0.4‰ to 27.5‰ (ref. 18), and in the west coast of India, the range is between 7‰ and 22‰ (ref. 19). Even within the mangrove wetland in different regions and micro habitats, there exist various levels of salinity. Significant salinity fluctuation in adjourning habitats of Pichavaram mangroves has been reported[15,20,21].

Several studies in the mangrove habitats have showed the important role of salinity, especially on the floral species of this ecosystem. For instance, Twilley and Chen[22], Hanh and Furukawa[23] stated the momentous role of salinity in the distribution and zonation patterns of tree species in the coastal woodlands. Naidoo[24] reported biomass reduction in *Bruguiera gymnorrhiza* due to higher salinity. Koch and Snedaker[25] documented the denaturing of terminal buds in *Rhizophora mangle* seedlings. Lin and Sternberg[26] established the negative effects on the photosynthesis mechanism in mangrove plants. Panda *et al.*[27] showed that increased salinity reduces the growth of mangrove leaves. Likewise, Munns and Termat[28] studied saline stress conditions related to mangrove plants and reported that higher salinity accelerates the leaf mortality rate and reduces the leaf primary production. Hoque *et al.*[18] concluded that an important species in the Sundarbans, 'sundari' (*Heritiera fomes*) faces a serious threat due to the salinity concentration prevalent in Bangladesh. They also documented a sudden reduction in mangrove forest cover which affects the climax community seriously. Kathiresan[29] witnessed the luxuriant growth of unworthy salt marsh plants like *Suaeda* species and formation of xerophytic vegetation in several parts of Pichavaram mangroves.

Generally mangrove flora can tolerate and withstand higher salinity[2]. The mangrove flora develops diverse mechanisms associated with anatomic and physiological characteristics to regulate salt absorption and exclusion[30]. However, the tolerance limit varies amongst the species, e.g. *Rhizophora mucronata* seedlings do well in 30‰ salinity while *Rhizophora apiculata* are better at 15‰ (ref. 31).

On the other hand, higher salinity would cause a profound impact on animals such as planktons, fungi, benthic forms, shrimps, crabs, fishes, waterbirds and other wild fauna which live in and around the mangroves. For instance, Balasubrahmanyum[32] reported a notable decrease in gastropods due to increasing salinity in the Pichavaram mangroves, while Sandilyan[15], Nagarajan[20] and Nagarajan and Thiyagesan[21] showed the decline of migratory water birds especially the small and large waders.

In addition, Kathiresan[29] states that higher salinity in mangroves leads to depletion of nutrients. The reduced availability of nutrients in this habitat might influence the population of planktons, benthic organisms and other macro invertebrates[33]. The changes in invertebrate population of any wetland could affect the top level predators such as birds[14]. It is needless to state that poor nutrients and higher salinity are the two great challenges to invertebrate diversity, which adversely reflects on the untapped biodiversity of the mangrove wetlands of India.

Increasing salinity level in mangroves is a universal problem which has existed for several decades, but in recent years, the condition has been exacerbated due to global warming, over evaporation, seawater intrusion, reduction of freshwater flow and coastal shrimp farming discharge[18]. In the Indian context, freshwater recharge is the principal reason[29,34]. For instance, Selvam[34] reported that many of the Indian mangroves are considerably deprived of freshwater recharge. Prior to the 1980s, the Pichavaram mangroves received 73 TMC (thousand million cubic feet) of freshwater from River Coleroon. By the late eighties, it had decreased to 31 TMC and currently it is 3–5 TMC.

On the basis of salinity data of 20 years (1971–90) for the Pichavaram mangrove wetlands, it has been predicted that salinity will increase by 5‰ in the year 2020 (ref. 35). To make matters worse, a natural calamity in the form of the tsunami in 2004 further increased the salinity level in this mangrove belt[36]. Moreover, environmentally toxic trace metals like mercury and lead have been recorded in several Indian mangroves[37,38]. Synergism between mercury and salinity[39] has been shown to have a significant impact on the invertebrate population[40]. Modassir[41] emphasized that even a low quantity of mercury has a profound impact on animals in the highly saline areas and a notable increase in the mortality rate of animals in that habitat. Here it is important to keep in mind that the mangrove faunal diversity in India is about 3.5 times greater than its floral diversity[3].

As stated earlier, mangrove vegetation can tolerate high salinity[2]. However several faunal species such as microorganisms, benthic invertebrates and larval forms which exclusively depend on the mangrove wetlands for their survival are highly sensitive to even a slight change in the salinity of this ecosystem[42]. Obviously several animal species, especially during the larval period, do not possess well-developed salt balancing mechanism like plants. So, larval forms of several animals would get severely affected and most of the time they would fail to withstand increasing salinity. It is needless to say that each and every species has a role to play in an ecosystem. If a particular group or a species is being eliminated from a habitat, it would have a profound impact on the entire ecosystem, most of the time it might be the starting point of the disaster[43]. So, immediate attention is required to control the rising salinity in the tidal forests of India in order to protect the unique marine wildlife diversity and genetic wealth of the entire tropic region.

In general, salinity is normally controlled by climate, hydrology, rainfall, tidal flooding and freshwater recharge[31]. After a long gap of three successive years (2007–2009) several parts of the Indian sub-continent had good rainfall. In the absence of rainfall, the salinity will relapse. Due to unpredictable and irregular climate it is not wise to depend on the natural factors alone to overcome the salinity crisis prevailing in the Indian mangroves. The Indian Government should encourage salinity control related research in mangrove habitats. Consortium of various national and international research agencies is a must. Failure to take pre-emptive steps to minimize the salinity would cause a great catastrophe to the entire tropic marine diversity, because the tropic marine food web is inextricably linked with Indian mangrove diversity. Exploration of the coastal wetlands and its organisms is still at a relatively early stage in India[44]. Drug researchers have pointed out that the coastal wetlands represent an untapped source of medicines and will be the new frontiers for drug discovery in this country[44]. Furthermore, the United Nations General Assembly has declared the year 2010 as the International Year of Biodiversity, so the decline in the Indian mangrove diversity has to be stopped in order to ensure the productivity of the entire tropics.


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