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Effects of Siltation, Temperature and Salinity on Mangrove Plants

TAHIRA NOOR
National Institute for Genomics and Advanced Biotechnology, (NARC)
Islamabad, Pakistan
NAZIMA BATOOL[1]
Department of Botany
Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Pakistan
ROOMINA MAZHAR
Department of Botany
Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Pakistan
NOSHIN ILYAS
Department of Botany
Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Pakistan.

Abstract:

Mangroves are extremely dynamic ecological entities which supply energy to aquatic as well as terrestrial habitats through their production and decomposition of plant debris. Tropical and subtropical region coastal zone dominating plant is mangrove and these ecosystems are known as very unique ecosystems with a large biodiversity. These trees have ability to survive in a high salt concentration them subjected to tides of the oceans. Mangrove plants shown number of adaptation such as pneumatophores, salt glands, salt exclusion and vivipary. Mangroves are chief and necessary ecosystems. They function in sediment trap provide protection to coral reefs from destruction. Mangrove ecosystem is excellent fish nurseries. The local people collect food, timber and charcoal from mangrove forests. Mangrove ecosystem destruction and fragmentation is observed. This destruction is caused by rigorous cutting, pollution and human activities. Siltation is one of the major reason mangroves ecosystem destruction. High siltation's suspend large particles cover and consequently smother the roots causing oxygen shortage and possible death of the trees. Siltation imposed water and oxygen stress. Mangrove responded to siltation by anatomical and physiological adaptations. Mangrove plants are shown anatomical changes such as smaller number of stomata and leaves. Though, some adaptations are species specific. Mangroves are thus negatively influenced by siltation and the trees will adapt their anatomical and physiological characteristics. In this review paper discuss mangrove plants anatomical and physiological adaptation to siltation.

Key Words: Siltation, Salt Stress, temperature fluctuation.

Introduction:

Mangroves forests consist of tropical trees and woody shrub like plants growing at intertidal zone and highly productive ecosystem. Mangroves plants prefer to settle in river deltas,

[1] Corresponding author: nazimabatool@gmail.com

estuarine and lagoons, they rarely settle in stagnant water. Mangrove trees often found in combination with coral reefs and seagrass beds (Kathiresan and Bingham, 2001). These ecosystems usually experience an average wave impact. Mangrove term describes a diverse group of tropical plants that are well adapted for the life in a tidal habitat (Sternberg *et al.*, 2007). There are three major mangrove elements such as major mangrove, minor mangrove elements and mangrove associates (Tomlinson, 1986). A species of major mangrove element adapted to stressful environment. True mangroves are evergreen and exclusive facultative woody halophytes (Komiyama *et al.*, 2008). The mangroves contain 40 to 70 species belonging to a total of 16 families of dicotyledons and monocotyledons (Kathiresan and Bingham, 2001). Mangroves forests are distributed globally in the intertidal zones of the tropical and subtropical regions shown in figure 1 (Giri *et al.*, 2011), the total area that is covered by mangrove forests is estimated at 110.000 up to 240.000 km². This was located in 118 countries and covered 0.7% of all tropical forests in the world. About one third of the world mangrove forests have been lost in the last 50 years. The total amount of mangroves per continent, Asia has the highest percentage of the worldwide mangrove area (42%), followed by Africa (20%) and North and Central America (15%). In Pakistan Mangrove forests and are found in the Indus delta and coastal areas of Arabian Sea around the coast of Karachi and Pasni in Balochistan (figure 2). The main species found is Avicennia marina, which grows in low height. According to estimates, these forests cover an area of 207,000 ha.

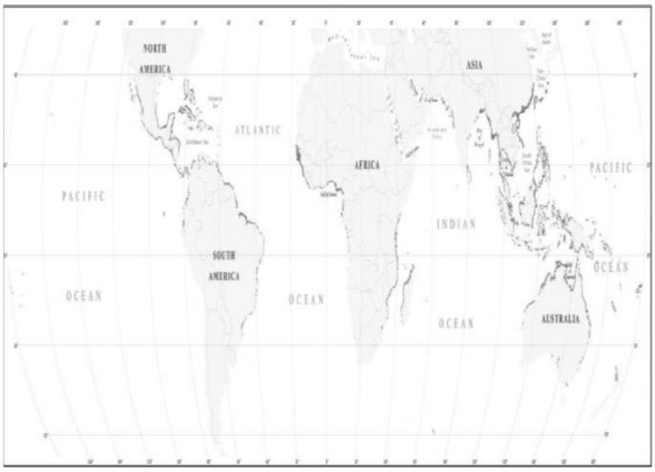


Figure 1. Mangrove plants distribution around world (Giri *et al.*, 2011)

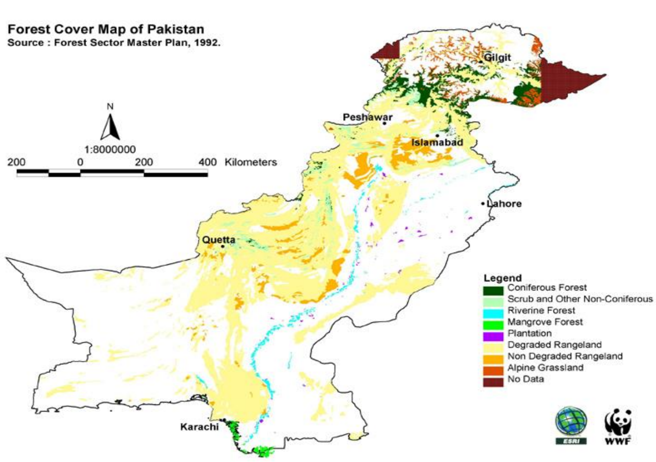


Figure 2. Mangrove forests distribution in Pakistan (Green Color)

Figure 3. Mangrove Forests

Figure 4. Pneumatophores(Plant roots)

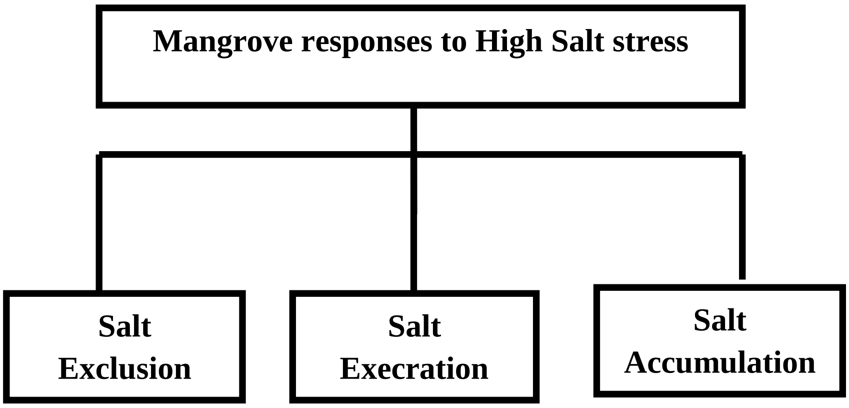
Major Threats:
Mangrove plant growth is affected by number of biotic and abiotic factors (Kathiresan and Bingham, 2001). High salt, low temperature, drought and high temperature are common abiotic stress conditions that adversely affect plant growth and production (Mohammad *et al*., 2008). Among Abiotic factor temperature fluctuation, salt stress and siltation existed long but the problem has been aggravated by human activity.

Temperature Fluctuation effect on mangrove plants: Mangroves plants do not adequately develop when annual average temperatures are below 19°C, which corresponds with the sea water isotherm of 20°C during the coldest period of the year (Alongi, 2002; Alongi, 2008). While mangrove plants are intolerant to freezing temperatures both air and water temperatures may never decrease below 0°C. Optimal temperatures for mangroves are not only limited by cold temperatures, but also by high temperatures because they hinder the tree settling. Photosynthesis of most mangrove species sharply declines when the air temperatures exceeds 35 (Moore *et al*., 1973), it seems that the temperature of both water and air are important regulators of the presence or absence of mangroves. Some adaptations of mangrove species to avoid too much water loss due to transpiration are thick leaves with wax deposition, the presence of small hairs on the leaves, good regulation of stomata and the storage of water within the leaves.

Salt Concentration Variations effects on growth of plants:
Salinity is one of the major environmental problems affecting plants of different regions of the world. The deleterious effects of salinity on plant growth are associated with low osmotic potential of soil solution causing physiological drought, nutritional imbalances and specific ion toxicity or combination of all these factors. Mangroves plants are facultative halophytes.

Consequently they can still grow and function well even up to a salinity of 90 ppt, but shown best growth when salinity fluctuates between 5 and 75 ppt (Krauss *et al.*, 2008). The diurnal fluctuations of salt concentrations accumulating in the rhizosphere are caused by the tides bringing seawater (35ppt) into the mangroves (Parida and Jha, 2010). Mangrove plants avoid salt uptake because they adapt to assure water uptake from the sea water which has an osmotic water potential of -2.5MPa (Hogarth, 2007). Water flows from a higher to a lower water potential (Steppe, 2011).

Mangrove plants have no salt resistant metabolism, they are adapted with some physiological mechanisms to exclude or excrete salt (Drennan *et al.*, 1982). The salt concentration within sap of different mangrove species ranged from 0.5 ppt up to a maximum of 8 ppt found in *Avicennia*. This is much lower than the salinity of sea water and indicates adaptations against the high salinity of the sea water. Mangrove ecosystem plants divided into two groups according to their ability to achieve a certain degree of salt tolerance. Mangrove plants are adapted to high salt concentration by the following physiological mechanisms. Such as salt exclusion by ultra-filtration at root level driven by the pulling force generated by transpiration (Tomlinson, 1986). Salt excretion by cuticular transpiration and salt glands positioned at the underside of the leaves Salt accumulation within leaf cells followed by defoliation to remove the stored salt. The plants may also accumulate compatible, cytoplasmic solutes ensuring osmoregulation (Popp *et al.*, 1993)



Chlorophyll and Cartenoid content increased significantly with the increase of salinity in *Kandelia candel*. Leaves of *Bruguiera sexangula* seedlings also proved the fact that chlorophyll content was accumulated under salt stress. Total Chlorophyll (Chl) content in *Kandelia candel* grown in 50‰ salinity increased significantly compared with that in 0‰, and Chl *a*/*b* was also reduced. Carotenoid pigments increased significantly. High salt concentration significantly reduce photosynthesis net photosynthetic rate, stomatal conductance, and transpiration rate. *Avicennia marina* has the ability to exclude and excrete salt. Due to the presence of salt glands on the leaves, the excess of salt can be secreted (Parida *et al.*, 2010) *Rhizophora marina* lacks salt glands, but has a more strict salt exclusion at root level, avoiding salt entering the sap of the tree. While most of the sodium chloride of the marine environment is excluded by the root system of *Rhizophora* during uptake of water. Rhizophora spp ratio of sodium to potassium in the younger leaves is much lower than that in the older leaves. It seems that this apparent selective retention of sodium is in fact due to translocation of potassium out of the older to the younger leaves. Salt balance in *Aegialitis* is maintained mainly by secretion of salt from the glands on the leaves.

Sedimentation Deposition effect on growth of plants:

Sedimentation is the tendency for particles in suspension to settle out of the fluid in which they are entrained, and come to rest against a barrier. Sedimentation is natural, slow process of settling out suspended solids in water towards the substrate. Sedimentation causes land forming and does not result in any additional negative effects on the trees. While high sedimentation deposition are implying negative effects on trees. Siltation is often caused by human interference which causes the natural sedimentation rate to increase. Sedimentation is a natural process of which an increase in sediment on the former top layer is established.

Mangrove forest is subjected to sedimentation when the sedimentation rate is higher than the erosion rate. Thus high sedimentation rate is causing an increase in the thickness of the upper soil layer. This process is known to be typical for mangrove ecosystems where it assures an essential import of nutrients. Mangroves function physically as sediment sinks where suspended solids are filtered out of the water resulting in a positive effect on the associated coral reefs and sea grass beds laying off shore. High siltation negative effects on plant performance occur when suspended solids accumulated too fast in the mangrove ecosystem. Moderate sedimentation rates can be positive for mangroves leading to enhanced growth of the trees (Ellis *et al.*, 2004). In particular, the enhanced phosphorus availability would be helpful for the growth of mangrove trees (Nye and Tinker, 1977). On the other hand, high sedimentation rates which exceed 1 cm/ year would increase death ratio within the mangrove forests (Ellison et al., 1998). Mangrove plants are shown lower growth under high siltation rate (Vaiphasa *et al.* 2007). Number of recent studies indicate that the loss of 100 ha of mangrove ecosystems by the deposit of dredged-up sediment originating from the Mokowe Sea Jet construction in Kenya (Abuodha *et al.*, 2001). High siltation not only influenced mature trees, but also their seedlings encounter many trouble and die due to siltation. High siltation perturb the life cycle of mangrove trees which leads to a faster decline of the forests and makes growth of plants more difficult.

Anatomical and physiological adaptations of mangrove plants:

Siltation causes a negative effect on mangrove trees and secondly, plants were shown anatomical and/or physiological characteristics variations under siltation sedimentation. High siltation most important effect on pneumatophores is getting smothered by siltation resulting in oxygen stress. Root damage and oxygen deficiency are caused by the inhibition of the gas exchange pathway between atmosphere, roots and soil (Thampanya *et al.*, 2002). This proved by observations that trees with partly covered pneumatophores exhibit an enormous oxygen stress and die when the pneumatophores are fully covered (Allingham *et al.*, 1995). *Rhizophora* trees seem are subjected to siltation due to their large amount of stilt roots, which appears less susceptible for forming a smothering layer of sediment and leave as such large root parts still capable of aeration. Though, this species turned out equally sensitive for siltation, probably their lenticels are positioned just above the substrate and are easily disturbed by the formation of a smothering layer (Terrados *et al.*, 1997).

There was no clear difference in stem conductance between high and low siltation. A decrease in stomatal and hydraulic conductance may result from a tree which can no longer adapt itself to the negative influence of stress, since the tree does not succeed in avoiding fluctuations in performance. For *Avicennia marina* as well as for *Rhizophora mucronata*, we observed a lower diurnal pattern in stomatal conductance for the trees in the high siltation sites. This observation indicate that a higher degree of siltation indeed imposes a higher factor of stress on a tree, influencing it negatively since the lower stomatal conductance indicate lower capacity for photosynthesis. There was no difference in hydraulic conductance between different species of mangrove when high siltation sites were compared with low siltation sites. This phenomenon was apparently caused by the higher amount of dehydrated cells within branches of high siltation plots and therefore it may be an indicator of higher water stress when siltation increases.

The stomatal conductance is linked with a water use efficiency of the tree, closing the stomata during most of the day, avoiding water loss by transpiration. The high initial values of the measurement days were according to the suggested hypothesis linking the influx of fresh dew water during the night. This was based on where negative sap flows were indicated for *Avicennia marina* at night and after rain fall. The osmotic gradient build up by the salinity within sap flow of *Avicennia* might drive the transport of dew from the outside of the leaf towards the internal leaf tissue

Anatomical differences were observed between highly and less silted sites. Anatomical adaptations that were found in mangrove plants increase in the number of leaves, although the average leaf size became smaller. Apart from this, the stomatal area was considerably lower for high siltation sites. All previous mentioned characteristics are found to be known as an attempt of trees and plants to cope with higher stress and to assure better water use efficiency. More severely regulated leaf vessel relations designate the higher amount of stress causing the trees to lose their opulence of anatomical freedom. The lower water content in leaves in high siltation plots is a result of the lower water availability and thus the ability of storing water in the leaves.

Anatomical changes in *Avicennia* trees depict that this plant opt for anatomical adaptations of the stomata. Stomatal density and pore area index increased as a known measure to increase the water use efficiency of the tree. While stress corresponds with a higher chance on cavitations of the vessels, adaptations decreasing the chance of the set in of embolism would consequently major importance for trees subjected to higher stress. Smaller vessel area and a higher phloem ratio are frequent knowledge of protecting trees against cavitations. Both adaptations were observed within the high siltation trees and therefore form another indication of the higher stress by siltation and the endeavour of the tree to survive with this less favourable environment.

For *Rhizophora mucronata*, anatomical adaptations were more directed towards changes in vessel anatomy. An increase in vessel density and total lumen area was found within trees standing in the high siltation plots. This adaptation again forms a protective adaptation to cope with higher chances of cavitations caused by higher stress originating from higher degree of siltation. More vessels forming the hydraulic architecture of the tree keep up a correspondence with a higher amount of transport routes for water flow and thus decrease the effect of cavitations (Terrados *et al.*, 1997).

Conclusions:

In the end we can say that temperature fluctuations, salt stress and siltation imposed water and oxygen stress in both studied mangrove species. Mangrove plantsshown adaptations to stress conditions in a similar way but some adaptations are species-specific, including the increased vessel density for *Rhizophora* and the higher stomatal density for *Avicennia* found in the high siltation sites. Mangroves are thus negatively influenced by siltation and the trees will adapt their anatomical and physiological characteristics. There is need of time to focus on more research on mangroves.

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