V. SUMMARY AND CONCLUSIONS

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Mangroves are unique plant community inhabiting the estuaries and are characteristic salt tolerant forest ecosystems in tropical and subtropical inter tidal regions (near river mouth) and are one among the world's most productive ecosystems of great ecological and economic significance. But right from the first half of 18th century these biological treasures were either looted to meet out greed or over exploited to meet out needs. The need for conserving the precious mangrove ecosystem is better realised in these days and several initiations have been taken in this regard.

Taxonomy is not an end in itself but a tool, by the use of which biological sciences can solve their problems. An attempt has been made to investigate the leaf histomorphology, micromorphology, pollen morphology, biochemical contents and hydrography of the mangrove ecosystem. The foliar epidermal features, histochemistry, pollen morphology, estimation of metabolites present in the leaves and hydrological parameters are investigated by conventional methods coupled with light and electron microscopy. The parameters under investigation are:

1) Stomatal studies - Stomatal ontogeny, stomatal index and stomatal frequency

2) Palisade ratio

3) Histochemistry of foliar epidermis

4) Biochemical components in the leaves

5) Pollen morphology

6) Hydrological parameters

Seven species belonging to six genera were collected from two different stations in the Cochin back water system. The presence of thick cuticle, waxy coating and sunken stomata throughout the leaf surface are xeric characters. A unique combination of xeric and hydrologic characters in mangrove species enables these species to flourish in a wet, yet physiologically dry habitat.

The development of stomata was studied for *Acanthus ilicifolus*, L. and *Acrostichum aureum*, L. - a pteridophyte and in both, the type of stomata is of diacytic but their origin is allelo-mesogenous and mesogenous respectively. The stomata are distributed all over the leaf surface without any definite pattern of orientation. The distributions of stomata can be seen only on the lower surface.

Stomatal index is almost constant within species even when they are collected from two different stations. Stomatal frequency values are highly variable and proved to be of little taxonomic significance. The stomata encountered in the members of the present study are anomocytic, paracytic, cyclocytic and diacytic. The reliability of palisade ratio as a

taxonomic character is emphasised by this study. The palisade ratio was constant and specific for each and every taxon.

Histochemical localization of different plant metabolites like starch, insoluble polysaccharides, sulphated and carboxylated polysaccharides, polyphenols, proteins and lipids in the foliar epidermis of seven taxa was carried out. Starch grains were observed in the guard cells of all species. The number of starch grains varied from one species to the other.

Insoluble polysaccharides are observed as amorphous or granular form with PAS in the cytoplasm of epidermal cells and subsidiary cells. In the guard cells, they occurred only in amorphous form. The guard cells, subsidiary cells and epidermal cells stained in varying shades of red and purple indicating the presence of insoluble polysaccharides.

With TBO, sulphated and carboxylated polysaccharides and polyphenols are localized in the guard cells, subsidiary cells and epidermal cells. This dye gives different staining reactions. Phenolic compounds when present take up a turquoise blue colour and are found in the epidermal cells, subsidiary cells and guard cells of *A.aureum*, L., *A.ilicifolius*, L., *R.mucronata*, Lam. and *B.cylindrica*, W.&A. In *E.agallocha*, L., *A.officinalis*, L. and *A.ilicifolius*, L., the pectins stained pink in the guard cells and subsidiary cells and epidermal cells. While lignin appeared as bright green in the cytoplasm of epidermal cells and subsidiary cells of *B. gymnorrhiza*, Lam.

Proteins stained blue with this test and staining reaction varied with species. They appeared as granular protein bodies and large globules in subsidiary cells and guard cells. Proteins are found in the guard cells of *R.mucronata*, Lam. and the epidermal cells of *B.cylindrica*, W.&A. The cytoplasm of the guard cells of *A.aureum*, L., developed more bluish black colour towards the poles.

Lipids are observed as globules in the epidermal cells, subsidiary cells and guard cells of *E.agallocha*, L. In *A.aureum*, L., very distinct lipid bodies could be observed in the guard cells, subsidiary cells and epidermal cells. Uneven distribution of lipid granules can be seen in the cytoplasm of subsidiary cells and epidermal cells of *B.gymnorrhiza*, Lam. and *R.mucronata*, Lam.

Biochemical composition of mangrove leaves was analysed and the concentration of pigments in leaves varied between plant species and period of analysis. The pigments in general attained their maximum peaks during summer months. The maximum photosynthetic pigments were observed in *A.officinalis*, L. in almost all seasons and the minimum in *R.mucronata*, Lam.

The carbohydrate content in the leaves varied between seasons and stations. The highest values of protein and tannin were observed in *R.mucronata*, Lam. in almost all seasons at both the stations.

A comparatively higher amount of moisture was obtained from A.officinalis, L. and *E.agallocha*, L. at different seasons. The maximum ash

content was estimated to be in *B.cylindrica*, W.&A. in all seasons. The observed highest value of nitrogen was in *A.ilicifolius*, L. The maximum sodium and potassium contents were found in *B.cylindrica*, W.&A. and *R.mucronata*, Lam. at the same season but at two different stations. An interesting relationship is observed between Na and K status in most of the plants, *ie.* when Na increases K decreases and vice versa. The present study also supports the idea that Na can substitute K to some extent at least in halophytes.

Pollen morphology has been studied, based on LM and SEM. Exine ornamentation, size and shape of pollen grains are also taken into consideration as supplementary characters. The size of the pollen varies from 110 to 133μm. The different pollen shapes encountered are prolate spheroidal and subprolate. Pollen grains were 3-colpate in *A.ilicifolius*, L., *A.officinalis*, L., *B.cylindrica*, W.&A., and 3-colporate in *B.gymnorrhiza*, Lam., *E.agallocha*, L. and *R.mucronata*, Lam. While in *A.aureum*, L., a fern, the spores are trilete, tetrahedral.

The monthly variations of hydrological parameters in the mangrove waters showed general fluctuations typical of an estuarine system and the general productivity of the mangrove areas are influenced by rainfall and general dynamics. The ecosystem studied has a strong influence of both varied salinities and tidal amplitude. Temperature was the strongest environmental gradient controlling different processes in mangroves. It can be expected that several climatically related environmental factors that

influence their growth and production, such as water status, insolation, temperature, salinity, soil aeration and redox potential are expected to vary seasonally.

The pH values ranged from 6.61 to 7.2, 6.55 to 7.0 and 6.35to 7.39 at stations 1, 2 and 3 respectively. The lower pH in the months of June to August is mainly due to rainfalls. The range in the pH values indicated the alkaline nature of the environment and there is no drastic change during the study period.

The pooled annual as well as season wise data indicated that high salinity is characteristic of pre-monsoon period and it ranged from 2.8 to 28.4ppt, 3.0 to 25.4 and 1.0 to 24.0ppt at stations 1, 2 and 3. Thus it can be inferred that the salinity in the mangrove regions was mainly controlled by the influx of fresh water than by any other phenomenon.

Maximum values of dissolved oxygen concentration in the water were noticed during monsoon at station 1. This is the most important parameter used as an index to assess the water quality and primary productivity.

The fragile mangrove ecosystem has suffered depletion, a fact that must be viewed with concern from the point of view of conservation. The inter-dependence of man and mangroves has changed to a great extent over time. Earlier man had a healthy two-way association with mangroves, *ie.* man encouraged the growth and colonization of mangroves and they, in turn provided fire wood, timber, medicine, food, *etc.* The major

problems concerning the destruction of mangroves in Kerala are lack of awareness among public, injudicial tourism activities and pollution from industrial effluents. The objective of this study accounts to focus attention on the structure of the mangroves in the Cochin estuarine system. A holistic approach towards conservation of wetlands is the need of the hour.

Puduvyppu in Ernakulam District can be regarded as the largest single stretch of mangroves in Kerala. Mangrove ecosystem constitutes a reservoir and refuge for many unusual plants and animals. It plays a vital role in the biology of its faunal component. The resident fauna constitute insects, crustaceans, molluscs, fishes, snakes *etc.* It is the nursery ground for many fin fishes and shellfishes. Prawn rearing in configuration with paddy cultivation is carried out in the coastal 'bheries' in Cochin backwaters. Mangroves reclaimed and converted to brackish water fisheries are quite common in Puduvyppu and Vallarpadam.

Soil erosion on the coastal tract is a frequent feature of Kerala. The degraded areas of Puduvyppu are now being restoried with suitable mangroves. It is believed that the mangrove vegetation also promotes sediment accretion and regarded mangroves as 'makers of land'. To maintain a rich biological diversity, these ecosystems must be protected by any means.

Attempting evaluation of chemical and biochemical constituents in the plant kingdom and assessment of the influence of the environmental

Parameters on these constituents is not new (Gopinathan, 1984). But the evaluations of seasonal changes on these chemical and biochemical constituents are only very rarely attempted. A work in fact requires hilation is that of Naidu and Swamy (1996), where the effect of the environmental parameters on the lipid content was the theme. A brief review on these matters can also be obtained from Ziegler (1964) and Holl (1975). Another significant contribution in these lines is the reports of the influence of seasonal variations on the primary production (Govindasamy *et al*, 2000). Very significant variations of the biochemical constituents with season are the nutshell of these works. The present study can be considered so as one of the most significant in the management of mangrove ecosystem.

The significant correlation observed between chlorophyll *a*, *b*, total chlorophyll and carotenoid and also between sodium and potassium indicates that the mangrove forest has very close similarity with the land forest system (Rains and Epstein, 1967). The most remarkable observation of the study is that, the total chlorophyll shows negative correlation in the pre-monsoon season with the carbohydrate, contradicting the previous observations. No possible explanations can be given here, as the confirmation of the factors leading to such behaviour is essential to explain this behaviour. As it is beyond the scope of the present work, it is not attempted here. Similarly the negative correlation observed in the case of

protein and nitrogen also requires further study. These observations are reported here as reference for the future workers.

A general survey of the correlation and the statistical analysis points out a high significant relation between the environmental conditionality and parameters with the chemical and biochemical constituents. Though the seasonal contributions may not contribute significantly towards the annual means, the short-term management, it can be seen from the study, requires a comprehensive analysis of the environmental parameters in relation to the plant constituents.

The regression analysis of the GPP and NPP with the environmental parameters such as temperature, pH, salinity and DO confirms the above argument. In both the stations, the net primary productivity was shown to be significantly depended on the above parameters and these parameters undergo considerable modification with the seasons.

The 't ' test between the stations generally showed no significant difference in terms of hydrological parameter GPP and the plant constituents except protein, carbohydrate, tannin and total chlorophyll. But the correlation analysis presented explains the behaviour of these parameters. This also emphasises the significance of the environmental condition on the mangrove productivity.

Acanthus ilicifolius, L. is a gregarious plant spreading by reclining stems to a large extent. All mangroves accumulate large amounts of salt in

their leaves regardless of whether they are 'salt secretors' or 'salt accumulators'. The presence of salt glands in the leaves and the salt tolerance of this plant to grow in association with *A.officinalis*, L., *E.agallocha*, L., *A.aureum*, L. and *B.cylindrica*, W.&A. make us to consider this as a true mangrove. Besides these *A. ilicifolius*, L. produces oviparous propagules like that of *Excoecaria*, L., *Sonneratia*, L. and *Lumnitzera*, Willd. The presence of roots from the stem gives additional support to the plant and these adventitious roots, which in turn give rise to plantlets resulting in the formation of extensive bushes at the peripheral areas of the mangrove habitats.

The chapters so far discussed reveal the immense scope of this subject for further study. Though these plants are belonging to different families, they are grouped together as mangroves based on their ability to withstand salt stress, certain common features and their xeric characters. According to Tomlinson who is considered as the authority of mangrove study, *Acanthus ilicifolius*, L. is only a mangrove associate while other scientists in this field regard this plant as a true mangrove. This is the only taxon falling under mangrove syndrome, which develop vegetatively by sending rhizomes. Based on the present study the occurrence of this plant with actual mangroves and the adaptations similar to other mangrove plants ensures it to be considered as a true mangrove.

Based on the hydrological parameters of the present study, among the three stations, *ie*. Puduvyppu, Vallarpadam and the lower waters of

rainbow bridge – the mouth of the market canal in the marine drive, in the Cochin back waters, the mangrove stations were found to be more productive than the control station. Among the two mangrove stations, Puduvyppu can be considered as a unique mangrove ecosystem because the biochemical constituents present in the leaves of seven mangrove species were more in this station compared to that of Vallarpadam and the water qualities in this station is more suited for the growth of the different mangrove species. On the whole, a conclusion can be reached that the mangrove ecosystem at Puduvyppu represents a unique one in the Cochin backwaters.