RUHUNA JOURNAL OF SCIENCE
Vol. 4, September 2009, pp 21-27
http://www.ruh.ac.lk/rjs/rjs.html
ISSN 1800-279X

Assessment and Comparison of salt Content in Mangrove Plants in Sri Lanka

N. P. Dissanayake and K. M. C. Amarasena

Department of Botany, University of Ruhuna, Matara

Abstract. Due to the predicted threats of global warming and sea level rise, the salt tolerance and salt accumulative abilities of plants have become popular contentious topics. Mangroves are one of the major groups of salt tolerant plants and several mechanisms are known as instrumental in their salt tolerance. Salt excretion through leaf drop is given as one, but its validity is questioned by some recent works compelling the necessity for further studies. Knowledge of the salt contents in different mangrove plants is a pre requisite for such studies. Hence, this study aimed to quantify and compare the salt content in mature leaves of nine mangrove species in Sri Lanka., i.e. *Aegiceras corniculatum*, *Avicennia marina*, *Avicennia officinalis*, *Bruguiera gymnorrhiza*, *Bruguiera sexangula*, *Ceriops tagal*, *Excoecaria agallocha*, *Lumnitzera racemosa*, *Rhizophora apiculata* and *Rhizophora mucronata* which are growing in the same mangrove system; the Rekawa lagoon in Sri Lanka. Two species of non mangrove plants, *Gliricidia sepium* and *Artocarpus heterophyllus,* which were growing in inland areas were also selected for comparison.

The concentration of Na^+ in leaves was considered as a measure of the salt concentration. The Na^+ in leaves was extracted by acid digestion and quantified by flame photometry. The salt content of mangroves was measured under two contrasting hydrological situations: at the highest and lowest water levels of the lagoon. Rekawa lagoon can be considered as a ‘barrier built estuary’, the highest water level occurs when the lagoon mouth is blocked due to the formation of the sand bar and the water level is increased by fresh water inflow, inundating the total mangrove area and decreasing the soil/water salinity. The water level of the lagoon becomes lowest when the lagoon mouth is opened (naturally or by dredging) and lagoon water is flushed out to the sea. Then the salinity of lagoon water becomes high due to sea water influx.

The results showed that the concentration of Na^+ in mangrove leaves was 3 to 12 times higher compared to that in leaves of selected non mangroves. Statistical analysis revealed that the variations in Na^+ content in leaves of different mangrove species were same under both hydrological regimes. *E. agallocha* and *R. mucronata* showed the highest salt content whilst *A. corniculatum B. sexangula* showed the lowest salt content. The three species, *A. marina*, *A. officinalis* and *L. racemosa*, showed the second highest salt content and the remaining two species *C. tagal* and *B. gymnorhiza*, showed the second lowest salt content. Apparently the interspecific variation in the concentration of Na^+ in mangrove leaves follow the interspecific variations in the salinity tolerance reported for the same species.

Key words; ***mangroves, salt accumulation, Na^+ in plants***

Introduction

Mangroves are woody plants which are adapted to grow on muddy or sandy intertidal areas of lagoons, estuaries and sheltered bays in tropical and some sub tropical areas. More than 60 species of true or exclusive mangrove species are recorded in the world (Kathiresan and Bingham, 2001). According to Jayatissa *et al.* (2002), 21 species of true mangroves and more than 18 species of mangrove associates occur in mangrove communities of Sri Lanka. Mangroves are important to Sri Lanka as about one third of the country's coastline in its original state has the potential to support mangroves and hence to provide 'green barriers' against ocean surges such as tsunami and cyclones (Jayatissa *et al.,* 2005).

As a result of predicted global climate change and sea level rise, many of the low-lying landward areas could be added newly to the interface between the sea and the land. With this gradual change, the vegetation of those areas could also be shifted gradually from normal plants to salt tolerant plants. As salt tolerant plants mangroves can grow in such harsh conditions and may become dominant plant type in such areas. As a preparatory mission for the predicted sea level rise, mechanisms behind the capacity of mangrove plants to tolerate saline conditions should be understood well and attempts should be made to give such abilities to other important plants also through advance techniques. It will allow getting the maximum use from the limited extent of arable lands in the future.

The salt content of sea water is dominated by high concentrations of Na^+ and Cl^-. However K^+, Mg^{++}, Ca^{++} and $SO4^{--}$ are also in significant concentrations (Läuchli and Lüttge, 2002).. Mangroves are adapted to overcome high sediment salinities through several mechanisms. Salt exclusion, salt secretion and salt accumulation are agreed as the three processes involved in that adaptability and mangroves appear to use a combination of the above processes to avoid heavy salt load (Kathiresan and Bingham, 2001).

Although there are some studies on the salt secretion and salt exclusion of mangroves indicating the salt concentration in each species (John *et al.,* (2002), most of the studies had been done using few species. Hence, a comparison of the salt content among many mangrove species cannot be done. Therefore it is important to conduct studies to fill this gap and enrich the knowledge.The prime objective of this project was to determine and compare the salt contents in leaves of mangrove and some non mangrove plant species.

Materials and Methods

The nine true mangrove species selected from Rekawa Lagoon were *Aegiceras corniculatum*, *Avicennia officinals*, *Avicennia marina*, *Bruguiera gymnorhiza*, *Bruguiera sexangula, Ceriops tagal, Excoecarea agallocha, Lumnitzera racemosa, and Rhizophora mucronata, and the non halophytic species selected from inland areas were Gliricidia sepium and Artocarpus heterophyllus.*

Three mature individuals of each mangrove species from different places of the lagoon were selected for sampling and considered as three replicates of the same treatment. When the water level of the lagoon is high, multiple leaf samples with mature leaves were collected randomly from each individual by removing each leaf at their abscission zone. Samples of the two non halophytic species selected from inland area were also collected following the same procedure. All samples were collected at the same time between 9.00 – 11.00 am on the same day with the help of several trained people and collected leaf samples were placed in separate plastic bags to transfer immediately to the laboratory. The same procedure was followed to collect samples from the same mangrove and non mangrove individuals when the water level of the lagoon was very low.

As a result of sea spray and salt secretion in salt secreting species, there may be some salt deposited on the surface of leaves in the samples. Therefore, in the laboratory, all the leaves were washed with de-ionized water to remove surface salts and other surface contaminants. Then they were gently dried with absorbent papers and immediately transferred to the drying oven. The leaves were kept in the drying oven at 60 ^{0}C until they were completely dried. One gram of dried leaves of each sample was digested in 2 ml of concentrated HNO_3. Then HNO_3 acid was evaporated and the residue was dissolved in deionized water to get 25 mL of aquas salt extraction. The salt contents in extractions were analyzed by flame photometry.

The soil salinity of the mangrove area at each sampling occasion was measured by using pore water. Pores in the soil were made at the area just beyond the high water mark to collect water samples and salinity was measured using a refractometer.

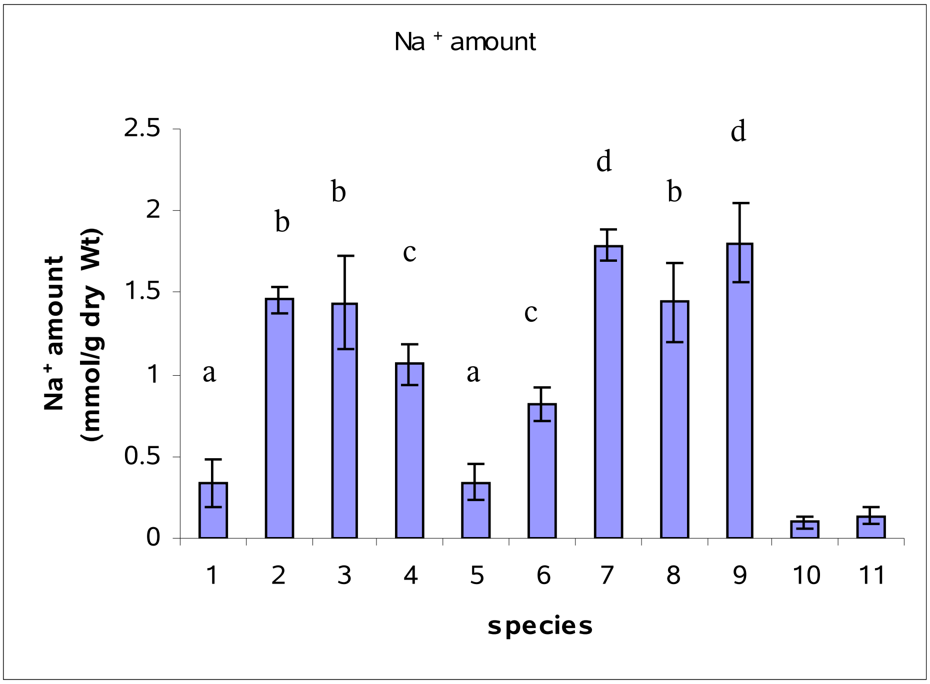
Means and standard deviations of Na^+ content in leaves were calculated and one way ANOVA test was performed to test significant interspecific differences in Na^+ content of mangrove leaves. Turkey's post-hoc tests were used to have pair wise differences between species. All statistical analysis was carried out using the standard statistical software JMPIN (3.2.6 version).

Results

The Sodicity or concentration of Na^+ in leaf extractions of the two species of non-halophytes used in this study, i.e. *Gliricidia sepium* and *Artocarpus heterophyllus*, was less than 0.1375 mmol/g dry weight, whilst that in the 09 mangrove species varied from 0.3334 ±0.168 to 1.8341± 0.114 mmol/g dry weight.

The results of the one way ANOVA that was carried out for Na^+ concentrations in leaf extractions at the high water level and low water level separately, revealed that the sodicity among the leaf extractions of different mangrove species varied in the same way under the both water regimes (Figure 1a and 1b). The sodicity (*ie*. concentration of Na^+), of the nine mangrove species falls into four categories as highest, higher, lower, and lowest. *E. agallocha* and *R. mucronata* showed the highest salt content (1.79-1.83 mmol/g dry weight). The three species, *A. marina*, *A. officinalis and L. racemosa, showed the next highest salt contents (1.44 - 1.20 mmol/g dry weight), C. tagal and B. gymnorhiza, showed lower salt contents (0.78 - 1.07 mmol/g dry weight) whilst A. corniculatum B. sexangula showed the lowest salt contents (0.33 - 0.34 mmol/g dry weight).*

1a.


Na + amount
Na+ amount
(mmol/g dry Wt)
2.5
2
1.5
1
0.5
0
a
b
b
c
a
c
d
b
d
1
2
3
4
5
6
7
8
9
10
11
species

1b.

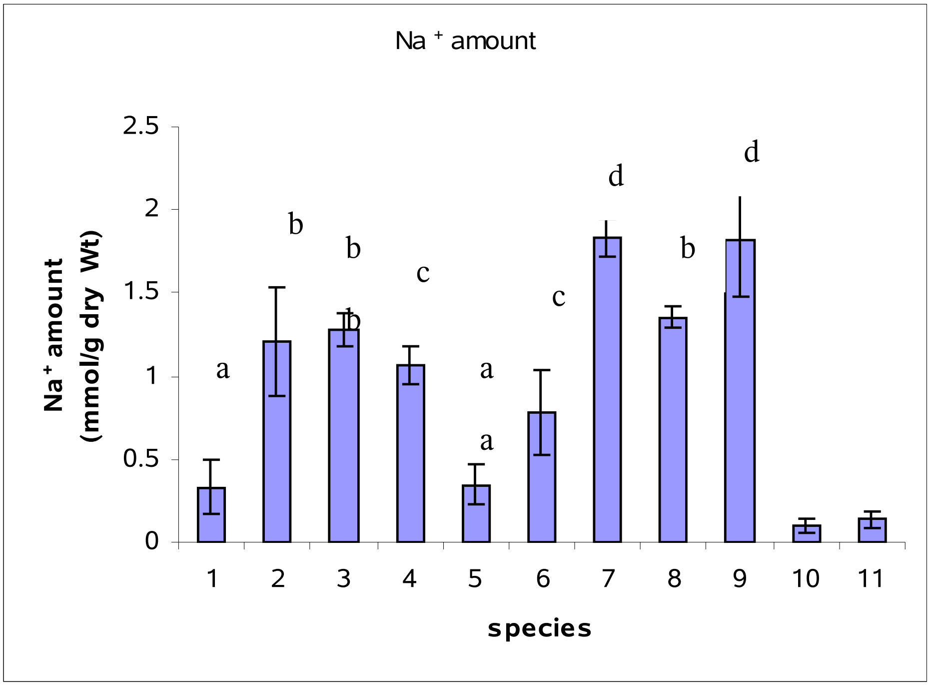

Na + amount
Na+ amount
(mmol/g dry Wt)
2.5
2
1.5
1
0.5
0
a
b
b
b
c
a
a
c
d
b
d
1
2
3
4
5
6
7
8
9
10
11
species

Figure 1. Means and standard deviations of the content of Na+ in leaves of diferent mangrove plants in Rekawa lagoon, Sri Lanka at the high water level (1a) and at the low water level (1b). (Same superscripts indicate species which are not significantly different in their Na^+ content.) 1-*Aegiceras corniculatum*, 2- *Avicennia marina*, 3- *Avicennia officinalis*, 4-*Bruguiera gymnorrhiza*, 5- *Bruguiera sexangula*, 6- *Ceriops tagal*, 7- *Excoecaria agallocha*, 8- *Lumnitzera racemosa*, 9- *Rhizophora mucronata*, 10- *Gliricidia sepium*, 11- *Artocarpus heterophyllus.*

The mean soil salinity of the mangrove area of Rekawa lagoon at the high water level and low water level were 4.2 ± 0.4 and 7.4 ± 0.6 respectively.

Discussion

The salinity that gives the salt content in a solution means the concentration of dissolved mineral salts present in the solution on a unit or weight basis. The major solutes comprising dissolved mineral salts in plant materials are the cations Sodium (Na^+) Potassium (K^+), Calcium (Ca^{2+}) and Magnesium (Mg^{2+}), and the anions Chloride (Cl^-), Sulfate (SO_4^{2-}), Bicarbonate (HCO_3^-), Carbonate (CO_3^{2-}) and Nitrate (NO_3^-) (Taiz and Zeiger, 1991). However in halophytes, the content of Na^+ and Cl^- is comparatively very high as those ions inevitably enter into plants when they grow in saline soils (Cram et al, 2002). Moreover, under the situation with excess and very high concentration of these salt ions, the salinity (*i.e.* concentration of dissolved mineral salts), sodicity (*ie.* concentration of Na^+), and the chlorinity (*i.e.* concentration of Cl^-) in plant tissues could be in more or less equal molarities. Therefore, the concentration of Na^+ or Cl^- resulted in the analysis of plant tissues in this study is considered as an alternative for the concentration of salts in the relevant tissue.

In this study, only two species of non-halophytic mesophytes were selected to measure and compare the salt content in leaves. It was considered that measurements from many species are not necessary as the fact that non halophytic plants posses very low salt concentrations (Bowman and Strain, 1986). The results of this study also indicated that the salt content in leaves of the non-halophytic species tested is very low and comparable with values given for other mesophytic species (Bowman and Strain, 1986). That comparability indicates that the measurements received for the Na^+ concentration in mangrove leaves also in this study are reliable.

The results of this study indicate that the salt concentration in different mangrove species vary remarkably and the pattern of those variations is almost same at the high water level as well as low water level of the lagoon. (Many of the lagoons in Sri Lanka including Rekawa lagoon, are actually 'barrier built estuaries' in which, the highest water level occurs by the fresh water inflow, when the lagoon mouth is blocked due to the formation of the sand bar. This highest water level could remain maximum for few weeks and during that time the whole mangrove area remains inundated by low saline water. Then the lagoon mouth is naturally or cut open and lagoon water flushed out to the sea, reducing the water level and emerging the mangrove area. This lowest water level could keep for longer period particularly in drought periods and the salinity of lagoon water can be increased due to sea water influx through the lagoon mouth.) In other words, the pattern of variations in the salt content of mangroves appears to be independent from the soil salinity.

However, the anaerobic condition of the soil in the intertidal area could be remarkably different during two occasions as the intertidal area was completely inundated at the highest water level and completely emerged and open to air at the lowest water level. Hence, the results of this study indicate that anaerobic or aerobic condition of the soil has no much effect on the salt accumulation in mangrove leaves.

These results also indicate that the Na+ concentration in different mangrove species vary remarkably and those variations of the Na+ concentration among different mangrove species are parallel to their salt tolerance reported by other studies. The salt tolerance of a plant can be defined as the plant's capacity to endure the effects of excess salt in the medium of root growth (Taiz and Zeiger, 1991). The two species which showed the highest Na+ concentration in this study, *R. mucronata* and *E. agalocha*, are reported as species which can perform better under high levels of soil salinity (Jayatissa et al, 2008., Kodikara, 2009). On the other hand, the salt tolerance of the two species, *A. corniculatum* and *B. sexanguila*, which showed the lowest Na+ concentration, are reported as low saline species (Jayatissa *et al.*, 2008., Kodikara, 2009). The remaining species i.e. *C.tagal, B.gymnorrhiza, A.officinalis, A.marina*, and *L. racemosa* showed intermediate levels in Na+ as well as in salinity tolerance (Jayatissa *et al.*, 2008).

This study may help to identify the species which can cope up with a high salt concentration and to calculate how much salt can be stored in the biomass of a mangrove forest. Furthermore, this work and findings could be a motivation to study the capacity of different mangroves to excrete salts via leaf drop.

References

Bowman, W.D. and Strain, B.R. (1986). Interaction between CO2 enrichment and salinity stress in the C4 non-halophyte *Andropogon glomeratus* (Walter) BSP. Plant, Cell and Environment. 10: 267- 270.

Cram, W.J., Torr, P.G. and Rose, D.A. (2002). Salt allocation during leaf development and leaf fall in mangroves. Trees, 16. pp 112-119.

Jayatissa, L. P., Dahdouh-Guebas, F. and Koedam, N. (2002) A revision of the floral composition and distribution of mangroves in Sri Lanka. Botanical Journal of the Linnaean Society. 138, 29-43

Jayatissa, L.P., Lo Seen, D., Hettiarachi, S. and Senanayake, G. (2005). Nature's protection against nature's fury: a post tsunami assessment of the importance of mangroves as a natural barrier against the wrath of the sea. Proceedings of Annual Science symposium, Faculty of Science, University of Ruhuna, Matara, Sri Lanka.

Kathiresan1 K. and Bingham2 B.L. (2001). Biology of mangroves and mangrove ecosystem. Advances in marine biology. 40: 81-251.

Kodikara, S. (2009). Mangrove seedlings perform better in moderate salinity than high and low salinities. Thesis submitted as a partial fulfilment for the B. Sc. (special) Degree in Botany. Department of Botany, University of Ruhuna. Sri Lanka. Pp

Teiz, L. and Zeiger, E. (1991). Plant Physiology. The Benjamin/Cumming Publishing Company, Inc., UK., pp.565.