Khulna University Studies 5(1) (2003): 15-20

MACRONUTRIENTS CONTENT IN DIFFERENT PARTS OF SEEDLING, SAPLING AND TREE OF *Bruguiera parviflora* OF KUALA SELANGOR NATURE PARK MANGROVE FOREST IN MALAYSIA

M. Hossain[a*1], S. Othman[b], J. S. Bujang[a] and M. Kusnan[a]

[a]*Department of Biology, Faculty of Science and Environmental Studies, University Putra Malaysia, 43400 UPM, Serdang, Selangor, D. E. Malaysia.*
[b]*Faculty of Science and Technology, , University Putra Malaysia, 43400 UPM, Serdang, Selangor, D. E. Malaysia.*

KUS-03/48-161103

Manuscript received: November 16, 2003 accepted: October 24, 2004

Abstract: Macronutrients (N, P, K, Ca, Mg, C and S) in different parts of seedlings, saplings and trees of *Bruguiera parviflora* were analysed for Kuala Selangor Nature Park Mangrove Forest. Relatively higher content of nitrogen (1.04 to 1.37%), phosphorus (0.12 to 0.18%), potassium (0.78 to 1.27%) and calcium (0.67 to 1.13%) were found in leaves of seedlings, saplings and trees than other parts. But, comparatively higher content of magnesium (1.1 to 1.2%) and sulphur (0.75 to 1.79%) was detected in roots of seedlings, saplings and trees, leaves, buds and flower of trees. Comparatively higher carbon (51.12 to 52.54%) content was detected in saplings and tree roots while a relatively lower content of all macronutrients were detected in stems and bigger branches (diameter > 2 cm) of saplings and trees. The study indicated that macronutrients distribution in *Bruguiera parviflora* were variable in the different plant parts and at various stages of plant development.

Key word: Macronutrients; Mangrove forest; *Bruguiera parviflora*; Plant parts

Introduction

Mangrove forests are economically and ecologically important (Field, 1995). They link between marine and terrestrial ecosystems. These communities are clearly important to the stability and maintenance of various adjoining ecosystems (Ong, 1982; Aksornkoae, 1993). Mangrove formations contribute to the marine food web through their production of detritus, and several commercially important species of marine animals are known to spend at least part of their life cycle in this ecosystem (FAO, 1985; Arshad *et al.*, 1997). Mangroves provide primary source of inorganic and organic compounds for estuarine production (Aksornkoae and Khemnark, 1984) and acts as an open pathway of nutrient transport to the aquatic ecosystem. The rate of nutrients transport is controlled by biological and physical factors (Boto, 1979) and simultaneously these factors also control the rate of import and storage of inorganic or organic compounds (Aksornkoae and Khemnark, 1984) as well as within stand nutrient cycling in a mangrove forest. Litter standing crops, litter production and estimate of slash production in a managed forest could be an approach for estimating productivity and functioning of a mangrove forest (Gong *et al.*, 1984) as well as the estimation of standing biomass and nutrient flux (Ong *et al.*, 1984; Gong and Ong, 1990). At the same time, measurement of nutrients in various parts of plant could be another useful approach of estimating mangrove productivity and functioning.

Macronutrients are essential for normal growth and metabolism, completion of life cycle and to detoxify the presence of heavy metals in the plant (Jones *et al*., 1991; Marschner, 1995). Nutrients content in plant parts are influenced by metabolic requirements (Baker and Walker, 1990). However, insufficient and excess amount of the nutrients poses various stresses on plant growth and metabolism (Boto, 1992; Marschner, 1995). Nutrients content in plant parts are not only differ from species to specie but also in different parts of a plant at different stages of growth (Jones *et al.*, 1991; Li, 1997). Nutrient uptake by the mangrove plants is impeded by poor aeration in the rooting zone and result in copping with low nutrient availability (Boto, 1992; Li, 1997). The copping mechanism may affect uptake, distribution, loading and excretion of micronutrients within the plant parts (Waisel *et al.*, 1986; Hutchings and Saenger, 1987; Tomlinson, 1994). *Bruguiera parviflora* occurs throughout the Southeast Asia to the tropical Australia. This species has some characteristics of pioneer species and serve as a nurse crop by creating suitable site condition for climax species (*Rhizophora* sp.) in the process of succession (Chapman, 1976; Tomlinson, 1994). Present study aims to assess the comparative content of macronutrients and their distributional trend in different parts of seedlings, saplings and trees of *Bruguiera parviflora*.

Materials and Methods

The study area consists of 100 ha of mangrove forest (Latitude $3^0$20’ N and Longitude $101^0$14’ E) in the Kuala Selangor Nature Park, Kuala Selangor, Malaysia. This mangrove forest has been totally protected since 1987 and categorized under Watson’s (1928) tidal inundation class 4. It appears as a strip with an average 200 m width, varies from 150 to 250 m from shoreward to landward, and ends at a man-made embankment. Species of mangroves from the families of *Avicenniaceae, Rhizophoraceae, Sonneratiaceae*

*Corresponding author: Tel: 6-0173417622; Fax: 6-03-86567454; E-mail: mahmoodhossain@hotmail.com
DOI: https://doi.org/10.53808/KUS.2003.5.1.0348-L

and *Euphorbiaceae* were found in the forest. The mean annual rainfall was about 1790 mm and mean minimum and maximum temperature were 24°C and 32°C, respectively (Malaysian Metrological Service). Nine plots (1 m x 1 m) were randomly selected and all *Bruguiera parviflora* seedlings (height < 1 m) within the plots were collected with root systems. Ten saplings (Diameter at Breast Height, 1-<4 cm) and six trees (DBH, 4-16 cm) of *Bruguiera parviflora* were selected randomly (avoiding suppressed, mechanically or insect damaged or infested with disease) and they were felled and uprooted. Sub-samples (about 100 g) of leaves, buds (saplings and trees), flower (trees), smaller branches (diameter < 2 cm), bigger branches (diameter > 2 cm), stems, barks (saplings and trees) and roots (homogenous sub-samples of smaller, diameter < 1 cm and bigger roots, diameter > 1 cm) were collected from the sampled seedlings, saplings and trees. Nine samples of topsoil up to 10 cm depth were collected randomly from the forest area using core sampler of 5 cm diameter (Allen, 1974). All samples were collected at the same time of plant sampling.

All plant samples were oven-dried at 80°C until constant weight and soil samples were air-dried. The samples were then ground and processed according to Allen (1974) for the total Nitrogen (Weatherburm, 1967) and total phosphorus (Timothy *et al*., 1984). Potassium content in the samples was measured by flame photometer (Jenway PFP, England). Calcium and magnesium were measured by atomic absorption spectrophotometer (AAS PERKIN ELMER 4100). Sulphur was determined following the method of Tandon (1993) and total carbon by Leco CR–12 carbon determinator, USA (Allen, 1974) and triplicate samples were used for each analysis in this experiment.

Macronutrients content in plant samples were compared by one-way analysis of variance (ANOVA) followed by Duncan's Multiple Range Test (DMRT, $p<0.05$) by using SAS (6.12) statistical software. The mean content of each nutrient was calculated from all plant parts. Sapling branches and tree branches diameter < 2 cm considered as one group in the graphical presentation. The trends of macronutrients distribution were derived from the principal plant parts (leaves, smaller branches, bigger branches, stems and roots).

Results and Discussion

Nitrogen content was comparatively (ANOVA, DMRT, $p<0.05$) higher irrespective of leaves of seedlings, saplings and trees. In addition, seedling stems contained higher nitrogen and remained above the mean nitrogen content of 0.63% (Fig. 1). Leaves and green parts contained higher nitrogen than woody parts such as stems and bigger branches (Binkley, 1986). According to Allen (1974) phosphorus and potassium contents in different plant parts also found to be in the range from 0.05 to 3% and 0.5 to 3%, respectively. Moreover, phosphorus and potassium are most abundant in reproductive and physiologically active tissue (leaves, buds and roots) (Meyer *et al*., 1973; Marschner, 1995). Similarly, leaves, buds, flowers and roots contained relatively higher phosphorus and potassium and remained above the mean content of 0.11 and 0.56%, respectively (Table 1 and Fig. 2 to 3).

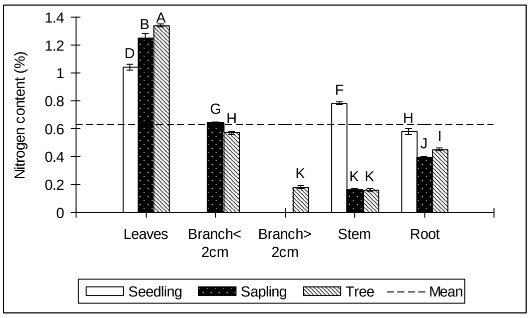

Fig.-1. Nitrogen content in different plant parts and the dotted line indicates the mean content of the combined plant parts. Similar alphabet on the bar is not significantly different at $p<0.05$

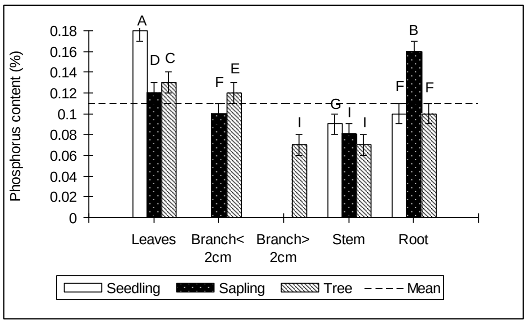

Fig. 2: Phosphorus content in different plant parts and the dotted line indicates the mean content of the combined plant parts Similar alphabet on the bar is not significantly different at $p<0.05$

Calcium is necessary for the continued growth of apical meristems and accumulated in the leaves and permanently fixed in the cell wall as calcium salt (Meyer *et al*., 1973; Jones *et al*., 1991) and this could be the reason for observing comparatively (ANOVA, DMRT, $p<0.05$) higher calcium content (0.77 to 1.44%) in leaves, buds, flowers and small branches (diameter < 2 cm) and remained above the mean content (0.5%) (Table 1 and Fig. 4). Relatively (ANOVA, DMRT, $p<0.05$) higher magnesium content (1.1 to 1.2%) was found in roots followed by leaves and remained above the mean content (0.49%) (Fig. 5) and higher sulphur content (1.08 to 1.79%) was observed in roots of saplings and trees, leaves, buds and flowers of trees (Table

1 and Fig. 6). Magnesium and sulphur in plant samples were higher compared to the ranges of 0.1 to 0.5% and 0.08 to 0.5%, respectively as reported by Allen (1974). Sulphur is the key constituent of several amino acids and plays an important role in plant metabolism (Jones *et al.*, 1991). Unlike phosphorus, sulphur salts of Ca, Fe and Al are fairly soluble and more available for plant uptake, but excess sulphur than the requirement often accumulated in leaves (Binkley, 1986).

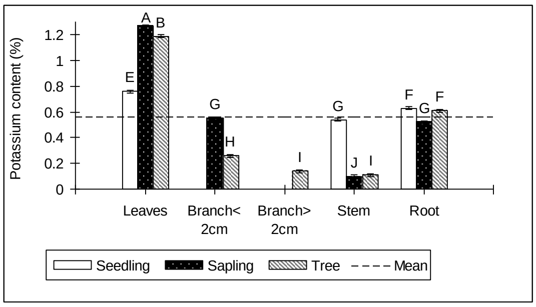

Fig.-3. Potassium content in different plant parts and the dotted line indicates the mean content of the combined plant parts. Similar alphabet on the bar is not significantly different at $p<0.05$

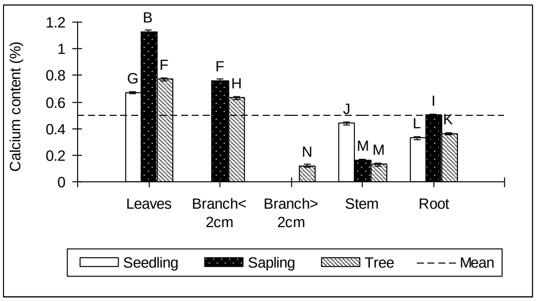

Fig.- 4. Calcium content in different plant parts and the dotted line indicates the mean content of the combined plant parts. Similar alphabet on the bar is not significantly different at $p<0.05$

Table 1. Macronutrient content in soil and buds, flower (trees), and barks of saplings and trees.

Plant Parts	Nitrogen (%)	Phosphorus (%)	Potassium (%)	Calcium (%)	Magnesium (%)	Carbon (%)	Sulphur (%)
Sapling							
Buds	0.97±0.01^{E}	0.15±0.01^{B}	0.86±0.01^{D}	1.44±0.02^{A}	0.89±0.01^{C}	45.51±0.01^{M}	0.42±0.01^{H}
Barks	0.54±0.01^{H}	0.09±0.01^{H}	0.13±0.01^{I}	0.94±0.01^{D}	0.14±0.01^{J}	44.27±0.01^{N}	0.54±0.04^{F}
Tree							
Flowers	0.80±0.03^{F}	0.14±0.01^{C}	1.03±0.03^{C}	0.83±0.01^{E}	0.57±0.01^{E}	46.16±0.01^{J}	1.49±0.03^{B}
Buds	1.10±0.02^{C}	0.16±0.01^{B}	0.84±0.02^{D}	0.97±0.02^{C}	0.64±0.01^{D}	45.56±0.01^{L}	1.30±0.06^{C}
Barks	0.46±0.01^{K}	0.14±0.01^{C}	0.13±0.01^{I}	1.11±0.01^{B}	0.08±0.01^{K}	46.34±0.01^{I}	0.68±0.03^{F}
Soil	0.38±0.01	0.08±0.01	0.70±0.01	0.27±0.01	1.08±0.01	3.71±0.01	0.69±0.02

Means with similar alphabets in the same column are not significantly different at $p<0.05$

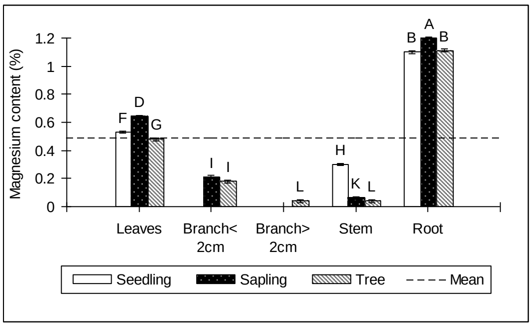

Fig.-5. Magnesium content in different plant parts and the dotted line indicates the mean content of the combined plant parts. Similar alphabet on the bar is not significantly different at $p<0.05$

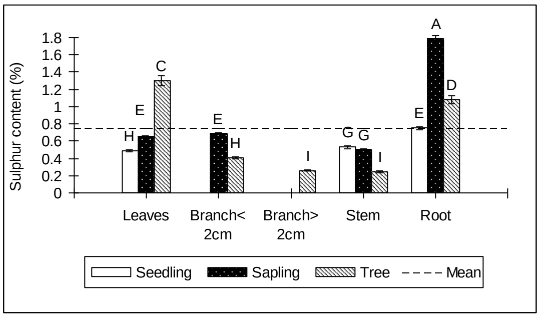

Fig.-6. Sulphur content in different plant parts and the dotted line indicates the mean content of the combined plant parts. Similar alphabet on the bar is not significantly different at $p<0.05$

A relatively (ANOVA, DMRT, $p<0.05$) higher carbon content was observed in leaves, branches and roots of sapling and tree (Fig. 7). During the process of photosynthesis, atmospheric carbon dioxide is transformed to carbohydrate and accumulated in plant biomass. The rate of photosynthesis is accelerated by higher temperature and higher light intensity, which results in higher carbon accumulation (Meyer *et al.*, 1973). In general, woody parts (stems, bigger branches and roots) of plants contained higher carbon compared to green parts (Jones, 1998), but the fluctuation in climatic condition (rainfall and temperature) and content of other nutrients can affect the carbon content of the respective parts of plant (Marschner, 1995). Carbon to nitrogen ratio in bigger branches of trees, stems and roots of saplings and trees was found to exhibit higher than mean ratio 116:1 (Fig. 8). Carbon to nitrogen ratio in plant parts especially in the litter regulates the rate of decomposition. Low C:N ratio (less than 25:1) usually indicated a higher content of all nutrients and consequently a favourable environment for high bacterial activities (Tam *et al*., 1990). The macronutrients (with the exception of magnesium and sulphur) were rich in the plant biomass when compared to the mangrove soil of the study area (Table 1 and Fig. 5 to 6). It has been reported that climatic condition (rainfall and temperature), soil edaphic factors, available nutrients in the substrate and concentration of other nutrients can affect the nutrient contents in plant parts considerably (Kabata-Pendias and Pendias, 1984; Walbridge, 1991; Jones, 1998) as well as mineral metabolism and uptake of nutrients by the roots (Jones *et al*., 1991; Marschner, 1995; Jones, 1998).

Table 2. Comparison of macronutrients content in different parts of different mangrove species

Species	Plant parts	Macronutrients (%)					Sources and Location
		N	P	K	Ca	Mg	
Rhizophora apiculata	Leaves	1.02	0.11	0.98	1.40	0.51	Ong *et al.* (1984)
	Branches	0.29	0.09	0.36	0.84	0.19	Matang Mangrove,
	Stem	0.20	0.02	0.33	0.42	0.07	Malaysia
Avicennia spp.	Leaves	1.96	0.14	1.10	0.25	0.14	Aksornkoae and Khemnark
	Branch	0.89	0.14	0.75	0.14	0.06	(1984)
	Stem	0.86	0.09	.051	0.11	0.07	Amphoe Khung mangrove,
Bruguiera spp.	Leaves	1.17	0.07	0.37	0.43	0.24	Thailand
	Branch	0.9	0.06	0.31	0.30	0.12	
	Stem	0.40	0.03	0.08	0.28	0.07	
Ceriops spp.	Leaves	1.08	0.06	0.78	1.46	0.14	
	Branch	0.67	0.04	0.55	0.94	0.07	
	Stem	0.44	0.03	0.31	0.54	0.03	
Rhizophora apiculata	Leaves	1.64	0.02	0.52	0.44	0.77	Gong and Ong (1990)
	Branch	0.55	0.03	0.16	0.25	0.28	Matang mangrove,
	Stem	0.40	0.03	0.06	0.29	0.20	Malaysia
	Root	0.45	0.03	0.17	0.11	0.54	
Aegiceras corniculatum	Leaves	1.37	0.12	0.50	-	-	Li (1997)
	Branches	0.75	0.19	1.03	-	-	Futian mangrove, South
	Stems	0.58	0.07	0.26	-	-	China
	Roots	0.48	0.17	1.48	-	-	
Kandelia candel	Leaves	1.39	0.13	0.64	-	-	
	Branches	0.54	0.15	0.85	-	-	
	Stems	0.68	0.07	0.21	-	-	
	Roots	0.44	0.16	1.26	-	-	

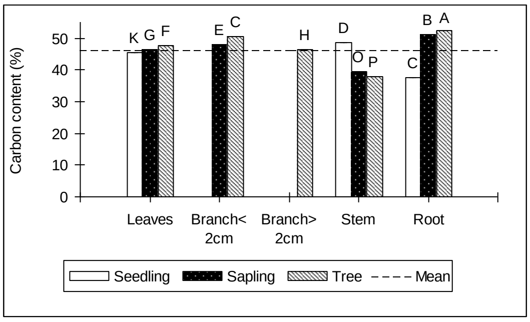

Fig.-7. Carbon content in different plant parts and the dotted line indicates the mean content of the combined plant parts. Similar alphabet on the bar is not significantly different at $p<0.05$

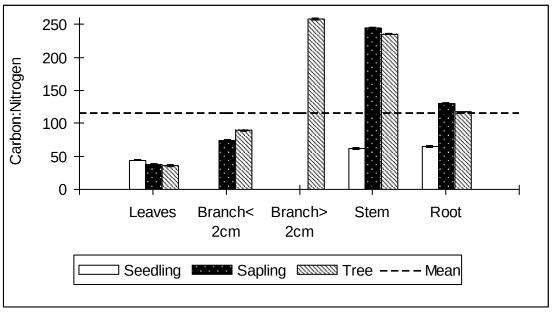

Fig.-8. Carbon to nitrogen ratio in different parts and the dotted line indicates the mean ratio of the combined plant parts.

The trend of nitrogen, phosphorus and calcium in seedlings parts was leaves > stems > roots (ANOVA, DMRT, $p<0.05$), while potassium, magnesium, sulphur and carbon showed different trend in seedlings parts. Nitrogen, potassium and calcium in saplings parts showed a trend with leaves > branches > roots > stems (ANOVA, DMRT, $p<0.05$), while phosphorus and magnesium showed trend of roots > leaves > branches > stem (ANOVA, DMRT, $p<0.05$) but the trend of sulphur and carbon was roots > branches > leaves > stem (ANOVA, DMRT, $p<0.05$). The trend of nitrogen and phosphorus in trees parts was as leaves > smaller branches > roots > bigger branches > stems (ANOVA, DMRT, $p<0.05$), but potassium and sulphur showed a trend with leaves > roots > small branches > bigger branches > stems (ANOVA, DMRT, $p<0.05$). The trends of calcium, magnesium and carbon in tree parts were leaves > small branches > roots > bigger branches > stems, roots > leaves > small branches > bigger branches > stems and roots > small branches > leaves >

bigger branches > stems (ANOVA, DMRT, $p<0.05$), respectively (Fig. 1 to 7). The fluctuation in environmental parameters and soil physiochemical characteristics may affect the uptake of nutrients and their contents in different parts of *B. parviflora* seedlings, saplings and trees. Moreover, each element characteristics, plant species, types of plant parts, physiological age of the tissue and seasons (dry and wet) may influence the nutrient contents in plant parts (Jones *et al*., 1991; Walbridge, 1991).

In the present study, nitrogen, phosphorus, potassium, calcium and magnesium in saplings and trees showed similar trend and contents for the above ground parts with *Rhizophora apiculata* at the Matang mangrove forest reserve, Malaysia as obtained by Ong *et al.* (1984) and for *Avicennia* spp., *Bruguiera* spp. and *Ceriops* spp. at the Amphoe Khlung mangrove forest, Thailand, obtained by Aksornkoae and Khemnark (1984). Different trends for macronutrients in above and below ground parts were observed with *Rhizophora apiculata* at the Matang mangrove forest reserve (Gong and Ong, 1990), *Aegiceras corniculatum* and *Kandelia candel* at Futian mangrove, South China (Li, 1997) (Table 2). From the above comparison, it was revealed that different mangrove species might have different rate of nutrient uptake and distributional pattern in their parts, which may have been also site specific. Present study showed different distributional pattern of macronutrients, which varied with seedlings, saplings and trees stages. The different content of macronutrients in plant parts and their distributional trends at seedling, sapling and tree stages suggested that different levels of macronutrients were required at the various stages of plant growth and development (Jones *et al.*, 1991; Marschner, 1995).

Conclusion

The plant species, physiological age of the tissue, position of the tissue on the plant, available form of nutrients in the substrate, concentration of other nutrients, climatic and soil edaphic factors affect the extent of nutrients variation in the plant parts. Moreover, various plant parts respond differently with the varying nutrient content in the substrate. Nutrients are stored within plant biomass and few macronutrients such as magnesium and sulphur tend to be lower in plants but comparatively higher in the soil. The nutrients are stored as biomass of the plants is important for internal nutrient cycling of the mangrove ecosystem.

Acknowledgements

The authors wish to thank the Department of Biology, University Putra Malaysia and Malaysian Natural Society for their financial and logistic support throughout the study period.

References

Aksornkoae, S. 1993. *Ecology and Management of Mangroves* IUCN, Bangkok, Thailand. 176 p.

Aksornkoae, S. and C. Khemnark. 1984. Nutrient cycling in mangrove forest of Thailand. In: *Proceedings of the Asian Symposium on Mangrove Environment Research and management* (eds. Soepadmo, E., A. N. Rao and D. J. Macintosh), University of Malaya, Kuala Lumpur. pp. 545-557.

Allen, S.E. 1974. *Chemical Analysis of Ecological Materials.* Blackwell Scientific publication, Oxford. 565 p.

Arshad, A., B. Japar Sidik. and M.S.M. Zaki. 1997. Roles of mangrove ecosystem. In: Malaysian fisheries: in *Fisheries and the Environment: Beyond 2000* (eds. Japar Sikid, B., M. F. Yusoff, M. S. M. Zaki. and T. Petr). University Putra Malaysia, Serdang, Malaysia. pp. 95-104.

Baker, A.J. and P.I. Walker. 1990. Ecophysiology of metal uptake by tolerant plants: in: *Heavy metal tolerance in plants; evolutionary aspects* (eds. Shaw, A. J.) Florida, CRC Press. pp. 155-78.

Binkley, D. 1986. *Forest Nutrition Management.* John Wiley & Sons, New York, USA. 290 p.

Boto, K.G. 1979. Nutrient and organic fluxes in mangroves. In: *Mangrove ecosystems in Australia: Structure, Function and Management* (eds. Clough, B.F.). Australian Institute of Marine Science, Canberra, Australia. pp. 239-258

Boto, K.G. 1992. Nutrients and mangroves. In: *Pollution in Tropical Aquatic Systems* (eds. Connell D.W. and D.W. Hawker). CRC Press, Boca Raton. pp. 129-146.

Chapman, J.V. 1976. *Mangrove Vegetation.* Strauss & Cramer GmbH, Leutershausen, Germany. 456 p.

FAO, 1985. *Mangrove Management in Thailand, Malaysia and Indonesia*. FAO, Rome.215 p.

Field, C.D. 1995. *Journey amongst Mangrove*. International Society for Mangrove Ecosystem, Okinawa, Japan. 140 p.

Gong, K.W. and J.E. Ong. 1990. Plant biomass and nutrient Flux in a Managed mangrove Forest in Malaysia. *Estuarine Coastal and Shelf Science* 31**:** 519-530

Gong, K.W., J.E Ong, C.H. Wong and G. Dhanarajan. 1984. Productivity of Mangrove Trees and its Significance in a Managed Mangrove Ecosystem in Malaysia. In: *Proceedings of the Asian Symposium on Mangrove Environment Research and management.* (eds. Soepadmo, E., A. N. Rao and D. J. Macintosh). University of Malaya, Kuala Lumpur. pp. 216-225.

Hutchings, P. and P. Saenger. 1987. *The Ecology of Mangroves*. University of Queensland Press, St Lucia, Queensland, Australia. 388 p

Jones, J.B.Jr., B.Jr Wolf and H.A. Mills. 1991. *Plant Analysis Hand Book: A practical sampling, preparation, analysis and interpretation guide.* Micro-Macro Publishing, USA. 321 p.

Jones, J.B.Jr. 1998. *Plant Nutrition Manual*. CRC Press, New York. 149 p.

Kabata-Pendias, A. and H. Pendias. 1984. *Trace Elements in Soils and Plants*. CRC Press. Florida. 356 p.

Li, M.S. 1997. Nutrient Dynamics of a Futian Mangrove Forest in Shenzhen, South China; *Estuarine Coastal and Shelf Science* 45:463–472

Marschner, H. 1995. *Mineral Nutrition of Higher Plants*. Academic Press, New York. 654 p.

Meyer, B.S., D.B. Anderson, R.H. Bohning and D.G. Fratiane. 1973. Introduction to plant physiology. D. Van Nostrand Company, New York. 268 p.

Ong, J.E. 1982. Mangroves and Aquaculture in Malaysia. Ambio 11 (3): 252-257

Ong, J.E., W. K. Gong and C.H. Wong. 1984. Seven Years of Productivity Studies in a Malaysian Managed Mangrove Forest, then What? In: *Coastal and Tidal Wetlands of the Australian Monsoon Region* (eds. Bardsley, N.K., S.D.J. Davie and D.C. Woodroffe). Australian National University. pp. 213-223.

Tam, N.F.Y., L.L.P. Vrijmoed and Y.S. Wong. 1990. Nutrient dynamics associated with leaf decomposition in a small subtropical mangrove community in Hong Kong. *Bulletin of Marine Science* 47 (1): 68-78

Tandon, H.L.S. 1993. *Methods of Analysis of Sols, Plants, Waters and Fertilizer* , Fertilizer Development and Consultation Organization, New Delhi. 144 p.

Timothy, R.P., M. YoshiakI and M.L. Carol. 1984. A manual of chemical and biological methods for seawater analysis. Pergamon press. 154 p.

Tomlinson, B.P. 1994. *The Botany of Mangroves*. Cambridge University press. USA. 419 p.

Waisel, Y, A. Ethel and M. Sagami. 1986. Salt balance of leaves of the mangrove Av*icennia marin*a. *Physiolgia Plantarum* 67:67-72.

Walbridge, M.R. 1991. Phosphorus availability in acid organic soils of the lower north Carolina coastal plain. *Ecology* 72: 2083-2100.

Watson, G.J. 1928. *Malayan forest Record 6: Mangrove Forests of the Malay Peninsula*. Fraser and Neave Ltd. Singapore. 368 p.

Weatherburm, M.W. 1967. Phenol-hypochlorite reaction for determination of ammonia; *Analytical Chemistry*. 39 (8): 971-974.