LITTER PRODUCTION AND PHYSICO-CHEMICAL CONDITIONS IN MANGROVE, AVICENNIA MARINA (FORSK.) VIERH., SWAMPS AT KARACHI BACK WATERS AND BAKRAN CREEK

PIRZADA JA SIDDIQUI*
RASHIDA QASIM*

SUMMARY: In the present work data on litter production and some physico-chemical parameters, such as dissolved oxygen, salinity, pH and temperature, is presented and discussed. Study area exhibits monospecific conditions and Avicenia marina (Forsk.) Vierh. is the sole representative species. Litter production fluctuates with seasons. 74% of the total production is contributed through the leaf-fall. Remaining 26% is comprised of twigs, fruits and flowers. Total amount of production is 3.71 ± 0.36 t. ha^{-1}. Pattern of variation is dissolved oxygen content was similar at the two sites studied except for the magnitude of values which were consistently low at the back waters. Salinity was high as that sea water indicating low influx of fresh waters. PH was generally alkaline and temperature varies with seasons.

Key Words: Productivity, mangrove swamps, Rhizosphere, back waters, Bakran Creek, litter fall.

INTRODUCTION

Mangrove vegetation supports food web through its litter production. Litter production is the shedding of vegetative or reproductive plant structures. Senescence, withering, death, and other stresses, such as, winds, are factors that govern litter production. As shown in Table 1, litter production can vary from as law as 0.8 metric tons per hactor a year to as high as 28.1 dry metric tons per hactor a year. Variability in the productivity of litter from place to place may be attributed to the climatic conditions and to other factors e.g., types of forest, fresh water drainage sediments and available nutrients for the plant growth. Following litter production, decomposition and mineralization of detritus occurs thus changing the water around and in close vicinity with high nutrients. Microorganisms (4), invertebrates (15, 18, 19) and fishes (14) have been reported to consume and help in mineralization.

Pakistan coast, being in a "sub tropical dry zone, bears thickest of low sporadic mangrove species largely of *Avicennia marina*. Lansat imaginary (17) measured an area of about 0.26 million hac; out of the 0.61 million hac. (44% of total area) of deltaic region is under mangrove vegetation along the Sindh coast of Pakistan.

In the present study an attempt was made to report the pattern and amount of litter production in magrove swamps of Karachi back waters. In addition some physico-chemical parameters, such as, dissolved oxygen, salinity, temperature and pH water and mud were also incorporated.

MATERIALS AND METHODS

Litter production studies were carried out in mangrove swamps of Karachi back waters (Manora Channel). Litter-pots ($0.25m^2$ in area) were fixed within the mangrove swamps in such a way that litter collected in them could stay above water level at high tides. Experiment was initiated with fifteen pots but ten of them were gradually lost hence last few months' observations are

*From Department of Biochemistry, University of Karachi, Karachi-75270, Pakistan.

averages based on five pots. Litter was recovered each month and brought to the laboratory where it was dried to constant weight at 80°C. Leaves and other materials were weighed separately.

Physico-chemical parameters (like, dissolved oxygen, salinity, temperature and pH) were measured at two sites; i.e. Karachi back waters (Manora Channel) and Bakran Creek of Gharo-Phitti Creek system. Dissolved oxygen was measured at low tides in samples collected from small pools within the mangrove stand and from nearby channel. Analysis was done according to Mar and Cresser (16). Salinity of water samples was measured by using salinometer (Model E-2 Tsurumi Seiki, Japan). Standard sea water (I.A.P.S.O. p71 11/10, 1975; cl. 10.374 0 / 00 England) was used for the calibration of machine. Temperature of the upper layer of mud, water and air was measured on a centigrade-thermometer. To measure pH of mud and water samples pH-meter (Demetra Model PM-65) was used.

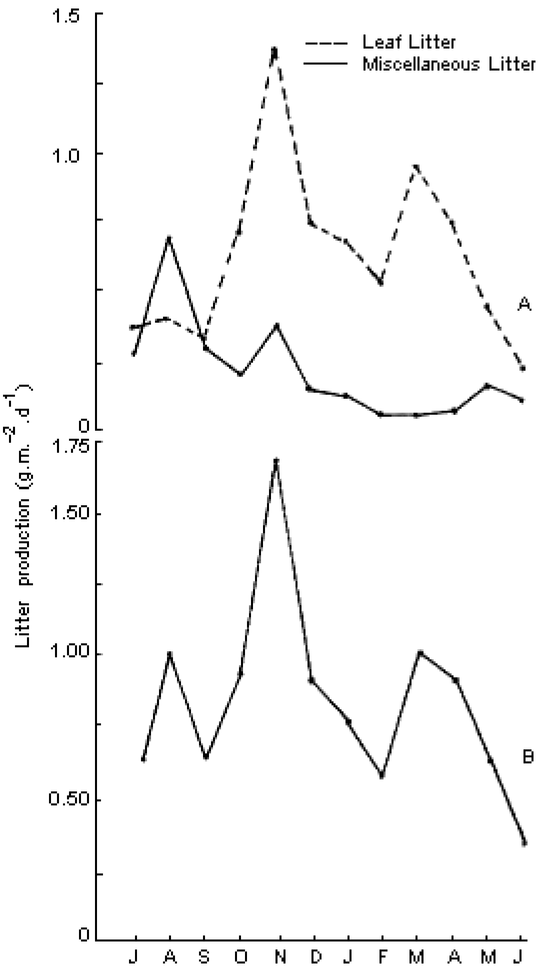

Figure 1: Monthly variation in leaf litter and miscellaneous litter (A) and total litter (B) production in a mangrove stand at the back waters.

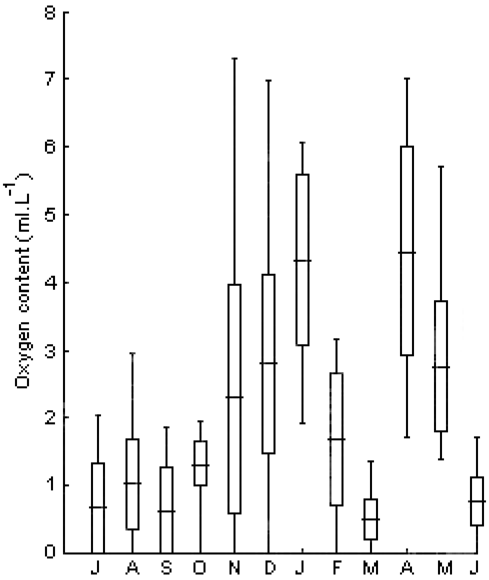

Figure 2: Monthly variation in dissolved oxygen content in water from the back waters at low tides. Horizontal lines indicate means, verticle lines denote range and box represent standard error values.

RESULTS AND DISCUSSION

Litter production

Average values of total litter, leaf litter, and miscellaneous litter fall are shown in Figure 1 (A and B). Total leaf fall values vary between 0.23 ± 0.039 $g.m.^{-2}$ d^{-1} and 1.35 $g.m.^{-2}$ d^{-1}, Figure 1A clearly reveals three peaks in the months of August, November and March. The highest value was recorded in November, Miscellaneous fall comprises of twings, fruits and flowers. Its values remain lower than leaf litter production except for the value recorded in August. During the whole year miscellaneous fall varies from a law of 0.5 ± 0.02 $g.m.^{-2}$ d^{-1} to a high of 0.70 ± 0.04 $g.m.^{-2}$ d^{-1}. Total litter fall, which is a cumulative effect of leaf and miscellaneous fall, shows three peaks of higher magnitude in the month of August, November and March (Figure 2B). Values for total litter fall vary from a minimum of 0.35 ± 0.04 $g.m.^{-2}$ d^{-1} to a maximum of 1.69 ± 0.12 $g.m.^{-2}$ d^{-1} in November 74% of total litter was contributed by the leaf component and the remaining 26% was composed of twings, fruits and flowers (Table 2).

On the whole total litter produced amounted to 3.71 tonnes in a hactor of mangrove swamp per year. If this value is applied to the total deltaic area covered under mangrove vegetation, the figure would become 96.46X10^4 tonnes litter per year. This enormous amount of litter in the

Table 1: Mangrove litter production rates of different parts of the world.

Location	Species	Production (t ha^{-1} $year^{-1}$)	Source
U.S.A	Florida *Rhiszophora* sp.	7.3	Heald (1971)
	Avicennia sp.	4.8	Lugo and Snedaker (1974)
	Southern *Rhizophora* mangle	8.8	Odum and Heald (1975)
	Florida *Avicennia* nitida	0.8 - 12.7	Pool al. (1975)
	A. nitida	4.9	Lugo and Snadaker (1974)
	Puerto Rico *Rhizophora* mangle	4.8	Golley *et al.* (1962)
	Hinchinbrook Mixed Forest Island Old.	3.7 - 28.1	Bunt (1978)
Thiland	Phuket *Rhizophora* apiculata island	6.7	Christensen (1978)
	Contaburi Criops sp.	6.26	Aksornkoase and
	Rhizophora sp.	7.52 - 8.31	Khemnark (1980)
Malaysia	Matang *Rhizophora* sp.	6.6 - 10.3	Ong *et al.* (1979)
Australia	Victoria *Avicennia marina*	2.0	Goulter and
	Sydney *Avicennia* sp.	4.58	Allaway (1980)
S. Africa	Mgeni *Avicennia*	9.67	Steinke (1980)
	Estuary *Brugiera*	9.71	

Table 2: Monthly variation in leaf-fall, miscellaneous fall and total litter fall in a mangrove stand at Karachi back waters.

MONTHS	Leaf fall (gm^{-2} day^{-1}) ± SE (Range)	Miscellanoeous fall (gm^{-2} day^{-1}) ± SE (Range)	Total litter fall (gm^{-2} day^{-1}) ± SE (Range)
JULY	0.37 ± 0.24 (0.34-0.44)	0.27 ± 0.07 (0.156-0.5)	0.62 ± (0.51-0.844)
AUGUST	0.40 ± 0.26 (0.34-0.44)	0.68 ± 0.37 (0.344-0.766)	1.08 ± 0.05 (8.94-1.20)
SEPTEMBER	0.34 ± 0.05 (0.233-0.455)	0.316 ± 0.097 (0.14-0.577)	0.658 ± 0.07 (0.536-0.86)
OCTOBER	0.706 ± 0.169 (0.381-1.16)	0.209 ± 0.16 (0.166-0.244)	0.913 ± 0.177 (0.577-1.41)
NOVEMBER	1.377 ± 0.13 (1.08-1.71)	0.388 ± 0.04 (0.28-0.466)	1.71 ± 0.12 (1.37-1.95)
DECEMBER	0.73 ± 0.104 (0.56-1.04)	0.148 ± 0.01 (0.137-0.177)	0.88 ± 0.099 (0.736-1.17)
JANUARY	0.612 ± 0.06 (0.45-0.72)	0.115 ± 0.01 (0.099-0.137)	0.73 ± 0.05 (0.599-0.82)
FEBRUARY	0.538 ± 0.05 (0.422-0.639)	0.06 ± 0.01 (0.032-0.086)	0.744 ± 0.12 (0.51-1.08)
MARCH	0.935 ± 0.048 (0.82-1.04)	0.045 ± 0.0188 (0.010-0.099)	0.978 ± 0.061 (0.844-1.137)
APRIL	0.77 ± 0.075 (0.602-0.969)	0.055 ± 0.011 (0.030-0.080)	0.833 ± 0.075 (0.658-1.025)
MAY	0.446 ± 0.0053 (0.44-0.46)	0.169 ± 0.0268 (0.107-0.215)	0.615 ± 0.032 (0.548-0.677)
JUNE	0.233 ± 0.022 (0.191-0.280)	0.127 ± 0.016 (0.0916-0.1611)	0.358 ± 0.033 (0.294-0.44)
Monthly average production (gm^{-2} .y^{-1} ± SE)	228 ± 33	79 ± 19	309 ± 35
Total annual production ($t.ha^{-1}$ .y^{-1} ± SE)	2.73 ± 0.28	0.95 ± 0.14	3.71 ± 0.36
TOTAL LITTER FALL	74	26	100

form of detritus may be used through artifical propagation of fish and shell fish in mangrove area, and/of by devicing means to get this organic matter recycled via shorter food chains. Mangrove forest produce litter throughout the year. Peaks of leaf and miscellaneous litter production do not generally conicide. Leaf fall is maximum in November after a dry season of October. Higher rates of litter fall have been reported during the period of extreme drought (12). However, Gill and Tombinson (6) and Heald (10) recorded a peak in summer and Pool *et al.* (21) observed high rates during wet season. High value for miscellaneous fall corresponds with the flower and fruit production by the plant in that season. Variations in litter production rate are dependent upon the growth conditions (6), temperature and salinity (11). These stresses govern largely energy balance and the cost of maintenance of photosynthetic tissues. In addition, local regimes of winds and rains may also effect the rate of litter production. Since litter generation in a mangrove stand is a function of many factors which may be persistant or may occur abruptly, one year data might not reflect a true functional perspective.

Physico-chemical parameters

Dissolved Oxygen: Seasonal variations in dissolved oxygen content are shown in Figures 2 and 3. Lower values were observed for the samples procured from the pools within the mangrove rhizosphere at low tides. Higher values were found in samples collected from the nearby channels. Comparison of data from two locations reveals that pattern of variation in oxygen content is similar except for the difference in the magnitude of values; higher values observed at Bakran creek and the samples from the Karachi back waters were constantly low in oxygen content. This could be attributed to the high and efficient flushing of tides at Bakran Creek (9) which causes less detritus accumulation and low oxygen consumption. Average values of dissolved oxygen ranged between 0.5 ml O_2L^{-1} and 4.46 O_2L^{-1} at the back waters and between 1.74 ml O_2L^{-1} and 7.61 ml O_2L^{-1} at Bakran creek.

In several instances samples from the back waters were observed to be anoxic. This condition has not been reported earlier in mangrove forests. If, however, can be attributed to the inorganic cycles prevailing in estuaries as described by Wood (24) Sulfar and iron cycles are more pronounced, specially in the anaerobic sediments of estuaries. Although sulfur, cycle remains confined to the sediments, there exist circumstances under which the products of sulfate reduction (hydrogen sulfide and hydrotilite) permeates the water causing complete deoxygenation and released of phosphoric acid. The question, why this does not occur at Bakron creek, can only be resolved if the tidol flushing is taken into account.

Salinity: Variation in salinity of sea water rhizosphere and non-rhizosphere are set out in Table 3. Values recorded in non-rhizosphere samples collected from two locations, run parallel but are lower than that of rhizosphere samples. Salinity in Bakran creek swamps fluctuates widely and throughout the year. Present values are quite higher than those reported by Dwevidi *et al.* (5) and Ramadhas *et al.* (22). Only slightly lower values were obtained in Bakran creek during July and August, when rain falls in the area. High salinity corresponds with the months of high air and water temperature. Rising salinity is one of the major stresses being experienced by mangroves (2). Cutting up of Indus load of fresh water and sediment, by building dams and reservoirs uphill has raised the salinity in estuaries and will continue to do so in future as well. Low rain fall and high evaporation and tran-

Table 3: Monthly variation in salinity of water at low tides in mangrove swamps at the back waters and Bakran Creek.

MONTH	BACK WATERS		BAKRAN CREEK	
	SALINITY ‰		SALINITY ‰	
	RHIZOSPHERE	NON-RHIZOSPHERE	RHIZOSPHERE	NON-RHIZOSPHERE
JUL. 84	32.03	31.64	29.12	29.20
AUG. 84	36.29	35.78	31.09	30.63
SEP. 84	36.67	36.38	36.83	36.54
OCT. 84	37.40	37.10	35.81	35.26
NOV. 84	37.34	37.07	36.92	35.79
DEC. 84	38.20	38.04	38.81	38.47
JAN. 85	37.81	37.76	41.02	38.60
FEB. 85	39.92	38.17	42.94	39.73
MAR. 85	39.84	39.23	41.57	39.93
APR. 85	42.02	36.09	46.49	39.92
MAY. 85	41.12	37.69	41.02	39.87
JUN. 85	41.02	39.55	40.38	39.42

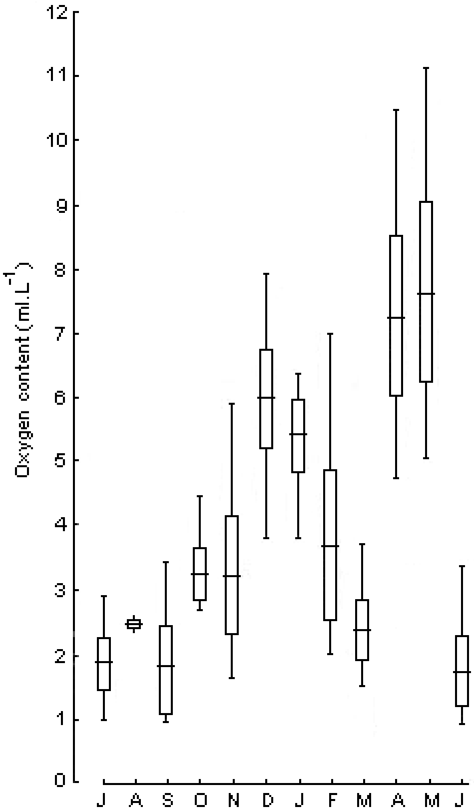

Figure 3: Monthly variation in dissolved oxygen content in water from Bakran Creek at low tides. Horizontal lines indicate means, verticle lines denote range and box represent standard error values.

spiration have generated semi-arid conditions in the Indus delta (2).

pH: Hydrogen ion concentration was measured in superficial mud and water samples collected at low tides. Results obtained (Table 4) reflect low pH values in water sample than mud during study period except in February and March at the back waters; and in January, February and October samples of Bakran creek. pH in mangrove swamps was generally alkaline. Acidic pH was recorded in few instances. Results of the present study are in good agreement with those of other workers (5,22). Reports for mud flats Wood (25) other than mangroves also support our findings according to this report the pH values from surface sediments have been vary from 5.9 to 9.2 in Zostera flats and from 8.0 to 9.2 in Thalassia and Diplanthera grasses.

Temperature: Air, water and mud temperatures are set out in Table 5. In Bakran creek temperature was slightly higher as compared to back waters. With few exceptions, air temperature was consistently higher than mud and water in the back water swamps. On the other hand, reverse is observed for Bakran creek. Fluctuations in temperature seems to be the consequence of variations in seasons, from winter to summer; the temperature was low during monsoon and winter.

Table 4: Monthly variation in pH values for mud and water of mangrove swamps at the back waters and Bakran creek.

MONTH	BACK WATERS		BAKRAN CREEK	
	pH		pH	
	MUD	WATER	MUD	WATER
JUL. 84	7.8	7.5	7.5	7.0
AUG. 84	6.7	6.6	6.5	6.4
SEP. 84	7.2	7.1	6.8	6.7
OCT. 84	6.7	6.7	7.1	7.2
NOV. 84	6.9	6.8	7.4	7.3
DEC. 84	7.4	7.3	7.8	7.4
JAN. 85	8.1	8.0	9.0	9.1
FEB. 85	7.2	7.5	9.3	9.4
MAR. 85	7.8	8.0	8.2	8.1
APR. 85	8.9	8.7	8.6	8.2
MAY. 85	9.2	8.9	9.3	9.1
JUN. 85	9.1	8.6	9.8	9.6

Table 5: Monthly variation in temperature of air, water and mud within and mud within a mangrove stand at the back waters and Bakran Creek.

MONTH	BACK WATERS			BAKRAN CREEK		
	TEMPERATURE (°C)			TEMPERATURE (°C)		
	AIR	WATER	MUD	AIR	WATER	MUD
JUL. 84	28.0	27.0	28.0	24.0	24.5	24.0
AUG. 84	25.0	24.0	24.0	26.0	25.5	25.5
SEP. 84	26.0	25.0	25.0	24.0	25.0	25.0
OCT. 84	24.0	23.5	24.0	25.0	25.5	25.0
NOV. 84	26.0	22.0	23.0	25.5	26.0	26.0
DEC. 84	19.0	18.0	18.0	24.0	21.0	22.0
JAN. 85	24.0	23.0	23.0	25.0	24.5	24.5
FEB. 85	26.5	25.0	25.0	26.0	27.5	25.0
MAR. 85	27.0	24.0	24.0	27.0	29.0	29.0
APR. 85	29.0	30.0	30.0	30.0	34.0	32.0
MAY. 85	29.0	27.5	28.0	30.0	33.0	34.0
JUN. 85	27.0	28.0	28.0	27.0	27.0	27.5

REFERENCES

1. Aksornkoae S, Khemnark C : Nutrient cycling in mangrove forest in Thailand. In: Proc. Asian Symp. on Mangrove Environ. Res. and Management, Kuala Lumpur, August, 1980.

2. Blasco F : Climatic factors and the biology of mangrove plants. In: SC Snedaker and JG Snedaker. The Mangrove Ecosystem: research methods. UNESCO. Paris, 1984.

3. Bunt JS : The mangroves of the eastern coast of Cape York Peninsula north of Cooktown. Great Barrier Reaf Marine Parks Authority, Workshop on Northern Sector, Townsvilte, USA, 1978.

4. Chirstensen B : Biomass and primary production of Rhizophora apiculata BL. In a mangrove in southern Thailand. Aquatic Botany, 4:43-52, 1978.

5. Dwivedi SN, Parulekar AG, Goswami SC, Untawale AG : In: Proceedings International symposium on the Biology and Management of Mangroves, ed by GE Walsh, SC Snedaker, HJ Teas, Honolulu, 1974, 1:115-125, Univ. of Florida, Gainesville, 1975.

6. Gill AM, Tomlinson PB : Studies on the growth of red mangrove (Rhizophora mangle L) III. Pnenology of the shoot. Biotropica, 3:109-124, 1971.

7. Golley F, Odum HT, Wilson RF : The structure and metabolism of a Puerto-Rican red mangrove forest in May. Ecology 43:9-19, 1962.

8. Goulter PFE, Allaway WG : Litter fall and decomposition in Avicennia marina stands in the Sydney region, Australia: Contribution to the 2nd Int. Symp. on Biology and Management of Mangroves and Tropical Shollow Water Communities, Papua New Guinea, July-August, 1980.

9. Haq SM : Overiew on pollution in the coastal environment of Pakistan and its possible implication for the marine ecosystem Proc. International Symposium on Marine Pollution Research. pp 33-53. Meyers (ed.) Louisiana State Univ. Baton Rouge, L.A. USA, 1976.

10. Heald EJ : The production of detritus in a south Florida estuary. Sea Grant Tech Bull (Univ Miami). No 6, pp 1971.

11. Hicks DB, Burns LA : Mangrove metabolic response to alterations of natural freshwater drainage to south western Florida Estuaries. Int Symp on Biol and Manag of Mangrove, 238-255, 1975.

12. Lugo AE, Snedaker SC : The ecology of mangroves. Ann Rev Ecology Systematic, 5:39-64, 1974.

13. Lugo AE, Snedaker SC : Properties of mangrove forest in southern Florida. International symposium on Biology and Management of Mangrove. Oct 1974. Honolulu, Hawaii, USA, 170-212, 1975.

14. Macintosh DJ : Fisherie and aquaculture significance of mangrove swamps, with special reference to the Indo-West Pacific region. In: J Muir, R Roberts (ed.) Recent Advances in Aquaculture. pp. 3-85, Croom Helm Ltd, London, 1982.

15. Malley DF : Adoptations of decapod crustaceans to life in mangrove swamps. Mar Res Indonesia, 18:63-72, 1977.

16. Mart IL, Cresser MSc : Environmental chemical Analysis Int. Text Book Company, London, 1983.

17. Mirza MI, Hasan MZ, Akhtar S, Ali J : Identification and area estimation of mangrove vegetation in Indus delta, using landsat data. In: Mangroves of Pakistan, Pakistan Agric Res Council, Islamabad, pp 19-21, 1983.

18. Odum WE, Heald EJ : Trophic analyses of and estuarine mangrove community. Bull Mar Sci, 22:671-738, 1972.

19. Odum WE, Heald EJ : Mangrove forest and aquatic productivity. In: AD Haster (ed.) Coupling of Land and Water Systems. Ecological Studies, Vol 10. Springer-Verlag, New York, 129-136, 1975.

20. Ong JE, Gong WK, Wong CH : Productivity of a managed mangrove forest in West Malaysia. Contribution to the Conference on Trends in Applied Biology in South-east Asia Penang, Malaysia, pp 9, Oct 1979.

21. Pool DJ, Snedaker SC, Lugo AE : Litter production in mangrove forsets of South Florida and Puerto Rico. In: G Walsh, S Snedaker, H Teas (eds), Proceeding of international Symposium on Biology and Management of Mangroves. Vol 1, 213-237, 1975.

22. Ramadhas V, Rajendran A, Venugoplan VK : Studies on trace elements in Pichavaran Mangrove (South India). Int Symp on Biol and Manag of Mangrove, Volume 1, 6-114, 1975.

23. Steinke TD : Degradation of mangrove leaf and stem tissue in situ in Megni E stuary, South Africa. In: Second Int Symp on Biol and Manag of mangrove and tropical shallow water communities, Papua New Guinea, July-Aug 1980.

24. Wood EFJ: Heterotrophic microorganisms in the Oceans In H Barnes (eds), Oceanogr Mar Biol Ann Rev 1:197-222, 1963.

25. Wood EFJ : Australian J Mar Fresh Water Res 10:304-315, 1959.

Correspondence:
Rashida Qasim
Department of Biochemistry
University of Karachi
Karachi-75270
PAKISTAN.