Pak. J. Bot., 43(1): 405-410, 2011.

DISTRIBUTION OF CHLOROPHYLL IN THE MANGROVE SEDIMENTS OF SONMIANI BAY, PAKISTAN

SUMERA FAROOQ[1*] AND P.J.A. SIDDIQUI

Centre of Excellence in Marine Biology, University of Karachi. Karachi-75270, Pakistan
[1]Present address: Department of Zoology, University of Karachi, Karachi, Pakistan
**Corresponding author E-mail: sumera_farooq@yahoo.com*

Abstract

Chlorophyll content especially chlorophyll *a* (Chl *a*) is a measure of microphytobenthos (MPB) biomass in sediments. In this study both vertical and horizontal variations in Chl *a* content in mangrove forest was detected. This is the first report on the vertical distribution of Chl *a* in the sediments of mangrove forests at Sonmiani Bay. The stations differ in chlorophyll content in sediments and range between 0.8-4.9 Chl *a* µg g^{-1}. Comparatively higher value of Chl *a* was obtained from Station II where nutrient loading from small ephemeral river was observed. Dry conditions, long exposure periods, and high Salinity may be responsible for low Chl *a* content in Sonmiani Bay mangrove sediments. The lower values of Chl *a* is an indication of lower standing stock of MPB and benthic primary productivity. The study provides the base line data and may be useful in the prediction of MPB abundance and benthic productivity in mangrove sediments.

Introduction

Chlorophyll content is a measure of phytoplankton and Microphytobenthos (MPB) biomass which are the main primary producers in estuarine environment (MacIntyre & Cullen, 1996). The productivity of benthic algae is dependent on various environmental variables such as availability of light, emersion periods during tidal cycle, etc. Various researches on estimation of benthic algal biomass in estuarine and mud flats has been carried out in past (Underwood & Paterson, 1993; Murphy *et al.*, 2008), and in most of the studies, the biomass of MPB is often expressed as chlorophyll *a* (Chl *a*), which is widely distributed and the most abundant pigment component in almost all species of phytoplankton hence is used to estimate phytoplankton biomass (Sun *et al.*, 1994).

Benthic microalgae (MPB) are known to be extremely variable and illustrate spatial and temporal heterogeneity (Brotas & Plante-Cuny, 1998; Azovsky *et al.*, 2004). In sediments and water column chlorophyll content is reported to vary both horizontally and vertically (Colijn & de Jonge 1984; Pinckney & Sandulli, 1990; Buffan-Dubau & Carman, 2000; Murphy *et al.*, 2008). The factors affecting the spatial variability of MPB have been evaluated by several authors (Brotas *et al.*, 1995; Me´ le´der *et al.,* 2005).

Mangrove forests are known for their high productivity and to provide habitat for a wide variety of fauna and flora. Mangroves are widely distributed along the coastline of Sindh and in only a few pockets along Baluchistan coast. Studies on the macro- and microalgae of mangrove forests are sparsely available (Saifullah & Taj, 1995; Shameel & Tanaka, 1992; Sidiqui *et al.*, 2000). Very little is known about the distribution of chlorophyll in the mangrove sediments and apparently no report is available on the vertical distribution of chlorophyll and abundance of MPB from mangrove forests of Pakistan. The aim of this study was to assess the distribution and abundance of MPB as indicated through chlorophyll in the sediments of Sonmiani Bay mangrove forest. Sonmiani Bay mangrove forest apparently seems to be different from other mangrove areas where high nutrient loads are available such as Manora Channel and Gharo-Phitti Creek, where organic effluents are brought in through Layari and Malir rivers, respectively (Beg *et al*., 1975). The data provided in this study can be used to predict the contribution of benthic productivity in mangrove forests.

Materials and Methods

Sediment samples were collected from three stations at Sonmiani Bay mangrove stand by inserting a hand corer (dia: 3 inch; length: 20 cm). Six cores were collected from Station I and Station II, whereas four cores were retrieved from Station III where mangrove plants are sparsely distributed. The cores were sliced at 1 cm interval up to 20 cm. The samples were transferred in labelled plastic bags and stored frozen (at -20ºC) for further analysis. Moisture content in surface sediments was estimated by drying sediments at 80^{o}C for 24 hours in drying oven. The chlorophyll content in the sediment samples was analysed using previously described method (Strickland & Parson, 1972). Known amount of sediment sample was extracted in 90% acetone stirred in the vortex and was placed in the freezer at -20ºC for 24 h. The samples were centrifuged and the supernatant were separated and read at 630, 647, 664 and 750nm on UV-spectrophotometer (Shimadzu). Values of Chlorophyll *a* (Chl *a*) content were calculated and expressed in μg g^{-1}.

Water samples were also collected from the channels near coring sites. The water samples were analyzed on site for Salinity, dissolved oxygen and nutrients. Salinity was obtained by Refractometer (Atago, Japan). Dissolved oxygen and nutrients were analyzed on Multiparameter bench spectrophotometer (HANNA Instruments).

Regression equation followed by one-way ANOVA (at 95% confidence limit based on pooled standard deviation) was applied on the data to ascertain the differences between stations. The data was subjected to Cluster analysis using normalized Euclidean distance and Spearman Rank Correlation based similarity matrix to visualize the correlation between the studied variables and stations.

Results and Discussion

The Chl *a* content in Sonmiani Bay sediments showed variable distribution at different stations and among cores collected from same station. The Chl *a* content in the surface sediments of Sonmiani mangrove stand was generally low, and only patchy algal growth was observed. The vertical profiles in the sediments from all stations for Chl *a* showed a decreasing trend with depth (Figs. 1 and 2). The surface sediments shows variation in Chl *a* and range between 0.8-4.9 μg Chl *a* g^{-1} (Table 1). Comparison of surface sediment values with values at 5 cm depth showed significantly lower values in deeper sediments (Fig. 3), particularly in C1, C2 and C4. In comparison the surface distribution of Chl *a* at Station III was low as compared to Stations I and II (Table 1).

The highest value of dissolved oxygen and nitrate was obtained from Station II and lowest from Station I (Table 2). Salinity was quite high in the water samples collected from Station III (Table 2). The water channel at Station III was very shallow as compared to the water channels at Station I and II. Shallow water and exposure to high solar radiation causes high rates of evaporation particularly at Station III, with concomitant increase in Salinity. The mean % moisture content was higher in the surface sediments obtained from Station III (Table 2), which appeared to be related to the finer grain size of the sediments at this station.

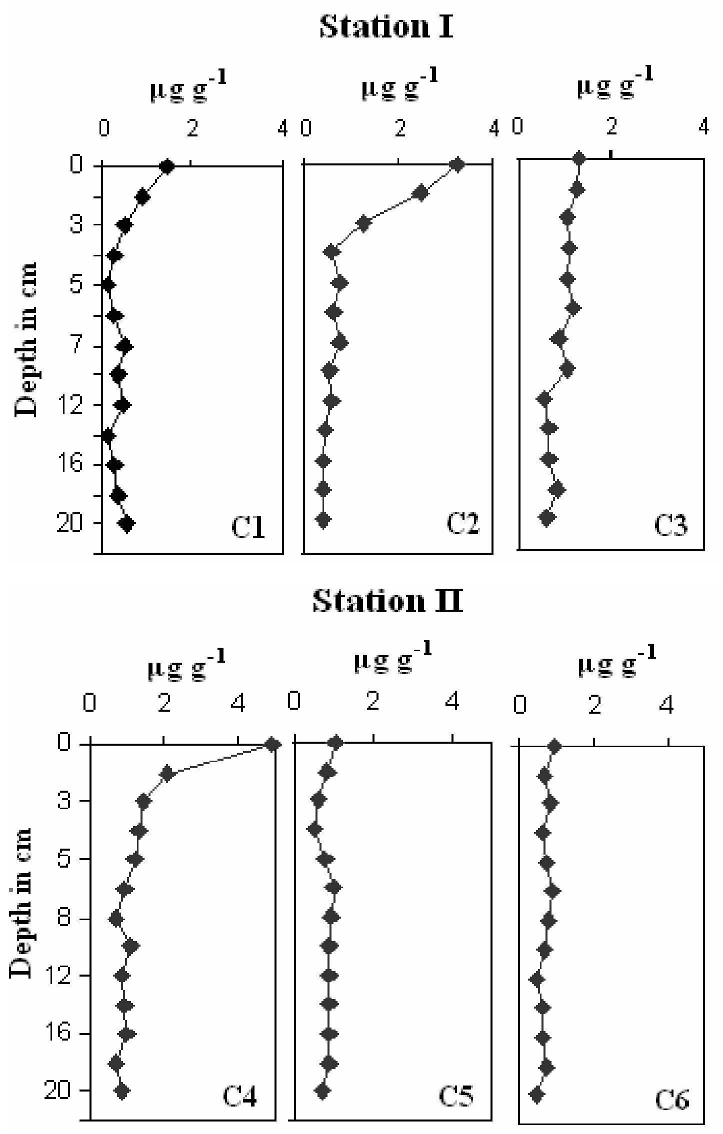

Fig. 1. Vertical profiles of Chl *a* in sediments at Station I and II. Each point is a mean of duplicate values.

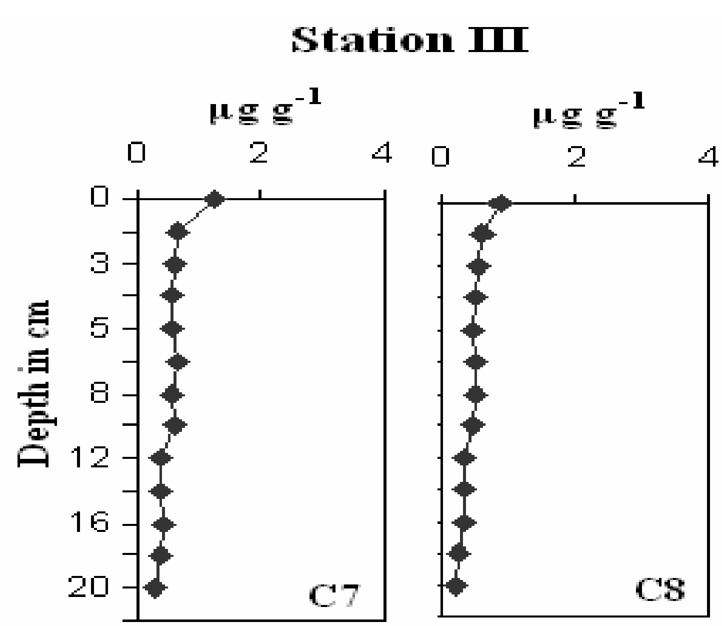

Fig. 2. Vertical profile of Chl *a* in sediments at Station III. Each point is a mean of duplicate values.

Table 1. Comparison of chl *a* μg g^{-1} content in surface sediments at three stations showing range and mean values ± standard deviatio.

	Range	Mean
Station I	1.3 – 3.23	2 ± 1.1
Station II	0.95 – 4.9	2.3 ± 2.3
Station III	0.87 – 1.27	1.1 ± 0.3

Table 2. Distribution of Dissolved oxygen, Salinity and nutrients in Channel waters; Moisture content in surface sediments of Station I, II and III. All values are mean.

	Dissolved O_2 mgL^{-1}	Salinity ‰	Ammonia mgL^{-1}	Nitrate mgL^{-1}	Moisture content %
Station I	1.6	48	4.7	6	19.7
Station II	4.2	40	4.8	6.4	28
Station III	3.9	65	4.96	5.76	35.5

Table 3. Results of linear regression and one-way ANOVA (<0.05 probability) of Chl a between stations.

Stations	R^2	F	P
II-I	18.9	0.23	0.714
III-I	50.3	1.01	0.49
III-II	98.1	51.16	0.088

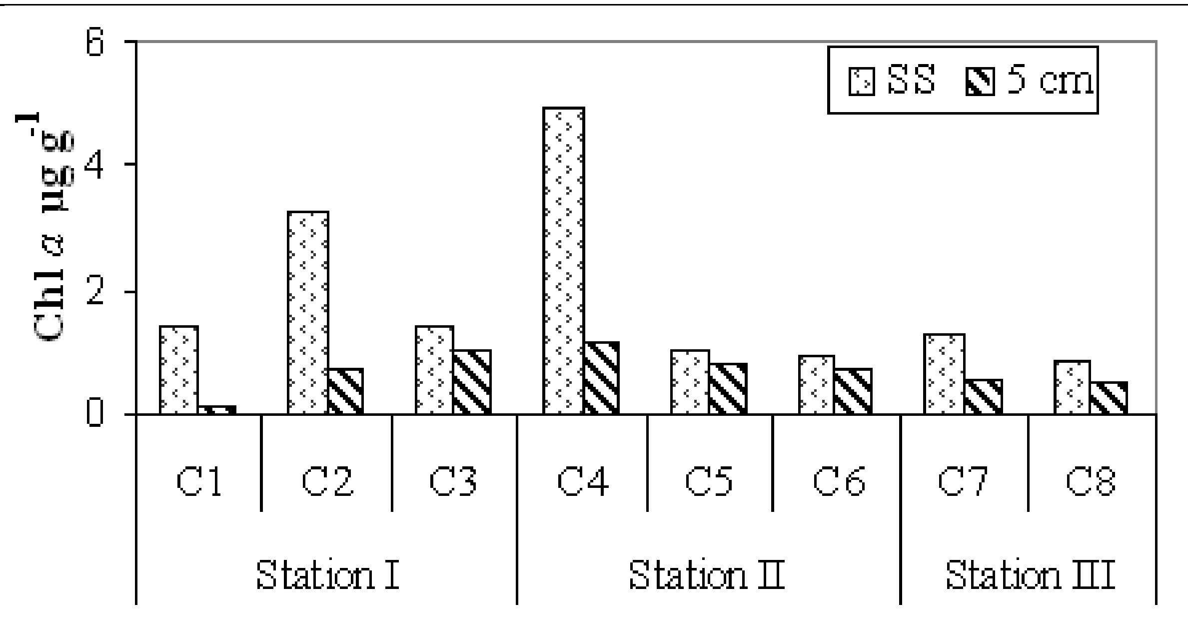

Fig. 3. Comparison of Chl *a* μg g^{-1} in surface sediments and at 5cm depth in studied cores.

Results of regression and one-way analysis of variance showed that Station I and II have small variation in Chl *a* distribution both horizontally and vertically. However, values at Station II are significantly different ($p<0.05$) from Station III (Table 3).This is further supported from the Correlation analysis between stations calculated through Spearman's rank correlation (Fig. 4).

Comparatively high Chl *a* values in surface sediments at Station II (particularly C4) may be due to the high nutrient loading from Porali river supporting high MPB abundance as reported by Farooq (2004) from the same station. Generally it appears that the surface sediments at Sonmiani Bay has very low MPB distribution as indicated by Chl a values (0.8-4.9 μg Chl *a* g^{-1} **),** which are much lower than the earlier reported values of 0 to 34 μg Chl *a* g^{-1} (Fielding *et al*., 1988) and 3 - 7.5 mg chl g^{-1} (Brotas *et al*., 1990).

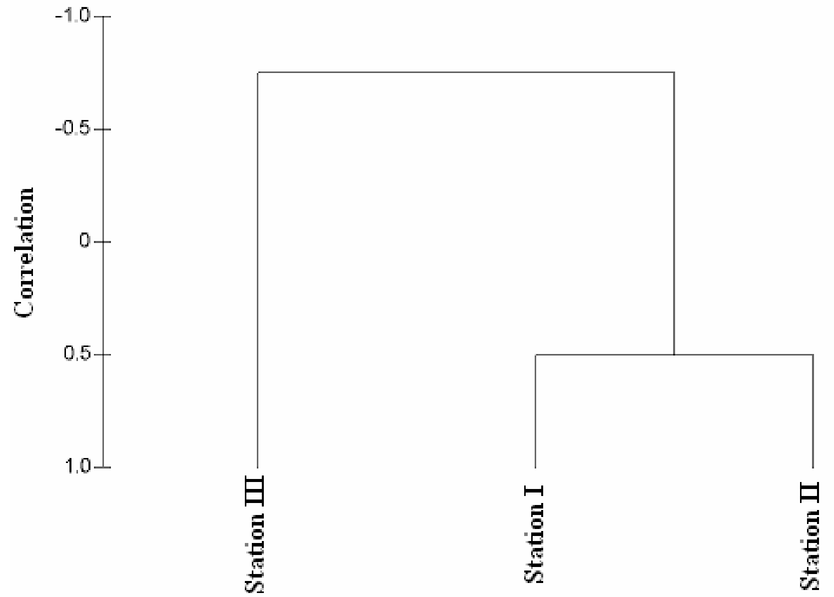

Fig. 4. Dendrogram of studied stations based on Spearman's Rank Correlation resemblance showing Correlation calculated for Chl a (Surface + 5 cm deeper sediments) and nutrients.

The Chl a data is therefore useful to predict standing stock of MPB. Lower values of Chl *a* observed in this study is an indication of lower MPB productivity in the sediments of Sonmiani Bay mangrove stand. The net microphytobenthic production of 14 mmol m^{-2} d^{-1} has been reported earlier from the mangrove forests in the Indus delta region of Pakistan (Kristensen *et al.*, 1992). The rates of benthic primary production found in mangrove forests are generally low compared to those from intertidal flats in other parts of the world (e.g., primary production of 41-170 mmol m^{-2} d^{-1} and biomass of 5-10 µg chl a g dw^{-1} in northern Europe; Kristensen, 1993).

Factors such as temperature and nutrient concentrations are directly related to variation in chl *a* distribution in sediments (Colijn & de Jonge, 1984; Shaffer & Onuf, 1985; Facca & Sfriso, 2007). The concentration of nutrient in Sonmiani Bay waters appears reasonable therefore; the relatively dry conditions due to long exposure periods during tidal cycles at Sonmiani are the possible cause of low Chl *a* content in sediments.

Conclusion

The results of this study showed that Sonmiani Bay mangrove sediments have low surface Chl *a*. The Chl *a* content vary both in vertical and horizontal distribution indicating a decreasing trend with depth and patchy distribution of MPB in sediments. Dry conditions and long exposure periods during tidal cycles may be responsible for low Chl *a* content in Sonmiani Bay mangrove sediments. The present data can be used to predict MPB abundance and benthic primary productivity in mangrove sediments. The lower values of Chl *a* is an indication of lower MPB abundance which are the main benthic primary producers in mangrove ecosystem. Thus, indicating low benthic productivity in mangrove forest at Sonmiani Bay.

References

Azovsky, A., E. Chertoprood, M. Saburova and I. Polikarpov. 2004. Spatio-temporal variability of micro- and meiobenthic communities in a White Sea intertidal sand flat. *Est. Coast. and Shelf Sci.*, 60: 663-671.

Beg, M.A.A., S.N. Mehmood and A.H.K. Yousufzai. 1975. Industrial effluents, their nature and disposal in the Karachi region, survey of the polluted Lyari river. *Proc. Pak. Acad.Sci*., 12: 115-131.

Brotas, V. and M. Plante-Cuny. 1998. Spatial and temporal patterns of microphytobenthic taxa of estuarine tidal flats in the Tagus estuary using pigment analysis by HPLC. *Marine Ecol. Prog. Ser*., 171: 43-57.

Brotas, V., T. Cabrita, A. Portugal, J. Seroˆdio and F. Catarino. 1995. Spatiotemporal distribution of the microphytobenthos biomass in intertidal flats of Tagus estuary (Portugal). *Hydrobiol.,* 300/301: 93-104.

Buffan-Dubau, E. and K.R. Carman. 2000. Diel feeding behaviour of meiofauna and their relationships with microalgal food. *Limnol. and Oceanog.*, 45: 381-395.

Colijn, F. and V. de Jonge. 1984. Primary production of microphytobenthos in the Sem- Dollard estuary. *Marine Ecol. Prog. Ser*., 14: 185-196.

Facca, C. and A. Sfriso. 2007. Epipelic diatom spatial and temporal distribution and relationship with the main environmental parameters in coastal waters. *Est. Coast. and Shelf Sci.,* 75: 35-49.

Farooq, S. 2004. *Comparative study on the ecology of mangrove swamps of Pakistan*. Ph.D. Thesis, Centre of Excellence in Marine Biology, University of Karachi. Pakistan.

Fielding, P.J., K.St. J. Damstra and G.M. Branch. 1988. Benthic diatom biomass, production and sediment chlorophyll in Langebaan lagoon, South Africa. *Est. Coast. and Shelf Sci*., 27(4): 413-426.

MacIntyre, H.L. and J.J. Cullen. 1995. Fine scale vertical resolution of chlorophyll and photosynthetic in shallow water benthos. *Marine Ecol. Prog. Ser*., 12: 227-237.

Me´ le´der, V., L. Barille´, Y. Rince´, M. Morançais, P. Rosa and P. Gaudin. 2005. Spatiotemporal changes in microphytobenthos structure by pigment composition in a macrotidal flat (Bourgneuf Bay, France). *Marine Ecol. Prog. Ser*., 297: 83-99.

Murphy, RJ., T.J. Tolhurst, M.G. Chapman and A.J. Underwood. 2008. Spatial variation of chlorophyll on estuarine mudflats determined by field-based remote sensing, *Marine Ecol. Prog. Ser*., 365: 45-55.

Pinckney, J. and R. Sandulli. 1990. Spatial autocorrelation analysis of meiofaunal and microalgal populations on an intertidal sandflat: scale linkage between consumers and resources, *Est. Coast. and Shelf Sci*., 30: 341-353.

Saifullah, S.M. and G. Taj. 1995. Marine algal epiphytes on the pneumatophores of mangroves growing near Karachi, Pakistan. In: *The Arabian Sea, Living marine Resources and its environment.* (Eds): M. F. Thompson & N. M. Tirmizi. Proc. of Int. conf., Karachi, Pakistan. American Inst. of Biol. Sci., Washington D.C. USA, p. 393-400.

Shaffer, G.P. and C. Onuf. 1985. Reducing the error in estimating annual production of benthic microflora: hourly to monthly rates, patchiness in space and time. *Marine Ecol. Prog. Ser*., 26: 221-231.

Shameel, M. and J. Tanaka. 1992. A preliminary checklist of marine algae from the coast and inshore waters of Pakistan. Cryptogamic fauna of Pakistan. *Na. Sci. Mus*., Tokyo, 1-64.

Sidiqui, P.J.A., S.N. Mansoor, Zaibunnisa, S. Hameed, S. Shafique, S. Farooq, R.A. Aziz and S. Saeed. 2000. Associated fauna and flora of macro-algal puffs inhabiting mangrove stands at Sandspit back waters, Karachi. *Pak. J. Mar. Biol*., 6(1): 43-53.

Strickland, J.D.H. and T.R. Parson. 1972. *A Practical Handbook of Seawater Analysis*. Fisheries Research Board of Canada.

Sun, M.-Y., C. Lee and R.C. Aller. 1994. Spatial and temporal distribution of sedimentary chloropigments as indicators of benthic processes in Long Island Sound. *J. of Marine Res*., 52: 149-176.

Underwood, G.J.C. and D.M. Paterson. 1993. Seasonal changes in diatom biomass, sediment stability and biogenic stabilization in the Severn Estuary. *J. Mar. Biol. Assoc. of the United Kingdom*, 73: 871-887.

(Received for publication 15 October 2009)