CONSERVATION OF MANGROVES WITH RESPECT TO THEIR POTENTIALITY OF ORGANIC CARBON ACCUMULATION IN SEDIMENTS OF THANE CREEK, MAHARASHTRA, INDIA

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ABSTRACT

Coastal areas play a vital role in the global carbon cycle either as sources of organic matter or as carbon sinks due to accumulation of organic matter in sediments. The primary source of organic matter to coastal sea sediments is from particulate detritus of plants, only few percent come from animals. The Thane Creek is fringed by mangrove on both the sides. Organic carbon entering mangrove food webs is either produced autochthonously or imported by tides/ rivers. Mangrove litter and benthic fauna are usually the most important carbon sources of the Creek. Litter from trees (leaves, propagules and twigs) and subsurface root growth provide significant inputs of organic carbon to mangrove sediments. Mangrove species have maximum potential to sequester atmospheric carbon and form carbon sinks which helps in maintaining the balance of ecosystem by absorbing and storing excess carbon from the atmosphere. Mangroves have been neglected as potential carbon sinks. Hence the study was undertaken to find out the carbon sequestration potential of two different mangrove species found in the area of Thane Creek. For this the sediment samples were collected monthly from beneath two different mangrove species namely *Avicennia marina* and *Sonneratia apetala* using PVC pipes as sediment cores to collect samples of different cm depth. The samples were collected monthly from Nov.2009 to Oct.2010.Among the two species, *Avicennia marina* is the dominant mangrove species and covers maximum area of the creek which adds to the major carbon source of the creek. Hence conservation of mangroves is very much essential and important for climate change mitigation strategy.

Key words: Coastal areas, Thane Creek, Mangroves, Organic carbon, Climate change.

I. INTRODUCTION

One of the key ecosystem services of mangroves, salt marshes and salt flats is the retention of carbon and nutrients within sediments. In mangrove ecosystem approximately half the nutrient and carbon stocks can be in sediments (Catherine Lovelock et al., 2007). The presence of mangroves along both sides of the Thane creek has made creek a highly productive ecosystem. Thus the sediments of Thane creek are rich in organic carbon due to loads of organic matter entering creek through mangroves and faunal biodiversity that reside near mangroves.

According to Mishra (2001) reported that mangrove leaves act as one of the sources of organic carbon to the underlying sediment. Organic carbon entering mangrove foodwebs is either produced autochthonously or imported by tides or rivers. Mangrove litter are usually the most important autochthonous carbon sources. (Kristensen et.al ,2007)He also stated that litter handling by the fauna not only affects microbial carbon transformations, but also the amount of organic carbon available for export. Most mangrove detritus that enters the sediment is degraded by microorganisms. Organic carbon that escapes microbial degradation is stored in sediments and in some mangrove ecosystems, organic-rich sediments may extend to several meters depth. The knowledge with respect to organic carbon accumulation in sediments by mangroves species is very scarce.Therefore it was decided to study the organic carbon accumulation through two mangrove species namely *Avicennia marina* and *Sonneratia apetala* respectively.

2. SELECTION OF AREA

The Thane creek is narrow and shallow at the riverine end due to the presence of the geomorphic head and broader and deeper towards the sea. The creek being tropical in location (Latitude 19° N), winter is not severe, and three seasons can be distinguished viz., monsoon (June to September), Post monsoon (October to February) and Pre monsoon (March to May). The Creek is tidally influenced with dominance of neritic waters and negligible freshwater flow except during the monsoon. Tidal range in the area varies 3 to15 m during neap and spring, respectively. (Goldin, 2001) Extensive mudflats are formed along the banks of the creek which are characterized by the growth of mangroves on both sides of the creek.

The present investigation was conducted by selecting two stations (station I and station II) located on the East and West bank of Thane creek respectively Further two substations were selected on the West bank namely station I A and station IB near Bhandup. Among the two substations, station IA is characterized by significant density of *Sonneratia apetala* and sewage outlet in close proximity located near Bhandup sewage treatment plant and station IB is 1.5 km away from this station and has less impact of sewage water. Similarly two sud stations were selected on the East bank near Airoli village namely station IIA and Station IIB respectively. The distance between two substations is 1.5 Km from each other. Station IIA was characterized by dominance of *Avicennia marina* reaching maximum height of about 20-25 ft. and very few stands of *Sonneratia apetala* which were short in height. Station IIB is located near Airoli jetty. The mudflats here are soft and sinking, brown in colour except at station located near Bhandup sewage Treatment plant where it is black to grey in colour.

Fig 1.Google map showing study area location

3. MATERIALS AND METHODS

Monthly sediment samples were collected from the intertidal mangrove mudflats at four stations using a metal scoop of 0.01 m^2 dimension. For pH, Moisture content and Organic carbon percent the samples were oven dried at 70°C. The samples were further pooled together seasonwise. Organic carbon content at different centimeter depth (15 centimeter approximately) was studied by collecting sediment using 1.5 inch diameter,1.5 ft long PVC Pipes beneath *Avicennia marina* and *Sonneratia apetala*. The pipes were then kept in oven at 70°C for 72 hours for drying. The sediment was then removed and divided into five centimeter each from top to bottom, pounded and analysed for organic carbon content by using Walkley and Black method (Trivedi *et al*., 1987) and pH was recorded by using digital pH meter.

The green leaves and dried fallen leaves of *Avicennia marina* and *Sonneratia apetala* were collected .They were properly washed to remove the soil, blotted to remove excess water and were then oven dried at 70°C., powdered and then sieved through 0.4 – 0.5 mm sieve. This leaf powder was used to analyse the organic carbon content. Organic carbon content (%) of the leaves was determined by using Walkley and Black method (Trivedi *et al*., 1987).The samples of macro benthos were collected along with the sediment samples to estimate organic carbon content for the seasonal study.

4. RESULTS AND DISCUSSIONS

4.1 Sediment pH

Table pH: Station wise and season wise variations in pH

pH	IA	IB	Average	IIA	IIB	Average
Monsoon	7.58	8.08	7.83	7.88	7.72	7.81
Post monsoon	6.76	7.89	7.325	7.5	7.69	7.46
Pre monsoon	7.33	7.19	7.26	8.08	7.55	7.64
Average	7.22	7.72	7.47	7.82	7.79	7.63

According to Alongi *et al*. (2000), the mangroves modify the sediment pH as they release organic acids into the sediment. In the present study the pH ranged between 6.76 and 8.08 with an average of 7.63 (Table pH) .In station wise comparisons there was no significant variation seen in the average value of pH which ranged between 7.2 to 7.9. pH was found to be slightly alkaline except at Station IA.

4.2 Moisture Content

Table MC: Stationwise and seasonwise variations in moisture content of sediments (%)

Moisture Content (%)	IA	IB	Average	IIA	IIB	Average
Monsoon	46.65	44.81	45.73	43.37	43.15	44.62
Post monsoon	57.97	59.8	58.885	57.47	57.88	58.31
Pre monsoon	42.05	36.73	39.39	44.91	40.47	41.09
Average	48.89	47.11	48	48.58	47.16	48.01

The moisture content was little high in post monsoon in the range of 57% to 58 %. The moisture content during monsoon and premonsoon season ranged between 44.26 % to 41.09%. On an average moisture content ranged between 47% to 48 %. Athalye (1988) also observed less fluctuation in the moisture content of the sediments of the upstream region of the Thane creek. The season wise trend of average moisture content showed significant increase in post monsoon and then decline in premonsoon and monsoon. Borkar (2004), while studying the sediments recorded higher moisture content in late post monsoon.

4.3 Sediment Organic Carbon

Table OC 1: Station wise and season wise variations in Organic carbon of Sediment (In percentage %)

Organic carbon (%)	IA	IB	Average	IIA	IIB	Average
Monsoon	2.40	4.89	3.65	0.63	4.64	2.63
Post monsoon	4.74	0.56	2.65	2.18	2.68	2.43
Pre monsoon	2.37	1.10	1.73	2.52	2.68	2.60
Average	3.17	2.19	2.68	1.78	3.33	2.56

In the present study the organic carbon in the sediments of Thane creek showed variations from 0.56% to 4.89 % (Table OC 1) with an average of 2.68 % to 2.56 % at stations on both East and West bank of Thane creek. Borkar (2004) reported the range of sediment organic carbon from 2.2% to 4.16% with annual average of 3.09% at High Level Water Mark which is higher compared to present data. Average organic carbon content was very high during monsoon except at station II A .This indicates lowering of organic carbon content percentage in sediment compared to that in 2004.

In station wise trend of average organic carbon showed the average value 2.5% on the East bank and the maximum 2.6% on the West bank. On the East bank the average sediment organic carbon was higher 3.6% during monsoon and minimum 1.73 % during pre monsoon. The high organic carbon content in monsoon may be due to high organic matter load carried and dispersed through heavy rainfall. The rainfall reported was very irregular.

The net content of organic carbon in mangrove sediment varies widely depending on the type of forest and the geomorphology of the site.(Gattuso 1998). In Thane creek the rate of sedimentation is 0.21 g C to 0.22 g $Cm^{-2}y^{-1}$. (Jha, 2006) and the average rate of Carbon accumulation is not known yet. According to Gattuso (1998) the quality and quantity of material exported from mangroves depend on forest type (riverine, fringe, or basin) and productivity, as well as on physical constraints (strength and frequency of tidal inundation, river flow, wind speed and its direction).

4.4. Sediment Organic Carbon beneath *Avicennia marina*

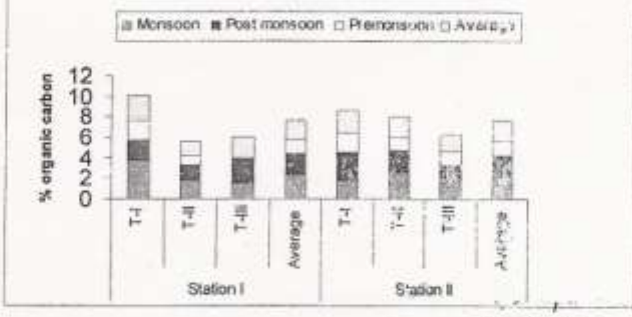
Table OC 2. Station wise and season wise variations in organic carbon of sediment beneath *Avicennia marina* at the depth of five cm. each (In percentage %)

Avicennia	Station I				Station II			
%OC	T-I	T-II	T-III	Average	T-I	T-II	T-III	Average
Monsoon	3.665	1.7534	1.4658	2.294	1.781	2.58	2.01	2.123
Post monsoon	2.054	1.5171	2.5286	2.033	2.781	2.1809	1.2643	2.075
Premonsoon	1.896	0.948	NA	1.422	1.833	1.264	1.422	1.506
Average	**2.538**	**1.406**	**1.997**	**1.916**	**2.131**	**2.608**	**1.565**	1.901

(T-1 Topmost layer; T-2 Second topmost layer; T-3 Third topmost layer)

On the West bank, the seasonwise trend the average organic carbon percentage beneath *Avicennia marina* showed high sediment organic carbon at the top layer 2.53% and then the decline 1.406% followed by increase of 1.997%(Table OC 2). This increase in organic carbon content at T III may be due to deposit of macrobenthos or due to the accumulation of litterfall. Also the overall organic carbon content was higher at station I then that compared with station II. *Avicennia species* on the East bank showed significant decrease depth wise with maximum 2.131 % and minimum 1.565%.

Fig. 1. Sediment organic carbon (%) [illegible] depth of five cm each



From Fig 1. It is clear that the average organic carbon does not vary much, but the organic carbon deposit at station IA in T-I is very high 2.53%.

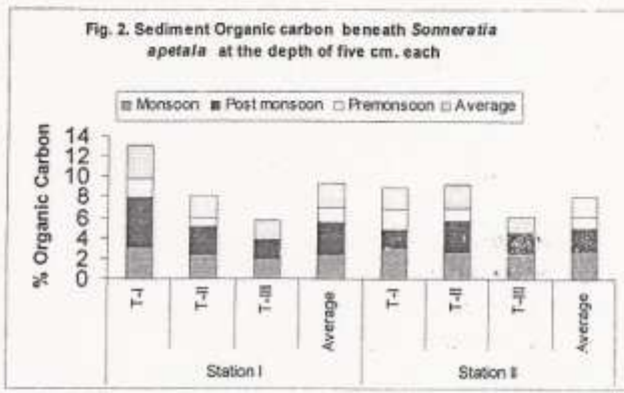
4.5. Sediment Organic Carbon beneath *Sonneratia apetala*

Table OC 3. Stationwise and seasonwise variations in Organic carbon of Sediment beneath *Sonneratia apetala* at the depth of five cm. each. (In percentage %)

Sonneratia	Station IA				Station IB			
% OC	T-I	T-II	T-III	Average	T-I	T-II	T-III	Average
Monsoon	3.14	2.36	1.923	2.474	3.160	2.686	2.497	2.787
Post monsoon	4.741	2.686	1.833	3.086	1.675	2.939	2.054	2.222
Premonsoon	1.896	0.948	NA	1.422	1.896	1.264	0	1.053
Average	3.259	1.998	1.878	2.327	2.244	2.296	1.517	2.019

(T-1 Topmost layer; T-2 Second topmost layer; T-3 Third topmost layer)

In the present study the organic carbon deposit at station I was much higher 3.25 % at T-I Layer. The seasonwise trend of sediment organic carbon beneath *Sonneratia apetala* showed significant decrease in organic carbon content depth wise with an average 2.3% to 2.0 % of organic carbon was stored in sediments. Ram and Zingde (2000) reported that the trend of decreasing percentage of organic carbon with depth indicates some accumulation in sediment over the years.



The Fig 2 shows the season wise deposit of sediment organic carbon under *Sonneratia* species. Thus when average values of sediment organic carbon under each species were compared, it was found that organic carbon content was more in the sediments beneath *Sonneratia* sp.. The average percentage was recorded in the topmost layer (T-1) of sediment ranging from maximum 3.259 % to minimum 1.901%. The sediment organic carbon in the second topmost layer (T-II) ranged between 1.998 % to 1.406 % which was slightly lower compared to T-1.

The third topmost layer (T-III) value ranged from 1.997% to 1.517%. Not much variation in the percentage organic carbon content was observed in T-II and T- III layers respectively. The average percentage of organic carbon accumulation at the depth of 15 cm was between 2.327% to 2.019 %. The sediment beneath *Avicennia marina* and *Sonneratia apetala* together deposits 4.35 % of OC in the sediments.

4.6. Organic Carbon content in green leaves (Fresh leaves) and litter fall (Dry leaves) of *Avicennia* and *Sonneratia* sp.

Table OC 4. Station wise and season wise variations in organic carbon in fresh and dry leaves of *Avicennia marina* and *Sonneratia apetala* (In percentage %)

Organic carbon (%)	*Avicennia marina*		*Sonneratia apetala*	
	Fresh leaves	Dry leaves	Fresh leaves	Dry leaves
Monsoon	37.64	13.03	35.05	13.03
Post monsoon	37.05	12.65	39.07	13.11
Premonsoon	43.38	13.03	42.52	13.03
Average	39.36	12.90	38.66	13.05667

The organic carbon content of the leaves of both the species of mangroves did not vary significantly. The OC content of fresh leaves was in range of 6.36 % to 38.88 % and that of dry leaves i.e. litter fall was 12.90 % to 13.05 %. Seasonal variations in organic carbon of mangrove leaves did not show a definite pattern .Mishra (2001) reported that mangrove leaves act as one of the sources of organic carbon to the underlying sediment. Thus around 12.9 % of organic carbon from litterfall of *Avicennia marina* to 13.05 % of organic carbon from the literfall of *Sonneratia apetala* may be deposited in the sediments annually. Also the sediment organic carbon beneath *Sonneratia* 2.3 % to 2 % was found higher compared to *Avicennia marina* 1.98% to 1.90%.

4.7. Organic Carbon content in Macrobenthos

Table OC 5. Station wise and season wise variations in Organic carbon in macrobenthos (In percentage %)

Organic carbon (%)	IA	IB	Average	IIA	IIB	Average
Monsoon	7.87	0.18	4.02	4.55	0.15	3.19
Post monsoon	7.9	1.89	4.89	7.9	0.63	4.58
Premonsoon	13.19	0.44	6.81	0.15	0.15	3.48
Average	9.65	0.84	5.24	4.2	0.31	3.75

The average organic carbon content at station I was observed significantly high 5.24 % than that of staion II 3.75 %. Also Among station IA and station IB of station I, the percentage organic carbon was 9.65 at station IA and 0.84 at station IB. During the study of macrobenthos the density of polycheates was recorded high at station IA.

Thus it can be stated that due to sewage water influence the density of polycheates was increased which also might have contributed to high organic carbon at station IA .Polychaetes are usually the most abundant taxon in benthic communities and have been most often utilized as indicator species of environmental conditions. (Dean 2008) Also station IA composed of considerable density of *Sonneratia apetala*.

5. CONCLUSION

Most leaf production enters the detrital pathway as litter fall (Saenger 1993). Leaves and, to a lesser extent, twigs, branches, and bark are shed as litter throughout the year. Reproductive parts are shed seasonally. Litterfall, which is negatively correlated with latitude, ranges from 5 to 70 mol C m-2 y-1 (mean = 32; Ref. Twilley 1992).

Thane creek is rich in organic carbon due to natural and anthropogenic sources of organic matter The organic carbon accumulated is therefore stored in the ecosystem for certain time before it is released and recycled back to the atmosphere.

Mangroves are carbon sinks but are being increasingly cleared by human beings. Only mangroves can provide a natural control of eroding shoreline and increasing tidal amplitude due to global warming. Coastal biodiversity including the million migratory birds that visit Mumbai are housed by the mangroves. Despite of its importance mangroves are under major threats today. Some of the major causes are:

- Land reclamation - Most industrial houses, developers, builders are reclaiming the mangrove lands illegally.
- Pollution - There are over 200 non point sources of industrial and domestic waste discharges that pollute entire water around the city - 6 times more than the assimilation capacity.
- Under the name of "development" creeks, rivers and other water bodies are altered in shape, size and course.

Thus Conservation of mangroves will increase fixation of atmospheric carbon and carbon accumulation in the form of organic matter that enters sediment through litter fall and residing mancrobenthos density. Destruction of mangroves results in the oxidation and release to the atmosphere of the organic carbon stored in the sediments.

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