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Biomarker pigment signatures in Cochin back water system – A tropical estuary south west coast of India

N. Aneeshkumar*, C.H. Sujatha

Department of Chemical Oceanography, Cochin University of Science and Technology, Cochin 682 016, Kerala, India

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ABSTRACT

Sedimentary biomarker pigments around Cochin estuary situated in the southwest coast of India were determined by HPLC. Fucoxanthin, an indicator of diatom was observed to be the most abundant carotenoid pigment in the estuary. Dinoflagellate derived carotenoid pigment peridinin was confined in the southern part of estuary and zeaxanthin pigment indicative of cyanobacteria were more found in sites influenced by anthropogenic activities. One compound having close similarity to fucoxanthin was also detected. Alloxanthin (cryptophyceae), chl b (green algae), canthaxanthin, neoxanthin, lutein and peridinin isomer were also detected by spectra and corresponding algal class were identified. The highest concentration of chl a (11.01 μg g^{-1}) found near to the anthropogenic affected area while the lowest chl a (0.65 μg g^{-1}) was recorded in industrial area. Degradation products of chl a, such as pheophorbide and pheophytin were observed and principal mode of mechanism of degradation were derived. Higher pheopigments content than chl a, reflects a density trapping of dead cells and early degradation of phytopigments from grazing activities.

1. Introduction

Estuaries are dynamic water bodies characterized by temporal changes occur over a spectrum of scales, ranging from short-term (hourly) driven primarily by tidal currents to long-term (seasonal or intra annual) caused by meteorological forcing or river discharge. In most tidal estuaries, the difficulty encountered in field observation is mainly due to the very variable stratification of water according to river flow and tidal coefficient. Therefore to distinguish and better understand the long-term development of estuarine ecosystems it is necessary to perform observations at different temporal scales. Some of the most direct indicators of estuarine development are the kinetics of carbon turnover and net primary production i.e. measurement of the preserved organic matter in sediments. (Wetzel, 1983; Dean, 1999). Earlier workers also reported (Bloesch et al., 1988) that about 10% of the estimated net primary production was deposited as organic carbon. Therefore, several studies in the marine system have looked for qualitative and quantitative relationships between the biomass abundances of the different phytoplankton class. Many methods of varying accuracy are available for phytoplankton analysis ranging from microscope to remote sensing.

Identification and enumeration of phytoplankton is usually done through microscopic examination which are mostly confined to micro (>2–200 μm) and nano (2–20 μm) plankton size. This procedure is time-consuming and also requires a high level expertise and taxonomic skill. Moreover, smaller organisms such as picoplankton (<2 μm) cannot be identified or counted with this approach. Conversely diagnostic biomarker pigment signatures can easily be studied to know the phytoplankton composition and their physiological status starting from old Paper Chromatography to spectrophotometric or fluorometric then recently by HPLC methods.

Recently these photosynthetic pigments markers have been used to a greater extent in oceanography for the quantification of the major taxonomic groups of phytoplankton and their degradation mechanisms (Barlow et al., 1997; Vidussi et al., 2001; Roy et al., 2006; Uitz et al., 2006) and individual carotenoids can be used as indicators of specific algae classes (Hodgson et al., 1997; Jeffrey et al., 1997). Indicator carotenoids include fucoxanthin (diatoms), diatoxanthin and diadinoxanthin (diatoms, dinoflagellates), alloxanthin (chryptophytes), lutein (green algae and higher plants), zeaxanthin (cyanobacteria) and peridinin synthesized by dinoflagellates (Johansen et al., 1974). Chlorophyll b (chl b) commonly ascribed to green algae while the β carotene and chlorophyll a (chl a) are more general indicators of total algal abundance.

* Corresponding author. Present address: AquaChem Industries, PO Box 75837, Manama, Kingdom of Bahrain.
E-mail addresses: akncusat@gmail.com (N. Aneeshkumar), drchsujatha@yahoo.co.in (C.H. Sujatha).

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However, selective loss of pigments with different stabilities during deposition can affect the relative abundance of specific carotenoid pigments (Sanger, 1988; Hurley and Armstrong, 1990; Leavitt, 1993; Cuddington and Leavitt, 1999; Bianchi et al., 2000). Distribution of major taxonomically significant pigments across micro algal Divisions/Classes were given in the Table 1.

The pigment-derived classes defined here do not strictly refer to the true size of phytoplankton as can be the case for studies based on chlorophyll size fraction. HPLC based pigment analysis may be insufficient for understanding the finer scales of phytoplankton dynamics and cannot generally be used to make taxonomic distinction with in the class. Certainly no single methodology or technique is ideal for resolving all the information relevant to the structure and dynamics of a phytoplankton community. Appraisal of present literature reveals that very little information is available on these aspects in the back waters of south west coast of India. Considering these in view, the current article focused to study the distribution of fossil pigments and their taxonomy in surface sediments situated in the Cochin back water systems.

2. Materials and method

2.1. Study area

The study area located in the Cochin backwaters, along 9° 58″ N to 10° 10″ N and 76° 10″ E to 76°30″ E and forma multitudinal hydrographic system along the Kerala coast on the south west coast of India (Fig. 1).

The back water system covers an area of approximately 300 km^2 with one permanent bar mouth maintained at 12 m depth at Cochin and two seasonal openings during the peak monsoon period. The estuary is 16 km wide in the Vembanad lake area and there are several narrow canals along with those emptying municipal waste and other particulate organic matter into the estuary. Several major rivers Periyar, Muvattupuzha and Pampa discharge freshwater into the estuarine system. This estuary was classified as a tropical positive estuary, prone to strong tidal currents. The character of the estuary is also influenced by the adjoining rivers, altogether giving rise to seasonal and tidal fluctuations of hydrological conditions.

Station one (S1), (9″ 58′ 084 N 76″15′ 498 E) is near to Cochin port; Station two (S2), (9″ 58′ 34 N 76″ 16′ E) is Bolgatty Island in the middle of estuary 500 m away from the above site a popular tourist haunt. The station three (S3), (9″ 57′ 387 N 76″ 19′ 579 E) is in the Champakara canal in close proximity to a fish market which is highly polluted. The waste from the fish market is habitually drained into the canal. Moreover waste from Cochin Corporation sites and urban and domestic wastes also considerably affect the pollution status of the canal. Fourth station (S4), Cheranellur ferry (10″ 04′ 350 N 76″14′968 E) is also in the Periyar River. The ferry connects Cheranellur to Varapuzha and to Eloor. One of the largest industrial manufacturing centers, the Udyogmandal Industrial Estate, is located on the branch of the river periyar which passes to the north of Eloor, an island in the upper tidal reaches of the river. Industrial chemicals, leather and other goods are manufactured here. Many of the factories are located on the mainland, but several others are clustered on the north of the island, including FACT

Table 1
Distribution of major and taxonomically significant pigments across micro algal Divisions/Classes.

Pigments*		Cyanobacterial radiation		Green lineage			Red Lineage								
		Cyanophyta (Cyanobacteria)	Prochlorophyta	Chlorophyta	Prasinophyta	Euglenophyta	Rhodophyta	Cryptophyta	Bacillariophyta	Chrysophyta	Raphidophyta	Eustigmatophyta	Haptophyta	Dinophyta	Prymnesiophyceae
Chlorophylls															
Chlorophyll a	Chl a	■					■	■	■	■	■	■		■	
Chlorophyll b	Chl b			■	■	■									
	Chl c1								■		■				■
	Chl c2							■	■	■	■			■	■
	Chl c3									■					■
	MgDVP		T		■										
Carotene	[Caro]														
Old terminology	IUPAC														
α	β, ε		□	T	□			□				□			T
β	β, β	□	□	□	□	□			T	T	■	■		T	T
γ	β, ψ			T											
Xanthophylls															
Alloxanthin	[Allo]							■							
Antheraxanthin	[Anth]			T	T	T									
Astaxanthin	[Ast]			T											
But-fucoxanthin	[But-fuco]									■					■
Canthaxanthin	[Cantha]	T		T								T			
Crocoxanthin	[Cro]								T						
Diadinoxanthin	[Diadino]					■			■	■	■			■	■
Diatoxanthin	[Diato]					T			T	T	T			T	T
Dinoxanthin	[Dino]													□	
Fucoxanthin	[Fuco]						■		■	■			■		■
19′ Hex-fucoxanthin	[Hex-fuco]														■
Lutein	[Lut]			■	□										
9′-cis neoxanthin	[Neo]			■	■	T									
Peridinin	[Perid]													■	
Prasinoxanthin	[Pra]				■										
Violaxanthin	[Viola]			■	■							■			
Zeaxanthin	[Zea]	■	■	□			■					T			

* Code: ■ = major pigment (>10%); □ = minor pigment (1–10%); T = trace pigments (<1%) of the total Chlorophyll and Carotenoids, Jeffrey et al. (1997), Wright (2005).