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PARTICULATE CARBOHYDRATE IN THE EUPHOTIC ZONE OF THE BAY OF BENGAL

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ABSTRACT

Particulate matter collected from the Bay of Bengal was analysed for carbohydrate and chlorophyll *a*. The distribution of chlorophyll *a* was different from that of carbohydrate. Chlorophyll *a* increased from north to south, whereas carbohydrate levels were higher in the northern Bay region. Carbohydrate/chlorophyll *a* ratio varied over a wide range (7.7 to 3350). The variations in carbohydrate/chlorophyll *a* ratio are attributed to differences in runoff from land.

INTRODUCTION

Measurement of particulate organic carbon in the world oceans have been made in many regions (Menzel, 1967; Raily, Van-Hemert and Wangersky, 1965; Menzel and Ryther, 1970) and have formed a basis for understanding the distribution of particulate organic carbon. However, there have been fewer studies on organic compounds such as carbohydrates, proteins and lipids.

A study of carbohydrates in particulate matter may provide a new insight into the distribution and fate of particulate organic matter in the sea. Handa and Yanagi (1969) determined the carbohydrate content of particulate matter in several regions of the northwest Pacific Ocean. Hitchcock (1977) studied the distribution of particulate carbohydrate in the upwelling zones off West Africa. Practically, no information is available in the Indian Ocean region.

This communication deals with the distribution of suspended carbohydrate from the euphotic zone, based on the data collected during the 37, 38, 39 and 40th cruises of R.V. *Gaveshani* in the Bay of Bengal during the period August-September, 1978. The distribution has been discussed particularly in relation to chlorophyll *a* representing the phytoplankton in the euphotic layer, which significantly contributes to the particulate carbohydrate.

MATERIAL AND METHODS

Samples were collected from 29 stations (Fig. 1) using a Van Dorn Sampler at 5 depths corresponding to 100%, 60% 30% 16% and 1% of incident (surface) illumination. Percent light attenuation was determined using a Kahlsico submarine photometer or a Secchi disc.

Samples were filtered on Whatman GF/D glass fibre filters (pore size 0.5 μm). Carbohydrate was estimated by phenol-sulphuric acid method as suggested by Hitchcock (1977). Dried filters were hydrolysed with 80% H_2SO_4 for 20 hrs at room temperature after which 2 ml of phenol (2·5%) and 10 ml of hydrazine sulphate (0·5%) were added to the hydrolysates with immediate mixing. The intensity of the resulting colour was measured at 490 nm in a Spekol Spectrophotometer. A Turner type fluorometer was used to estimate the fluorescence in 90% acetone extracts of the chlorophyll *a* in the dried filters.

RESULTS AND DISCUSSION

Fig. 1 represents the area under investigation which has been divided into three regions, *i. e.*, northern, central and south. Eachern region is further grouped into two zones, *viz.*, inshore (upto 200 m depth) and offshore (>200 m depth).

Northern region: In the inshore water particulate carbohydrate values varied from 10.4–174.2 μg/l (Table I). The minimum was obtained at 1 m depth whereas maximum was at 50 m depth. In the offshore region carbohydrate concentration varied from 3·9–129·35 μg/l. Minimum value was observed at 38 m whereas maximum at 25 m depth (Table I).

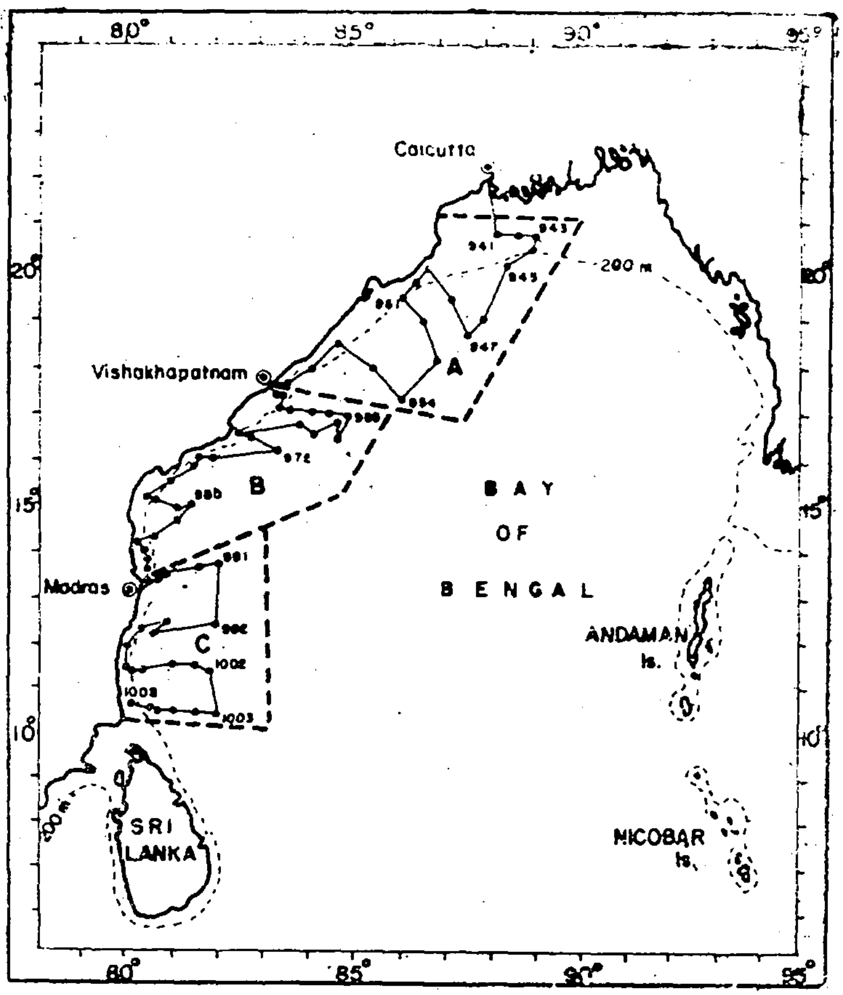

Fig. 1. Map showing the location of stations: A. Northern Region, B. Central Region and C. Southern Region.

Central region: The carbohydrate values in the inshore waters ranged from 29.9–106.6 μg/l with the minimum at 1 m and maximum at 5 m depth (Table I). In the offshore waters the concentration varied from 22.1–200 μg/l; minimum being at 20 m depth and maximum at 40 m (Table I.

Southern region : Carbohydrate values ranged from 9.75–239.2 μg/l for inshore and 7.8–122.2 μg/l for offshore region (Table I). For inshore region minimum value at 2 m depth and a maximum was noted at 50 m depth. In the offshore waters minimum concentration was at 50 m and maximum concentration was at 40 m.

The values of particulate carbohydrate showed considerable variation within the surface and 7 m which was the maximum limit of euphotic zone in the present study. In general, the carbohydrate values for the entire water column were more in the northern region decreasing southwards.

Variations in the vertical distribution of the mean value of carbohydrate and carbohydrate/chlorophyll *a* ratio from 29 stations are shown in Tables I and II. The vertical distribution was erratic and did not show any particular trend, which might perhaps be attributed to the variations in the concentration of suspended matter. At all the stations the vertical profiles of carbohydrate/chlorophyll *a* ratio showed very wide range. The carbohydrate/chlorophyll *a* ratio for the depths sampled ranged from 7.7 to

Table I. Distribution of particulate carbohydrate in different regions of the Bay of Bengal.

	NORTHERN REGION		CENTRAL REGION		SOUTHERN REGION	
Depth (m)	Inshore (Average con. μg/l)	Offshore (Average con. μg/l)	Inshore (Average con. μg/l)	Offshore (Average con. μg/l)	Inshore (Average con. μg/l)	Offshore (Average con. μg/l)
0	67·21	71·825	53·04	84·825	34·775	23·14
1	10·40	—	29·90	—	—	—
1·5	—	—	58·50	—	—	—
2	109·20	—	74·10	63·70	9·75	—
3	43·87	—	57·20	—	49·40	—
4	42·90	—	48·10	—	—	32·50
5	51·675	81·250	106·60	66·138	57·2	16·25
6	51·185	—	—	55·90	19·50	—
7	—	17·55	59·367	—	—	—
8	—	—	76·70	—	—	58·50
10	83·85	94·90	—	77·74	44·85	25.35
12	11·70	—	—	—	—	—
15	68·25	14·625	103·90	—	40·30	33·80
16	—	—	92·30	—	—	—
20	80·60	—	41·60	22·10	31·85	48·317
25	48·10	129·35	—	73·45	46·80	23·40
30	113·10	—	55·90	—	42·90	—
35	—	24·05	—	—	—	22·533
38	—	3·90	—	—	—	—
40	67·60	—	39·00	200·20	12·35	122·20
45	—	—	—	—	—	—
50	174·20	88.40	—	89·05	239·20	7·8
75	—	56·875	—	—	—	18·417

3350· These variations indicate the existence of significantly higher concentrations of carbohydrate not associated with living matter in certain regions· This material may be of detrital origin resulting from the degradation of dead organic matter in the overlying surface water· Such exceptionally high values of carbohydrate/chlorophyll *a* ratio probably result from an accumulation of detrital carbohydrate or derived from suspended sediment or both· At certain locations, this ratio declined with depth· At station 950, the value ranged from 543 at 0 m depth to 7·7 (12 m) and 3 (25 m)· Such a decrease in ratio was influenced by chlorophyll *a* maxima· From 30 m onward the chlorophyll *a* had decreased markedly·

Concentration of particulate matter in a given area of the ocean would be expected to vary seasonally if the material formed in the euphotic zone sinks rapidly into deeper layers· The size and chemical composition of sinking particle would decrease and would change with depth if they were oxidized or dissolved· Horizontal transport of water with varying concentrations of particulate matter in the area would be expected to produce spatial variations that might or might not be seasonal·

The concentration of total carbohydrate in the area of observation was generally less than those reported for the estuarine waters but greater than those recorded from the open ocean region (oligotrophic waters)· Kamat (1976) reported 0·2 to 0·6 mg/l of particulate carbohydrate in the estuarine waters around Goa· Marshall and Orr (1964) reported a maxima of 315 to 1800 μg/l of particulate carbohydrate in Lock Striven

Table II. Carbohydrate-chlorophyll ratio in different regions of the Bay of Bengal·

	NORTHERN REGION		CENTRAL REGION		SOUTHERN REGION	
Depth (m.)	Inshore (Av. ratio)	Offshore (Av. ratio)	Inshore (Av. ratio)	Offshore (Av. ratio)	Inshore (Av. ratio)	Offshore (Av. ratio)
0	663·42	667·78	221·31	1132·313	436·67	406·46
1	20·80	—	38·15	—	—	—
1·5	—	—	38·08	—	—	—
2	253·95	—	99·46	320·10	29·82	—
3	229·69	—	147·21	—	809·84	—
4	304·25	—	632·90	—	—	—
5	396·81	924·29	543·88	1458·75	209·00	559·93
6	454·53	—	—	185·70	219.43	—
7	—	210·54	150·397	—	—	—
8	—	—	871·60	—	—	—
10	1427·97	808·85	—	798·37	173·76	874·14
12	7·7	—	—	—	—	—
15	631·94	78·77	236·94	—	30·08	676·00
16	—	—	56·54	—	—	—
20	—	—	115·60	474·12	158·89	940·18
25	555·385	2093·08	—	379·43	30·08	835·71
30	555·12	—	588·42	—	54·65	—
35	—	106·46	—	—	—	783·23
38	—	—	—	—	—	—
40	258·02	—	157·26	1275·16	425·86	—
45	—	—	—	—	—	—
50	3350·00	1912·65	—	602·37	1044·54	251·61
75	—	837·995	—	—	—	314·85

Biggs and Wetzel (1968) observed high particulate carbohydrate concentration 300–910 μg/l, associated with the halocline. In this detrital rich area there was no significant correlation between chlorophyll *a* and particulate carbohydrate. Handa and Yanagi (1969) reported a range of 10 to 26μg/l of carbohydrate carbon for the surface waters of Kuroshio current with slightly higher values in the Oyashio area and 13 to 39 μg/l particulate carbohydrate in the open ocean surface water of the Pacific off Washington and Oregon. Hitchcock (1977) reported 50 to 150 μg/l of particulate carbohydrate in the upwelling area of West Africa. It is apparent that the values in the present study were intermediate between the estuarine and oceanic values which are possibly the result of productivity of these water being greater than that of the open ocean water or due to the contribution of terrestrial and sedimentary sources. The variation of particulate carbohydrate may be because of degradation and utilization of carbohydrate by diatoms as they sink down the euphotic zone. Such utilization was proposed by Handa and Yanagi (1969) in explaining the decrease of glucose with depth in diatoms dominated Pacific waters. As phytoplankton and zooplankton contribute only 8·4% of POC (Radhakrishna, 1978' personal communication) the high proportion of carbohydrate seems to be associated with terrigenous material.

It is interesting to note that the distribution of particulate carbohydrate is quite dissimilar to that of chlorophyll *a*. While chlorophyll *a* increases from north to south, particulate carbohydrate showed a decrease which is probably due to dilution and a large amount of land runoff brought by large river in the northern region, contributing to particulate carbohydrate. The productivity of this area is relatively low (666 mgC/m²/day, Radhakrishna, personal communication). The riverine contribution in the southern region is less as is evident from the higher saline condition and productivity (1408 mgC/m²/day, Radhakrishna, personal communication).

The carbohydrate/chlorophyll *a* indicate that the terrestrial and sedimentary input was much greater than that of phytoplankton presumably because of the huge quantities of terrigenous particles brought in by the Ganges and Brahmaputra river. While studying the distribution of chlorophyll *a* in the Indian Ocean, Qasim (1978) observed the wide variation of chlorophyll *a* in northern and southern regions which were attributed to land-mass effect. Radhakrishna (personal communication) while studying the distribution of particulate organic carbon from the Bay of Bengal considered phytoplankton carbon as only 4% of POC. This would explain the irregularity in the carbohydrate/chlorophyll *a* ratio.

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