

## Distribution of particulate organic carbon in the central Bay of Bengal

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**Abstract.** Particulate organic carbon (POC) was measured for 77 water samples collected over a 3000 m water column along 88° E in the central Bay of Bengal. The POC values varied from 80 to 895  $\mu\text{g}$  per litre at the surface and 171 to 261  $\mu\text{g}$  per litre at 2000 m. The POC decreased with increasing water depth at all the stations. Deep water concentrations of POC were higher than those reported from other oceanic waters. Distribution of POC was not influenced by water masses. The POC was not significantly correlated with chlorophyll *a*.

**Keywords.** Particulate organic carbon; Bay of Bengal; chlorophyll *a*.

### 1. Introduction

Earlier studies on particulate organic matter (POM) of small particles ( $< 50 \mu\text{m}$ ) collected by conventional sampling bottles produced contradictory results. In his review, Riley (1970) argued that POM is biodegradable and varied spatially and temporally. Subsequently, Menzel (1974) opined that POM is refractory and homogeneous below a depth of 300 m water column. However, studies using  $\delta^{13}\text{C}$  data indicate that the former is the case (Eadie and Jeffrey 1973; Eadie *et al* 1978). Recent studies based on a large number of samples and covering wider geographic areas demonstrate that particulate organic carbon (POC) generally decrease with water depth (Gordon and Cranford 1985; Wangersky 1976; Copin-Montegut and Copin Montegut 1983), show a small scale variability (Wangersky 1974; Gordon *et al* 1979) and are correlated with surface primary productivity (Wangersky 1976; Gordon 1977).

As compared with the large POC data collected over the years from different oceanic regions, very little information is available on the POC distribution in the oceanic waters of the Bay of Bengal. Few studies carried out earlier are restricted to the euphotic zone (Radhakrishna 1978; Radhakrishna *et al* 1978; Bhattathiri *et al* 1980).

This paper presents the data on the distribution of POC in the oceanic waters (0 to 3000 m) of the Bay of Bengal. The general feature emerging from the results are compared and discussed with the data collected from other oceanic regions.

### 2. Materials and methods

Seawater samples were collected using Niskin water samplers (5–10 l) from surface to 3000 m depth at nine stations during 19th cruise of ORV SAGAR KANYA in the central Bay of Bengal from 10 October to 15 November 1985 (figure 1). For POC analysis, duplicate aliquots of 1 to 1.5 l were filtered through precombusted (450°C,

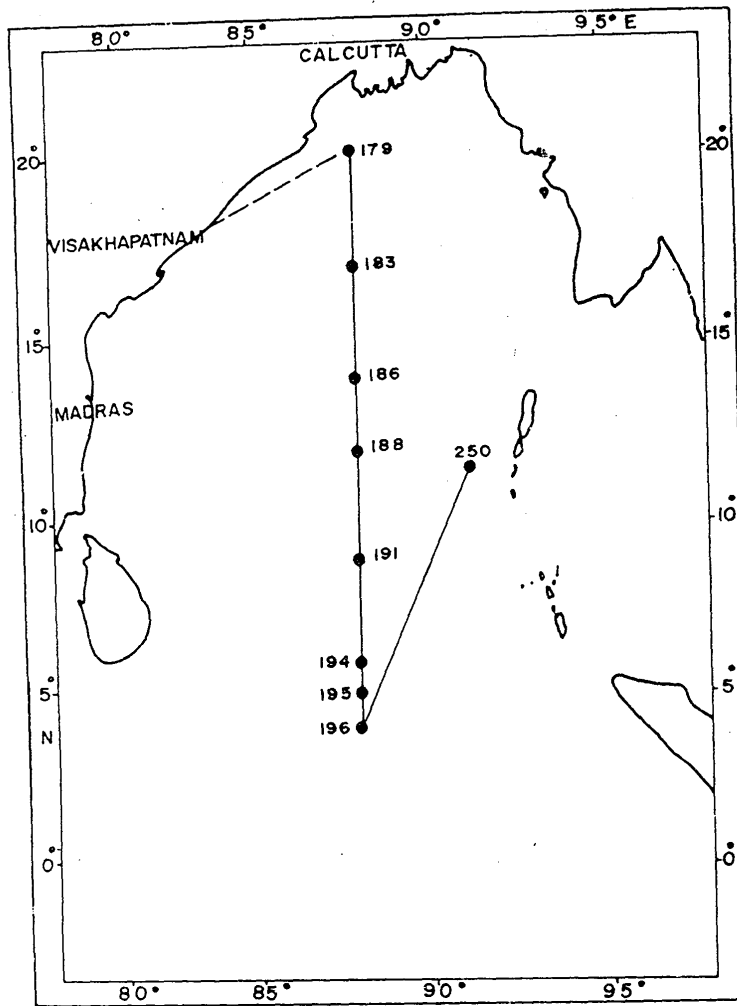


Figure 1. Location of sampling sites.

3 hr) 47 mm GF/C (1.0  $\mu\text{m}$  pore size) glass fibre filters. The suspended matter left on the filters was analyzed for POC and Chl *a*.

The POC was analyzed spectrophotometrically after wet oxidation of carbon by acid dichromate (Parsons *et al* 1984). The precision of the method at 50  $\mu\text{g C}$  was  $\pm 1.2$  ( $n = 6$ ). The Chl *a* concentration was also measured spectrophotometrically after extracting with 90% acetone (Parsons *et al* 1984). The precision of the analysis at 5  $\mu\text{g l}^{-1}$  was  $\pm 0.2$  ( $n = 5$ ). The Chl *a* values were not corrected for pheopigment. Temperature and salinity data were collected using ME-Multisonde CTD profiling system installed on board. The accuracy of the measurement of the system was temperature  $\pm 0.02$  and salinity  $\pm 0.01/\text{‰}$ .

### 3. Results and discussion

Particulate matter collected from the central Bay of Bengal was analyzed for POC and Chl *a*. In the upper 100 m water column, POC concentrations ranged from 80 to 895  $\mu\text{g l}^{-1}$  ( $\bar{x} = 443 \pm 160 \mu\text{g l}^{-1}$ ;  $n = 45$ ). These values are in the same range

as those reported earlier (Radhakrishna 1978; Radhakrishna *et al* 1978; Bhattathiri *et al* 1980). The mean surface concentration of POC decreased regularly with increasing depth upto 2000 m (figure 2). At 2000 m these values varied from 171 to 261  $\mu\text{g l}^{-1}$  ( $\bar{x} = 205 \pm 37 \mu\text{g l}^{-1}$ ;  $n = 4$ ). A single observation at 3000 m showed a small increase in POC concentration (figure 2).

Throughout the water column, POC concentrations showed large variations at all the stations and were similar to those reported for other oceanic regions (Gordon *et al* 1979). Such spatial differences could be either due to variations in the surface primary production or allochthonous organic matter inputs at these stations. Despite these large variations, POC concentration decreased with increasing depth at all the stations (figure 2). This gradual decrease with depth indicates biological utilization as particulate matter settles to the sea floor (Gordon and Cranford 1985).

A considerable differences of opinion has arisen regarding the distribution of POC in the deep waters. Menzel (1974) concluded that the distribution of POC in deep waters is homogeneous in depth, time and space, while others have reported regional and vertical variabilities of POC (Riley 1970; Wangersky 1976; Gordon 1977; Copin-Montegut and Copin-Montegut 1983; Gordon and Cranford 1985). Vertical distribution of POC in the Bay of Bengal suggests that the latter is the case.

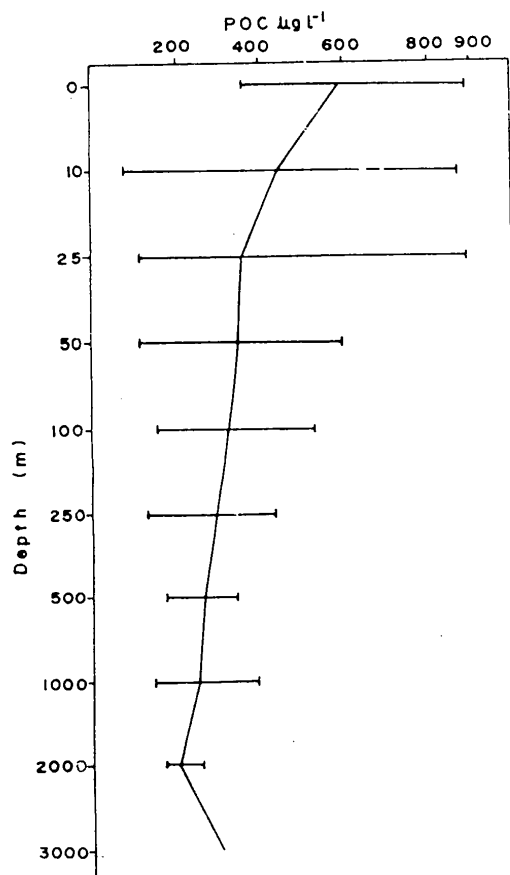


Figure 2. POC concentration vs depth profiles from the oceanic waters of the Bay of Bengal. Bar value indicates the range variations, the central value being the mean.

Table 1. Watermasses and POC in the Bay of Bengal.

Watermass	Depth (m)	Salinity (‰)	Temperature (°C)	n*	Mean POC $\mu\text{g l}^{-1}$ (Range)
Bay of Bengal subtropical water	0-100	31.22-35.04	20.50-29.16	45	443.57 $\pm$ 160 (80.1-895.85)
A mixture of Persian Gulf and Red Sea water	250-1000	34.98-35.09	6.48-13.24	18	270.68 $\pm$ 89 (131.8-436.5)
Indian Ocean deep and bottom water	> 1000	34.74-34.8	1.61-2.87	5	262.83 $\pm$ 55 (171.4-361.7)

\*Number of samples

The POC values of the Bay of Bengal are comparatively higher than those reported from other seas and oceans (Menzel 1974; Wangersky 1976; Gordon 1977; Gordon and Cranford 1985). Higher values were in fact expected because surface primary production is high in the Bay of Bengal (Qasim 1977). Moreover large amount of suspended matter containing high organic matter is introduced into the Bay by six major rivers flowing through the various geological formations of Indian subcontinent (Rao 1985). Probably this high amount of organic matter and primary production are responsible for the higher values of POC observed here.

In order to assess the influence of hydrographical features on the distribution of POC, temperature and salinity data were collected. These values were used to characterize the water masses (Mamayev 1975). Three well-defined water masses were identified (table 1). Based on this, water column was divided into surface (< 100 m), intermediate (250 to 1000 m) and deep waters (> 1000 m). Irrespective of water mass, the mean and range of POC decreased in these depth groups (table 1). This strongly suggests active transport of POC from surface to deep water rather than advection of water masses containing higher and lower levels of POC.

Phytoplankton biomass (as Chl *a*) is generally the main source of POC in the marine environment. A simple regression analysis between Chl *a* and POC was used to find out the contribution of Chl *a* carbon to POC. A non-significant relationship ( $r = 0.20$ ;  $n = 45$ ;  $Y = 428.80 + 45.10 X$ ) between these two parameters suggests that not much of Chl *a* carbon was associated with POC. On the other hand, this indicates that POC is detrital in nature.

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### References

- Bhattathiri P M A, Devassy V P and Radhakrishna K 1980 Primary production in the Bay of Bengal during southwest monsoon of 1978; *Mahasagar-Bull. Natl. Inst. Oceanogr.* **13** 315-323

- Copin-Montegut C and Copin-Montegut G 1983 Stoichiometry of carbon, nitrogen and phosphorus in marine particulate matter; *Deep Sea Res.* **30** 31–46
- Eadie B J and Jeffrey L M 1973  $\delta^{13}\text{C}$  analyses of oceanic particulate matter; *Mar. Chem.* **1** 199–209
- Eadie B J, Jeffrey L M and Sackett W M 1978 Some observations on the stable carbon isotope composition of dissolved and particulate organic carbon in the marine environment; *Geochim. Cosmochim. Acta* **42** 1265–1269
- Gordon D C 1977 Variability of particulate organic carbon and nitrogen along the Halifax–Bermuda section; *Deep Sea Res.* **24** 257–270
- Gordon D C and Cranford P J 1985 Detailed distribution of dissolved and particulate organic matter in the Arctic Ocean and comparison with other oceanic regions; *Deep Sea Res.* **32** 1221–1232
- Gordon D C, Wangersky P J and Sheldon R W 1979 Detailed observations on the distribution and composition of particulate organic material at two stations in the Sargasso Sea; *Deep Sea Res.* **26** 1083–1092
- Mamayev O I 1975 *Temperature salinity analysis of world ocean waters* (Amsterdam: Elsevier) pp. 369
- Menzel D W 1974 in *The sea* (ed.) E D Goldberg (New York: Interscience) pp. 659
- Parsons T R, Matai Y and Lalli C M 1984 *A manual of chemical and biological methods of seawater analysis* (Oxford: Pergamon) pp. 63–104
- Qasim S Z 1977 Biological productivity of the Indian Ocean; *Indian J. Mar. Sci.* **6** 122–137
- Radhakrishna K 1978 Primary productivity of the Bay of Bengal during March–April 1975; *Indian J. Mar. Sci.* **7** 58–60
- Radhakrishna K, Bhattathiri P M A and Devassy V P 1978 Primary productivity of the Bay of Bengal during August–September 1976; *Indian J. Mar. Sci.* **7** 94–98
- Rao C H M 1985 Distribution of suspended particulate matter in the waters of eastern continental margin of India; *Indian J. Mar. Sci.* **14** 15–19
- Riley G A 1970 Particulate organic matter in seawater; *Adv. Mar. Biol.* **8** 1–118
- Wangersky P J 1974 Particulate organic carbon: Sampling variability; *Limnol. Oceanogr.* **19** 980–984
- Wangersky P J 1976 Particulate organic carbon in the Atlantic and Pacific oceans; *Deep Sea Res.* **23** 457–465