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DISTRIBUTION OF ORGANIC MATTER IN SHELF SEDIMENTS OFF GODAVARI, EAST COAST OF INDIA

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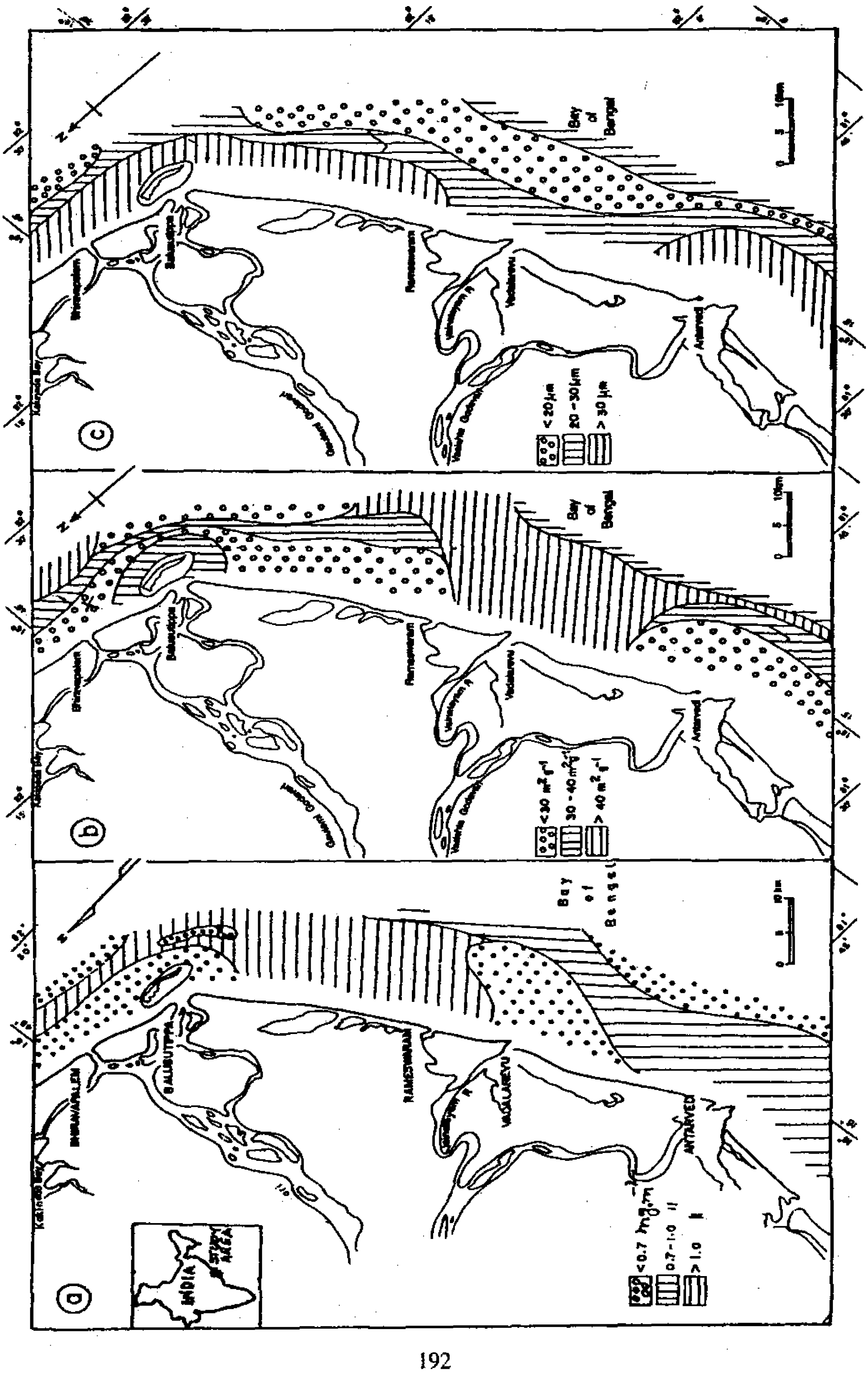
Distribution of organic matter (OM) in shelf sediments off Godavari is significantly influenced by river inputs, primary productivity, specific surface area (SSA) of sediments and hydrodynamic conditions. The OM and SSA of the sediments varied with seasons. Enrichment/depletion of OM is discussed in terms of its monomolecular coverage. Despite predominant inputs from river runoff, productivity and higher SSA, the sediments are depleted with respect to their monolayer accumulation during monsoon and pre-monsoon seasons due to relatively high energy conditions in the region. On the other hand, postmonsoon witnessed higher accumulation due to decrease in energy conditions.

Introduction

Sediments are potential sinks attracting accumulation of various materials into them. The organic matter in sediments is adsorbed on the surface of their mineral grains and thus is controlled by the size of the sediments than the distinct organic particles themselves. Keil and Hedges (1993) clearly report that the surface area of the sediment is the prime factor in controlling the rate of accumulation of organic matter in many coastal sediments, including biogenic, irrespective of the nature of adsorption, viz., physical or chemical. However, factors such as source, productivity and bottom water oxygen, sedimentation rate and burial efficiencies also influence the rate of accumulation and preservation. Though the nature of the organic matter in the shelf sediments off Godavari was studied by a few investigators (Rao, 1960; Kalesha, 1979; Krishna Rao and Swamy, 1991), the factors influencing its distribution and deposition were not investigated. Since many organic molecules that associate with mineral surfaces have great geochemical implications of the environment, an attempt is made in this paper to establish a relation between bulk organic matter and specific surface area of the sediments off Godavari River.

Methodology

Sixty sediment samples collected along 5 transects at Bhiravapalem, Balusutippa, Rameswaram, Vadalarevu, and Antervedi (Fig.1a) during May (premonsoon), September (monsoon) and January/February (post monsoon) at 10m, 20m, 30m and 50m depth contours in the inner shelf off Godavari were used to estimate the organic matter in them by wet oxidation method (Loring and Rantala, 1992). While the textural parameters were computed by standard methods (Folk, 1974), the specific surface area, y ($m^2.g^{-1}$) of the sediment was calculated from the measured percentage x of the clay fraction (<2um) using the formula $y = 1.44 + 0.59\,x$, (Rabitti et al, 1982).


a
b
c
INDIA
STUDY AREA
Kakinada Bay
BHIRAVAPALEM
BALUSUTIPPA
RAMESWARAM
VASALAREVU
ANTARVEDI
Bay of Bengal
<0.7 mg m⁻³
0.7-1.0 "
> 1.0 "
< 30 m² g⁻¹
30 - 40 m² g⁻¹
> 40 m² g⁻¹
< 20 μm
20 - 30 μm
> 30 μm
Gautami Godavari
Vasishta Godavari

Results and discussion

The measured values of organic matter (OM), surface specific area (SSA) and OM to SSA ratio, shown in the Table 1, exhibited distinct seasonal variations.The measured organic matter (OM) registered a decreasing seasonal trend from post monsoon (26. 67) to premonsoon (22.65) and to monsoon (19.76 $mg.g^{-1}$). Similarly, the mono layer accumulation (OM:SSA) of organic matter decreased from postmonsoon (1.562) to monsoon (0.612) and premonsoon(0.591 $mg.m^{-2}$). On the other hand the specific surface area (SSA) increased from postmonsoon (28.78) to monsoon (34.55) and premonsoon (38.05 $m^2.g^{-1}$). The predominant textural types of sediments in the study area comprise silty-clay and sand-silt-clay. Statistically, the organic matter is found to be inversely related to grain size, Mz (r = -0.50 at P = 99.9%) in the present study. Similar results were obtained earlier, where in the organic matter exhibited significant positive correlation with clay (r = 0.72 at P = 99.9%) and a negative correlation with sand (r = 0.48 at P = 99.9%) indicating its association with fine component of the sediment. The increase in organic carbon with specific surface area was found be independent of mineralogy of the sediment particles (Suess, 1973). Smectite which is characterized by a relatively higher reactive surface area compared to other clay minerals is the dominant clay mineral in the study region and can adsorb more dissolved organic matter. This can explain the higher concentrations of organic matter with sediments of lower grain size.

Table1: Sediment organic matter (OM), specific surface area (SSA) and monolayer accumulation (OM:SSA) in the shelf sediments off Godavari in different seasons.

Season	Depth (m)	OM ($mg.g^{-1}$)	SSA ($m^2.g^{-1}$)	OM:SSA ($mg.m^{-2}$)
Premonsoon	10	15.74	31.79	0.506
	20	25.18	38.30	0.645
	30	26.43	40.32	0.648
	50	23.45	41.80	0.564
	Average	**22.65**	**38.05**	**0.591**
Monsoon	10	18.76	32.42	0.584
	20	17.86	32.60	0.586
	30	22.87	41.37	0.555
	50	19.52	31.83	0.723
	Average	**19.75**	**34.55**	**0.612**
Postmonsoon	10	24.93	22.75	1.473
	20	21.98	27.21	1.131
	30	27.08	27.92	2.547
	50	32.70	37.25	1.098
	Average	**26.67**	**28.78**	**1.562**

Fig1: Distribution of organic matter accumulation: (a) specific surface area, (b) and grain size and (c) in the shelf sediments off Godavari.

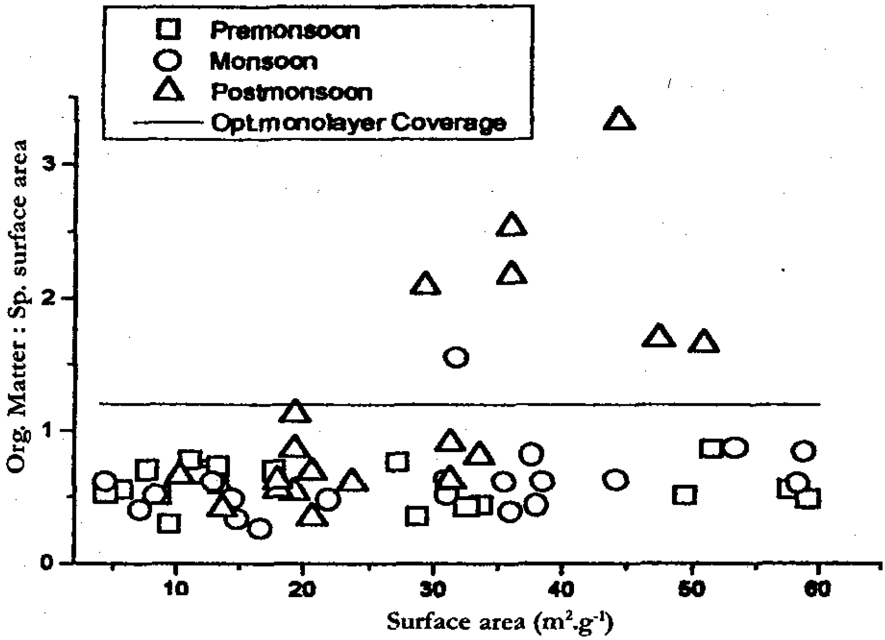


Fig 2: Dependance of organic matter accumulation on monomolecular layer coverage in shelf sediments off Godavari River.

However, specific surface area normalized organic matter offers a more meaningful source of information than the percent organic matter for interpretation and comparison of the concentrations. Further, by eliminating the mass based problems associated with traditional weight percentage measurements and textural influences on them, the organic matter enrichment in sediments with respect to surface area allows better evaluation of factors that influence its accumulation and preservation in the sediments (Keil and Cowie, 1999). Organic matter enrichment in the sediments is expressed in terms of its monomolecular layer coverage which corresponds to about 1.2 mg. m^{-2} (Keil and Hedges, 1993). Organic matter falling significantly above or below the monolayer represents the sample with either abnormally high or low organic loadings, which in turn depend on hydrodynamic sorting of carrier sediments. Simple winnowing and transport of organic rich minerals either as distinct debris or as organic matter sorbed on to mineral surfaces cannot fully account for the regional and/or seasonal differences in shelf regions. (Keil and Cowie, 1999). In the present study, accumulation of organic matter in sediments in relation to monolayer indicates a significant increase (>3) during postmonsoon and depletion during premonsoon and monsoon seasons (Fig.2).

The Indian coast experiences higher energy conditions with higher wave heights during southwest monsoon (June to September). Further, the study region enjoys relatively low energy conditions during postmonsoon compared to premonsoon and monsoon seasons (Chandramohan *et al*, 1992). Hence enrichment of sedimentary organic matter with respect to monolayer accumulation in postmonsoon, inspite of relatively low specific surface area (Table 1) can be attributed to decrease in energy conditions prevailing in this season.

Low organic matter content in the eastern continental shelf compared to world average for nearshore sediments was attributed to the low planktonic production in the overlying waters and dilution by land derived humus and detritus (Rao,1960). Low carbonate content in sediments of river-estuarine and adjoining shelf regions (Rao, 1958) also suggests dominance of land derived loading. Suspended matter derived from river estuarine system was found to be present upto 100 m depth contour off Godavari during monsoon (Rao, 1985). More than 90% of sediment transport in Indian seas occurs during July-September. Sediment trap experiments in the Bay of Bengal revealed accumulation of 40-50% of the total annual flux during southwest monsoon (Ittekot *et al,* 1991). Though river runoff contributes sediment organic matter significantly to the Bay of Bengal, the overlying waters are oilgotrophic (Sreepada *et al,* 1996) with low surface primary productivity (2.5 -11 mg C m^{-3}. day^{-1}). Pyto and zoo plankton contribute only about 8% of particulate organic carbon (POC) (Bhosle et al, 1981). It is therefore presumed that organic matter in the region is predominantly river derived, its distribution is mainly influenced by energy conditions prevailing in the region and a significant amount of it is being transported to offshore particularly during monsoon season.

The spatial distribution map (Fig.1a) of average monolayer accumulation (OM:SSA) shows that it is higher at 30m (1.26) followed by 10m (0.85), 50m (0.80) and 20m (0.77) off Godavari indicating an initial increase followed by a decrease towards open sea. This is particularly pronounced at river mouths like Vadalarevu, Balusutippa and Bhiravapalem where river discharges are high. The influence of energy conditions is also evident in the map of organic matter accumulation (Fig.1a) with relatively higher values at Rameswaram (10m) where in there is no river influence. Grain size (Fig.1c) generally decreases towards open sea with higher values at 10m (av.35.87) and lower values at 50m (av.21.31) particularly at river mouths with high river discharges namely Vadalarevu and Balusutippa and Bhiravapalem. SSA of the sediments is relatively low at Rameswaram, and Antervedi compared to Vadalarevu and Balusutippa indicating the influence of river discharges and energy conditions (Fig.1b). These observations suggest that organic matter associated with larger grains settle at 10m depth and that portion bound to fine fraction settles at 30-50 m depth. Further, the overall distribution of organic matter accumulation in the sediments which exhibits similar accumulation trends of flowing towards north east and north off the coast indicates the impact of hydrodynamic conditions. This is also supported by the earlier report of northward annual net transport of sediment along the east coast (Chandramohan and Nayak, 1991).

Conclusion

The study revealed that monomolecular layer coverage (adsorption) and hydrodynamic conditions prevailing in the region seem to have a significant influence on the accumulation of sedimentary organic matter in addition to river inputs and productivity in the water column. Although, there is a higher input of land derived organic matter during monsoon, prevailing high energy conditions in the study region do not favour its accumulation. Postmonsoonal enrichment is attributed to decrease in the energy conditions, in spite of relatively low specific surface area of the sediment.

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