DISTRIBUTION OF TOTAL PHOSPHORUS IN THE SHELF SEDIMENTS OFF THE WEST COAST OF INDIA

by P. S. N. MURTY,* C. V. G. REDDY *and* V. V. R. VARADACHARI,
National Institute of Oceanography, Ernakulam

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The total phosphorous content in the sediment samples collected from different stations on the continental shelf along five sections normal to the coast near Bombay, Karwar, Mangalore, Cochin and Alleppey has been determined and the distribution studied. The study reveals that the sediments off the Kerala coast are uniformly rich in phosphorus while those off Karwar and Mangalore are relatively poor with those off Bombay coming in between. The distribution of phosphorus in these sediments has been discussed in relation to upwelling and biological productivity.

INTRODUCTION

In a marine environment the productivity depends upon the concentration and distribution of nutrients like phosphates, silicates and nitrates dissolved in water. It is an accepted fact that the bottom sediments, where the regeneration takes place in part, act as reservoirs for these nutrients under favourable circumstances. While considerable work has been done on the distribution of these nutrients in the waters of the Arabian Sea and Bay of Bengal, except for the work done by Seshappa (1953) and Seshappa and Jayaraman (1956) on the sediments in the inshore region off Calicut, practically no information is available on the distribution of phosphorus in the shelf sediments off the east and west coasts of India. Hence bottom samples collected from the continental shelves covering the regions between 'Swatch of no ground' to Karaikal in the Bay of Bengal and between Bombay and Quilon in the Arabian Sea have been analysed for their total phosphorous content and the distribution studied. Some of the results that are brought to light as a result of these studies on the distribution of phosphorus in the Arabian Sea particularly in relation to upwelling and biological productivity are presented here.

FIELD AND LABORATORY PROCEDURES

Samples of bottom sediments from the shelf and slope regions were obtained along five sections (Fig. 1) during the 25th and 26th cruises of I.N.S. *Kistna* using the Phlegar Corer and La Fond-Dietz Snapper. In the region

* *Present address*. National Institute of Oceanography, C.S.I.R. Building, Rafi Marg, New Delhi 1.

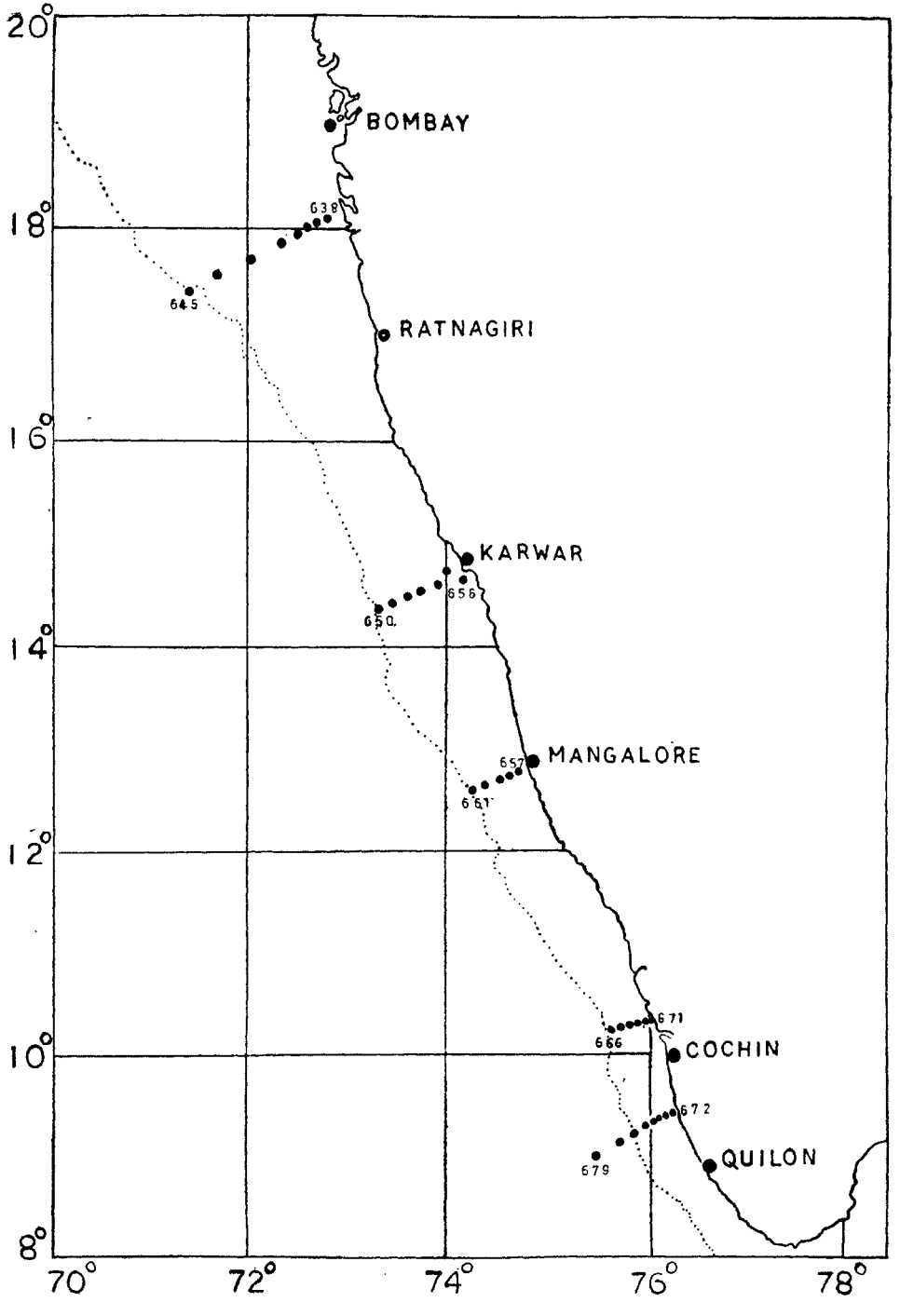

FIG. 1. Map showing the station locations.

under study, the width of the continental shelf is about 90 miles in the north and it gradually narrows down to about 30 to 35 miles in the south. A number of small rivers empty into the sea and their effect on the shelf may be very local. The sediments along the section off Bombay coast range from silty clays to silty sands in the shelf region to clayey silts in the slope region. Along the section off Karwar they range from clayey silt to silty clays and silty sands in the shelf region to clayey sands in the slope region. The sediments along the section off Mangalore range from clayey silts to silty sands. Off Cochin they range from silty clays to silty sands. Along the section off 'Ambalapuzha' (about 30 miles north of Quilon) they range from clayey silts to silty clays and silty sands. The samples collected from these five sections represent essentially the upper 12″ to 32″ in the case of core samples and the upper 4″ in the case of the snapper samples.

In the case of the core samples each core was cut into 4″ long bits and from each bit silt and clay fraction was separated from the sand fraction by wet sieving through ASTM Sieve No. 230. In the case of the snapper samples the sample was thoroughly mixed before the silt and clay fraction was separated from the sand fraction. The silt and clay fraction thus separated was dried at about 60° C in a hot air oven and then pulverized. A suitable quantity of the sample was taken and the total phosphorous content determined by the method as described by Rochford (1951). All the measurements were made on the 'Unicam' spectrophotometer at 700 mμ. The total phosphorus estimated here includes different forms of phosphates, viz. interstitial phosphate, adsorbed phosphate, organic phosphate and insoluble inorganic phosphate.

Results

The total phosphorous content has been determined on samples collected from 33 stations distributed over five sections mentioned above. In the case of the core samples depth distribution has been studied. The results obtained are shown in Table I. An analysis of the data shows that the following broad generalizations can be made in regard to the distribution of the total phosphorus in these sediments:

1. The sediments off Cochin and Alleppey coasts are uniformly rich in their total phosphorous content.

2. The sediments off Karwar and Mangalore coasts are uniformly poor in phosphorus.

3. The sediments off Bombay coast are generally richer in phosphorus than those off Karwar and Mangalore but are, with a few exceptions here and there, poorer than those off Cochin and Alleppey.

4. In the case of core samples the total phosphorous content shows no trend with depth.

TABLE I

Sl. No.	Stn. No.	Depth in fathoms	Type of sample	Sediment level in inches	Texture	Total phosphorus in micro-grams per gram of silt
Off Bombay:						
1.	638	13	Corer	0–4	Silty clay	410
				4–8	,,	320
				8–12	,,	340
2.	639	17	Snapper	0–4	Silty sand	390
3.	640	19	Corer	0–4	Sandy clay	400
				4–8	,,	560
				8–12	,,	270
4.	641	19	,,	0–4	Silty clay	740
				4–8	,,	260
				8–12	,,	1,240
				12–16	,,	420
				16–20	,,	520
				20–24	,,	810
				24–28	,,	290
5.	642	26	,,	0–4	,,	1,370
				4–8	,,	540
				8–12	,,	290
				12–16	,,	190
				16–20	,,	520
				20–24	,,	810
				24–28	,,	290
6.	643	38	Snapper	0–4	,,	760
7.	645	250	Corer	0–4	Clayey silt	350
				4–8	,,	620
				8–12	,,	1,430
				12–16	,,	1,400
				16–20	,,	1,540
				20–24	,,	570
				24–28	,,	590
				28–32	,,	810
Off Karwar:						
8.	650	110	,,	0–4	Clayey sand	240
				4–8	,,	260
				8–12	,,	280
				12–16	,,	100
				16–20	,,	180
				20–24	,,	230
				24–28	,,	170
				28–32	,,	220
9.	651	55	,,	0–4	Silty sand	330
				4–8	,,	210
				8–12	,,	200
				12–16	,,	190
				16–20	,,	310

TABLE I—*contd.*

Sl. No.	Stn. No.	Depth in fathoms	Type of sample	Sediment level in inches	Texture	Total phosphorus in micro-grams per gram of silt
10.	652	42	Corer	0–4	Silty sand	240
				4–8	,,	240
				8–12	,,	240
				12–16	,,	160
				16–20	,,	110
11.	653	32	Snapper	0–4	,,	250
12.	654	25	,,	0–4	,,	240
13.	655	12	Corer	0–4	Silty clay	110
				4–8	,,	190
				8–12	,,	130
				12–16	,,	120
14.	656	10	,,	0–4	Clayey silt	130
				4–8	,,	140
				8–12	,,	100
				12–16	,,	160
				16–20	,,	60
				20–24	,,	40
				24–28	,,	70
				28–32	,,	110
Off Mangalore :						
15.	657	10	,,	0–4	,,	180
				4–8	,,	190
				8–12	,,	330
				12–16	,,	280
				16–20	,,	430
16.	658	17	,,	0–4	,,	300
				4–8	,,	180
				8–12	,,	320
				12–16	,,	270
				16–20	,,	240
				20–24	,,	240
				24–28	,,	190
17.	659	23	,,	0–4	Silty sand	140
				4–8	,,	220
				8–12	,,	260
18.	660	43	,,	0–4	Clayey sand	230
				4–8	,,	220
				8–12	,,	260
19.	661	105	,,	0–4	Silty sand	140
				4–8	,,	120
				8–12	,,	90
Off Cochin :						
20.	666	46	Snapper	0–4	,,	1,000
21.	667	32	,,	0–4	,,	900
22.	668	23	,,	0–4	,,	680

TABLE I—*concld.*

Sl. No.	Stn. No.	Depth in fathoms	Type of sample	Sediment level in inches	Texture	Total phosphorus in micro-grams per gram of silt
23.	669	17	Snapper	0–4	Silty sand	990
24.	670	14	,,	0–4	,,	1,050
25.	671	13	,,	0–4	Silty clay	730
Off Ambalapuzha:						
26.	673	9	Corer	0–4	Clayey silt	1,322
				4–8	,,	1,115
				8–12	,,	1,221
27.	672	10	,,	0–4	Silty clay	1,137
				4–8	,,	1,410
				8–12	,,	1,010
28.	674	20	,,	0–4	Silty sand	1,979
				4–8	,,	1,054
				8–12	,,	670
				12–16	,,	1,348
29.	675	27	,,	0–4	,,	755
				4–8	,,	1,052
				8–12	,,	620
30.	676	29	Snapper	0–4	,,	521
31.	677	85	,,	0–4	,,	830
32.	678	250	Corer	0–4	,,	578
				4–8	,,	970
				8–12	,,	620
33.	679	370	,,	0–4	,,	860
				4–8	,,	950
				8–12	,,	780

DISCUSSION

The importance of upwelling as a factor giving rise to sediments rich in phosphorus has been well established. The formation of sediments rich in phosphorus on the continental shelves off the coast of Peru, Chile, South-West Africa and North America has been attributed to the phenomenon of upwelling (Dietz *et al.* 1942) followed by a slow rate of deposition of detrital matter. The existence of upwelling on the west coast of India has been brought to light by investigations of several workers (Ramamritham and Jayaraman 1960; Jayaraman and Gogate 1957; Banse 1959; Carruthers *et al.* 1959). The dependence of upwelling and sinking on the coastal currents has been stressed by Varadachari (1961). Investigations by Varadachari and Sharma (1964) on the circulation of surface waters in the North Indian Ocean show that along the different coasts in the area divergence (and hence upwelling) is associated with a

clockwise coastal circulation and convergence with a counter-clockwise circulation and that the coastal circulation is clockwise along the west coast of India from February to September. Departures from this relationship between coastal circulation and the surface divergence may occur during periods of strong on-shore or off-shore winds. Recent investigations by Reddy and Sankaranarayanan (1967) on the distribution of nutrients in the shelf-waters along the west coast of India, covering the region between Ratnagiri and Quilon during the monsoon and post-monsoon periods, reveal two distinct environmental conditions characterized by nutrient deficient layers in the post-monsoon periods and nutrient rich surface layers in the monsoon period. The nutrient levels show a general increasing trend towards the south from Ratnagiri and this distribution has been attributed to upwelling with an increasing trend towards the southern region.

The present investigation reveals that the sediments off the Kerala coast are uniformly rich in phosphorus while the sediments off the Central part of the west coast (Karwar and Mangalore region) are uniformly poor in phosphorus with the sediments off the Bombay coast coming in between. This distribution of total phosphorus in the sediments bears a close correspondence to the distribution of phosphorus in the waters and also to the differences in the abundance of sea fish. Thus the differences found in the concentration of total phosphorus in sediments in the different regions off the west coast of India may perhaps be attributed to the differences in upwelling in the different regions and to the corresponding variations in the levels of biological productivity and the subsequent chain of events of the regenerative phase such as the settling of the organic detritus to the bottom and the bio-diagenetic processes operating at the mud water interface and in the sediments. Another important factor that may have to be considered in regard to the contribution of phosphorus to the sediments is run off from land. Not much work has been done on this coast in this direction but the available information shows that the contribution from run off is negligible (Rao and George 1959).

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