

## DISSOLVED INORGANIC PHOSPHORUS AND NITROGENOUS COMPOUNDS IN THE SEDIMENTS OFF BOMBAY AND GULF OF KUTCH

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### ABSTRACT

Distribution of interstitial phosphate, nitrate, nitrite and ammonia and adsorbed phosphate in the sediments near Bombay and Gulf of Kutch areas were studied. The fractionation of phosphorus and nitrogenous compounds in the sediments seems to be related to the texture of the sediments and their proximity to the coast.

High concentration of adsorbed phosphate was found near Bombay, at the mouth of Gulf of Cambay and in the Central Gulf of Kutch. In general, the interstitial phosphate of the sediments was higher in the Gulf of Kutch. Among the nitrogenous compounds, ammonia was dominant in the interstitial waters.

The variance in the levels of these compounds in the sediments and in the overlying waters suggests controlled exchange of the compounds between the mud water and surface.

### INTRODUCTION

Productivity of a marine or estuarine environment is, in particular, related to the concentration and distribution of inorganic nutrients dissolved in water. The bottom sediments, where the dead organic matter gets deposited and where it undergoes chemical and bacterial decomposition, act as reservoir of nutrients under favourable conditions. The nutrients thus released from the sediments are made available to the upper layers of water column by physical processes such as upwelling, currents, etc. Thus, the study of the distribution of these nutrients in the sediments can help to understand the potential availability of nutrients in any particular region of interest. Some work on this aspect of the marine sediments has been reported from the east coast of India by Murty and Reddy (1968) and from the west coast of India by Jayaraman and Seshappa (1957). The present paper deals with the distribution of the nutrients in the sediments of the regions off Bombay and Gulf of Kutch.

### MATERIAL AND METHODS

Sediment samples were collected either by grab or by snapper and water samples by 'Hydrobios' watersampler during the second cruise of RV *Gaveshani*. Sediments were analysed for textural characteristics by the technique of Inman (1963). The sediment samples were frozen on board and later analysed for silt percentage and chemical analysis in the shore laboratory following the methods of Rochford (1951). A silt suspension was prepared by eluting the sediment through Endeco's 240 mesh sieve and the solution was made upto one litre. Two 100 ml aliquots of this silt suspension were drawn in two 250 ml

reagent bottles. To one bottle, 5 ml of saturated NaCl solution and to the other one 5 ml of 1N NaOH solution was added. The solutions in the two bottles were well mixed and allowed to flocculate for 24 hours. After this period, the supernatant liquid in the NaCl extract was siphoned out, diluted and used for estimating the nutrients in the interstitial water. Similarly, the supernatant liquid from the NaOH extract was siphoned out, diluted and used for adsorbed phosphate measurements. Standard methods were followed for the estimation of nutrients from the interstitial waters and adsorbed phosphate.

In order to facilitate the comparison of the concentration of nutrients in the interstitial waters with those of the overlying waters, the former were calculated in terms of  $\mu\text{g-at/l}$ , from the percentage moisture of the sediment.

#### RESULTS AND DISCUSSION

Figs. 1 & 2 show the location of the stations near Bombay and in the Gulf of Kutch areas. The nutrient data for the sediment and overlying waters wherever collected, are presented in Table I. The sediment at the stations off Bombay was mostly a mixture of sand and clay having comparatively higher moisture content while the sediment in the Gulf of Kutch was mostly silty clay having lower moisture content. At the station 26, oppo-

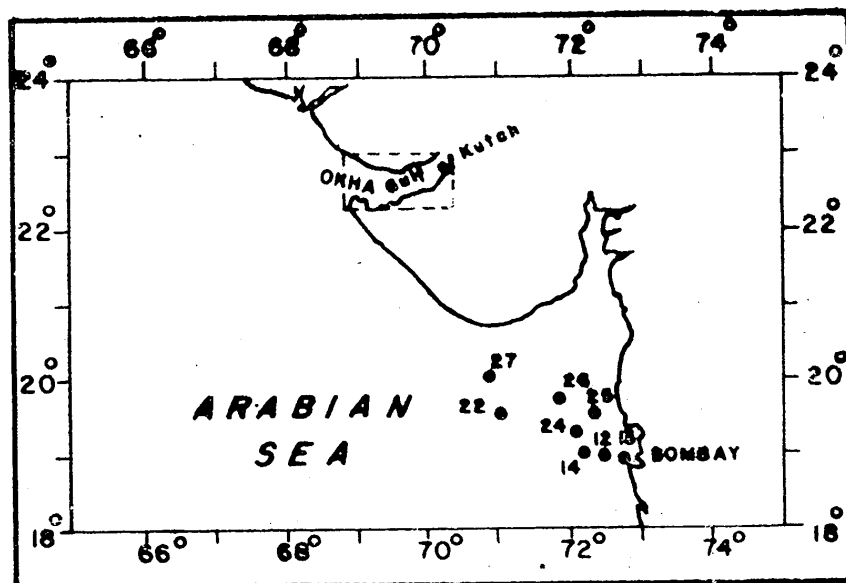


Fig. 1. Map showing station positions at Bombay region.

site to the mouth of Gulf of Cambay, the sediment had the highest moisture content (61.03% with respect to wet mud, while, the sediment with the lowest moisture content (25.9% w.r.t. wet mud) was observed at the station 54 in the Gulf of Kutch. Within the Gulf of Kutch itself, the moisture content varied from place to place, it was low (average 39.4%) at the mouth, high at midway stations (average 46.2%) and decreased again towards the head of the Gulf (average 40.8%). Silt content of the sediment showed almost a reverse relationship with moisture percentage specially in the Gulf of Kutch. It was high at the mouth (average 96.43% w.r.t. dry mud), decreased (average 71.1%) at midway stations and became low (average 67.1%) towards the head of the Gulf.

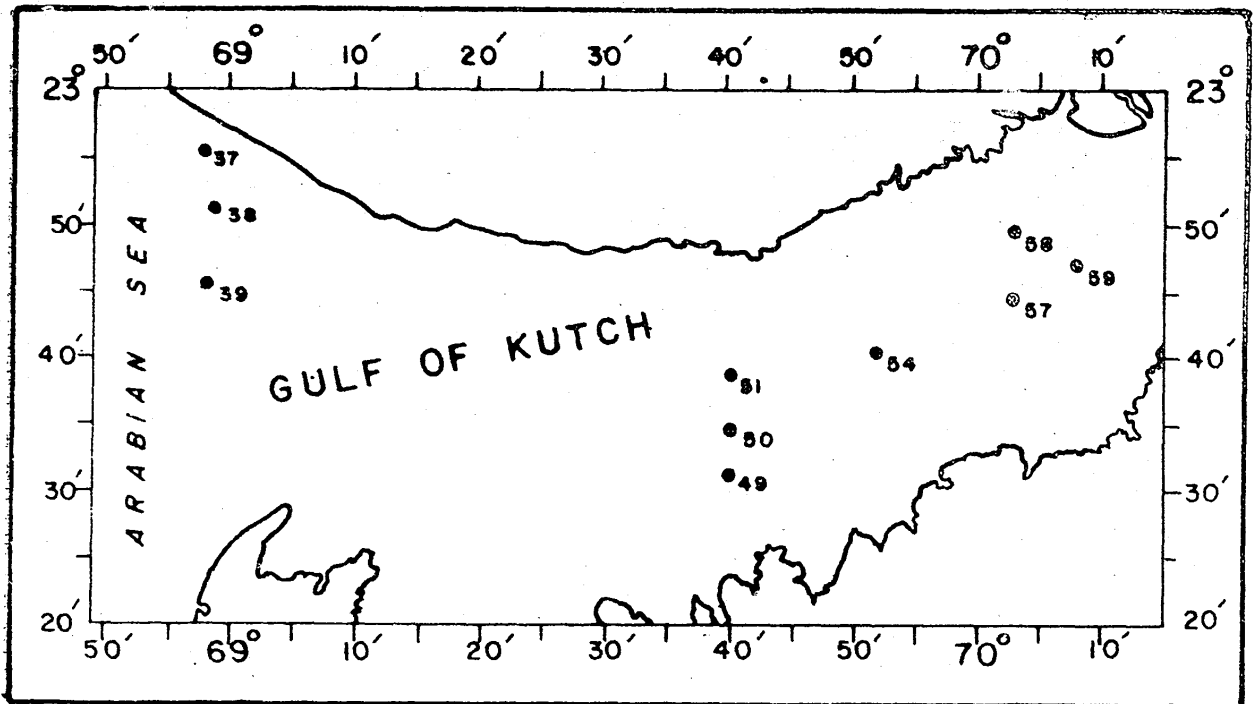


Fig. 2. Map showing station positions in the Gulf of Kutch.

#### *Adsorbed phosphate*

The concentration of adsorbed phosphate near Bombay was quite high. It varied between 4.34 and 16.43  $\mu\text{g/g}$  of silt. It can be seen from Table I that the concentration increases towards the shore. At stations 25 to 27 at the mouth of the Gulf of Cambay, the concentration of adsorbed phosphate is higher than that of the Bombay area ranging from 11.4 to 37.8  $\mu\text{g/g}$  of silt. It shows an increasing trend toward the Gujarat coast. In the Gulf of Kutch, adsorbed phosphate shows wide variations with the location from the mouth to the head of Gulf. It ranges from 4.96 to 9.92  $\mu\text{g/g}$  at the mouth (stns. 37 to 39), at midway it shows the highest concentration ranging from 22.6 to 53.0  $\mu\text{g/g}$  (stns. 51 to 54 and 57) and decreases again ranging from 7.13 to 11.47  $\mu\text{g/g}$  towards the head of the Gulf (stns. 58 and 59).

In the Gulf it is seen that the concentration is high at the centre and decreases towards the coast.

#### *Interstitial water*

Soluble inorganic phosphate in interstitial waters presents wide range of concentrations, ranging from 31.89 to 366.61  $\mu\text{g-at/l}$ . Though the maximum concentration of phosphate was observed at stn. 12 near Bombay, the general concentration in this area was found to be low (51.17  $\mu\text{g-at/l}$ ) while in the Gulf of Kutch it was high averaging 164.75  $\mu\text{g-at/l}$ . However, no spatial variations were observed in the Gulf of Kutch.

It is seen from Table I that the high concentration of 'interstitial' phosphate is associated with high silt percentage and low moisture content.

#### *Inorganic nitrogen compounds*

Of all the forms of inorganic nitrogen compounds, the ammonia nitrogen is present in the highest concentrations followed by nitrate-nitrogen. The ammonia concentration

Table I. Physico-chemical characteristics of sediments and bottom waters.

Stn. No.	Depth in metres	Nature of sediment	% moisture w. r. t. wet mud	% silt w. r. t. dry mud	Absorbed phosphate $\mu/g$ silt	Interstitial waters						Bottom water		
						$PO_4^{3-}-P$ $\mu g-at/l$	$NH_4^+-N$ $\mu g-at/l$	$NO_2^- -N$ $\mu g-at/l$	$NO_3^- -N$ $\mu g-at/l$	$PO_4^{3-}-P$ $\mu g-at/l$	$NO_3^- -N$ $\mu g-at/l$	$NO_2^- -N$ $\mu g-at/l$	$NH_4^+ -N$ $\mu g-at/l$	
12	33.5	Silty sand	40.37	59.03	16.43	366.6	1040.4	131.28	797.62	0.84	4.09	0.32	2.24	
13	15.0	Silty sand	38.26	58.18	11.78	88.86	1829.6	188.20	1173.5	0.84	1.97	0.61	2.24	
14	62.5	Clayey sand	59.60	39.40	12.71	38.59	503.3	18.46	228.2	0.59	0.96	—	—	
22	48.0	Sand	50.55	53.99	4.34	31.65	217.6	11.87	57.37	1.21	4.17	0.24	0.86	
24	48.0	Clay	47.56	70.94	14.26	44.15	336.4	12.61	90.41	1.30	2.5	0.45	1.34	
25	24.0	Clay	41.11	70.50	11.47	21.89	681.9	12.16	51.1	2.96	3.2	0.96	2.34	
26	31.0	Clay	61.03	97.30	20.46	81.90	57.35	40.96	81.9	5.09	3.2	—	1.74	
27	16.0	Silty clay	58.50	87.71	37.82	153.8	2119.6	34.20	34.2	×	×	×	×	
37	16.0	Silty clay	37.65	98.80	6.20	212.5	751.2	26.6	26.6	×	×	×	×	
38	15.0	Clayey silt	38.10	94.34	4.96	131.2	1102.4	26.2	26.2	×	×	×	×	
39	26.0	Silty clay	42.60	96.17	9.92	187.8	504.6	23.5	10.4	×	×	×	×	
49	38.0	Sand silt clay	45.00	53.82	8.68	133.3	800.0	22.0	—	×	×	×	×	
50	38.0	Silty clay	46.96	95.02	8.06	210.8	—	48.97	289.6	1.15	1.70	0.34	0.74	
51	41.0	Sand silt clay	46.55	64.65	53.01	118.1	—	66.6	163.6	×	×	×	×	
54	39.0	Sandy clay	25.91	27.43	43.40	84.9	—	30.9	100.3	1.34	1.44	0.72	2.28	
57	21.0	Sand silt clay	39.50	66.64	22.63	126.6	—	227.8	53.2	1.03	0.56	0.39	2.05	
58	21.0	Sand silt clay	36.64	50.95	11.47	199.2	—	25.9	60.2	×	×	×	×	
59	15.0	Clayey sand	46.55	83.84	7.13	163.3	—	20.4	92.4	—	2.61	—	2.11	

— Data not available. × Water samples not collected.

ranges from 217.6 to 2119.0  $\mu\text{g at/l}$ . High concentration of interstitial ammonia were observed near Bombay, at the entrance of the Gulf of Cambay and in the Gulf of Kutch. 'Interstitial' nitrate ranges from 26.2 to 1173.5  $\mu\text{g-at/l}$ . Like ammonia, high concentrations of nitrates were found near Bombay (stns. 12, 13 and 14) and in the Gulf of Kutch (stns. 50, 51, 54) while it was low at the mouth of the Gulf of Cambay (stns. 22, 24, 25, 26, 27) and at the mouth of Gulf of Kutch (stns. 37, 38, 39). 'Interstitial' nitrite was present in low concentrations averaging 28.85  $\mu\text{g-at/l}$  except at the stns. 12 and 13 near Bombay and at stn. 57 in the Gulf of Kutch where it was comparatively higher. The highest nitrite concentration observed was 227.8  $\mu\text{g-at/l}$ . It can also be seen from Table I that the phosphate, nitrate and nitrite concentration of the bottom water near Bombay is low, but it shows increasing trend towards the Gulf of Cambay while it is low at the few stations occupied in the Gulf of Kutch. Ammonia concentration in the bottom waters ranges from 0.86 to 2.34  $\mu\text{g-at/l}$ . High concentrations of ammonia were found near Bombay and towards the head of the Gulf of Kutch.

It is seen from Table I that high concentrations of adsorbed phosphate and low 'interstitial' nutrients occur near Bombay and towards the head of the Gulf of Kutch where the sediment is sandy-silt having low silt content and comparatively higher moisture content. At the mouth of the Gulf of Kutch where the sediment is silty clay having higher silt percentage and low moisture content, it is found that the concentration of adsorbed phosphate is low but the concentration of nutrients in interstitial water is high indicating that the texture of the sediment plays an important role in the exchange of nutrients at the water-sediment interface.

The permeability of the mud is determined by porosity, particle size and the degree of compaction of the sediment. The ability of water to circulate through the sediments depends on its degree of compaction (Jayaraman and Seshappa, 1957). Sediment having high silt percentage is more compact and the ability of overlying water to pass through it, is reduced restricting the changes of factors responsible for the phosphate solubility and adsorption-desorption equilibria in the sediment and thus resulting in retention of large quantities of phosphate in the interstices between mud particles. The low adsorbed phosphate observed may also be related to the mineral characteristics of silt and clay particles and the physico-chemical properties such as salinity, pH etc. of the interstitial and overlying waters. This observation is tentative since we do not have the data on the required parameters. This is consistent with the observed high values of interstitial nutrients associated with the sediments having high silt content. At some locations, the observed low values of interstitial phosphate and other nitrogenous compounds in the sediments, with low silt content and higher moisture content, may be attributed to the loose nature of the sediments where the overlying water is free to circulate and exchange the nutrients with the sediment. The low silt content and high adsorbed phosphate found in these sediments do reflect a greater adsorbing capacity of silt particles as well as on the physico-chemical conditions of the medium.

From the foregoing account, it is evident that the fractionation of nutrients within the sediment is closely related to the texture of a particular sediment-type and its proximity towards the coast. Relatively high values off Bombay coast are attributed to the effect of industrial and domestic effluents discharged into the coastal waters. The extent of variability observed in the concentration of phosphorus as well as nitrogenous compounds in the sediments and overlying waters indicate controlled exchange of the compounds between the mudwater interface.

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