

TABLE 1 — ESTIMATED DEPTH AND WIDTH VALUES

Anomaly	Accepted model	Depth km	Width km
PROFILE 1			
B	Semi-infinite slab	0.5	—
C	Semi-infinite slab	1.2	—
D	Dyke	0.3	3.8
PROFILE 2			
G	Dyke	0.5	0.5
H	Dyke	0.5	0.6
I	Dyke	0.2	0.3
PROFILE 3			
J	Dyke/Tabular body	0.3	—

and 2.5 km. By joining the positions of similar anomalies on their respective profiles, it can be seen that the anomalies have a north-north-east-south-south-west trend. Similar anomalies are not observed on profile 1, perhaps due to the shorter length of the profile. It is seen that the physiography of the sea in the study area is not reflected in the magnetic anomalies. The depths and widths computed from these anomalies range from 0.3 to 1.2 km and 0.3 to 4 km respectively. Since the profile directions are not exactly perpendicular to the lineations of the anomalies, the observed parameters are apparent.

A study of the structure, tectonics and geology of the land areas to the north and south of the Gulf of Kutch³⁻⁶ shows that (i) a NNE-SSW trending median high extends into the offshore regions off the Gulf of Kutch; (ii) strong positive gravity anomalies exist off south of Okha which are attributed to thick traps⁷; (iii) the Deccan traps are exposed along the western and southern coasts of Kutch and Kathiawar coast, and a few volcanic plugs comprising alkali olivine basalts occur along the coast of Kutch; and (iv) the structure of Kutch is controlled by WNW-SSE trending and NNE-SSW trending faults. The structures of Kutch were developed mostly within the Mesozoic rocks in the pre-Deccan trap time and the traps flows rest disconformably over eroded or depressed parts of folded Mesozoic rocks^{8,9}.

The observed NNE-SSW trends of the magnetic anomalies in the Gulf of Kutch represent structural trend indicating that the onshore trend in Kutch extends into the gulf also. The observed depths and widths indicate that the sources causing the anomalies are at shallow depths and that they are narrow. However, mention may be made here that some other anomalies such as at A, E, F and K are also discernible from the data analysed. Since they do not appear to be well resolved (might be due to the interference by the adjacent bodies effect) or incomplete they were not used for depth computations. However, they have been made use of in deciphering the trends of the anomalies. The data indicate that the thickness of sediments

overlying the basalt may be of the order of 500 m and may be rarely more. Based on the available geological data and the shallow magnetic source causing the anomalies it is suggested that the observed anomalies are related to the structures within Deccan traps which are located at shallow depths. A detailed geophysical survey with a shallow draught vessel will indicate more clearly the structure and tectonics of the Gulf of Kutch. The authors are indebted to Dr S. Z. Qasim and Shri H. N. Siddiquie for their encouragement. Thanks are due to Shri P. S. N. Murty for going through the manuscript.

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Bromide/Chlorinity Ratio in the Bay of Bengal

S. W. A. NAQVI & C. V. G. REDDY

National Institute of Oceanography, Dona Paula 403004, Goa

Received 16 January 1978; revised received 17 April 1978

Eighty samples, collected during the cruises of *RV Gaveshani* in the Bay of Bengal from July to Sept. 1977, have been analysed for bromide. Bromide/chlorinity ratio for the surface samples from the northern Bay (0.00321 ± 0.00007) is significantly lower than that for the deeper layers in this region and for all the values obtained from the central and central-west Bay of Bengal (0.00343 ± 0.00005). The latter is found to be close to the oceanic value (0.00347). This has been attributed to the immense runoff from the rivers. The riverine water is apparently poor in bromide relative to chloride.

INVESTIGATIONS on the ratios between some major constituents in the northern Indian Ocean have been undertaken. Sen Gupta *et al.*¹ have studied the ratios of calcium, magnesium and fluoride with chlorinity and found them to differ significantly from their normal oceanic values. The present paper gives the results of variations in another major constituent, namely bromide with chlorinity in the Bay of Bengal.

Eighty samples from surface to 1000 m depth were collected during 20th and 21st cruises of *RV Gaveshani* from July to Sept. 1977. The station locations are given in Fig. 1. Metallic Nansen bottles and CTD samplers were used for the

SHORT COMMUNICATIONS

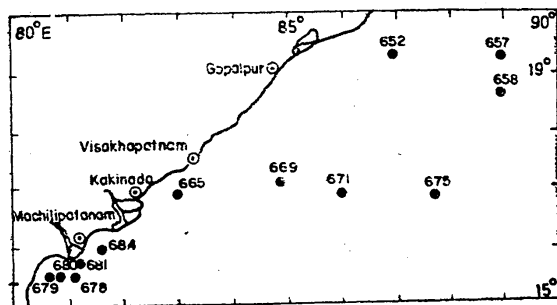


Fig. 1 — Location of stations

collection of these samples. The analysis for bromide could not be performed on board the ship and the samples were brought to the shore laboratory where they were analysed by the method of Kolthoff and Yutzy² as described by Kremling³. Salinity was determined on board shortly after the collection using an AUTOSAL salinometer with a sensitivity of $\pm 0.003\%$. From salinity, chlorinity was obtained using the relationship $S_{\text{‰}} = 1.8066 \text{ Cl}_{\text{‰}}$.

Surface values of bromide/chlorinity ratio at stations 652, 657 and 658 (0.00321 ± 0.00007) were much lower than those from deeper layers at these stations as well as those from the other locations at all the levels (0.00343 ± 0.00005). These low values (Table 1) were associated with low salinities (av. 26.76%) and the average concentration of bromide for these samples was 0.0474 g/kg .

The Bay of Bengal is an area of positive water balance where an excess of precipitation over evaporation occurs annually. It has been estimated to be 1500 km^3 (ref. 4). Taking the annual runoff from the rivers of India, Bangladesh and Burma as 3000 km^3 , Sen Gupta *et al.*¹ have calculated an average dilution of 5.5% for the upper 25 m of the entire Bay. However, since most of the dilution by the rivers occurs in the northern Bay, this value for dilution appears to be too low for this region. Based on the salinity of the surface samples from the 3 stations, we have calculated dilution ranging from 17 to 40%. Bromide/chloride ratio is slightly higher in the atmosphere than in the sea water⁵ indicating that the precipitation will result in a slight increase of this ratio in sea water. However, owing to low concentrations of the halogens in the atmosphere, this factor may be considered as insignificant. Therefore, the low bromide/chlorinity ratio must be the result of river runoff. Judging from the low values of the ratio obtained, it can be inferred that the river water causing dilution should be much poor in bromide as compared to chloride. A similar decrease in fluoride/chlorinity ratio has been observed¹.

During the 2nd leg of 21st cruise, the area covered was largely coastal, close to the mouths of rivers Godavari and Krishna. No decrease for the surface samples from these stations was noticed. This may be because of relatively low dilution by these rivers as compared to the northern region during the period when the samples were collected. This is reflected by the high salinity in the surface layers (av. 34.04% for 23 samples from surface to

50 m). It is also possible that bromide/chlorinity ratio for the fresh water from these rivers itself is comparable to that of the sea water.

Morris and Riley⁶ studied bromide/chlorinity ratio in samples collected from all over the world oceans and found no significant variations in the ratio either with depth or with locations. For a land-locked sea, namely the Baltic, they observed a decrease in the ratio with depth, which they attributed to the influence of fresh water. This is perhaps the first report where the runoff from the rivers has been found to affect this ratio so significantly in oceanic waters.

TABLE 1 — BROMIDE/CHLORINITY RATIO FOR THE SURFACE SAMPLES FROM STATIONS 652, 657 AND 658

Station No.	Depth m	$S_{\text{‰}}$	Br (g/kg/ $\text{Cl}_{\text{‰}}$)
652	0	29.97	0.00332
657	0	24.7	0.00314
	20	27.22	0.00325
658	0	25.61	0.00317
	10	26.3	0.00318
Mean		26.76	0.00321

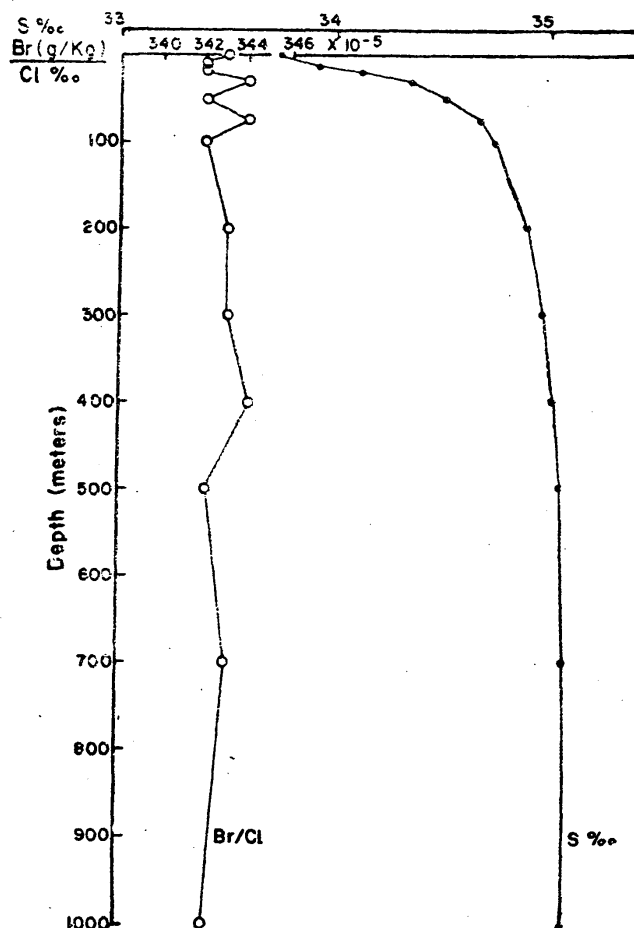


Fig. 2 — Vertical profiles of average bromide/chlorinity ratio and salinity

Notwithstanding the low values observed for the surface samples from stations 652, 657 and 658, there was no appreciable variation in the ratio with locations. Therefore, all other values were pooled together and averaged for various depths to study the general depthwise distribution of this ratio. These values, along with the corresponding average salinity values, are plotted with depth (Fig. 2). There is no significant variations in the ratio with depth. This is in agreement with the findings of Morris and Riley⁶. The overall bromide/chlorinity ratio for this region was 0.00343 ± 0.00005 with a mean bromide concentration of 0.0655 g/kg when the surface values from the above 3 stations are excluded. This is close to the value reported for some other areas of the oceans^{6,7}.

Sen Gupta *et al.*¹ have reported high fluoride/chlorinity ratio for the Persian Gulf and Red Sea waters which find their way to the Arabian Sea. A similar increase in bromide/chlorinity ratio also may be expected in these water masses. Chelle⁸ has reported high value (0.0043) of this ratio for the Red Sea though his results have been regarded to be too high by several authors⁷. Absence of a maximum at the depth where Persian Gulf and Red Sea waters could be expected to occur indicates that the effect of these waters is not very appreciable in the region under study unlike the south-western Bay where these water masses are reported to be present⁹. Therefore, it appears that these water masses lose their characteristics as they move north into the Bay due to lateral and vertical mixing.

The authors express sincere thanks to Dr S. Z. Qasim, Director, for suggesting suitable modifications in the manuscript and to their colleagues from Physical Oceanography Division for analysis of the samples for salinity.

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Total Mercury Concentrations in the Arabian Sea Waters off the Indian Coast

S. Y. S. SINGBAL, SUJATA SANZGIRI & R. SEN GUPTA
National Institute of Oceanography
Dona Paula, Goa 403004

Received 6 February 1978; revised received 8 March 1978

During the 16th cruise of RV *Gaveshani* water samples were collected at 9 stations from different depths along 2 north-south transects for the deter-

mination of total mercury, which was estimated applying cold-vapour atomic absorption spectrophotometry. Concentrations of the metal at the surface varied from 26 to 130 ng l⁻¹ (av. 77 ng l⁻¹).

THERE is continuous addition of heavy metal ions into the marine environment mostly due to industrial and domestic releases. These ions enter the marine system by precipitation and river runoff. Increasing awareness of the potential hazards of these toxic metal ions to the ecosystem, has stimulated attempts to study their background levels in the marine environment.

Dissolved inorganic mercury probably occurs mostly¹ as HgCl₂⁰. Its concentration in open ocean water usually lies in the range 10-50 ng l⁻¹, but considerably higher concentrations may occur in inshore waters and especially in polluted estuaries². Organomercury compounds, mainly methyl mercury, are known to be present in marine organisms and in anoxic marine sediments. Although there is indirect evidence for their presence in coastal waters they have not as yet been detected in ocean waters.

Information about concentrations of mercury in the seas around India is practically non-existent. A few studies have, however, been carried out on mercury concentrations in a few food fishes from the waters around Bombay⁴⁻⁶. With rapid industrialization there is a great risk of discharge of toxic material, containing mercury, into the marine system. Hence the importance to collect baseline data to establish background levels of mercury in the seas around India needs no emphasis.

The present investigation has been undertaken as a part of the project at NIO on protection of marine environment and monitoring of pollutants in the Arabian Sea.

Samples were collected using a set of 2 all PVC Van Dorn bottles (10 l each) at all the 9 stations along the 2 transects (Fig. 1). Immediately after collection they were transferred to acid-washed 2.5 l glass bottles and their pH adjusted to 1.8 with 9N H₂SO₄. Samples were stored 2-3 weeks on board before being transferred to the shore laboratory. The analytical methods employed were broadly as per Gardner and Riley⁷. The atomic absorption spectrophotometer used was the Hilger-Watts Atomspek H 1550 running it at the cold-vapour phase.

For the determination of blanks sea water was stripped of mercury twice with 15 ml portions of dithizone. The stripped sea water was then spiked with 50, 100, 200 ng mercury as acidified mercuric chloride and analysed as the samples.

Replicate runs of the samples established a standard deviation, expressed as coefficient of variation, of $\pm 2\%$.

Before attempting any interpretation we make the reservation that the values include both the dissolved mercury and a part of mercury present in particulate matter. This is because we could not filter the samples on board before acidification. Acidification prior to filtration can be expected to introduce a part of particulate mercury due to