

Bromide in Some Coastal & Oceanic Waters of India

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Bromide concentration and bromide/chlorinity ratio are estimated in coastal waters of Goa, Minicoy lagoon, western Arabian Sea and western Bay of Bengal. The influence of precipitation and river runoff on bromide and bromide/chlorinity ratio is discussed.

Studies on bromide concentration in ocean waters show that bromide (g.kg^{-1}) to chlorinity ratio of 0.003473 is remarkably constant with depth. However, in the waters of the Baltic Sea, where runoff and precipitation exceed evaporation, bromide/chlorinity relationship decreases in the freshwater zone². In this communication, bromide concentration and bromide/chlorinity ratios in coastal waters of Goa, Minicoy lagoon, western Arabian Sea and western Bay of Bengal are presented.

Seawater samples were collected from standard hydrographic casts using Niskin samplers and PVC rosette CTD probe samplers. Coastal water samples were examined for chlorinity by the method of Grasshoff³ while the others obtained during cruises 95 and 102 of *R V Gaveshani* were measured using an Autosal salinometer with a sensitivity of $\pm 0.003 \times 10^{-3}$. Bromide analysis was carried out by the spectrophotometric method⁴. Replicate runs on samples gave a coefficient of variation of $\pm 2\%$.

Coastal regions of Goa—Coastal waters differ from normal seawater because of temporal and spatial variations in composition. Surface seawater samples were collected for 9 months (Sept. 1981 to May 1982) at 3 stations in the coastal waters of Goa (Fig. 1a). The general trend of variation of bromide and chlorinity was similar at all stations. Bromide/chlorinity ratio of 0.00347 varied only very slightly suggesting that coastal regime had no effect on this relationship. Monthly variations (average of all 3 stations) are depicted in Fig. 2. Comparatively lower levels of bromide in Sept., immediately after the monsoon, indicate the effects of heavy precipitation on surface seawater; these dilution effects are confirmed by the differences between premonsoon and postmonsoon averages which were respectively 67.84 and 66.24 mg.kg^{-1} .

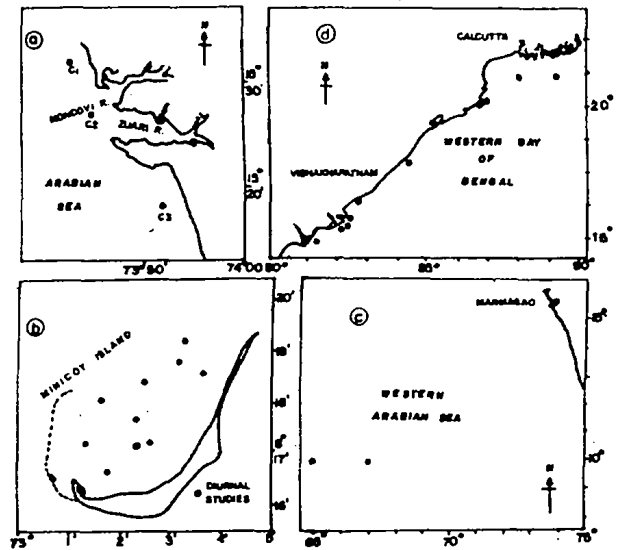


Fig. 1—Location of stations

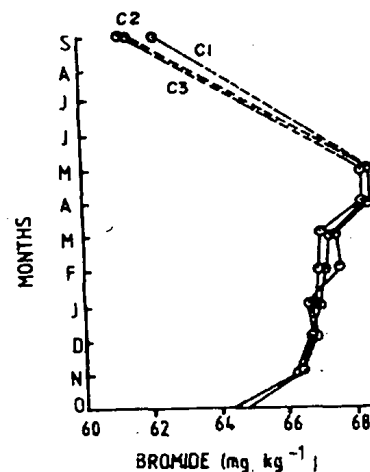


Fig. 2—Monthly variations of bromide and bromide/chlorinity in the coastal waters of Goa (values are pooled average of 3 stations)

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Minicoy lagoon—Samples were collected from 9 stations during cruise 102 of *R V Gaveshani* (Fig. 1b). Averages for the samples at 9 stations were $65.49 \pm 0.16 \text{ mg.l}^{-1}$ (bromide) and 0.003477 ± 0.000002 (bromide/chlorinity ratio). The invariance of bromide/chlorinity ratio indicates the conservative behaviour of bromide in the lagoon waters. At one station diurnal studies were carried out and it was found that the bromide variations do not follow the tidal rhythm.

Western Arabian Sea—The measurements of bromide in the waters of the Arabian Sea and Bay of Bengal are of particular interest from the standpoint of interaction between precipitation, evaporation and chemistry of seawater. The Arabian Sea is a region of negative water balance where the annual excess of evaporation over precipitation and runoff varies between 7 and 10 km³ (ref. 5). Samples were collected from 2 stations during cruise 102 of *R V Gaveshani* (Fig. 1c). The average concentrations (pooled values of 2 stations) of bromide and bromide/chlorinity ratio at different depths are shown in Fig. 3. The bromide/chlorinity ratio did not vary with respect to depth, location and watermass. Bromide content and bromide/chlorinity ratio in the upper 100m were respectively 70.21 mg.l^{-1} and 0.003477. These values are of the same order of magnitude as those in the eastern⁶ and central Arabian Sea⁷ (Table 1), indicating that bromide was chemically similar all over the sea.

Western Bay of Bengal—In the Bay of Bengal the water balance is positive⁸ and the annual excess of precipitation over evaporation is of the order of 1500 km³ (ref. 9). Most striking seasonal variations occur in the Bay of Bengal where they are associated with the monsoon. Measurements of bromide carried at 11 stations (Fig. 1d) during cruise 95 of *R V Gaveshani* in the Bay of Bengal waters clearly demonstrate the significant influence of river runoff on the chemistry of the upper 100 m of the sea (Fig. 3). The heaviest rains draining into the bay dominate the oceanographic conditions of the northern region¹⁰. The rivers in the Bay of Bengal influence the water properties to different degrees near their confluences. On the whole, bromide is closely associated with salinity and the surface concentrations are in general relatively lower than the deeper layers. Compared to the northern region the southern region did not show much decrease for the surface samples, which may be due to greater addition of bromide by the rivers in the southern Bay of Bengal or due to lesser volume of runoff from the rivers. The surface bromide contents (mg.l^{-1}) in decreasing order of magnitude for different rivers are as follows: mouth of Godavari (59.54), Mahanadi (53.74) and Hooghly (51.09).

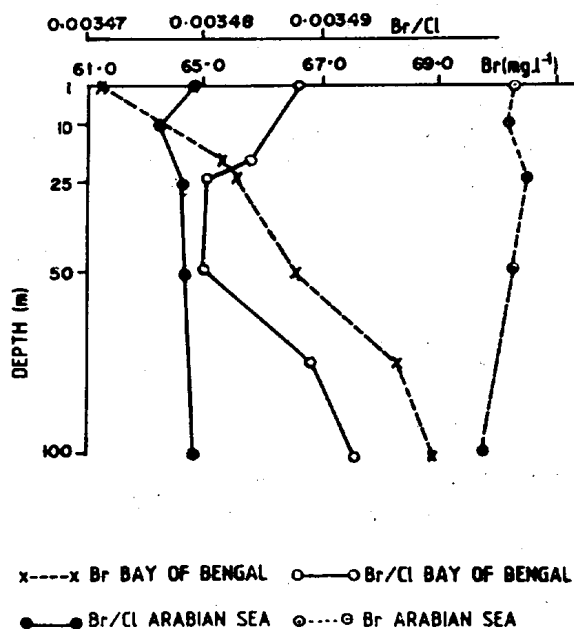


Fig. 3—Average depth profiles of bromide and bromide chlorinity in the Arabian Sea and Bay of Bengal

Table 1—Overall Averages of Bromide Levels and Bromide/Chlorinity Ratios with Std Errors in the Western, Eastern and Central Arabian Sea

Arabian Sea (area)	Br $\text{mg l}^{-1} \pm \text{Std error}$	Br ⁻ /Cl [±] Std error
Western (0-100 m)	70.21 ± 0.14	0.003477 ± 0.000001
Eastern (Ref. 6)	70.03 ± 0.075	0.003474 ± 0.000005
Central (Ref. 7)	68.02 ± 0.27	0.003478 ± 0.0000037

Since the water at the mouths of the rivers in the Bay of Bengal, represent special environments with properties that differ from seawater, it was of interest to examine their influence on the bromide/chlorinity relationship. There was however no apparent change in the ratio in the mouth regions of the different rivers. Therefore all the values when averaged gave a concentration of $65.21 \pm 0.09 \text{ mg.l}^{-1}$ for bromide and 0.003483 ± 0.000002 for bromide/chlorinity ratio.

Distribution of bromide and chlorinity in the 4 marine and estuarine systems indicated that the distribution of bromide in the sea is governed mainly by physical processes.

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References

- 1 Culkin F, in *Chemical oceanography*, Vol 1, edited by J P Riley & G Skirrow, 1965, 121.
- 2 Morris A W & Riley J P, *Deep-Sea Res*, 13 (1966) 699.
- 3 Grasshoff K, in *Methods of seawater analyses*, edited by K Grasshoff (Verlag Chemie, Weinheim, New York), 1976, 31.
- 4 Saenger P, *Helgol Wiss Meeres*, 23 (1972) 32.
- 5 Schott J, *Geographie des Indischen & Stillen Ozeans* (Verlag Boysen, Hamburg), 1935, 33.
- 6 De Souza F P, *Indian J Mar Sci*, 11 (1982) 173.
- 7 De Souza F P & Sen Gupta R, *Mahasagar-Bull Natn Inst Oceanogr*, 14 (1981) 309.
- 8 Sen Gupta, Naik S & Singbal S Y S, *Mar Chem*, 5 (1978) 125.
- 9 Venkateswaran S V, *Indian J Met-Geophys*, 7 (1956) 265.
- 10 Fairbridge R W, Reid G K, Olausson E & Peterson S, (eds), *Encyclopaedia of oceanography*. (Reinhold Publishing Corporation, New York), 1966, 110.