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NOTES

ON THE DISTRIBUTION OF BROMIDE AND BROMIDE/CHLORINITY RATIOS IN THE WATERS OF THE ARABIAN SEA OFF CENTRAL INDIAN COAST

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ABSTRACT

Water samples from surface to 2000 m depth at two stations in the Arabian Sea collected during the 82nd cruise of R. V. *Gaveshani* in November, 1980 were analysed for bromide. The average bromide concentration was 0·068 g/kg ± 0.00027 and the bromide/chlorinity ratio was 0·00347±0·0000037. These agree with the values reported from other oceanic areas.

Bromide is considered as a major and conservative element in seawater having a concentration of 0·0673 g/kg at 35‰ salinity with a fairly constant bromide/chlorinity ratio of 0·003473 (Culkin, 1965; Morris and Riley, 1966). The variation range (2%) found by the latter workers for 211 samples representative of all the major seas and oceans corresponds to 13 times the coefficient of variation for replicate analyses of the same sample. It is possible, therefore, that some of the variability observed reflects natural variations.

Very few reports are available on the concentration and chemistry of major elements in the seas around India. Observations on calcium, magnesium and fluoride have been made by Sen Gupta, Naik and Singbal (1978) and Noronha, Moraes and Sen Gupta (1981). Only one study has been made, so far, on the bromide/chlorinity relationship in the waters of the Bay of Bengal (Naqvi and Reddy, 1978). The present report appears to be the first attempt at understanding the chemistry of bromide in the Arabian Sea.

Samples were collected from standard hydrographic casts at two stations in the Arabian Sea (15°00'N, 70°00'E and 13°40'N, 67°56'E), using metallic Nansen bottles and PVC rosette samples of Conductivity–Temperature–Depth probe. The samples were stored in well cleaned and sealed polythene bottles. Salinities were measured aboard ship using an autosal salinometer with a sensitivity of ±0·003‰. Chlorinity was obtained from salinity using the relationship, $S‰ = 1.80655\ Cl‰$. All bromide analyses were carried out in the laboratory applying the spectrophotometric method of Saenger (1972). A coefficient of variation of ±1·47% was obtained from replicate runs of several samples.

Values of salinity, oxygen, pH, concentrations of bromide and bromide/chlorinity ratios as functions of depth are presented in Fig. 1.

A check on the redox equilibria of Br (Sillen, 1961) shows, as might be expected, that the predominating species, at the pE and pH of the ocean must be Br^- at equilibrium.

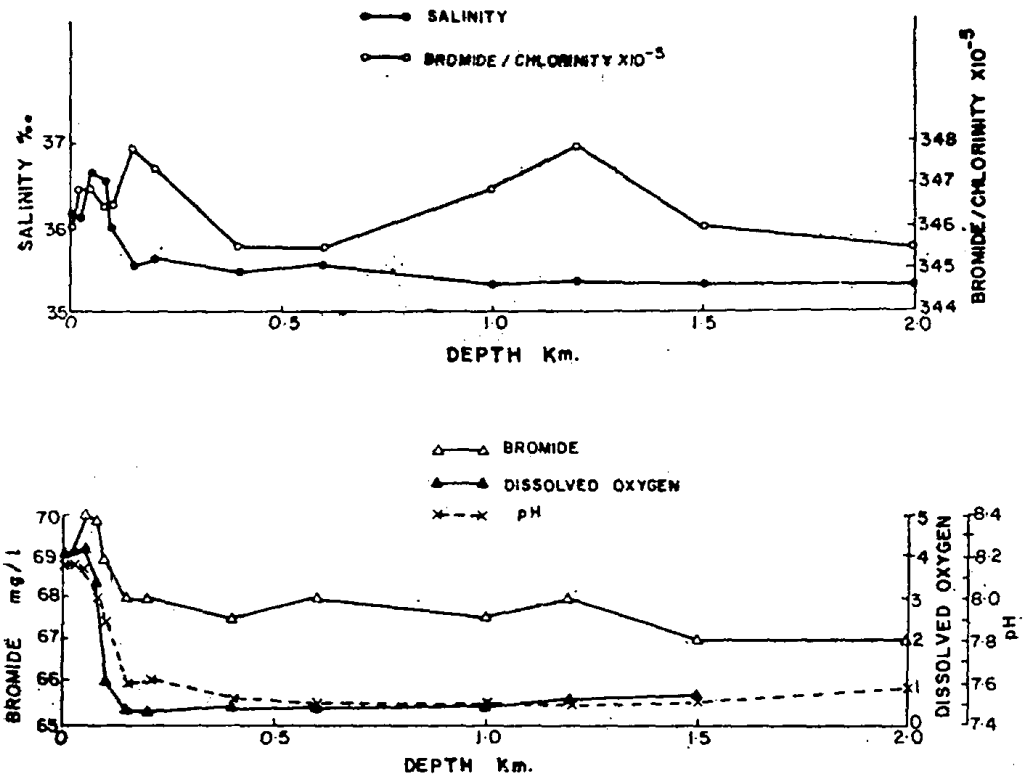

Fig. 1. Depth profiles of average values of various parameters.

We have $BrO_3^- + 6H^+ + 6e^- \leftrightarrow Br^- + 3H_2O$, $\log K = 146{\cdot}3$

By inserting pE = 12·5, pH = 8·1, we find the ratio $[BrO_3^-]/[Br^-] \approx 10^{-23}$. Thus bromine can be present in seawater only as the bromide ion.

In normal well-oxygenated seawaters the values of pH and pE will not deviate much from the above figures. Fig. 1 shows that below about 50 m, which is the depth of the surface mixed layer, concentration of bromide decreases with the decrease in pH and O_2. We attribute this to watermass effect as the salinity also decreases indicating the conservative character of bromide in seawater. At 1200 man increase in the concentration of bromide is noted which is also reflected in higher Br/Cl ratio. This is probably the effect of Red Sea water as at this depth σ_t is 27·6 which is characteristic of Red Sea outflow into the Arabian Sea. A high Br/Cl ratio of 0·0043 has been reported for Red Sea water (Culkin, 1965).

Surface values of bromide concentration at these stations (average 0·069 g/kg) were higher than those from deeper layers (average 0·067 g/kg). These high values were associated with high salinities (average 36·14‰). The average bromide/chlorinity ratio for these samples was 0·00346. Low bromide/chlorinity ratios ranging from 0·00314–0·00332 have been reported by Naqvi and Reddy (1978) from observations from the stations off the mouth of the River Ganges in the Bay of Bengal, attributing this as dilution effect by river runoff. Arabian Sea receives much less river runoff and is an area of a negative water balance, where evaporation exceeds precipitation

and runoff (Sen Gupta, Sankaranarayanan, De Souza and Fondekar, 1976). Higher values of bromide and Br/Cl ratio are the results of this.

Thus, there was no appreciable variation in the ratio with depth or location. Therefore, all the values were pooled together for all the depths and the averages were 0·068 ± 0·00027 for bromide and 0·00347 ± 0·0000037 for bromide/chlorinity ratio. This compares well with the oceanic mean value of 0·0673 g/kg (Culkin, 1965).

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