

## ON THE DISTRIBUTION OF FLUORIDE, CALCIUM AND MAGNESIUM IN THE WATERS OFF THE CENTRAL WEST COAST OF INDIA

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### ABSTRACT

The distribution of fluoride, calcium and magnesium was studied in the waters off the central west coast of India. The average F/Cl, Ca/Cl and Mg/Cl ratios observed are  $(6.83 \pm 0.023) \times 10^{-5}$ ,  $(0.02194 \pm 0.00068)$  and  $(0.06332 \pm 0.0027)$  respectively. The depthwise variations of fluoride, calcium and magnesium and their ratios to chlorinity have been discussed.

*Key words:* West coast, fluoride, calcium, magnesium, chlorinity.

### INTRODUCTION

The distribution of the major ions fluoride, calcium and magnesium have been studied in the northern Indian Ocean by Sen Gupta, Naik and Singbal (1978). The contents of these ions and their variations with chlorinity have also been reported in the Andaman Sea (Noronha and Moraes, 1981). Naqvi and Reddy (1979) studied the variations in the calcium content in the Laccadive Sea. As a continuation of this study, samples were collected from the Arabian Sea during the 46th cruise of RV *Gaveshani*, to study the distribution of fluoride, calcium and magnesium. The present data are compared with the data reported earlier.

### MATERIAL AND METHODS

Samples were collected in polyethylene containers from the hydrographic casts using Nansen bottles and rosette samplers of CSTD from 19 stations along five transects between  $14^{\circ}40'N$  to  $15^{\circ}41'N$  and  $71^{\circ}24'E$  to  $74^{\circ}05'E$  (Fig. 1). They were analysed on board for salinity using an 'AUTOSAL' salinometer and in the shore laboratory for calcium, magnesium and fluoride by the methods described elsewhere (Sen Gupta, Naik and Singbal, 1978). Calcium, magnesium and fluoride were estimated with a coefficient of variation of  $\pm 0.23\%$ ,  $\pm 0.21\%$  and  $\pm 2\%$  respectively.

### RESULTS AND DISCUSSION

#### *Fluoride*

To study fluoride concentration and its variations with chlorinity, fluoride and F/Cl values at each depth for all the stations were pooled together to calculate the average concentration at different depths and is shown in Fig. 2. The average concentration of fluoride and the F/Cl ratio in the area surveyed were found to be  $1.33 \pm 0.004$  mg/kg and  $(6.83 \pm 0.023) \times 10^{-5}$  respectively. This agrees well with the values observed in the Arabian Sea by Sen Gupta, Naik and Singbal (1978). Greenhalgh and Riley (1963) reported the mean F/Cl ratio of  $6.7 \times 10^{-5}$  whereas a value of  $6.9 \times 10^{-5}$  has been reported by Brewer, Spenser and Wilkiniss (1970). The

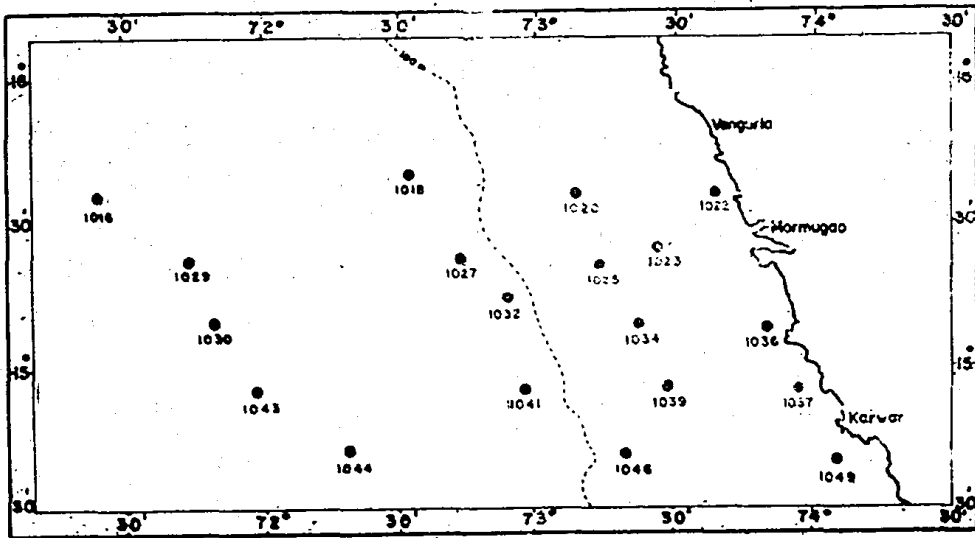


Fig. 1. Map showing the station positions.

most probable value for the mean F/Cl ratio is  $6.75 \times 10^{-5}$  in normal seawater (Warner, 1971). The value of average F/Cl reported here is well within the range reported by these workers.

Based on the fluoride concentration, the entire water column can be divided into 3 distinct layers (Fig. 2): (i) Surface layer (0–100 m), middle layer (100–1200 m) and (iii) bottom layer (1200–2000 m). In the surface layer, the fluoride concentration increased upto 25 m and then remained constant upto 100 m. In the middle layer, it decreased slightly up to 200 m and then remained constant at the depth of low oxygen concentration (300–1200 m) with a slight decrease at 1000 m. In the bottom layer below 1000 m fluoride increased with a gradual increase in the oxygen concentration. Kullenberg and Sen Gupta (1973) observed that fluoride can be removed with the decrease in oxygen but it redissolves when oxygen concentration increases. This may be the reason for the observed changes in the fluoride concentration. A small variation in fluoride/Cl in all the three layers can be attributed to the variations in the salinity.

High fluoride and F/Cl ratio is observed at stations 1025 and 1027. The average fluoride concentration at these stations was 1.39 mg/kg with F/Cl ratio of  $7.17 \times 10^{-5}$ . The depthwise variation in the F/Cl ratio in the transect in which these stations lie is shown in Fig. 3. This ratio at other stations in this transect is almost consistent with the normal values found at stations in the other transects. Examination of the  $\sigma_t$  values also shows the usual trend of variation. Kester (1971) related such features to oceanic processes and suggested that these anomalies are not merely due to analytical or sampling errors. The differences between these and the average values does not lie within the precision of the analytical method and hence this feature may be due to the coastal influence on the waters at these stations.

### Calcium

The average concentration of calcium at these stations is  $427 \pm 4$  mg/kg and the average Ca/Cl ratio is  $0.02194 \pm 0.00068$ . A value of 0.02168 with an ave-

DISTRIBUTION OF FLUORIDE, CALCIUM AND MAGNESIUM

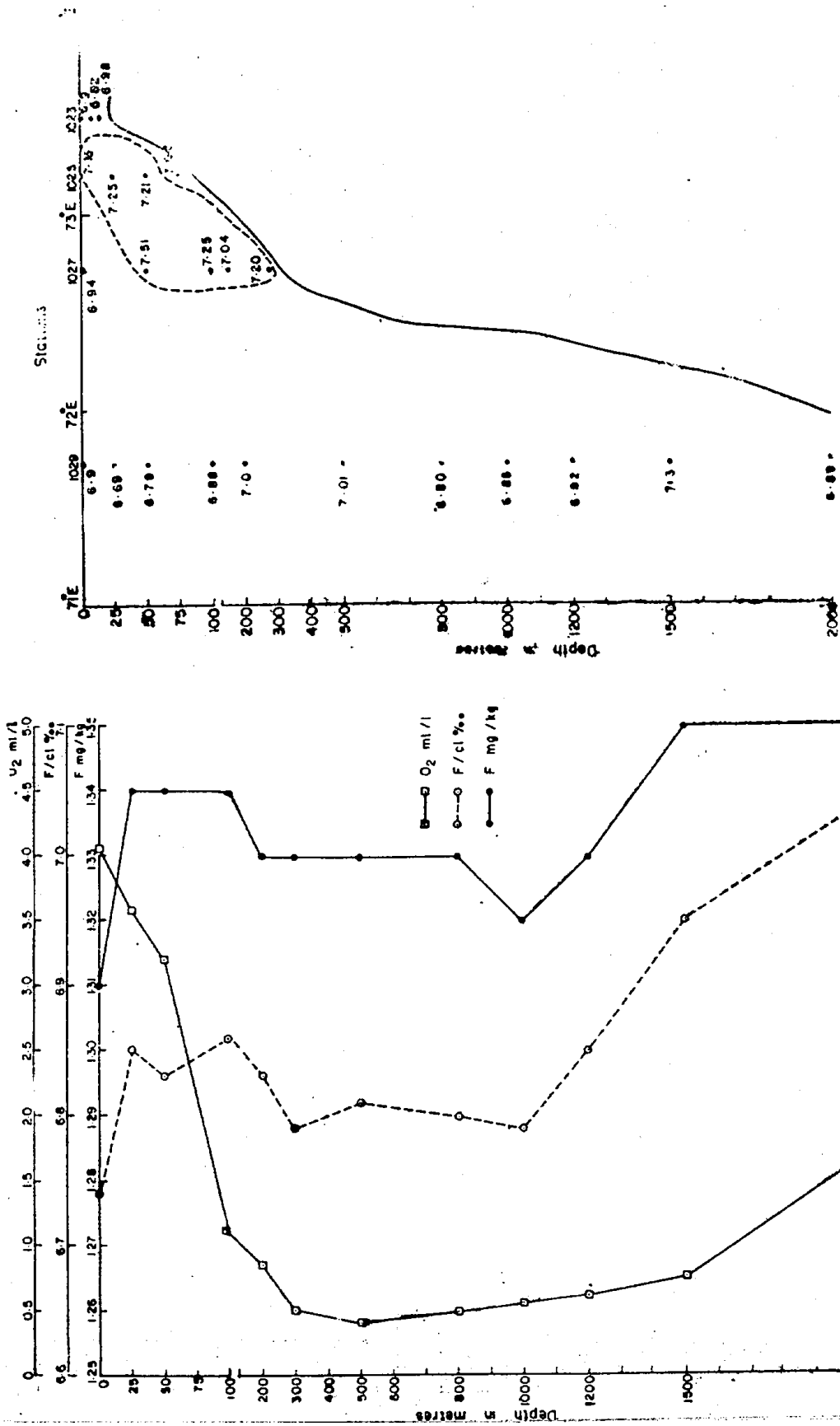


Fig. 3. Anomalous values of F/Cl<sub>∞</sub> ratio at some stations in a transect between 72°30' to 74°05'E.

Fig. 2. Depthwise variation in the average values of F (mg/kg), F/Cl % and O<sub>2</sub> (ml/l).

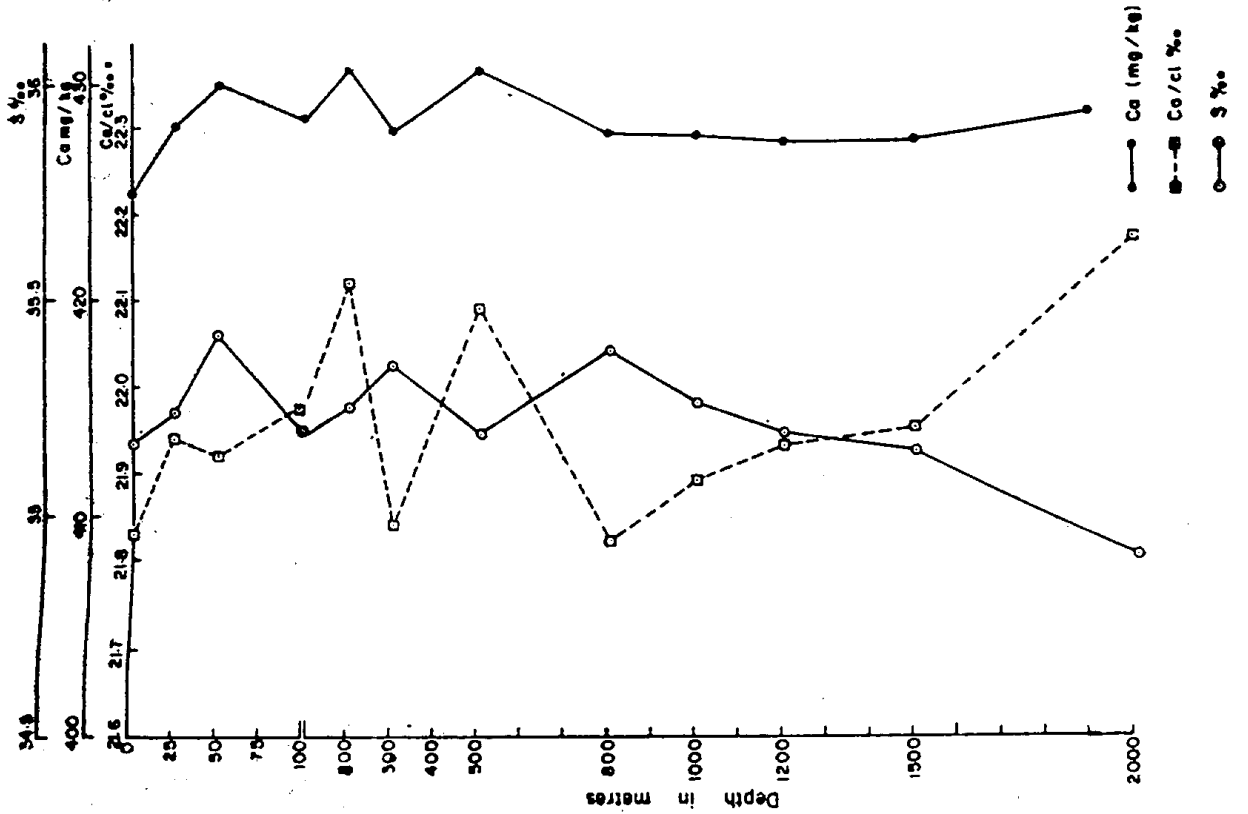


Fig. 4. Depthwise variation in the average values of calcium (mg/kg), Ca/Cl<sub>2</sub> % and S %.

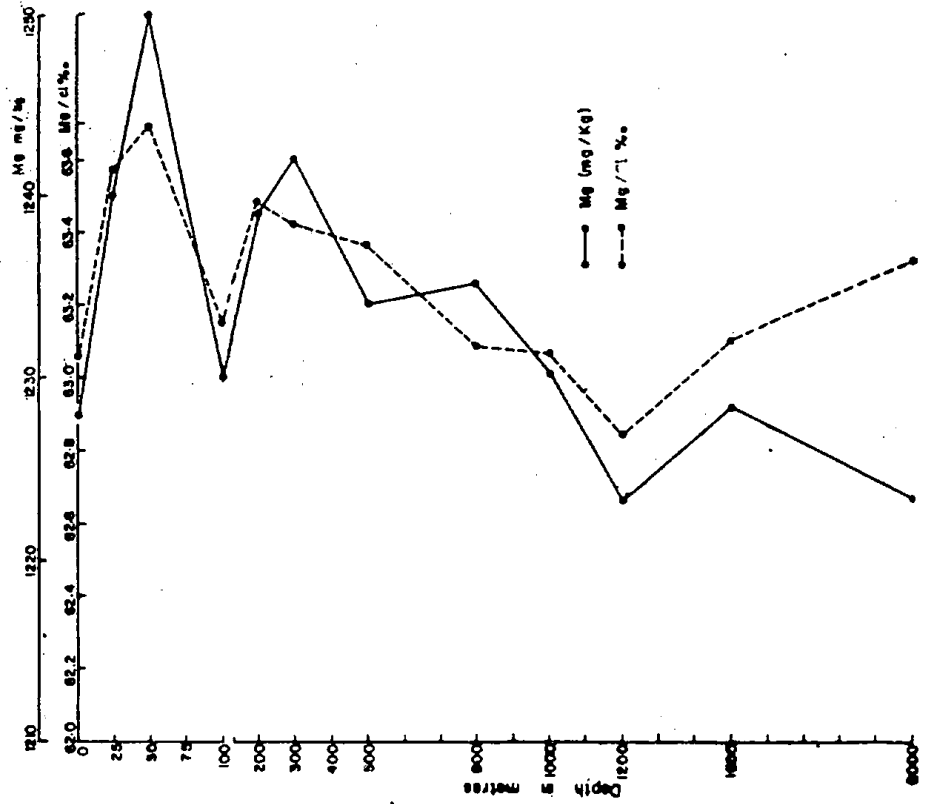


Fig. 5. Depthwise variation in the average values of magnesium (mg/kg) and Mg/Cl<sub>2</sub> %.

average calcium concentration of 424 mg/kg has been reported for the Laccadive Sea where the average salinity values ranged from 35‰ to 36.25‰ (Naqvi and Reddy, 1979). The depthwise variations in the calcium, the Ca/Cl ratio along with salinity variations are shown in Fig. 4. The higher value of Ca/Cl observed in the area is due to lower salinity compared to the Laccadive Sea. The maximum average salinity being 35.42‰ at 50 m and minimum is 34.82‰ at 2000 m. Two maxima in the Ca/Cl are observed at 200 and 500 m depth which coincide with the maximum calcium concentration of 430 mg/kg at both the depths. A similar concentration of calcium is also observed at 50 m but the Ca/Cl is found to decrease due to higher salinity. Between 800 to 2000 m the calcium concentration was almost constant whereas the Ca/Cl ratio increased due to gradual decrease in salinity. A minimum value of Ca/Cl is observed at 800 m which is due to the increase in salinity. From the pattern of distribution of calcium and the Ca/Cl as shown in Fig. 4, it can be said that the calcium shows slight variations from surface to bottom and the variations in the Ca/Cl are mainly due to changes in the salinity at different depths.

### *Magnesium*

The average concentration of magnesium in the area of study is  $1234 \pm 17$  mg/kg and the average Mg/Cl ratio is  $0.06332 \pm 0.0027$ . The average ratio reported so far (Carpenter and Manella, 1973; Riley and Tongudai, 1967; Culkin and Cox, 1966) ranged from 0.06625 to 0.06628 for different oceans. The value obtained in this study is much lower than these values, and the difference does not lie within the limit of analytical error. The large difference in the value may be due to the following reasons. Arabian Sea being a region of negative water balance there is an excess of evaporation over precipitation and runoff in this area, resulting in an increase in the salinity in the subsurface layers. The maximum and the minimum values for salinity and its variations have been discussed earlier. An average concentration of 1268 mg/kg of Mg with an average Mg/Cl value of 0.06616 have been estimated for stations lying between 86°E to 99°E at 5°N latitude (Naik, unpublished work). An average maximum salinity measured in this area is 35.08‰. It is observed that salinity in the area under study is higher than that observed at 5°N latitude.

Magnesium concentration showed significant vertical variations as compared to calcium (Fig. 5). The maximum being 1250 mg/kg at 50 m and a minimum being 1223 mg/kg at 1200 and 2000 m. Between 300 and 1200 m there was a gradual decrease in the magnesium concentration and the Mg/Cl ratio also showed a decrease at these depths. It can be noted that though the calcium concentration show almost constant values from 300 to 1200 m the magnesium concentration showed a gradual decrease with decreasing salinity. Therefore it may be inferred that this layer of water column is characterised by a watermass which has similar calcium concentration as that of the water above but depleted in magnesium.

### ACKNOWLEDGEMENTS

We are grateful to Dr. S. Z. Qasim for going through the manuscript and suggesting valuable improvements. Our sincere thanks are due to Mr. C. V. G. Reddy and Dr. R. Sen Gupta for all help and suggestions for this work.

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