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ECOLOGY OF INDIAN ESTUARIES: X. DISTRIBUTION OF TOTAL PHOSPHORUS, TOTAL NITROGEN AND TOTAL POTASSIUM IN THE SEDIMENTS OF ASHTAMUDI ESTUARY

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ABSTRACT

The distribution of total phosphorus, total nitrogen and total potassium in the sediments of Ashtamudi, a tropical estuarine system (8°53′–9°2′N latitude and 76°31′–76°41′E longitude) has been studied from riverine to marine area in relation to the texture of the sediment and hydrographical features of the bottom waters. The values of total phosphorus, total nitrogen and total potassium are in the range 0.63–7.32 mg.g^{-1}, 1.49–13.78 mg.g^{-1} and 0.4–3.1 mg.g^{-1} respectively. The pattern of distribution of total P with the textural relationship is discussed. The input of allochthonous phosphates from sewage is traced in the system. The reason for the higher values for total nitrogen in the riverine area is attributable to the admixture of industrial and agricultural wastes.

Key-words : Ecology, nutrients, estuary, Ashtamudi.

INTRODUCTION

The nutrient economy of an aquatic ecosystem is mainly governed by the sediments and knowledge on the role of sediment nutrients is especially useful in determining the sediment-water interactions which eventually affects the productivity. As a part of an overall programme in understanding the ecology of the Ashtamudi estuarine system, the distribution of total phosphorus, total nitrogen and total potassium in the sediments from riverine to marine area in relation to textural features of the bottom mud and hydrographical features of the bottom water has been studied.

For the present study 52 stations were selected in the Ashtamudi estuary, the second largest estuarine system in Kerala lying between 8°53′–9°2′N latitude and 76°31′–76°41′E longitude covering an area of 32 sq. km. The estuary branches off into eight creeks, known by different names. The Kallada River originating from the Western Ghats enters the estuary after traversing for about 120 km. On the basis of geographical features and the noticeable ecological differences the stations have been grouped into different zones, such as River (A), Confluence (B), Kanjirakode (C), Ashtamudi (D), Chavara (E), Thopilkadavu (F), Kandachira (G) and Marine (H).

MATERIALS AND METHODS

Samples of sediments were taken from 52 stations of the Ashtamudi Estuary from 3–17 March, 1981 using a metal corer following the method des-

cribed by Abdul Azis (1978). Each sample covered a surface area of approximately 34 cm^2 and a sediment volume of 718 cm^3. A portion of sediment was oven dried at 100–105 °C overnight. Samples for the estimation of total phosphorus, total nitrogen and total potassium were done by double acid fusion method using sulphuric acid and perchloric acid. Total phosphorus was determined by colorimetric method using amino-napthal-sulphonic acid-reduced molybdophosphoric blue colour method (accuracy $\pm$ 1%, Jackson, 1967), total nitrogen by modified Kjeldahl method and the total potassim by a flame photometer (Jackson, 1967). Oven dried samples were used for the grain size analysis following the international pipette method (Piper, 1950). Samples of the bottom water were also taken and the estimations were done using the methods described by Strickland and Parsons (1965).

RESULTS AND DISCUSSION

The average values of grain size in the Ashtamudi estuarine system showed that the variations in the coarse and fine sand are quite wide. While the coarse fraction varied between 14.31 and 60.85% in the marine and Kanjirakode zones the fine sand fluctuated between 19.87 and 64.35% in the Kanjirakode and marine zones respectively. The fluctuations in the average values of silt and clay were very little and the values ranged between 2.34 and 6.26% in the marine and confluence zones, and 4.08 and 6.26% in the Ashtamudi and confluence zones respectively.

Among the hydrographical features of the bottom water, salinity was the only factor showing a gradient from the river to the marine zone. The penetration of saline water was noticed all along the estuarine system up to the riverine area and the average value of salinity in the river zone was 17.67×10^{-3}. The value showed an increase in the confluence zone and intermediate values were obtained in the Kanjirakode, Ashtamudi, Chavara and Kandachira zones. A relatively higher value (25.42×10^{-3}) was recorded in the Thopilkadavu zone where most of the stations were nearer to the marine zone. The marine zone recorded the maximum value (28.64×10^{-3}) during the entire survey. The temperature and dissolved oxygen values of the bottom water in the system showed minor variations and ranged between 31.1 °C and 31.8°C (zones E and F) and 3.16 $ml.l^{-1}$ and 5.2 $ml.l^{-1}$ (zones E and B) respectively. The average values of phosphate and nitrate ranged between 6.70 $\mu g.at.l^{-1}$ in the Kanjirakode and 3.80 $\mu g.at.l^{-1}$ in the marine zone and 3.3 $\mu g.at.l^{-1}$ in the river zone and 1.45 $\mu g.at.l^{-1}$ in the Kandachira zone.

The values of total P ranged from 1.09–3.24 $mg.g^{-1}$ in the marine zone; 1.28–4.64 $mg.g^{-1}$ in the Thopilkadavu zone; 1.28–4.02 $mg.g^{-1}$ in the Chavara zone; 0.98–4.6 $mg.g^{-1}$ in the Ashtamudi zone and 0.89–3.75 $mg.g^{-1}$ in the Kanjirakode zone. An increasing trend was discernible from the confluence zone towards the river zone. The phosphorus content varied from 1.78–7.32 $mg.g^{-1}$ in the river zone; 0.63–6.25 $mg.g^{-1}$ in the confluence zone and 2.18–5.63 $mg.g^{-1}$ in the Kandachira zone (Fig. 1).

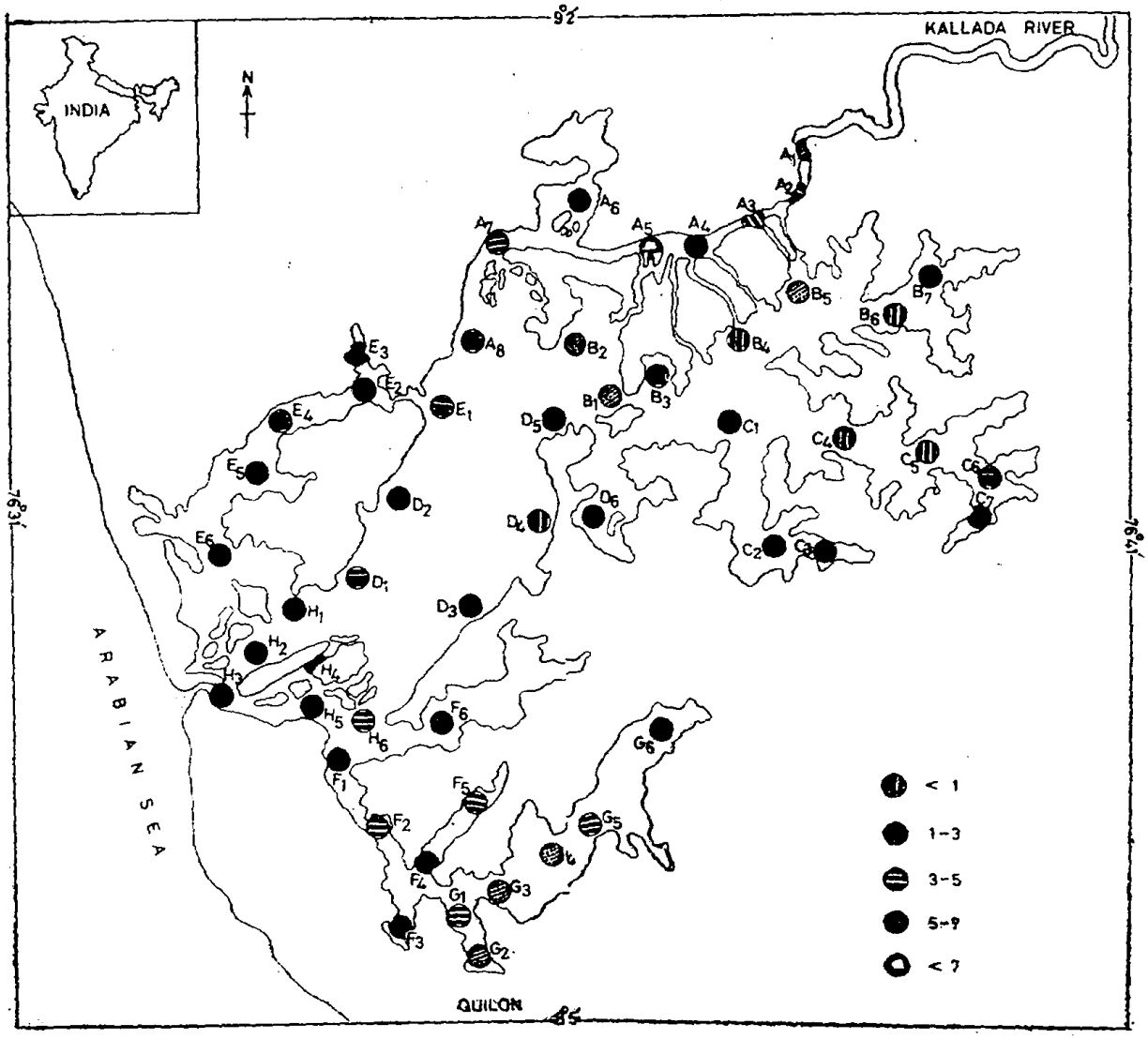

Fig. 1. Distribution of total phosphorus (mg.g^{-1}) at different stations in the Ashtamudi Estuary.

The distribution pattern of total phosphorus is peculiar in that the sediments receiving the input of allochthonous phosphorus in the polluted Kandachira zone, show the highest concentration of total phosphorus. The distribution of total P in the confluence zone sediments is found to be similar to the river zone sediments. Kanjirakode had the lowest average value for total P in the entire estuary closely followed by the marine zone sediments. These low values can be attributed to the unstable physical structure of the sediments caused by navigational movements as well as tides. This is in contrast to the observation in the Cochin backwaters where a decreasing trend of total P from marine to brackish zone was noted by Ansari and Rajagopal (1974). In the

Kandachira zone, among the six stations G_1 and G_2 are polluted by sewage disposal from the nearby town and the phosphorus content in the respective stations were 4.64 $mg.g^{-1}$ and 5.63 $mg.g^{-1}$ whereas in the other stations the P contents were less when compared to the first two stations. Though the stations G_4 and G_6 are polluted by the retting process, low values of P are recorded. This indicates that the high values in the first two stations are mainly due to the sewage effluents from the nearby town. Such an influence of sewage effluents on the increase in total P in coastal and estuarine sediments has earlier been reported (Aston and Hewitt, 1977 and Sankaranarayanan and Panampunnayil, 1979). The particle size exerts a control in phosphorus distribution in sediments, silts and smaller sized grains showing an adsorption effect of increasing phosphorus content with decreasing grain size (Aston and Hewitt, 1977). The dominant role in the adsorption of phosphates by estuarine silts in sediments is also reported by Jitts (1959). The percentage of fine grained (clay) sediments in the Kandachira zone varied from 3.13 to 18.23%. The higher percentage of clay (18.23%) in station G_2 coincides with the highest total P in the sediments. In the river zone the sediments are characterised by the dominance of clay fraction except in station A_6 where the coarse sand (56.43%) dominates showing the minimum concentration of phosphorus, a situation similar to what Murty and Veerayya (1972) noticed in the Cochin backwaters.

Regarding the total nitrogen content (Fig. 2) a distribution gradient from the marine zone to Ashtamudi, Kanjirakode, confluence and river zones was noticeable and the values of respective zones ranged between 1.73–2.23 $mg.g^{-1}$ (H_6 and H_1), 1.49–2.48 $mg.g^{-1}$ (C_5 and C_7), 1.59–2.76 $mg.g^{-1}$ (D_6 and D_1), 1.86–4.42 $mg.g^{-1}$ (B_7 and B_3) and 2.10–13.78 $mg.g^{-1}$ (A_3 and A_5). In the Chavara, Thopilkadavu and Kandachira zones the values of total N content fluctuated between 1.54–5.04 $mg.g^{-1}$ (E_6 and E_4), 1.68–8.08 $mg.g^{-1}$ (F_4 and F_2) and 1.96–5.56 $mg.g^{-1}$ (G_6 and G_2) respectively.

The distribution of total nitrogen in the system is found to be correlated with the distribution of organic carbon. The maximum level in the concentration or organic carbon (Balakrishnan Nair, Arunachalam, Abdul Azis, Krishnakumar and Dharmaraj, 1983) in the riverine area and the higher values in the Chavara and Kandachira zones coincided with the highest total nitrogen in the respective zones. Higher values of nitrogen and organic carbon and their ratio may be especially useful in identifying sediments containing excess nutrients because of contamination by domestic and agricultural waters (Michael Reddy, 1977). Organic matter and total nitrogen in the riverine sediments are of allochthonous origin contributed by fertilizer seepage from the nearby paddy fields. All the stations in the marine zone are near to the bar mouth and the tidal influx and efflux along with heavy siltation are more acute so as to change the whole physical structure of the sediments. Moreover in the marine zone there is dredging for navigational purposes. The unstable conditions in the marine zone may be the possible explanation for the lowest concentration of total nitrogen in the area.

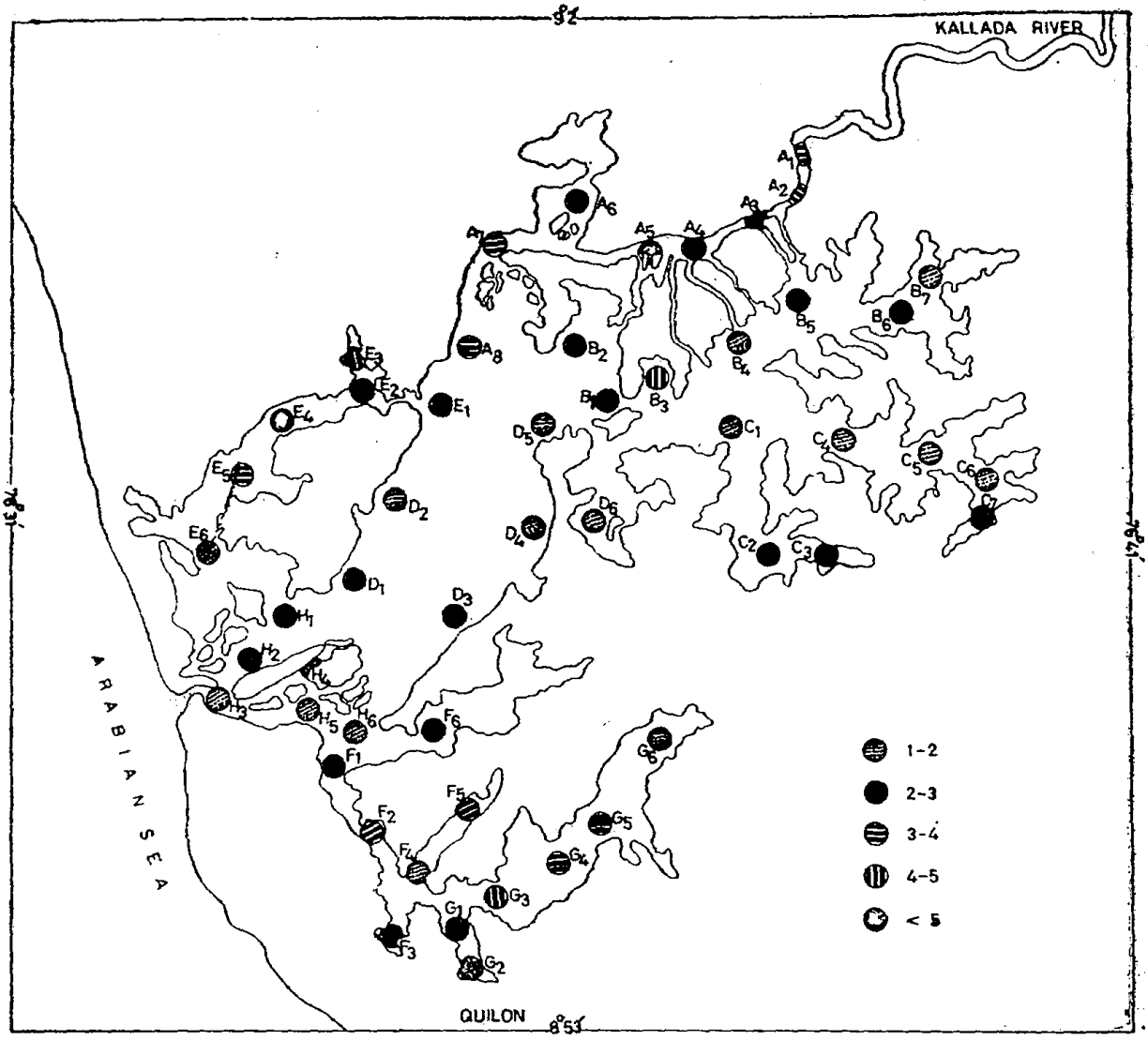

Fig. 2. Distribution of total nitrogen (mg.g^{-1}) at different stations in the Ashtamudi Estuary.

The interzonal variations in the values of potassium were meagre. The values of total K in the Kanjirakode sediments showed the minimum concentration with a fluctuation of 0.40–1.30 mg.g^{-1} (C_5 and C_7). An increasing trend was noticeable from the confluence zone (0.50–3.10 mg.g^{-1} in B_5 and B_2) to the river zone and the maximum was noted in this zone (1.90–3.10 mg.g^{-1} in A_6 and A_1). Despite the wide fluctuations in between the stations (Fig. 3) the average values in the Ashtamudi, Chavara, Thopilkadavu, Kandachira and marine zones were in the range of 1.20–1.67 mg.g^{-1}. The distribution of total potassium in the estuarine system shows little variation among the zones and the Kanjirakode zone sediments recorded the minimum con-

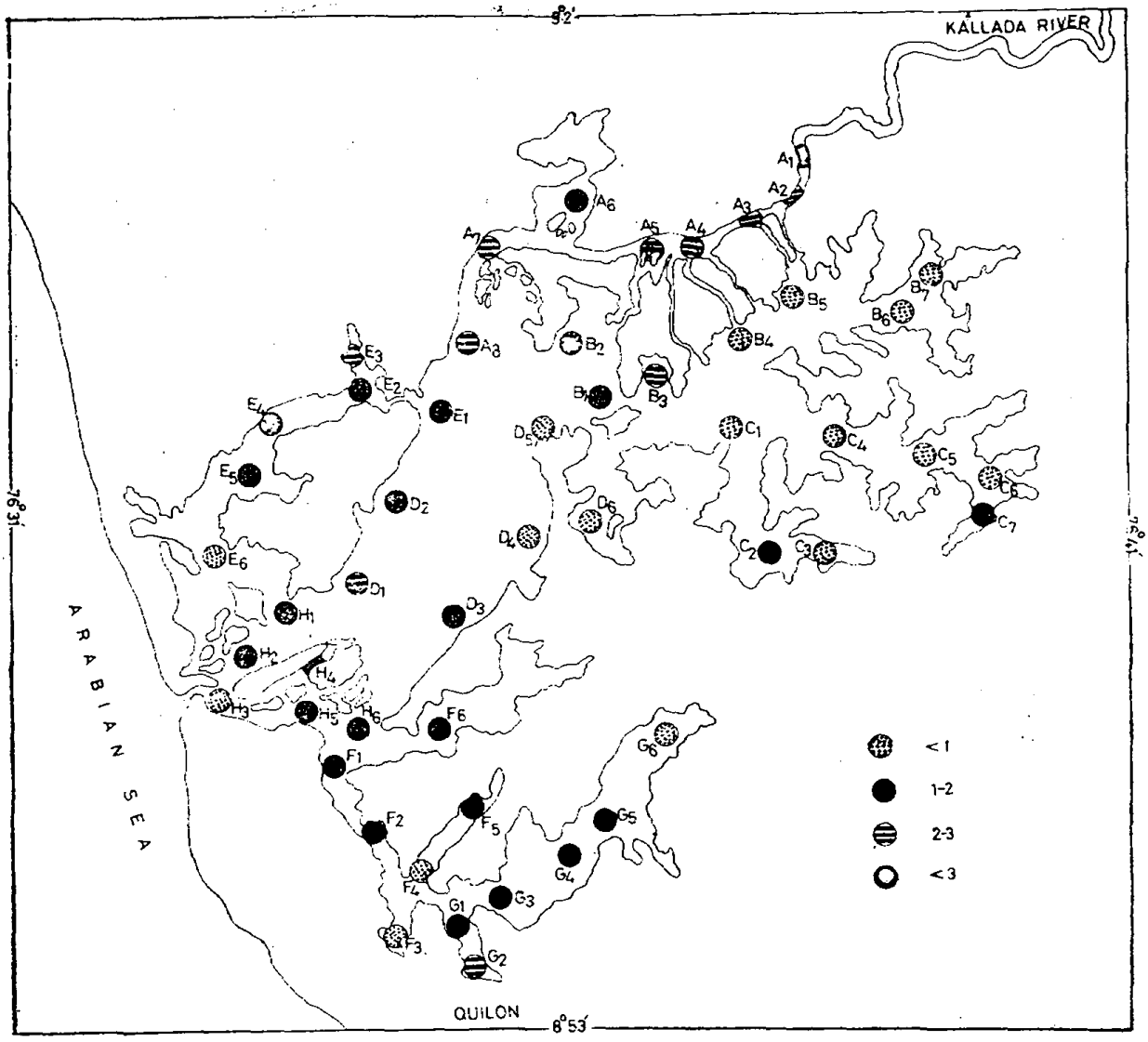

Fig. 3. Distribution of total potassium (mg.g^{-1}) at different stations in the Ashtamudi Estuary.

centration. An increasing trend in the total potassium content was noticeable from the confluence to the river zone.

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REFERENCES

Abdul Azis, P.K., 1978. *Ecology of the retting grounds in the backwater system of Kerala*, Ph.D. Thesis, University of Kerala, Trivandrum.

Anon., 1974. *Water Resources of Kerala*, Government of Kerala, Advance Report, 111 pp.

Ansari, Z.A. and M.D. Rajagopal, 1974. Distribution of mud phosphates in the Cochin Backwater. *Mahasagar—Bulletin of the National Institute of Oceanography*, **7**: 69–72.

Aston, S.R. and C.N. Hewitt, 1977. Phosphorus and carbon distributions in a polluted coastal environment. *Estuarine and Coastal Marine Science*, **5**: 243–254.

Balakrishnan Nair, N., M. Arunachalam, P.K. Abdul Azis, K. Krishnakumar and K. Dharmaraj, 1983. Ecology of Indian Estuaries: Distribution of organic carbon in the sediments of the Ashtamudi Estuary. *Indian Journal of Marine Sciences*, **12**: 225–227.

Jackson, M.L., 1967. *Soil Chemical Analysis*, Prentice Hall of India Private Limited, New Delhi, 583 pp.

Jitts, H.R., 1959. The adsorption of phosphate by estuarine bottom deposits. *Australian Journal of Marine and Freshwater Research*, **10**: 7–21.

Michael M. Reddy, 1977. Nutrients and metals transported by sediments within Genesee river watershed, New York, USA. In: *Interactions betweeen Sediments and Freshwater*, edited by H.L. Golterman, B.V. Publishers, The Hague, 473 pp.

Murty, P.S.N. and M. Veerayya, 1972. Studies on the sediments of Vembanad Lake, Kerala State: Part II — Distribution of total phosphorus. *Indian Journal of Marine Sciences*, **1**: 106–115.

Piper, C.S., 1950. *Soil and Plant Analysis*, Inter Science Publishers, New York. 67 pp.

Sankaranarayanan, V.N. and S.V. Panampunnayil, 1979. Studies on organic carbon, nitrogen and phosphorus in sediments of the Cochin backwater. *Indian Journal of Marine Sciences*, **8**: 27–30.

Strickland, J.D.H. and T.R. Parsons, 1965. A practical hand book of sea-water analysis. *Bulletin of the Fisheries Research Board of Canada*, **125**: 1–203.