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SPATIAL AND SEASONAL VARIATION IN HEAVY METALS IRON, ZINC, MANGANESE AND COPPER IN THE INDUSTRIAL REGION OF THE ENNORE ESTUARY, MADRAS

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ABSTRACT

An estuarine surveillance programme, with a view to assess the current status of the water quality of estuarine zone of Ennore, Madras was carried out during the period from November 1987 to October, 1988. Water and sediment samples were collected from three different stations in the estuarine zone of Ennore. The levels of iron, zinc, manganese and copper were estimated in water and sediment samples. There were only slight seasonal fluctuations in the levels of metals in the water as well as sediment with higher concentrations occurring during the monsoon seasons. The concentration of iron, zinc, manganese and copper in water and sediment exceeded the admissible limit. The pattern of changes in trace metal levels is discussed with reference to variations at the three stations and during different seasons.

INTRODUCTION

WITH THE RAPID PHASE of industrialization, the problems created by the discharge of heavy metallic toxicants are of great concern in the management of marine and estuarine ecosystem (Qasim and Siddiqui, 1960 ; Azariah, 1985 ; Subramanian and Varadaraj, 1989). Among the various types of pollutants, heavy metal is considered to be of serious concern (Holden, 1973 ; Vernberg and Vernberg, 1974). There are numerous reports from developed countries on the contamination and sedimentary load of heavy metals in marine and estuarine environment and their consequences on the environmental quality. However, few studies have been carried out pertaining to the seasonal variations in the levels of heavy metals in the water and sediments of the estuarine environment of the east coast of India. Hence, it was felt necessary to assess the levels of different trace metal in the water and sediment of the Ennore estuary located at the northern border of highly populated Madras city.

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MATERIAL AND METHODS

Description of the study area

The present work was carried out at the Ennore estuary (13°14'N and 80°20'E) located 20 Km north of Madras (Fig. 1). The Kortaliyar river forms the estuary at Ennore, which is connected to the Buckingham canal and discharges their contents into the Bay of Bengal.

Sampling Design

To monitor the water quality of Ennore estuary, three stations S I, S II and S III were

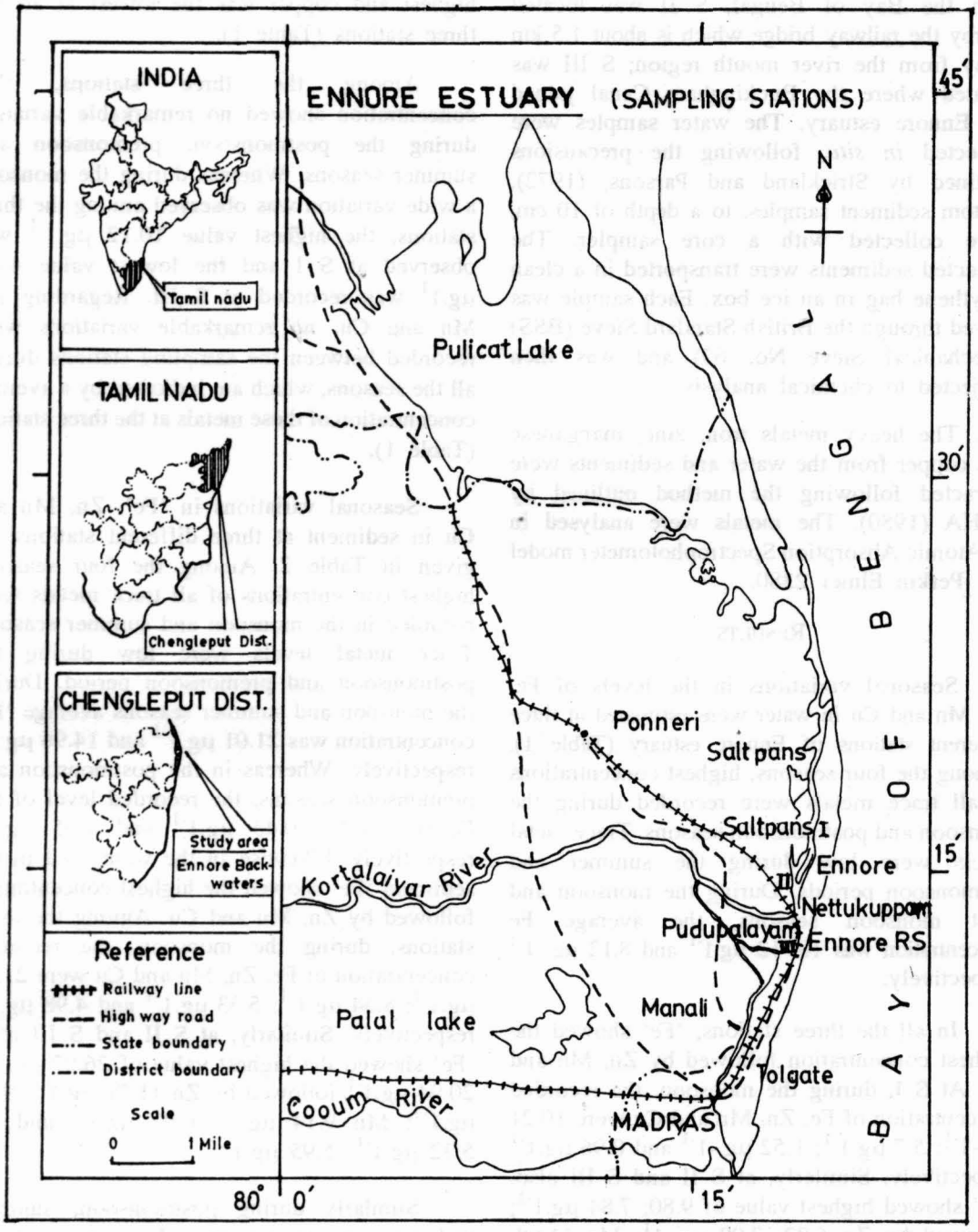

FIG 1. Map of the Ennore estuary showing locations of the stations.

selected (Fig. 1). S I was located nearby the mouth, at a point where Ennore estuary joins with the Bay of Bengal, S II was located nearby the railway bridge which is about 1.5 km away from the river mouth region; S III was located where the Buckingham Canal joined the Ennore estuary. The water samples were collected *in situ*, following the precausions outlined by Strickland and Parsons, (1972). Bottom sediment samples, to a depth of 10 cm, were collected with a core sampler. The collected sediments were transported in a clean polythene bag in an ice box. Each sample was sieved through the British Standard Sieve (BSS) (Mechanical Sieve No. 63) and was then subjected to chemical analysis.

The heavy metals iron, zinc, manganese and copper from the water and sediments were extracted following the method outlined by APHA (1980). The metals were analysed in an Atomic Absorption Spectrophotometer model No. Perkin Elmer 2380.

RESULTS

Seasonal variations in the levels of Fe, Zn, Mn and Cu in water were estimated at three different stations of Ennore estuary (Table 1). Among the four seasons, highest concentrations of all trace metals were recorded during the monsoon and postmonsoon seasons. Trace metal levels were low during the summer and premonsoon periods. During the monsoon and post monsoon seasons, the average Fe concentration was 10. 12 $\mu g.1^{-1}$ and 8.12 $\mu g. 1^{-1}$ respectively.

In all the three stations, 'Fe' showed the highest concentration followed by Zn, Mn and Cu. At S I, during the monsoon, the recorded concentration of Fe, Zn, Mn and Cu were 10.21 $\mu g.\text{-}1^{-1}$; 5.7 $\mu g.1^{-1}$; 1.52 $\mu g.\text{-}1^{-1}$ and 0.96 $\mu g.1^{-1}$ respectively. Similarly, at S II and S III also, 'Fe' showed highest value of 9.80; 7.84 $\mu g.1^{-1}$; followed by Zn 6.82; 7.08 $\mu g.\text{-}1^{1}$; Mn 11.08; 1.60 $\mu g.1^{-1}$ and Cu 0.79; 1.0 $\mu g.\text{-}1^{1}$ respectively. Similarly, during postmonsoon, summer and premonsoon season, 'Fe' concentration was the highest and copper was the lowest at all the three stations (Table 1).

Among the three stations, 'Fe' concentration showed no remarkable variation during the postmonsoon, premonsoon and summer seasons. Whereas during the monsoon a wide variation was observed among the three stations, the highest value 10.12 $\mu g.1^{-1}$ was observed at S I and the lowest value 4.4.0 $\mu g.1^{1}$ was recorded at S III. Regarding Zn, Mn and Cu, no remarkable variations were recorded between the sampling stations during all the seasons, which are indicated by a average concentration of these metals at the three stations (Table 1).

Seasonal variations in 'Fe', Zn, Mn and Cu in sediment at three different stations are given in Table 2. Among the four seasons, highest concentrations of all trace metals were recorded in the monsoon and summer seasons. Trace metal levels were low during the postmonsoon and premonsoon period. During the monsoon and summer seasons average 'Fe' concentration was 21.01 $\mu g.1^{-1}$ and 14.96 $\mu g.1^{-1}$ respectively. Whereas in the postmonsoon and premonsoon seasons, the recorded level of the Fe was only 10.43 $\mu g.1^{-1}$ and 4.65 $\mu g.1^{-1}$ respectively. Likewise in the water and in the sediment 'Fe' showed the highest concentration followed by Zn, Mn and Cu. Among the three stations, during the monsoon, the recorded concentration of Fe, Zn, Mn and Cu were 21.01 $\mu g.1^{-1}$; 8.34 $\mu g.1^{-1}$; 5.33 $\mu g.1^{-1}$ and 4.98 $\mu g.1^{-1}$ respectively. Similarly, at S II and S III also, 'Fe' showed the highest value of 26.07 $\mu g.1^{-1}$; 20.94 $\mu g.1^{-1}$ followed by Zn 11.71 $\mu g.1^{-1}$; 9.85 $\mu g.1^{-1}$; Mn 9.14 $\mu g.1^{-1}$ 6.07 $\mu g.1^{-1}$ and Cu 5.32 $\mu g.1^{-1}$; 5.95 $\mu g.1^{-1}$.

Similarly during postmonsoon, summer and premonsoon seasons, Fe concentrations were the highest and Cu were lowest at all

TABLE 1. *Showing the trace metal content (Fe, Zn, Mn & Cu) in waters of the Ennore estuary during different seasons. (November 1987 - October, 1988)* $\mu g.1^{-1}$

		MONSOON (November-January)			POSTMONSOON (February-April)			SUMMER (May-July)			PREMONSOON (August-October)		
Station	Metals	Max.	Mini.	Average	Max.	Mini.	Average	Max.	Mini.	Average	Max.	Mini.	Average
S I	Fe	13.40	7.35	10.12	9.63	6.53	8.12	6.63	4.56	5.90	6.40	3.11	4.47
	Zn	6.98	3.1	5.7	7.35	3.32	5.75	6.25	2.14	5.39	6.00	2.25	4.27
	Mn	2.10	0.93	1.52	7.05	1.08	3.09	1.42	0.96	1.26	2.0	1.10	1.32
	Cu	1.04	0.93	0.96	1.06	0.95	1.0	1.08	0.70	0.88	0.98	0.89	0.92
S II	Fe	12.31	8.30	9.80	10.76	2.30	6.05	6.81	1.89	4.60	5.10	4.20	4.50
	Zn	7.72	5.25	6.82	7.56	5.08	6.63	4.33	4.25	4.28	5.0	1.90	3.10
	Mn	1.24	0.98	1.08	1.51	1.28	1.36	4.15	0.85	2.09	1.03	0.99	1.01
	Cu	1.13	0.58	0.79	1.02	0.98	1.0	2.00	0.97	1.32	1.50	0.58	0.96
S III	Fe	11.20	6.12	7.84	10.76	2.15	5.86	8.25	4.54	5.80	6.0	2.58	4.40
	Zn	7.56	6.55	7.08	7.11	2.56	5.46	4.60	2.79	3.80	6.0	2.16	3.7
	Mn	2.50	1.07	1.60	1.46	0.57	1.0	3.64	0.95	1.89	1.08	1.02	1.04
	Cu	1.09	0.96	1.0	1.02	0.96	0.98	1.07	0.92	0.98	1.08	0.60	1.02

TABLE 2. *Showing the trace metal content (Fe, Zn, Mn & Cu) in Sediment of the Ennore estuary during different seasons (November 1987 - October, 1988)* $\mu g.^{-1}$

		MONSOON			POSTMONSOON			SUMMER			PREMONSOON		
Station	Metals	Max.	Mini.	Average	Max.	Mini.	Average	Max.	Mini.	Average	Max.	Mini.	Average
S I	Fe	26.42	16.98	21.01	19.56	5.46	10.43	18.32	12.12	14.96	5.46	4.08	4.65
	Zn	11.4	6.51	8.34	4.66	2.34	3.3	6.96	2.19	4.66	6.0	3.0	4.53
	Mn	6.10	4.84	5.33	3.45	1.84	2.42	4.50	2.50	3.45	5.10	3.48	4.34
	Cu	8.15	3.10	4.98	4.30	1.23	2.39	4.50	2.50	3.32	4.30	1.65	2.68
S II	Fe	33.60	13.20	26.07	9.36	6.46	7.75	19.16	10.48	15.6	6.48	5.20	5.71
	Zn	15.50	4.57	11.71	4.80	3.74	4.32	10.50	3.52	6.20	10.50	3.0	5.67
	Mn	12.91	2.84	9.14	3.54	2.07	2.56	4.80	3.74	4.32	10.50	3.0	5.67
	Cu	7.44	3.10	5.32	3.20	1.66	2.19	3.74	1.30	2.81	3.20	1.38	2.06
S III	Fe	25.40	16.02	20.94	22.20	10.00	14.68	19.36	14.20	16.53	9.08	5.42	7.0
	Zn	13.37	5.86	9.85	10.45	2.56	5.40	11.86	2.86	6.25	6.50	4.05	5.18
	Mn	0.09	3.26	6.07	5.50	4.40	4.85	9.20	2.80	5.11	9.20	2.90	5.7
	Cu	6.72	5.12	5.95	6.55	2.44	3.82	5.05	3.01	3.82	5.60	3.10	4.23

the three stations. Among the three stations, Fe concentrations showed no remarkable variation during monsoon season whereas during postmonsoon, summer and premonsoon seasons a wide variation was observed among the three stations, the highest value 26.07 $\mu g.l^{-1}$ (monsoon) was observed at (Near railway Bridge) S II and the lowest value 4.65 $\mu g.l^{-1}$ (Premonsoon) at S I (mouth regions). Regarding Zn, Mn and Cu, no remarkable variations were recorded between the sampling stations during all the seasons, which are indicated by a average concentration of Zn, Mn, Cu, metals at the three stations (Table 1).

DISCUSSION

The results of the present study provide evidence that the Ennore estuary, located on the East Coast of India, has been subjected to environmental stress due to heavy metal pollution. Among the four metals studied Fe seems to be the dominant metal both in the water and sediment. The copper concentrations were low in both the samples at all the three stations throughout the study period.

Ouseph (1992), reported the low concentration of Fe and high concentrations of Zn and Cu in the Cochin estuary and stated that the high levels of metals may be due to the anthropogenic input ie, from the effluent discharge from the local industries, harbour activity and sewage into the estuary. He has quoted that the effluent discharge point showed high concentration of metal which indicates that the transport route of heavy metal may be from industrial sources. In addition to the above observation he has stated that the Fe concentration was found to increase from monsoon to non-monsoon periods in the Cochin estuary whereas in the Ennore estuary Fe was found to decrease from monsoon to non-monsoon periods. Sankaranarayanan and Rosamma Stephen (1978) reported higher levels of Fe, Zn and Mn in the Cochin backwater. Whereas, Zingde *et al*, (1976) reported 42.3 $\mu g.l^{-1}$ of Zn and 102.2 $\mu g.l^{-1}$ of Mn and 69.77 $\mu g.l^{-1}$ of Cu in the Mandovi-Zuari estuaries, Goa. Sivasamy (1990) reported lesser values of Zinc and copper in the water and sediments of coastal regions of Ennore. The recorded values were 1.670 $\mu g.l^{-1}$ and 6.30 $\mu g.l^{-1}$ of Zn, and 1.704 $\mu g.l^{-1}$ and 0.800 $\mu g.l^{-1}$ of Cu in water and sediment respectively. From the above reports, it is stated that when compared to other estuaries, the incidence of recorded values of heavy metals were relatively lesser in the Ennore estuary. The higher contents of Fe in the estuary may be due to the anthropogenic input from the industrial sources, urban sewage, flyash sedimentation from Ennore Power station and harbour activity. The lesser values of copper in the estuary may be due to the biological utilisation of copper containing materials by the aquatic organisms which is supported by Lee (1970) who reported that the differential profile of copper, when compared with the other heavy metals, is suggestive of biological fractionation of some selectivity in absorption or due to secondary mobilization of metals by organic substances. In conclusion by comparing with the maximum permissible level of metals laid by ISI (1982), in the open coastal water are 50 mg/l for Fe, for Zn 15 mg/l, for Mn 50 $\mu g/l$ and 1.5 mg for Cu. The present study indicate that the movement of metals was not localized at one station but it was spread out at all the three stations. During the past two decades, many factories like Kothari Chemicals, Eveready Batteries Ltd., EID — parry, Ennore Foundries, Ashok Leyland, Ennore Thermal Power Station, Ennore Steel Enterprises Ltd., have been put into operation nearby Ennore backwaters and discharge their effluents into the estuary directly through Buckingham canal. Regular monitoring should be done to have better quality for fishery resources in nearby future. The implementation of water quality management model for the study area is recommended.

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