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Implications of physical parameters and trace elements in surface water off Pondicherry, Bay of Bengal, South East Coast of India

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ABSTRACT

The heavy metals generally, enter the aquatic environment through atmospheric deposition, erosion of geological matrix or due to anthropogenic activities caused by industrial effluents, domestic sewage and mining wastes. The main objectives of this paper is to understand the processes controlling major and trace elements in the surface water and to identify natural and anthropogenic sources in the coastal environment using distribution of elemental concentrations to establish regional baseline levels. Totally, 25 samples were collected from offshore Pondicherry and Veerampattnam upto 12 mts depth.Metal enrichments observed close to the major urban areas in the Pondicherry coast are associated with the industrialized activities areas rich in Zn and Pb in the coastal sediments.The higher concentration is observed in the Pondicherry region than the Veerampatnam.

Keywords: Implications of Physical Parameters, Trace Elements, Off Pondicherry,South East Coast of India

1. Introduction

The geochemical composition of estuarine and coastal marine sediments is largely governed by the physicochemical characteristics (pH, Eh, O2, etc.) of the depositional environment and associated natural biogeochemical processes such as diagenesis, adsorption/desorption on/from organic matter, and precipitation-dissolution of Fe-Mn oxyhydroxides (e.g. Berner, 1980). Ganapathi and Raman (1973) revealed that North Madras showed relatively higher values of Fe, Cu, Mn, Zn and Hg than the stations north of Visakhapatnam, due to the discharge of large amount of sewage and other waste from various outlets along the coast.

Sanzgiry *et al*. (1981) studied for the first time the trace metal concentration in both the dissolved and particulate fractions of the Andaman Sea water samples. Ray *et al*. (1984) studied the dissolved components in the estuarine waters of Mahanadi River. The seasonal study on the distribution of trace metals like Mn, Fe, Co, Ni, Cu, Zn, Cd and Pb in both dissolved and particulate phases of surface and bottom waters of Visakhapatnam Harbor was carried out by (Satyanarayana *et al*., (1985).They reported that dissolved and particulate trace metals in Visakhapatnam Harbor waters were higher when compared to the adjacent coastal waters. Sarin *et al*. (1985) calculated the monsoon fluxes of Na, K, Ca, Mg, Si and clay particulate Al, Mn, Fe, Co from Krishna and Godavari rivers to the Bay of Bengal.

Heavy metals like Cu, Zn, Pb, Hg and Cr in the estuarine and nearshore waters and sediments have been reported along the coast of Bay of Bengal. Subramanian *et al*. (1987) studied the heavy metal content in suspended particulate and bed sediments of a tropical perennial river and estuary, central Kerala, Some studies were carried out on the distribution of heavymetals

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in water and sediments from Indian regions are limited (Pragatheeswaran et al.,1986; Subrahmanyam and Ananthalakshmi Kumari , 1990; Ramachandran, 1990; Satyanarayana et al., 1990; Subramanian and Mohanachandran,On the east coast of India, the available information on the concentration of heavy metals in the sediments is limited. (Padma, and Periakali, 1999) .Only limited studies have been carried put in this region, hence am attempt has been made to identify the water geochemistry and know the trace metals in this region.

2. Study Area

The present study area extends between off Pondicherry and Veeranampatnam (Figure.1). It falls in the survey of India toposheets 58m1/16, 58N1/8 prepared in the scale of 1:50,000.. The study area experiences a tropical sub-humid type of climate with an annual mean temperature of 25°C and average annual precipitation of 1200 mm. The coastal districts have an excellent network of coastal road and railway line connecting Pondicherry to Cuddalore.

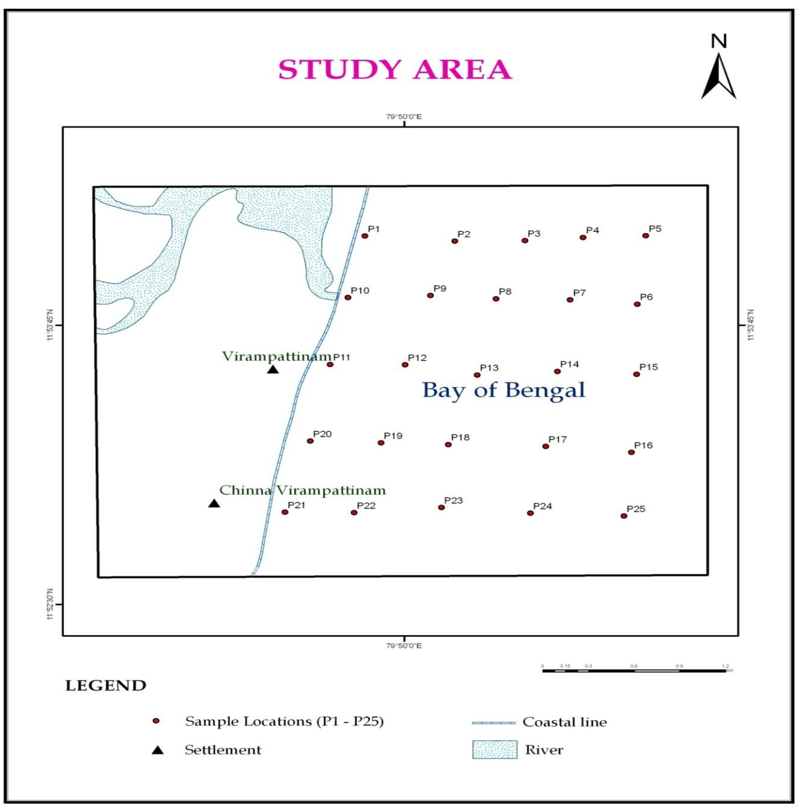

Figure 1: Sampling locations of the study Area

3. Materials and methods

3.1. Field work

Totally, 25 water samples were collected from offshore Pondicherry and Veerampattnam upto 12 mts depth. The offshore samples were collected at grid like pattern at five transects

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keeping the stations at Off Pondichery, Off Sunambu River, Veerampatnam1, Veerampatnam 2, and Chinna Veerampatnam. Global Positioning System (GPS) was used to locate the sample sites in the offshore region. (Figure.2 and Table.1) Surface water samples were collected in pre cleaned and acid washed polypropylene bottles and they were filtered in Millipore filter paper [mesh size 0.45].

For the determination of total trace metals in sub-samples of the sediment sample, solution B was used to estimate Mn, Cr, Cu, Ni, Co, Pb, Zn, Cd following the method of Loring and Rantala (1992). The resulting solution was aspirated to the flame Atomic Absorption Spectrophotometer [Perkin – Elmer Model 700] for the determination of Zn, Cu, Fe, Mn, Co, Pb, Cd and Ni. available in the Department of Earth Sciences, Annamalai University.

Figure 2: Collection of sediment samples

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Table.1**:** Geographical locations of the study area

Sample No.	Longitude	Latitude
P1	79º 83' 83"	11º 90' 63"
P2	79º 84' 32"	11º 90' 43"
P3	79º 84' 73"	11º 90' 29"
P4	79º 84' 83"	11º 90' 27
P5	79º 84' 92"	11º 90' 23"
P6	79º 84' 90"3	11º 89' 74"6
P7	79º 84' 60"3	11º 89' 76"8
P8	79º 84' 30"3	11º 89 789
P9	79º 83' 94"	11º 89' 88"5
P10	79º 83' 51"2	11º 90' 01"4
P11	79º 83' 46"9	11º 89' 30"8
P12	79º 83' 90"8	11º 89' 28"6
P13	79º 84' 20"7	11º 89'16"8
P14	79º 84' 52"8	11º 89' 19"
P15	79º 84' 90"3	11º 89' 15"8
P16	79º 84' 90"3	11º 88' 59"1
P17	79º 84' 52"8	11º 88' 60"1
P18	79º 84' 12"2	11º 88' 67"6
P19	79º 83' 60"8	11º 88' 73"
P20	79º 83' 24"4	11º 88' 76"2
P21	79º 83' 11"6	11º 88' 29"1
P22	79º 83' 67"2	11º 88' 16"3
P23	79º 84' 08"9	11º 88'17"3
P24	79º 84' 55"	11º 88' 13"1
P25	79º 84' 99"9	11º 88' 07"7

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4. Results and discussions

4.1. Temperature

The present study does not show much variation in temperature at different depths in the offshore stations (29^{o}C to 30^{o}C). This is due to the fact that the stations are located in the nearshore environment with in the depth of 20 m.

4.2. Hydrogen Ion Concentration

pH is an expression of the hydrogen ion concentration. It is used to express the acidic and alkaline nature of the water. The pH value depends upon the salinity and temperature of the water and the climatic condition present in that area. the chemical and biological condition of water also place a role in the control of pH concentrations. The pH of the natural water system depends on the concentration of carbonate, bicarbonate and hydroxyl ion present. Ragothaman (1974) stated that the values of pH do not vary much in the different stations during any month, in the Bay of Bengal, off Porto Novo. Since the fluctuation of pH values is meager, the alkaline medium is maintained throughout within the limits for the tolerance of the fauna. Kumar (1988) noted that the pH values of the bottom waters do not vary much in the different stations during any season. Similarly, the mean pH values for all the 25 sampling stations do not exhibit considerable changes.

4.3. Manganese

Manganese is the second most abundant cation in sea water next to sodium. It does not appear to take part in the biological cycle; thereby it behaves as a conservative element in sea water. Therefore, its ratio to chlorinity is more or less constant except in nearshore areas where fresh water and other industrial activities modify the relationship between these two ions. In the present study, values of Manganese fall between 2.38-51.38 µg/l and Average valve is 13.440. Distribution of Mn (µg/l) in surface waters of Bay of Bengal, Off Pondicherry. (Figure 3 and Table.2).

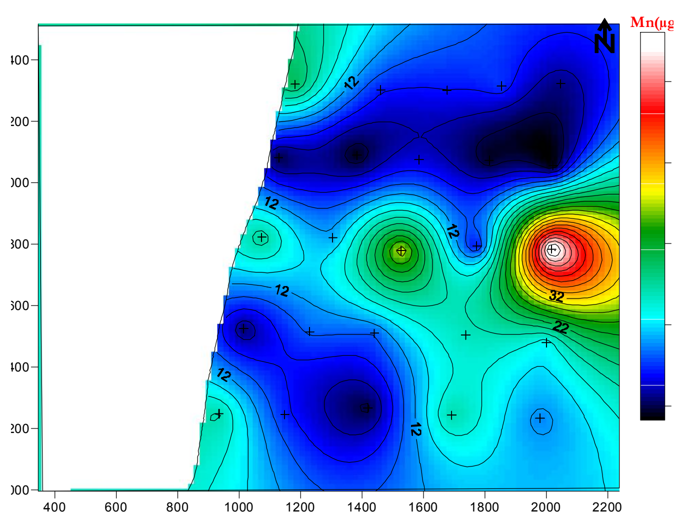

Figure 3: Distribution of Mn in the surface waters of the study area

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Table.2: Analytical values of Trace Metals in Surface Waters of the Study Area

Sample No	Mn(µg/l)	Cr(µg/l)	Cd(µg/l)	Cu(µg/l)	Pb(µg/l)	Zn(µg/l)	Ni(µg/l)
P1	22	1.88	0.85	4.88	8.75	80.13	3.75
P2	8.25	1.25	0.32	4.63	8.75	34.25	3.25
P3	8	1.25	0.33	4.63	8.75	33.5	4.63
P4	9	1.75	0.35	4.75	6.25	41.5	2.63
P5	5	1.75	0.98	10.75	7.5	38.88	12.25
P6	2.38	0.63	0.21	3.25	13.75	12.75	3.13
P7	3.13	1.13	0.37	2.13	2.5	24.25	2.25
P8	6.88	1.5	0.23	3.88	8.75	29.88	2.75
P9	2.75	1	0.2	2.5	3.75	19.63	2.13
P10	3.75	1	0.31	2.38	5	15	2.25
P11	19.25	2	0.42	4.88	16.25	59.88	3.5
P12	12.38	0.88	0.45	3.13	18.75	23.38	3.25
P13	29.63	2	0.82	5.5	47.5	47.5	4.75
P14	7.88	0.5	0.8	4.5	11.25	23	5.63
P15	51.38	5.75	3.75	6.88	15	67.13	7.5
P16	14.88	6	4	2.63	10	21.75	4.88
P17	17.5	9.88	5.38	4.88	10	39.38	5.75
P18	10.13	7	3.88	4.13	11.25	17.63	4.88
P19	10.38	6	5	2.5	11.25	19.25	6.13
P20	4.63	6.38	3.38	1.25	1.25	6.13	3.13
P21	18.25	10.5	4.63	4	11.25	61.63	8.13
P22	8.5	5.25	3.75	2.75	10	19.75	5.88
P23	3.55	1.2	0.21	2.18	5.5	15.8	2.15
P24	18.25	3.5	0.32	4.58	14.25	57.88	2.5
P25	11.38	0.78	0.35	2.13	16.75	21.38	2.35
Min	2.38	0.5	0.2	1.25	1.25	6.13	2.13
Max	51.38	10.5	5.38	10.75	47.5	80.13	12.25
Average	13.440	3.399	1.736	4.137	12.324	33.981	4.586

4.4. Nickel

Seawater contains approximately 0.5-2 ppb of nickel. Phosphate fertilizers contain traces of nickel. Nickel is often present in agricultural soils situated near fossil fuel industries. Organic matter often adsorbs nickel, causing coal and oil to contain traces of the element. Nickel compounds may also be found in sludge, and in slags and fly ashes from waste incinerators. In the study area nickel values ranges from 2.13 – 12.75 µg/l,and Average valve is 4.586 µg/l are higher in concentration at Chiina Veeranampatnam ranging upto 12.75 µg/l (Figure.4).

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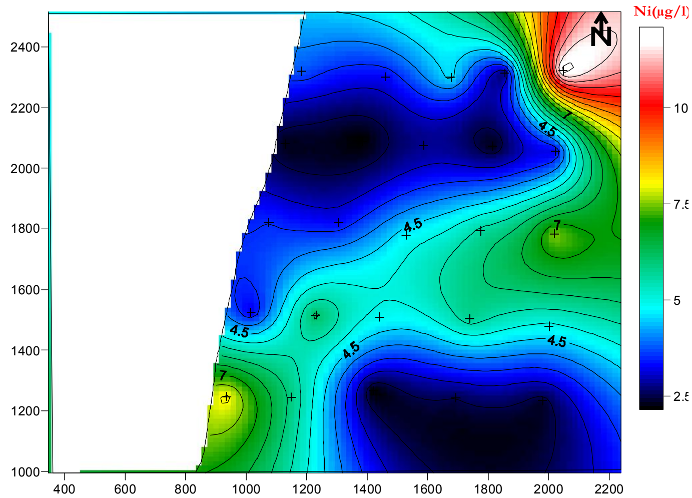

Figure 4: Distribution of Ni in the surface waters of the study area

4.5. Zinc

Zinc is naturally present in water. The average zinc concentration in seawater is 0.6-5 ppb. The solubility of zinc depends on temperature and pH of the water in question. When the pH is fairly neutral, zinc in water insoluble. Solubility increases with increasing acidity. Above pH 11, solubility also increases. Zinc dissolves in water as ZnOH+ (aq) or Zn_2+ (aq). Anionic $ZnCO_3$ has a solubility of 0.21 g/L. Zinc is a relatively nontoxic element. In the study area Zinc values ranges from 6.13 – 80.13 µg/l,and Average valve is 33.981 µg/l. Excessive intakes of zinc occur only with the inappropriate intake of supplements. In the study area, the zinc concentration is slightly fluctuating in all the stations. High concentration of zinc is may be due to more discharge of zinc containing fertilizers, pesticide through the rivers. (Figure.5).

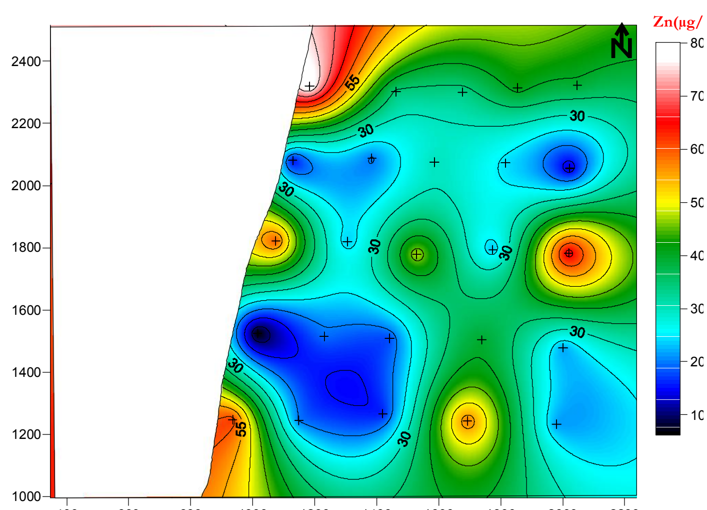

Figure 5: Distribution of Zinc in the surface waters of the study area

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4.6. Lead

Seawater contains trace amounts of lead (2-30 ppt). Under normal conditions lead does not react with water. However, when lead comes in contact with moist air reactivity with water increases. A small lead oxide (PbO) layer forms at the surface of the metal. When both oxygen and water are present, metallic lead is converted to lead hydroxide ($Pb(OH)_2$): $2Pb(s) + O_2(g) + 2H_2O(l) \rightarrow 2Pb(OH)_2(s)$.Lead and lead compounds are generally toxic pollutants. Lead (II) salts and organic lead compounds are most harmful ecotoxicologically. Lead salts are attributed to water hazard class 2, and consequently are harmful. The same applies to lead compounds such as lead acetate, lead oxide, lead nitrate, and lead carbonate. In the study area Lead values ranges from 1.25 – 47.5 µg/l,and Average valve is 4.137µg/l. All the stations shows more are less similar values except Veeranampatnam deeper depths shows higher values. (Figure 6).

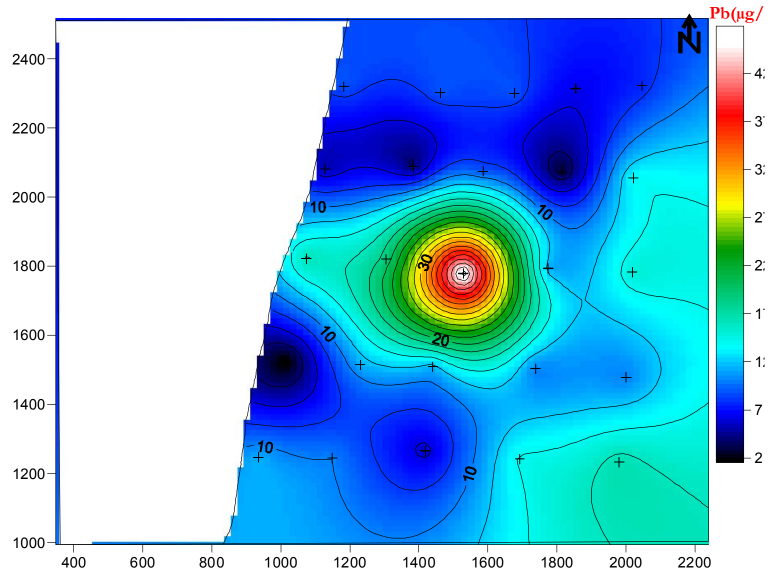

Figure 6: Distribution of Lead in the surface waters of the study area

4.7. Copper

Copper is a comparatively heavy metal. The density of liquid copper is 8.22 g/cm^3 (4.75 oz/in.^{3}) near the freezing point. Very high values of the elements reveal anthropogenic input from the coastal industries. The antifouling paints used for the sea water intake pipeline structure is one of the major sources of higher concentrations of copper. The high concentrations of copper leaching from the ship's antifouling paint have been reported in the Indian Ocean (Danielson, 1980). In the study area Copper values ranges from 1.25 – 10.75 µg/land Average valves is 4.137 µg/l. (Figure.7).

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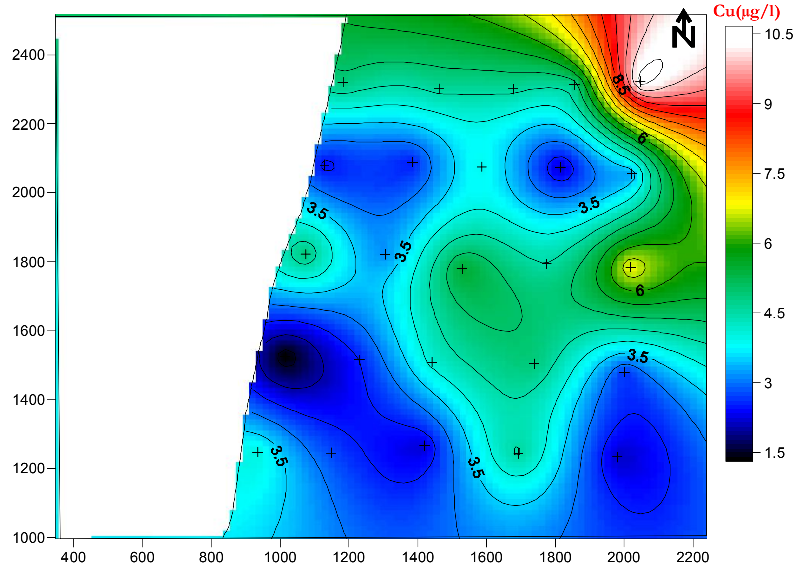

Figure 7: Distribution of Copper in the surface waters of the study area

4.8. Chromium

Chromium does not occur freely in nature. The main chromium mineral is chromite. As was mentioned earlier, chromium compounds can be found in waters only in trace amounts. Seawater chromium content varies strongly, and is usually between 0.2 and 0.6 ppb. Chromium may be present in domestic waste from various synthetic materials. Through waste incineration it may spread to the environment when protection is insufficient. In the study area Chromium values ranges from 0.5– 10.5 µg/l,and Average valve is 3.399 µg/l At Veeranampattnam and Chinna Veeranampattanam shows higher concentration. (Figure.8).

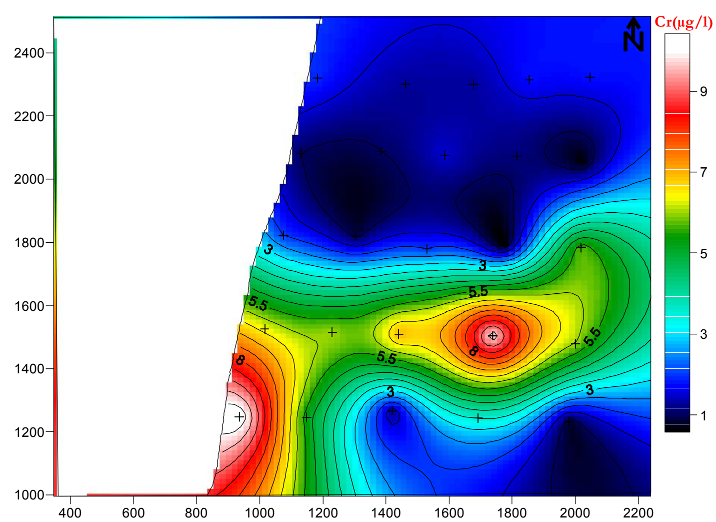

Figure 8: Distribution of Chromium in the surface waters of the study area

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4.9. Cadmium

The Cadmium concentration of the surface water off Veeranampatnam shows higher concentration. In the study area Cadmium values ranges from 0.2 – 5.38 µg/l,and Average valve is 1.736 µg/l (Figure.9).

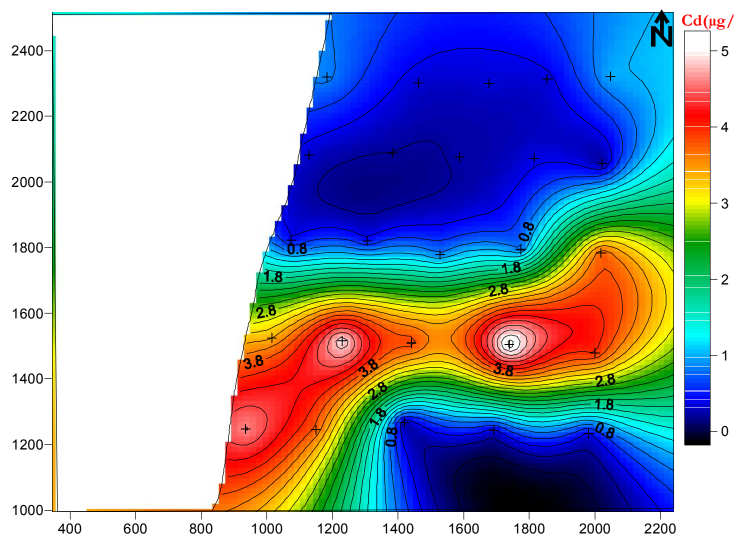

Figure 9: Distribution of Cadmium in the surface waters of the study area

4.10. Discussion

In the study area the surface temperature is slightly higher. The surface water temperature showed an increasing trend from November through June and was influenced by the intensity of solar radiation, evaporation, freshwater influx and cooling and mix up with ebb and flow from adjoining neritic waters (Ajithkumar et al.,2006; Saravanakumar et al., 2008).

Hydrogen ion concentration (pH) in surface waters remained alkaline at both stations with maximum value summer seasons. Generally, its seasonal variation is attributed to factors like removal of Co by photosynthesis through bicarbonate degradation, dilution of seawater by freshwater influx, low primary productivity, reduction of salinity and temperature, and decomposition of organic matter (Paramasivam and Kannan, 2005; Bragadeeswaran et al., 2007). The recorded high summer pH might be due to the influence of seawater penetration and high biological activity (Govindasamy et al., 2000) and due to the occurrence of high photosynthetic activity (Sridhar et al., 2006; Saravanakumar et al., 2008).

In water sample the accumulation of heavy metals was observed in the order of Zn>Mn>Pb>Ni>Cu>Cr>Cd. Highest recorded value among heavy metals was Zn which varied from and the lowest recorded value among heavy metals was Cd. Transportation to and from the port and industrial activities also play a major role in increasing the metal level in this region The distribution pattern of metals was Cr > Ni > Zn >Pd > Cu > Cd and it outweighs the presence of metals associated with the bottom sediments contaminated with anthropogenic inputs (Jonathan and Ram Mohan, 2003). Various river channels, which may

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act as pathways for accumulation of trace element concentration in this region in Karaikkal, Kalpakkam and Tarangambadi areas (Srinivasalu, et al., 2005); our results corroborate the above findings.

Concentrations of heavy metals in water in all the stations varied in nature . Variability in the distribution of metals appeared to be more related to hydrobiological conditions. Concentrations of dissolved metals especially of Cu and Zn were high during the summer season. Cd and Hg concentrations were high during the summer. Generally, the natural sources of heavy metals in coastal waters are through land and river runoff, and the mechanical and chemical weathering of rocks. The components also were washed from the atmosphere through rainfall, wind blown dust, forest fire, and volcanic particles, adding to the distribution of heavy metals in water (Bryan, 1984). Low levels of Cu in the surface could be due to the adsorption of Cu on to the particulate matter and consequent settlement to the bottom. Levels of the metals observed in the present study are significantly higher or similar to the levels reported from the coastal and nearshore waters in and around India especially from the Bay of Bengal. It is therefore concluded that the Tranquebar coastal area is getting polluted with these metals, thus substantiating the view of Ramachandran (1990) who reported that the coastal waters of Tamil Nadu state are likely polluted with heavy metals.(Sankar et al, 2010)

The higher concentration of metals observed during monsoon could be attributed to the heavy rainfall and subsequent river runoff, bringing much industrial and land derived materials along with domestic, municipal, and agricultural wastes, which include residues of heavy metal containing pesticides (Pragatheeswaran et al., 1986; Senthilnathan and Balasubramanian, 1997; Ananthan et al., 1992,2005, 2006; Karthikeyan et al., 2004, 2007). Zn and Cu always have a tendency to couple with organic carbon. Decomposition of the organic matter remain are found to release heavy metals back to sediments and accumulated; and this process might be responsible for the strong association of Zn and Cu with organic carbon (Bardarudeen et al., 1996). Zn and Cu are generally good indicators of anthropogenic inputs (Forstuer and Wittman, 1979). The extensive use of antifouling paints during the peak fishing season in postmonsoon would have released cuprous oxide which in turn enriches the Cu content in the water (Ananthan et al., 1992, 2005, 2006). Eventually, it would be settled from the water column by flocculation and sedimentation (Karthikeyan et al., 2007). In summer, these metals might slightly elevated in content because the low salinity and high pH water might have caused the adsorption of these metals, leading to their removal from the water column. Our findings also coincide with Sankar et al, 2010.

5. Conclusion

In general, the present study clearly showed significant variations in the accumulation of heavy metals in water. The present baseline information of the heavy metals in water would form a useful tool for further ecological assessment and monitoring of these coastal environments. Over all from this study it is observed that off Pondicherry the concentrates of heavy metal is more than the Veeranampatnam. The higher concentration of metals in this region could be attributed to the heavy rainfall and subsequent river runoff, bringing much

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industrial and land derived materials along with domestic, municipal, and agricultural wastes, which include residues of heavy metal containing pesticides.

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