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Research Article

A MULTIDIMENSIONAL POLLUTION THREATENED TO ODIYUR LAGOON, SOUTH EAST COAST OF TAMIL NADU, INDIA

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A B S T R A C T

The Odiyur Lagoon is situated in Cheyyur Taluk of Kancheepuram district, Tamil Nadu, on the southeast coast of India. The present study aims at the distribution of metals in the odiyur lagoon, in order to enhance the data inventory for the region and help to understand the influence of anthropogenic activities. Sodium is the dominant cation among the other cation in the study area and the order of abundance cation is Na>K>Mg>Ca. Iron and manganese concentrations show high in station 3 and 5 indicating high in western part of the lagoon which is landward side and gradually decreases towards eastern side. It is observed that lagoon is moderately enhanced with heavy metals in water samples due to anthropogenic activities. Hence the management should consider the reduction of heavy metals in the Odiyur Lagoon.

INTRODUCTION

The quality of coastal waters in many regions of the world has deteriorated in recent years as human population and activities have increased along coastal regions (Cloern, 2001; Newton *et al*., 2003).Accordingly, ecological disturbances have been reported in different lagoons, estuaries and coastal water bodies around the world (Heisler *et al*., 2008).Lagoons have been historically important as sheltered sites of habitation providing access to both the land and the sea, comprising 15% of the world coastal zone, in which lakes, salt marshes, tropical mangroves, swamps, and deltas are also included. Coastal zones and lakes are important issues in the international debate on the environmental and sustainable development. They have become the major site for extensive and diverse economic activities.

Rapid urbanization, industrialization, excessive use of fertilizers and pesticides, etc. have resulted in heavy metal pollution of land and water resources. The increasing load of heavy metals has caused imbalance in aquatic ecosystems and the biota growing under such habitats accumulate high amounts of heavy metals (Cu, Zn, Cd, Cr, Ni, etc.) which in turn, are being assimilated and transferred within food chains by the process of magnification (Pergent& Pergent Martini, 1999). Direct discharge or wet and dry depositions of contaminants increase the concentration of trace elements in aquatic systems, thus resulting in their accumulation in sediments (Dunbabin and Bowmer, 1992; Sinicrope *et al*, 1992). In contrast with most organic materials, metals cannot be transformed by microorganisms and therefore accumulate in water, soil, bottom sediments and living organisms (Miretzkyetal, 2004). The chemical behavior of heavy metals during estuarine mixing is assumed to play an important role in their geochemical cycles. It is well established that, during mixing of fresh and saline waters, the partitioning of metallic species between thesolution and suspended particles is controlled by two counteractive biological processes. One is the removal of metals by flocculation of humic and fulvic acids-metal complexes and precipitation of iron and manganese oxides. The other process is the gain by desorption of dissolved metals from particles (Roux *et aL*., 1998).Numerous studies on the distribution and behavior of heavy metals in various estuaries in different parts of the world have revealed that individual metals exhibit contrasting behavior between estuaries, and sometimes even within the estuary. Factors which are important in controlling heavy metal behavior include estuarine flushing time (Kalpana *et al*., 2015), complexation with dissolved inorganic and organic species (Comans and van Dijk, 1988; Owens and Balls, 1997)and interactions with suspended solids (Tumer et aI., 1993; Benoit *et al*., 1994) and sediments (Evans et aI., 1977; Owens and Balls, 1997).The present study aims at the distribution of metals in the Odiyur lagoon, in order to enhance the data inventory for the region and help to understand the influence of anthropogenic activities.

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Study Area

The Odiyur/Cheyyur Lagoon (12°22'-12°17' N; 79°58' - 80°03' E) is situated in Cheyyur Taluk of Kancheepuram district, Tamil Nadu, on the southeast coast of India (Figure 1). The lake is about 10 km long and 5 km wide; with shallow water depth. The lake has a number of small freshwater canals flowing into it from the irrigation tanks, agricultural lands, and catchment areas. The land use land cover map of thestudy area is drawing in (figure 2). The agricultural land is situated northern, western and southern side of theodiyur lagoon on the other hand in eastern side Bay of Bengal, sand dune and east coast road present. Fig.1 is indicating land use /land cover map of study area. The sea grass Halophilaovalis is common and scattered throughout the lagoon. Remnants of mangroves occur at some sites near to the coast. Besides crab and prawn species, 24 species of fish have been recorded from the lagoon. A total of 17 species of water birds were recorded during the survey of the Odiyur-Cheyyur Lagoon. The study area is hot and hashumid climate. It receives rain from both southwest and northeast monsoons as well as cyclic storm. The minimum and maximum temperatures are 20°C & 37°C. The geomorphological feature mostly occurs alluvial plain, sand dunes, estuarine, mud flats, salt marsh, micro delta, and lagoon. The dominant soil is alluvial sandy soil in this area.

METHODOLOGY

Twelve water samples were collected from Odiyur lagoon during the month of October 2013. The lagoon maximum water depth was below one meter hence only surface water samples were collected and the location waschosen randomly to get acomplete study of the lagoon. The samples were collected by pre-cleaned stopper-fitted polyethylene bottle and the samples were kept in the ice box. 2ml of con. HNO_3 was added to each sample (500ml), which was used for trace element studies. Another (1 liter) water sample collected using the bottlefor analysis of physicochemical parameter. pH was determined onboard immediately after collection using Elico portable water quality analyzer. Major ions (Na, K, Ca, Mg, and Cl) were determined by titrimetric method followed by APHA, 1995.Trace element concentration of Cr, Cu, Co, Ni, Pb, Zn, Mn, and Fe were determined from unfiltered samples based on the liquid – liquid extraction procedure by Mentasti *et al*., (1989). Water samples for trace element were analyzed by PerkinElmer AA 700 AAS, Department of Applied Geology, University of Madras. Table no. 1 shows the concentration of trace element and physicochemical parameter of the study area.The data were subjected to statistical computations such as PCA, Cluster analysis using Statistica version 8 (StatSoft, Inc., Tulsa, Oklahoma), and correlation matrix using (SPSS) in University of Madras.

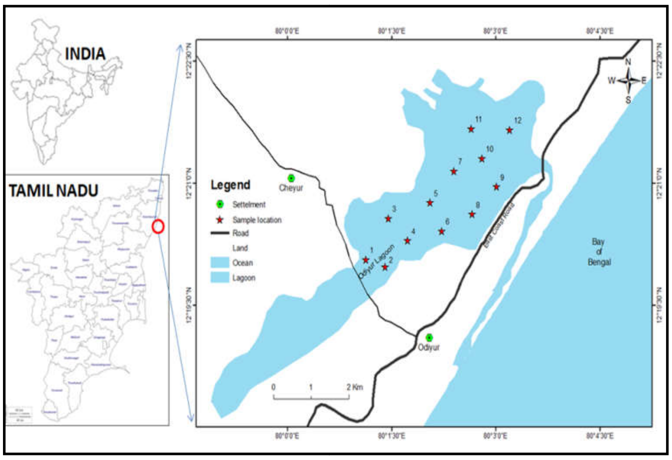

Figure 1 Map of study area showing sample location

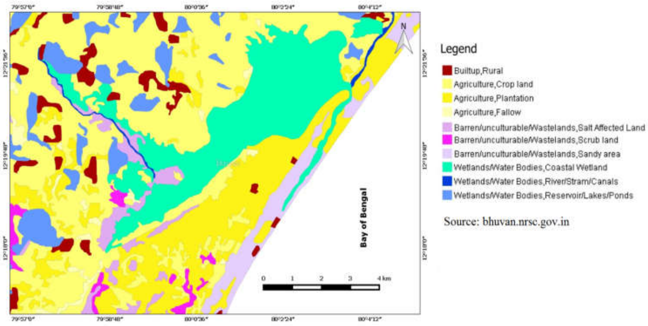

Figure 2 shows land use/ land cover map of study area

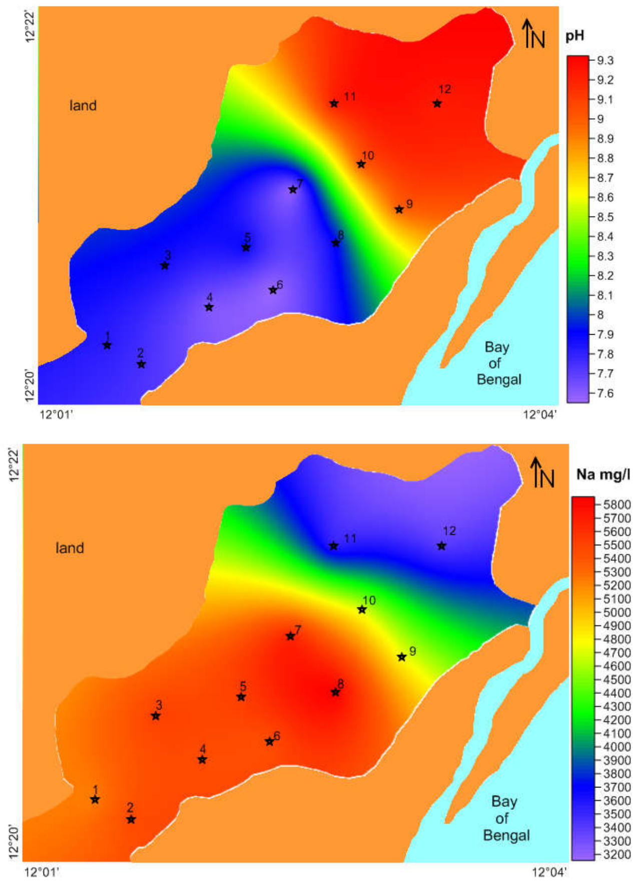

Figure 3 shows special distribution map of pH and Na

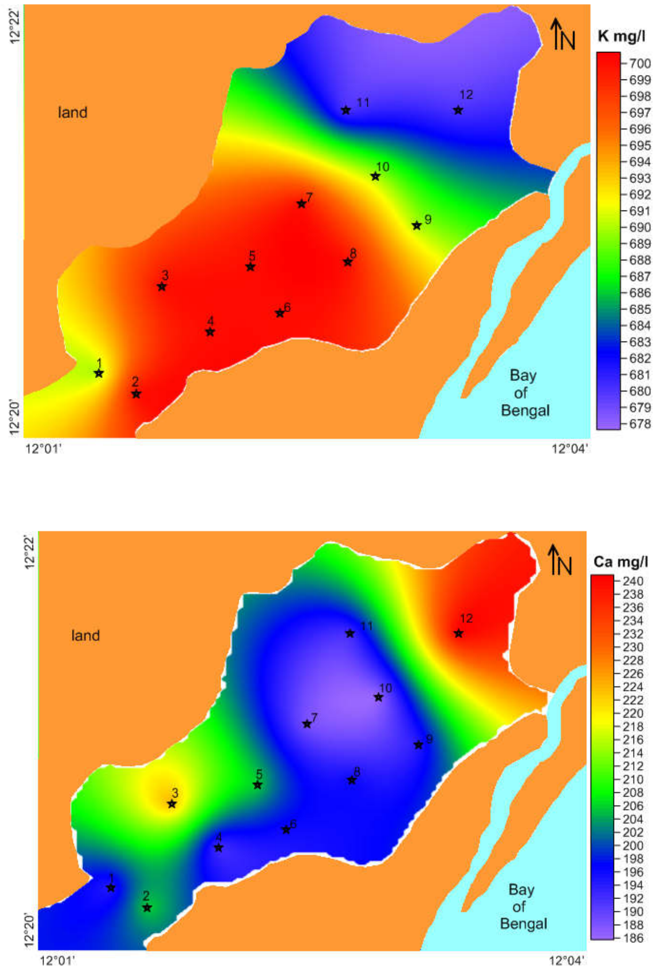

Figure 4 shows special distribution map of K and Ca

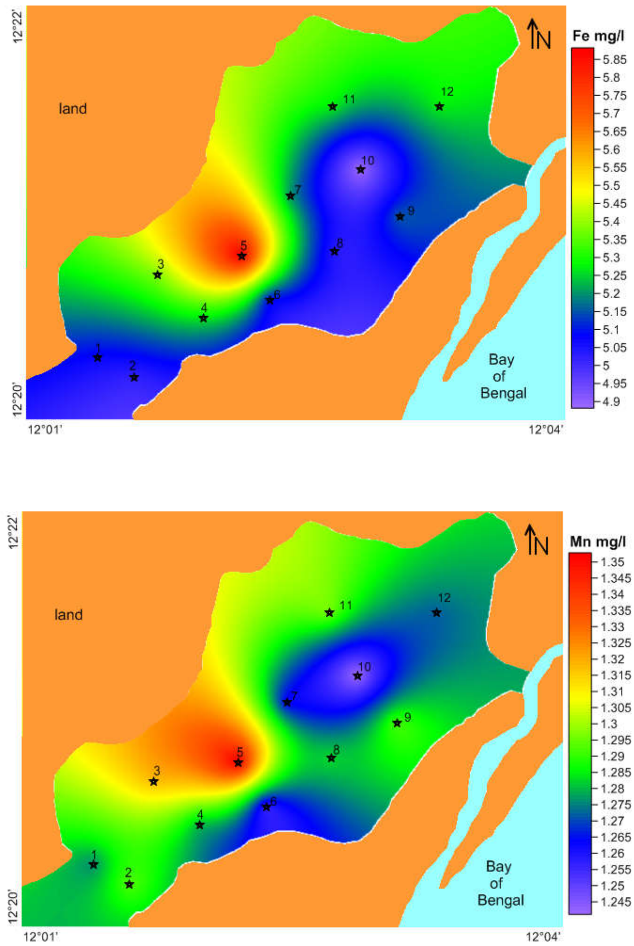

Figure 6 shows special distribution map of Fe and Mn

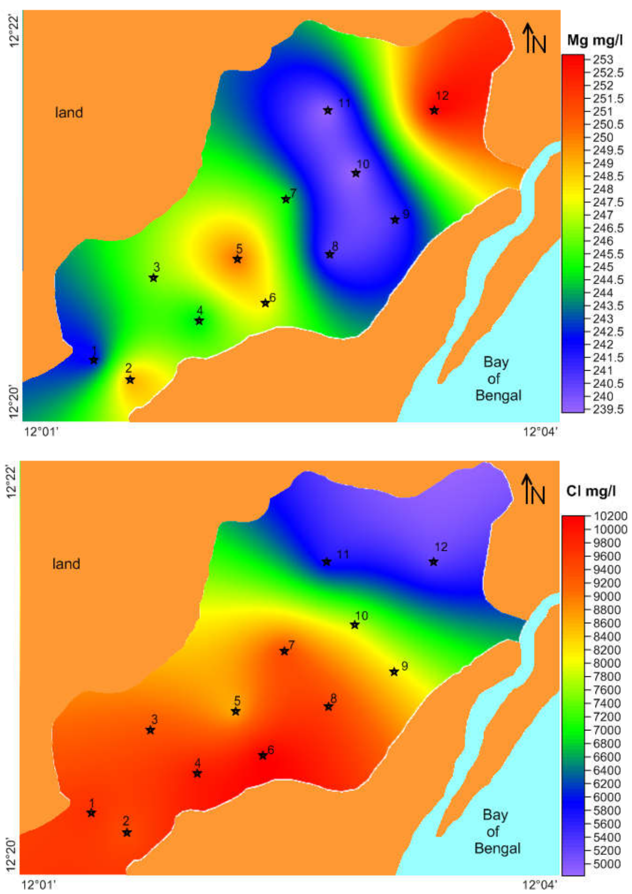

Figure 5 shows special distribution map of Mg and Cl

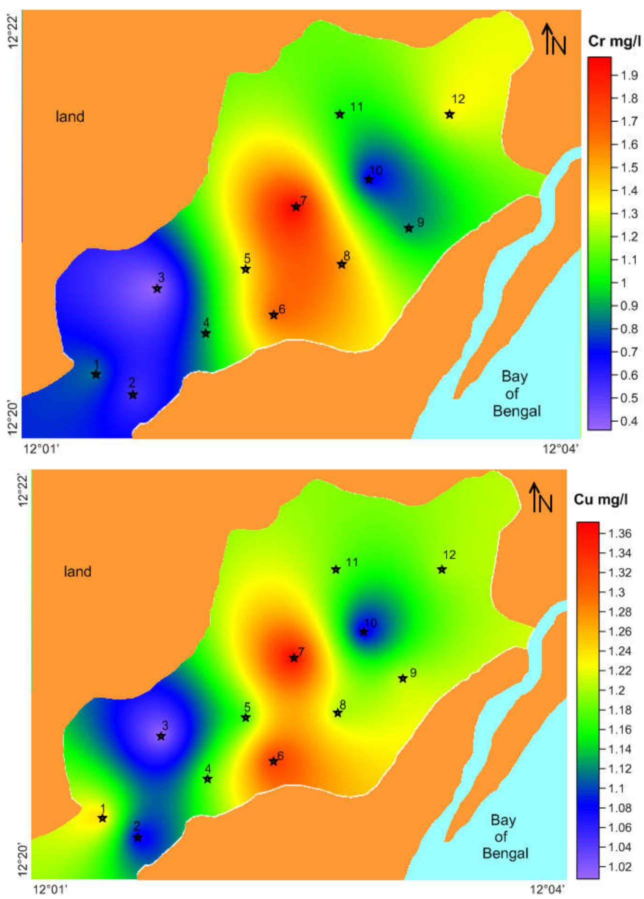

Figure 7 shows special distribution map of Cr and Cu

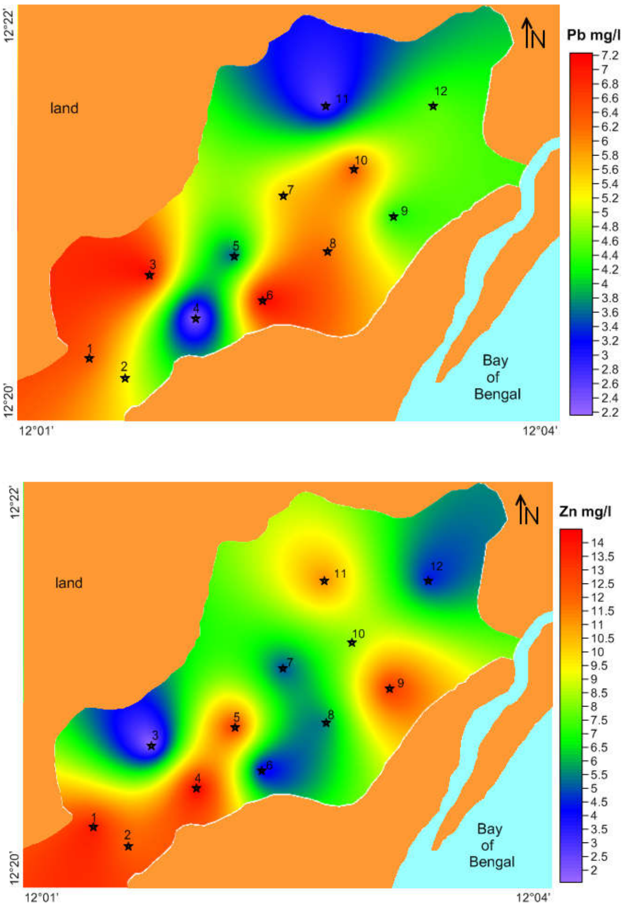

Figure 8 shows special distribution map of Pb and Zn

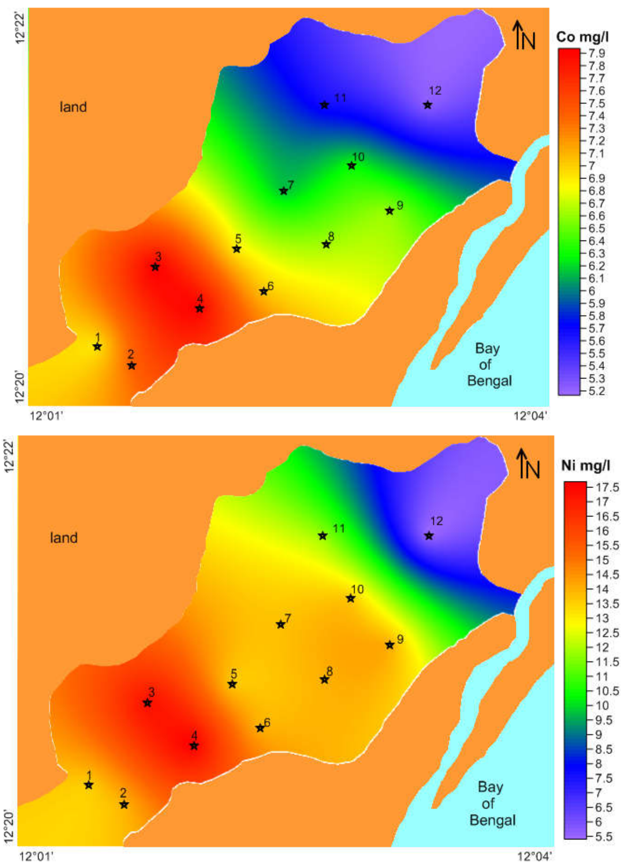

Figure 9 shows special distribution map of Co and Ni

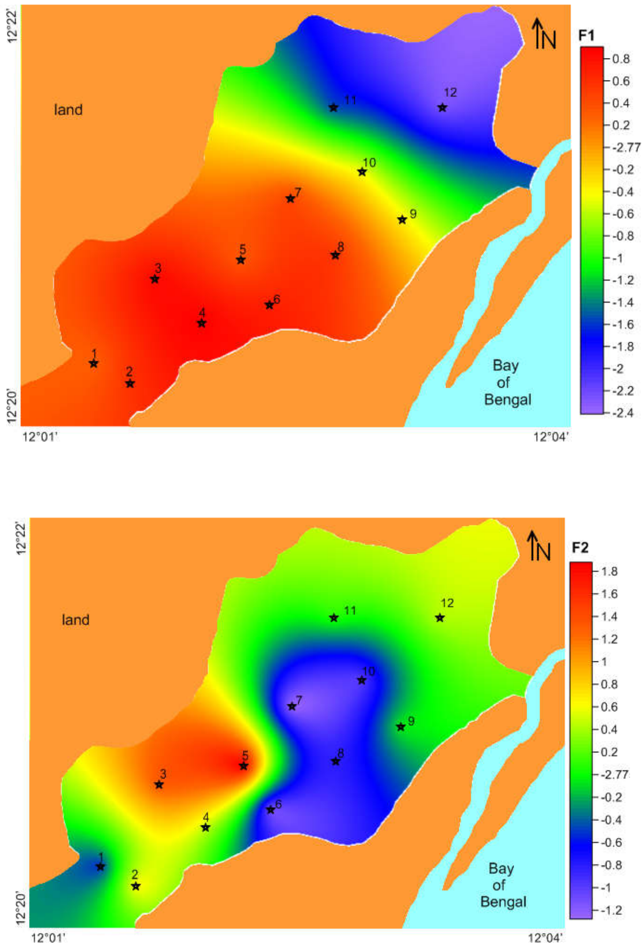

Figure 10 shows special distribution map of factor 1 and 2

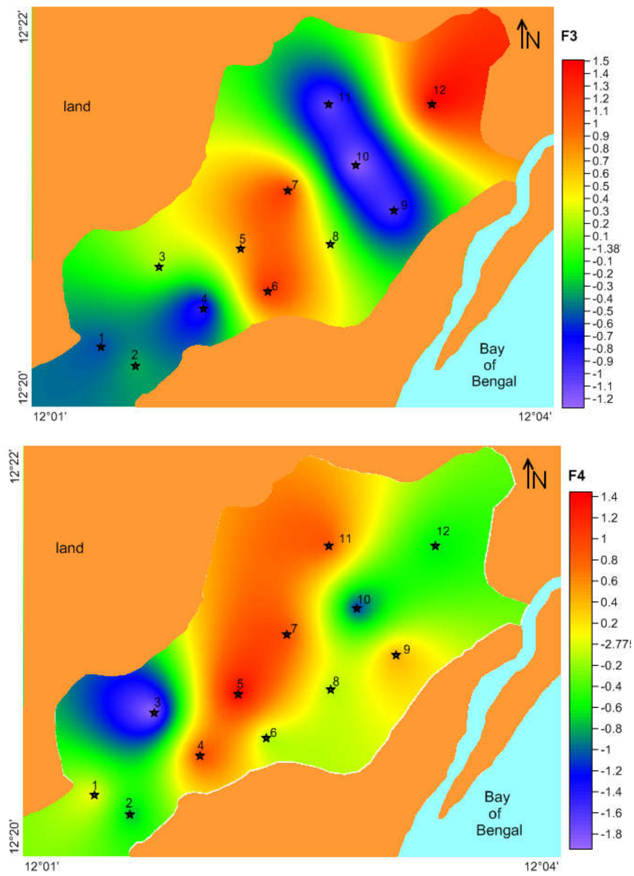

Figure 11 shows special distribution map of factor 3 and 4

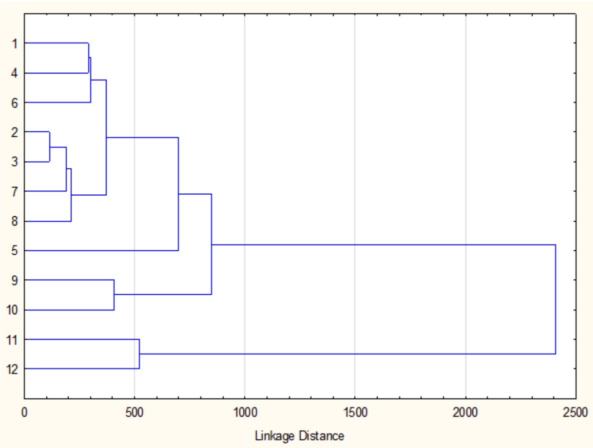

Figure 12 shows Dendogram of spatial clustering of sampling sites.

RESULT AND DISCUSSION

Physico Chemical Characteristic of water Sample

The pH concentration ranged from 7.5 to 9.2 with average 8.2. The pH of these waters indicates that the waters are alkaline reflecting the dominance of marine environment. The spatial distribution map (Fig. 3) demonstrate that high value is recorded in stations 12, 11, 10 and 9 which is near to the mouth of the sea and the lower value is recorded stations 6 and 7 which is far from sea mouth. During high tide, water entering into these regions has some influence on the pH of this location.

Sodium is the dominant cation among the other cation in the study area and the order of abundance cation is Na>K>Mg>Ca.

Table 1 shows estimated value of trace elements and Physico-chemical parameters of Odiyur Lagoon water

S.NO	pH	Na	K	Ca	Mg	Cl	Fe	Mn	Cr	Cu	Pb	Zn	Co	Ni
							ppm							
1	7.8	5240	690	194	241.90	9700	5.07	1.28	0.83	1.25	6.32	13.80	6.92	13.56
2	7.8	5460	700	206	249.08	9400	5.02	1.29	0.53	1.07	5.26	12.02	7.41	13.96
3	7.9	5510	700	224	246.40	9300	5.38	1.32	0.36	1.01	7.14	1.53	7.94	17.30
4	7.6	5450	700	192	244.40	9900	5.27	1.28	0.89	1.18	2.14	14.53	7.92	17.70
5	7.9	5520	700	206	250.29	8600	5.88	1.35	1.35	1.17	3.56	12.96	6.88	13.62
6	7.6	5440	700	196	248.00	10200	5.09	1.26	1.66	1.33	7.24	3.72	7.03	14.01
7	7.6	5670	700	188	245.00	9400	5.20	1.26	1.98	1.37	5.56	4.92	6.14	13.75
8	7.9	5860	700	196	240.57	9500	5.04	1.28	1.55	1.20	6.16	5.43	6.63	14.01
9	9.0	4770	690	194	240.80	8200	5.15	1.29	0.86	1.21	4.25	13.18	6.60	14.10
10	9.0	4700	690	186	239.36	7800	4.88	1.24	0.65	1.07	6.33	8.13	6.28	13.66
11	9.2	3520	680	192	239.36	5700	5.27	1.30	1.02	1.18	2.56	11.25	5.66	11.80
12	9.2	3380	680	241	253.20	5200	5.27	1.27	1.34	1.20	4.52	4.33	5.21	5.40
Min	7.6	3380	680	186	239.36	5200	4.88	1.24	0.36	1.01	2.14	1.53	5.21	5.40
Max	9.2	5860	700	241	253.20	10200	5.88	1.35	1.98	1.37	7.24	14.53	7.94	17.70
Avg	8.2	4982.86	693.57	203	245.06	8450.00	5.24	1.29	1.10	1.19	5.03	8.70	6.70	13.28

Table 2 indicating result of correlation matrix

	pH	Na	K	Ca	Mg	Cl	Fe	Mn	Cr	Cu	Pb	Zn	Co	Ni
pH	1.000													
Na	**-.885**	1.000												
K	**-.885**	**.955**	1.000											
Ca	.193	-.343	-.221	1.000										
Mg	-.236	-.009	.171	**.739**	1.000									
Cl	**-.901**	**.946**	**.887**	-.407	-.055	1.000								
Fe	-.117	.028	.132	.346	.477	-.121	1.000							
Mn	-.130	.145	.203	.322	.301	-.014	**.842**	1.000						
Cr	-.211	.109	.125	-.143	.183	.038	.142	-.194	1.000					
Cu	-.237	.079	.020	-.331	.013	.153	-.040	-.340	**.855**	1.000				
Pb	-.300	.391	.307	.077	.015	.413	-.430	-.340	.011	-.006	1.000			
Zn	.056	-.029	-.113	-.419	-.253	.037	.127	.253	-.309	-.056	**-.647**	1.000		
Co	**-.712**	**.735**	**.761**	-.115	.046	**.798**	.093	.299	-.445	-.346	.160	.161	1.000	
Ni	**-.614**	**.746**	**.727**	**-.502**	-.362	**.779**	.007	.181	-.317	-.211	.101	.180	.863	1.000

Table 3 shows result of factor analysis

	1	2	3	4
pH	-.90	.00	-.32	-.11
Na	**.96**	-.06	.13	.04
K	**.94**	.07	.23	.02
Ca	-.37	**.56**	**.52**	-.46
Mg	-.05	.49	**.74**	-.09
Cl	**.97**	-.16	.04	.01
Fe	.01	**.76**	.33	.44
Mn	.15	**.87**	.05	.24
Cr	-.05	-.44	**.69**	**.54**
Cu	.00	-.58	.46	**.61**
Pb	.34	-.41	.32	-.68
Zn	.03	.24	-.64	**.56**
Co	**.87**	.33	-.20	-.18
Ni	**.86**	.08	-.40	.01

Sodium concentration is fluctuating from 3380mg/l to 5860 mg/l with an average concentration of 4982mg/l in lagoon water.

The spatial distribution diagram (Fig. 3) illustrate that Sodium value is more in middle and southern part of lagoon due to shallow water and more evaporation. Station no 8 shows high concentration where water depth is low on the other hand station no 12 shows low value where water depth is high compare to other stations. The presence of more concentration of sodium on the landward side of the lagoon may due to the agricultural activities in the surroundings.

Potassium is the second major cation after sodium in water of study area. Estimated Potassium concentration ranges from 680mg/l to 700 mg/l with an average concentration of 693.57mg/l in lagoon water. In general potassium concentration is high in marine water. The potassium value does not show any spatial variation with lagoon (Fig. 4). Presence of high content of Sodium and potassium in the study area may be also be contributed due to application of fertilizers which may cause a negative impact on soil, pH, soil structure deterioration and the increasing feature of acid irrigation or other agricultural operations or from the benefits derived from it is not possible or very scarce (Serpil Savci, 2012).

The concentration of calcium is varying from 186 mg/l to 241 mg/l with an average concentration of 203 mg/l. Calcium concentration is showing (Fig. 4) lower in middle of lagoon compare to northern and near the bank of the lagoon. The maximum concentration is observed at station 12 and minimum concentration is observed at station 10.

Magnesium concentration oscillated from 239.35 mg/l to 253.2 mg/l with an average concentration 245.06 mg/l. Generally magnesium content is higher in sea water compared to fresh water. Station 12 shows higher concentration compare to other station which is near to sea mouth (Fig. 5). The addition of calcium and magnesium might be due to their exchange with other cations during early stages of mixing and their removal due to their involvement in biological or geochemical processes as suggested by Panigary *et al*. (1999) in the coastal waters around Orissa.

Chloride concentration varies from 5200 mg/l to 10200 mg/l with an average concentration 8450 mg/l. Chloride concentration gradually decreases from southern side to northern side of the study area as seen in the spatial distribution diagram (Fig. 5). In this study area, chloride concentration is more in shallow depth due to evaporation activity and usage of fertilizers (OMOE, 2003).

Trace Element of water Sample

Iron concentration of lagoon ranges from 4.88 mg/l to 5.88 mg/l with an average concentration 5.24 mg/l. The spatial distribution map (Fig. 6) indicates the concentration of iron gradually increases from eastern to western direction. Manganese concentration in lagoon water varies from 1.24 mg/l to 1.35 mg/l with an average value 1.29 in (Fig. 6). Iron and manganese concentrations show high in station 3 and 5 indicating high in western part of the lagoon which is landward side and gradually decreases towards eastern side. The iron in the earth mainly derived from the crustal weathering, additionally Fe and Mn can be converted to complex hydroxy compounds that may eventually precipitate and their oxides are excellent scavengers for trace metals (Jonathan *et al*., 2004).

Concentration of chromium ranges from 0.36 mg/l to 1.98 mg/l with an average value 1.10 mg/l in lagoon. Even though Chromium is unevenly distributed in the study area (Fig. 7), higher concentration present in station 6, 7 and 8 which occurs in an eastern and middle portion of the lagoon near to ECR road. The contribution of chromium in the study area may be due to emission from engine parts, brake emissions, wear and tear of chrome plated vehicular parts, yellow paints on the road used for marking and metallic products (Adhikary,2015).

Copper concentration varies from 1.01 mg/l to 1.37 mg/l with an average concentration 1.19 mg/l in lagoon water. Spatial distribution diagram (Fig.7) of copper is indicating higher concentration occurring in eastern and middle portion of station 6 and 7 which is near to ECR road which may be due to water runoff, various emissions from automobiles, and wet and dry depositional processes (Davis *et al*., 2001; ATSDR, 2004).

The concentration of lead is varying from 2.14 mg/l to 7.24 mg/l with an average concentration of 5.03 mg/l. In Figure 8 Lead value shows high in middle and southern part of station no. 3 and 6 compare to the north side of the lagoon which may be due to anthropogenic activities such as agriculture, motor vehicles fuel and depositions of dust due to transportation (Alegria *et al*., 1991;Robert A. Duce *et al*., 2009).

The zinc concentration ranges from 1.53mg/l to 14.53 mg/l with an average concentration 8.7 mg/l in lagoon water. Even though Zinc is unevenly distributed in the study area (Fig no. 8) but higher concentration present in eastern and southern part at stations 1, 2, 4, 5 and 9 of the study area. Zinc is introduced into the environment from numerous sources. The most significant contributors of zinc is from the wear of tire dust, brake dust and body rust (Wei Zhu *et al*., 2008; Councell *et al*., 2004).

The cobalt concentration is varying from 5.21 mg/l to 7.94 mg/l with an average concentration of 6.70 mg/l. The spatial distribution diagram (Fig. 9) of cobalt indicates higher on the southern side at the station no. 2, 3, 4 and gradually decreases towards the north side of the lagoon. Although so many naturally and anthropogenic sources for cobalt contamination in water among of them Agricultural runoff is one main cause in the present study area (Nagpal, 2004).

The concentration of nickel ranges from 5.40 mg/l to 17.70mg/l with an average concentration of 13.28 mg/l. The special distribution diagram (Fig. 9) of nickel shows higher concentration in a south portion of the lagoon at stations 3 and 4 and gradually decreases to north direction. Nickel typically accumulates at the surface from deposition by industrial and agricultural activities (Cempel and Nikel, 2006).

Correlation Analysis

Correlation coefficient measures degree of association among dependent variable. Direct correlation exits when an increase or decrease of one parameter value will affect positively or negatively of other parameter value (Patil and Patil, 2011). According to (Liu *et al*. 2003) The factor loadings are classified as strong, moderate and weak based on the loading values of >7.0, 0.7-0.5 and 0.5-0.4 respectively represented in (table no 2). pH is indicating negatively correlate with all element but moderate to strongly negative correlate with Ni, Co, Na, K, and Cl may be due to the heavy metal presence in fertilizers. Sodium strongly positive correlate with potassium and chloride, and moderately correlated with trace elements such as cobalt and nickel. Calcium moderate positive correlate with magnesium and negatively correlates with nickel. Chloride is strongly positive correlate with Na and K and moderately positive correlate with trace element Co and Ni. Iron significantly positive correlate with most of the element and strongly positive correlate with manganese only. Chromium is strongly positive correlate with copper and lead significantly negative correlate with zinc.

Factor Analysis

Inter elemental relationship studies were very useful because associations between variables that can show the overall coherence of the data set and indicate the participation of the individual chemical parameters in several influence factors, a fact which commonly occurred in hydrochemistry (Helena *et al*., 2000). The result of factor analysis mentioned in (table no 3).

The grouping of analyzed parameters is analyzed as Varimax rotation factor analysis and four factors are presented as seen in Fig factor 1 (F1- Na, K, Cl, Co & Ni), factor 2 (F2 – Ca, Fe &Mn), factor 3 (F3 – Ca, Mg & Cr)and factor 4 (F4 – Cr, Cu & Zn). The domination of ALTMs data is showing (Na, K, Cl, Co, and Ni) in factor one (F1) which is indicating agricultural and evaporation factor. Particularly high level of sodium, potassium, chloride, cobalt, and nickel containing fertilizers make a negative impact pH the increasing feature of acid irrigation or other agricultural operations (Serpil Savci, 2012;Nagpal, 2004) as it is observed in Factor 1. Calcium, iron and manganese show positive loading in factor two (F2) indicating that second influence factor is due to weathering. Similarly, calcium and magnesium show a positive loading in factor three (F3) indicating due to chlorophyll (Onuoha *et al*., 2010). Chromium, copper, and zinc are dominant in factor four (F4) indicating element come from high way road runoff.

Cluster Analysis

Cluster analysis groups objectives based on similarities within groups, and dissimilarities of other groups. The groups are divided by their unique characteristics, which often helps to interpret the data (Vega *et al*., 1998). Many studies have shown that cluster analysis reliably classifies surface water quality, and can guide future sampling strategies (Wunderlin *et al*., 2001; Simeonov *et al*., 2003; Singh *et al*., 2004). In this study, hierarchical agglomerative cluster analysis was performed on the normalized dataset by means of the wards method, using single Euclidean distances as a measure similarity (Simeonov *et al*., 2003; Shrestha and Kazama, 2007).

Cluster analysis gives a dendogram (Fig. 12), which is identify 3 number of the cluster among of 12 locations from Odiyur lagoon. Cluster 3 is indicating sample comes from nearest of sea inlet water depth is high compare to other station. Likewise, cluster 2 is shows inter mediate cluster. Cluster 1 clearly emphasizes the sample locations are far from sea inlet and shallow water region.

CONCLUSION

The present study summarizes the various physico-chemical parameters in the waters of the Odiyur Lagoon and provides an exploratory statistical data output. The domination of ALTMs data is showing (Na, K, Cl, Co, and Ni) in factor one (F1) which is indicating agricultural and evaporation factor. Calcium, iron and manganese show positive loading in factor two (F2) indicating that second influence factor is due to weathering. Similarly, calcium and magnesium show a positive loading in factor three (F3) indicating due to chlorophyll (Onuoha et.al. 2010). Chromium, copper, and zinc are dominant in factor four (F4) indicating element come from high way road runoff. The study showed that physico-chemical properties and heavy metal concentration of the estuarine zone were significantly affected usage of fertilizers by the near agriculture zone and weathering from the nearby zones.

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