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Determining environmental sensitivity of mangrove forest at Hara protected area

Mohsen Dehghani[1*], **Abdolreza Karbassi**[2]

[1*]*Department of the Environment, Islamic Azad University, Bandar Abbas Branch, Bandar Abbas, Iran*

[2]*Graduate Faculty of Environment, University of Tehran, Tehran, Iran*

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Abstract

The Hara Protected Area, one of the coastal marine ecosystems, has so much importance by having biological diversity covered by mangrove forests. The unique features of this area have led to rapid urban, rural, industrial and tourism expansion and possess economic and social importance. This study has been carried out in order to analyze the quality of physicochemical parameters of surface waters and heavy metals in sediment by selecting 27 sampling stations in the year of 2011. The results of the study proved that the difference between measuring the measuring parameters in 4 months (February, May, August, and November) is mostly considerable. Besides, the measuring parameters in the northern stations of the Hara Protected Area was mostly more than central southern regions which would be due to population density and industrial activities in this area.

***Corresponding Author:** Mohsen Dehghani ✉ dehghani933@gmail.com

Introduction

The marine ecosystem is the largest system, and pollution of this ecosystem is generated by land, sea sources and atmospheric (Kasmin, 2010). Sea pollution has become a serious environmental problem worldwide. Coastal habitats are more prone to pollution impacts than marine habitats (EPA, 2012). Considering that coastal regions are popular for municipal and industrial expansions, they can act as a center of many pollutants (Hernández-Romero *et al.,* 2004). Main contribution to the marine pollution comes from land-based activities such as wastewater, solid waste, agricultural run-off (Gasim *et al.,* 2013).

In the tropical-to temperate climatic transition zones, the mangrove ecotone is dynamic, visually striking, and highly productive (Saintilan *et al.,* 2014). Mangrove forests are being destructed due to population growth, communication pressure and development. Hence, protection and stable management of mangroves in coastal areas takes high priority in many countries (Katharesan and Rajendran, 2005). In fact, Mangrove forests are the important ecological wetland-coastal systems that are in danger (Sathirathai, 2001). Ellison and Farnsworth have classified Mangroves destruction factors in 4 groups: mining, pollution, climate changes, and reclamation (Ellison and Farnsworth, 1996).

Chog (1990) believes 45% of Indonesian mangroves are severely affected by human activities (Chog *et al.,* 1990). Beside, waste waters effects that lead to increasing of Nitrite and Phosphate and other water physicochemical parameters concentration can be mentioned as the examples of expansion of human activities (Lee, 2008). Obire and his colleagues introduced discharging of industrial waste water as the reason of coastal area's pollution (Obire *et al.,* 2003). Many studies proved that heavy metals intensify the process of mangrove ecosystem destruction. Negative effects of mineral mining, industrial waste waters and metals such as Manganese, Copper, Iron, Zinc, Chromium, Cobalt, Lead and tin on Hara trees have been proved (Akhand, 2012; QuSheng *et al.,* 2007). In addition, many researches have shown that concentration of nutrients in mangrove forests is more than other coastal ecosystems (Johnston *et al.,* 2003).

The purpose of this study is to measure sediment and water physicochemical parameters in area to determining the environmental sensitivity. IUCN has defined a series of six protected area management categories, based on primary management objectives. Hara protected area is located in south of Iran and has great ecological significance. The area is a major habitat for migratory birds in the cold season, and for reptiles, fish, and varieties of arthropoda and bivalves. The "Hara Protected Area" on Quesm and the nearby mainland is a biosphere reserve where commercial use is restricted to fishing (mainly shrimp), tourist boat trips, and limited mangrove cutting for animal feed.

Materials and methods

Study area

Located in the north of Iran and shores of Persian Gulf, the Hara Protected Area is in the same level with IUCN Category V Protected Areas. This area is located geographic coordinates 27 00- 26 40 N and 55 52- 55 21 E and covers an area of 82360 hectares. Mangrove forests, in this area, as one of the most valuable habitats are known as the widest Mangrove coverage in the Persian Gulf and mangroves, but only trees of the genus Avicenna in this area. More than 96 species fish (44 families) and 121 species birds of 37 families were observed and introduced in this area (IDOE, 2010).

Land use

Presence of communities inhabiting in and about of this area, huge amount of human activities, industries and mines and other utilization cause an additional threat to these ecosystems. Hence, various kinds of pollutant can impact on the Hara Protected Area which would be mentioned as; domestic and industrial waste waters, mineral industry wastes and domestic waste.

Sampling

In order to analyze the coastal area biologically, 27 sampling stations on the Hara Protected Area were selected (Fig. 1). Sampling was undertaken in 4 months (February, May, August, and November) in 2011. Coordinates of sampling station were registered via GPS. Water samples were taken from surface waters (10 to 20 cm) by bottles 250 cc and deposit samples were taken from surface deposits by Grab (Buckley and Winter, 1992). Water and deposit quality parameters were analyzed by standard methods (APHA, 1998; ASTM, 2001). Analysis of the results of sampling stations was classified in 3 regions; northern regions of the Hara Protected Area, southern regions of the Hara Protected Area, and central regions of the Hara Protected Area. The measured results were analyzed by SPSS software.

Fig. 1. A satellite image of the location of Hara Protected Area.

Results

Physicochemical parameters

The result of physicochemical parameters' measuring showed that the average temperature of water in May and November varies between 20.8 ºC and 33.9 ºC(Table 1). The highest level of PH was measured 8.43 in May and the lowest level of pH was measured 8.31 in February. Salinity (Sal) level in August, May, February and November was respectively measured 38.5, 38.3, 37.9 and 37.8 in thousand. The highest level of turbidity (Turb) was measured 8.55 NTU in November and the lowest level was measured 7.18 NTU in May. Electric conductivity (Cond) was evaluated 56.0 mS/cm in May, 50.7 mS/cm in August, 55.4 mS/cm in November and 47.1 mS/cm in February. The highest amount of insoluble solids was gauged 48/0 in November and the lowest amount was gauged 40.9 in February (Fig. 2).

While there wasn't a considerable difference in the results of May, November and February, the highest amount of dissolved solids was reported 50147 mg/L in August. The lowest level of dissolved oxygen (DO) was measured 4.92 mg/lit in February and the highest level was measured 5.69 mg/L in August. The amount of COD varied between 60.98 mg/L and 54.47 mg/L. The average amount of Nitrite in sampling stations was different between 0.79 mg/L in August and 0.25 mg/lit in May. The maximum amount of phosphate in sampling stations was reported 0.92 in August and 0.39 in May.

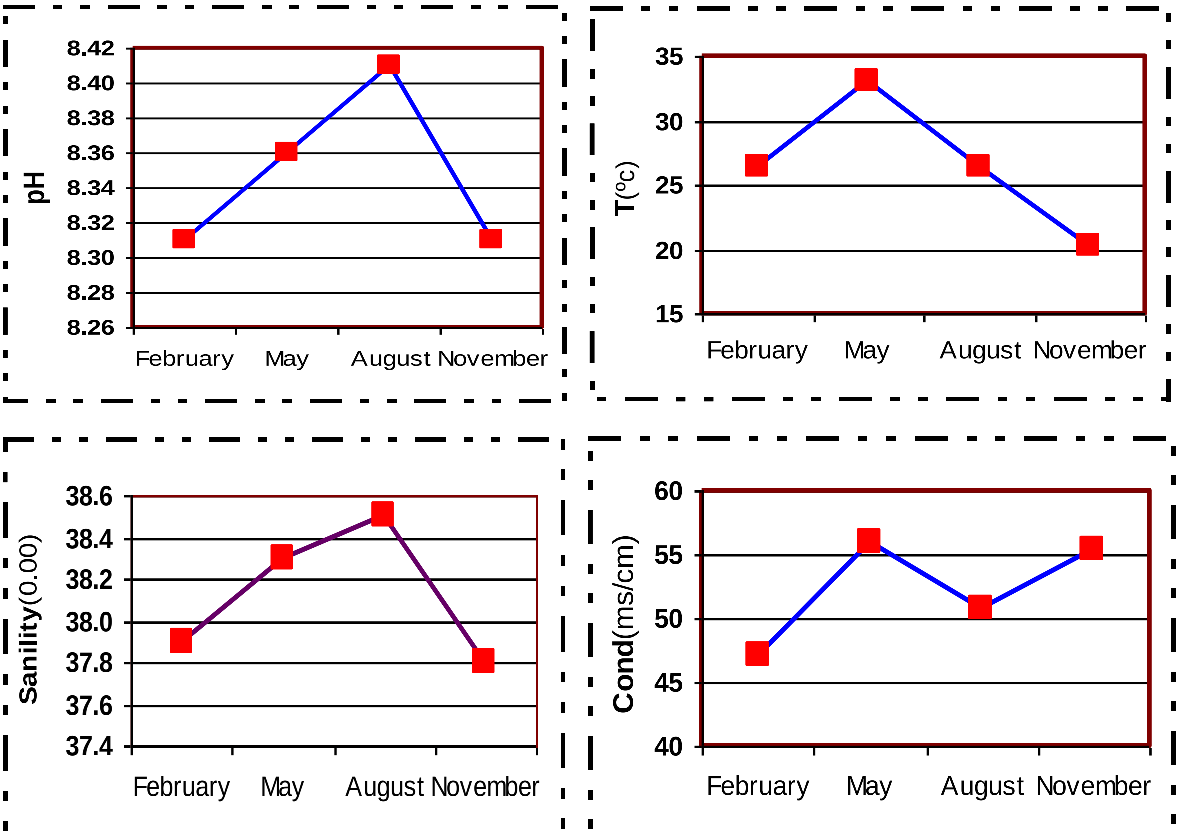
Besides, the annual average of physicochemical parameters in 27 sampling stations showed that the annual temperature of water is 27.1 ºC. Annual average of pH was measured 8.38 and average amount of salinity was measured 38.1 in thousand. The average amount of turbidity was gauged 7.80 NTU and annual average of electric conductivity was registered 52.3 mS/cm. Annual average of total amount of dissolved and insoluble solids was respectively measured 45.74 and 49408 mg/lit. The average amount of solute oxygen and COD respectively was calculated 5.93 mg/lit and 56.46 mg/L. Annual concentration of Nitrite and phosphate in study area respectively was calculated 0.502 ppm 0.519 ppm. The result of annual average of parameters is presented in table 2.

Heavy metals

According to the results of heavy metals' measurement on marine deposits from 27 sampling stations; the highest, the lowest, and the average concentration of Cadmium was respectively measured 2.25 ppm, 0.13 ppm and 1.00 ppm. The highest, the lowest and the average concentration of Lead respectively was evaluated 43.70 ppm, 20.80 ppm and 62.63 ppm. The highest and the lowest amount of Nickel respectively was measured 13/55 ppm and 42.56 ppm. Copper's concentration varied between 8.18 ppm 51.06 ppm and average concentration worked out 30.11 ppm. The highest, the lowest and the average concentration of Iron was measured respectively 1894, 3239, and 771 ppm (Table 3).

Table 1. Average and standard deviation of measured parameters in 27 sampling station.

parameters	May	August	November	February
T(ºc)	33.9 (0.59)	27.1(0.75)	20.8 (1.05)	26.4 (0.69)
pH	8.43(0.18)	8.71(0.19)	8.77(0.17)	8.31(0.19)
Salinity (0.00)	38.3(0.4)	38.5(0.7)	37.8(0.6)	37.9(1.0)
Turb (NTU)	7.20(2.21)	7.17(2.16)	8.55(1.01)	8.26(0.43)
Cond (mS/cm)	56.0(5.0)	50.7(2.1)	55.4(2.8)	47.1(3.4)
TDS (mg/L)	48564(6860)	50146(6799)	49677(7270)	49019(7780)
TSS(mg/L)	47.4(11.7)	46.2(12.6)	48.0(12.8)	40.9(12.6)
DO (mg/L)	5.27(0.51)	5.69(0.17)	5.67(0.45)	4.92(0.27)
COD (mg/L)	54.47(22.45)	60.98(21.97)	55.89(22.76)	54.69(22.14)
NO_2^-(mg/L)	0.256(0.070)	0.705(0.180)	0.638(0.167)	0.432(0.128)
PO_4^{-3} (mg/L)	0.397(0.140)	0.620(0.211)	0.544(0.170)	0.491(0.217)



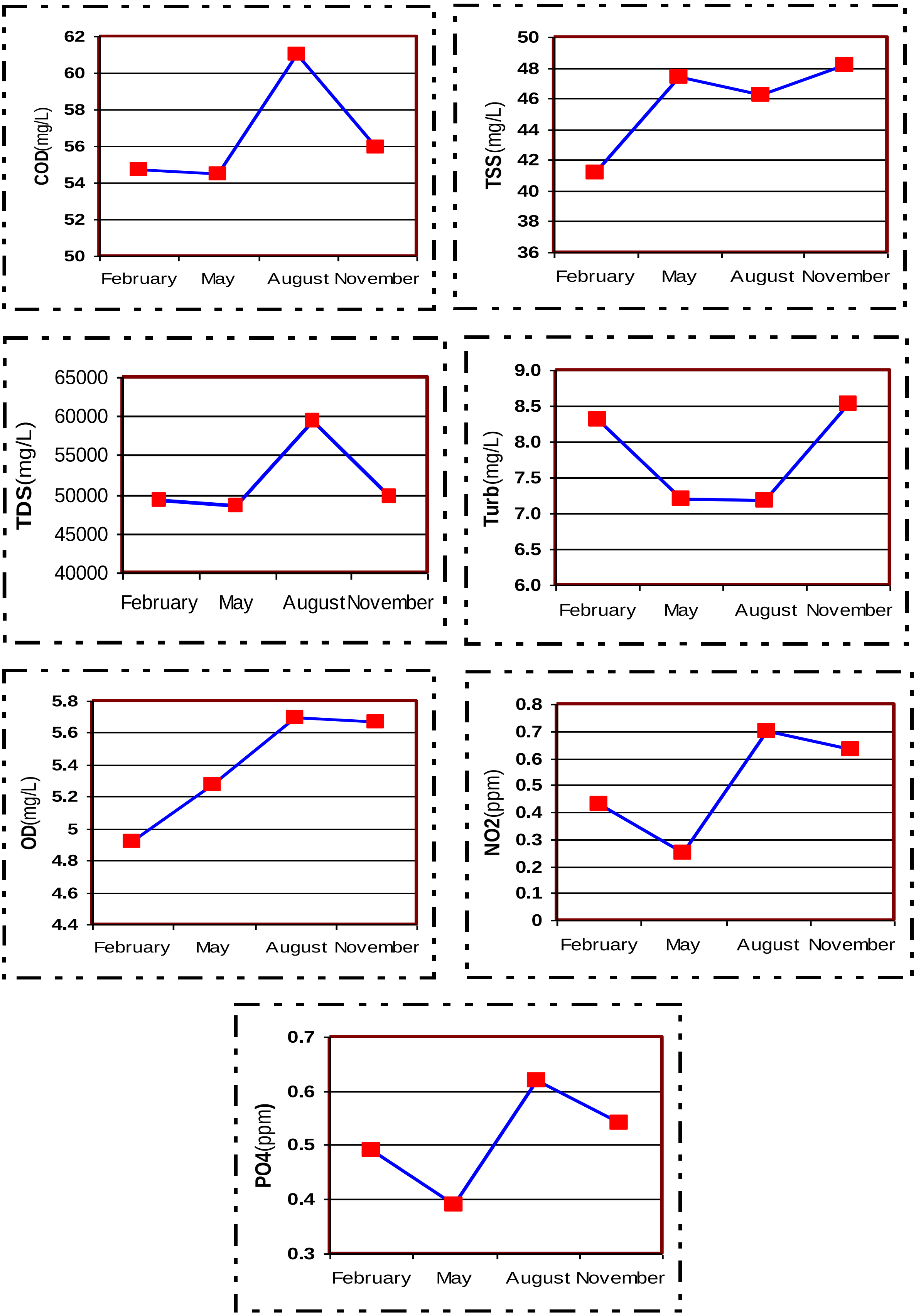


Fig. 2. The average measured parameters in 4 sampling months.

Table 2. Annual average of physicochemical parameters in 27 sampling stations.

Parameters	Average(±SDE)	Min	Max
T(°c)	27.1(0.5)	18.7	34.9
pH	8.38(0.10)	8.02	8.9
Salinity (0.00)	38.1(0.30)	36.0	42.3
DO (mg/L)	5.93(0.25)	4.21	6.27
Turb (NTU)	7.80(1.28)	3.1	11.5
Cond (ms/cm)	52.3(2.68)	40.8	68.2
TDS (mg/L)	49408(7058)	30547	65800
TSS(mg/L)	45.74(12.53)	11.24	78.6
COD (mg/L)	56.46(22.06)	10.16	115.67
NO_2^- (mg/L)	0.502(0.129)	0.123	0.991
PO_4^{-3} (mg/L)	0.519(0.185)	0.137	0.987

Table 3. Average, maximum, minimum and standard deviation of concentration of measured heavy metals.

Heavy metals	Average(±SDE)	Min	Max
Cd(ppm)	1.00(0.23)	0. 31	2.25
Pb(ppm)	43.70(10.67)	20.80	62.63
Ni(ppm)	25.08(8.05)	13.55	42.65
Cu(ppm)	30.11(4.45)	8.18	51.06
Fe(ppm)	1894(803)	771	3339

Discussion

The results taken from T-test in 4 measuring months proved that there is a considerable difference between the level of pH, salinity, dissolved oxygen, electric conductivity, and temperature in May and February. The analysis of the results of average of salinity, turbidity, electric conductivity, nitrite, phosphate and DO during February and August between the showed a considerable difference. Comparison of the results of November and February indicated a significant difference in the average level of pH, temperature, insoluble solids, solute oxygen, nitrite and electric conductivity. The analysis the results the average concentration of lead, cadmium, COD, dissolved and insoluble solids and turbidity in 3 regions showed a considerable difference in region north and south of the Hara Protected Area. Besides, results of region north and center of the Hara Protected Area, between the average concentration of nickel, cadmium, phosphate and COD. Comparison of the results of region center and the north of the Hara Protected Area showed a considerable difference in the average concentration of turbidity, dissolved and insoluble solids, COD, phosphate, copper, nickel, lead and cadmium.

Table 4. Pearson correlation index between measured physicochemical parameters in the surface waters of the Hara Protected Area.

	Temper-ature	pH	Salinity	TUR	CON	TDS	TSS	DO	COD	NO_2^-	PO_4^{-3}
Temperature	1										
	.										
pH	0.030	1									
	0.709	.									
Salinity	0.208**	-0.046	1								
	0.008	0.567	.								
TUR	-0.263**	0.015	-0.157*	1							
	0.001	0.855	0.048	.							
Cond	0.104	0.103	0.052	-0.025	1						
	0.190	0.196	0.517	0.757	.						
TDS	-0.023	0.124	-0.072	0.250**	-0.145	1					
	0.774	0.117	0.365	0.001	0.068	.					
TSS	0.017	0.053	0.063	0.476**	0.131	0.193*	1				
	0.835	0.502	0.429	0.000	0.098	0.014	.				
DO	-0.253**	-0.005	0.151	-0.232**	0.316**	-0.096	0.020	1			
	0.001	0.947	0.056	0.003	0.000	0.226	0.805	.			
COD	0.004	-0.157*	-0.026	0.362**	0.122	0.286**	0.339**	-0.001	1		
	0.959	0.048	0.747	0.000	0.126	0.000	0.000	0.988	.		
NO_2^-	-0.597**	0.047	0.026	0.105	-0.147	0.066	0.077	0.271**	-0.044	1	
	0.000	0.556	0.744	0.184	0.064	0.410	0.335	0.001	0.584	.	
PO_4^{-3}	-0.246**	0.013	-0.053	0.269**	-0.066	0.140	0.256**	0.025	0.147	0.576**	1
	0.002	0.866	0.508	0.001	0.405	0.078	0.001	0.755	0.064	0.000	.

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Table 5. Pearson correlation index between measured heavy metals in the marine deposits of the Hara Protected Area.

	Cd	Ni	Pb	Cu	Fe
Cd	1				
	.				
Ni	0.596**	1			
	0.000	.			
Pb	0.520**	0.576**	1		
	0.001	0.000	.		
Cu	0.105	0.122	0.059	1	
	0.525	0.458	0.722	.	
Fe	0.499**	0.332*	0.579**	0.399*	1
	0.001	0.039	0.000	0.012	.

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

The analysis of Pearson correlation index proved that there is a positive correlation between the annual average of temperature and a negative correlation between turbidity, solute Oxygen and phosphate. In the analysis of heavy metals' correlation in deposits, cadmium has a correlation with nickel, lead and iron (Table 4,5).

Considering the cluster analysis, turbidity and TSS parameters are categorized in the same group with the less difference. The relevance of these 2 parameters with COD reveals the pollution source of the organic matters. Having biological origin, Nitrite and phosphate are being produced from domestic waste waters and are categorized in the same group. According to the results of the heavy metals' cluster analysis, Iron and lead are in the same category and nickel and cadmium are in another category which shows having the same origin (Fig. 3, 4).

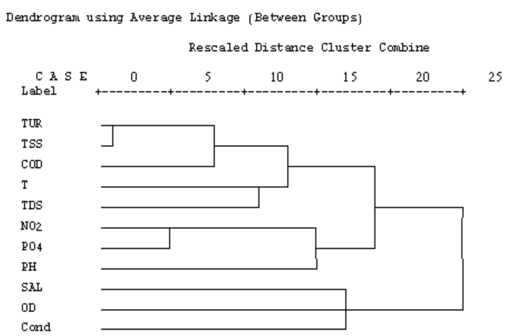


Fig. 3. Dendrogram of the measured physiochemical parameters in the water samples.

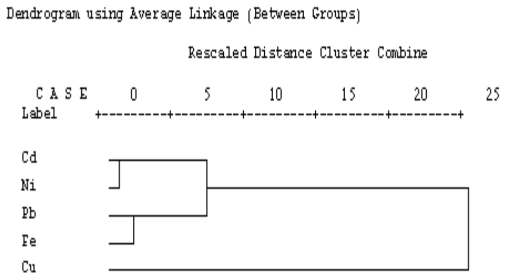


Fig. 4. Cluster dendrogram of the measured heavy metals in the deposits samples.

Rapid increase in human population and industrialization of communications, especially from the half of the century onward, has lead to serious issues and environmental pollution. Pollutants like industrial, urban and agricultural waste waters, domestic, industrial and mining sewage and oil pollutant of the sea makes marine environments in danger.

Sugirtha and Sheela reported nitrite and phosphate in surface waters of southern India respectively 0.01 and 0.01 mg/L, which is less than the values measured in the present study (Sugirtha and Sheela, 2014). Result assessment of the levels of coastal marine pollution of Chennai city showed: pH;7.8-8.3, temperature;30°C, turbidity;10NTU, DO;4mg/L, COD;250mg/L, nitrite;10mg/L, Cd;0.01mg/L, Pb;0.1mg/L, Cu;0.02mg/L, Ni;0.01mg/L, and Fe;0.1mg/L (Palanisamy *et al.*, 2007). The ranges and mean values of water temperature, salinity, pH and dissolved oxygen total suspended matter in Aqaba Gulf is reported: temperature;26.55 °C, salinity;40.44, pH ;7.2 and DO;7.4 mg/L (Abdel-Halim *et al.,* 2007). Öztürk *et al.*, determination the concentrations of heavy metal in sediment samples of Avsar Dam Lake in Turkey were as follows; Cd: 0.34 – 1.23 mg/L; Cu: 18.2 – 38.4 mg/L; Fe: 19680 – 28560 mg/L; Ni: 19.8 – 39.4 mg/L and Pb concentration 0.64 – 6.35 mg/L were found (Öztürk *et al.,* 2009).

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