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Fishing Port Pollution due to the Vessel Activities along Bandar Abbas Coast, Iran

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ABSTRACT

Bandar Abbas fish quays activities impacted on chemical compounds of the coasts. Three stations as Posht e Shahr (Ps), Sayadan (Sa) and Shilat (Sh) were selected to investigate the oil spill pollution and heavy metal concentrations in the regions. The sediment samples were collected in June and November 2017 then extracted. The highest concentrations were Fe>Zn>Pb>Cu>Cd respectively in the Sh quay. The cluster results indicated that Ni and Zn have the same sources but Pb, Cu and Cd were from different sources. Ni and Zn entered the environment due to the activities of ship repairs and coastal construction. Pb, Cu and Cd sources were from oil spills of fishing boats. The ERLQ and ERMQ toxicity rates of Ni at Ps and Sa were at the occasional but the Sh was at the frequent occurrence level. In November, the Cd toxicity at Sh was at occasional level. The new rules needed to control the pollution of quays operation.

1. Introduction

The Persian Gulf, which located at latitude of 24 ° to 30 °N and longitude of 47 ° to 57 ° E, is one of the most important waterways in the world. About 60% of the world's marine oil tanker transports via this area [1]. It is the third largest gulf in the world after the Gulf of Mexico and the Hudson Bay [2]. The concentration of elements in the sediment structure depends on their concentrations in the local environment and their bioavailability. That is why, in various studies, especially those having environmental, time and spatial limitations, they are used as indicators for environmental health assessments [3,4]. Metals are naturally found in aquatic environments, but their concentrations are increased recently, which have severe impacts on shallow coastal areas [5]. According to various studies, the concentrations of minor metals are influenced by many activities, and unique impacts on the concentrations, so they are known as the detectors [6,7]. The effects of various human activities can be measured by the concentrations of the minor metals which trapped in the sediments or the corals aragonite [8]. Bandar Abbas is the largest city and capital of Hormozgan Province in the north coast of the Persian Gulf. It is located in the south of Iran with GIS: 27 ° 18'32 "N 56 ° 26'66" E. The present study aimed to investigate the concentrations of the heavy metals around three fishing quays in Bandar Abbas city coastline. Due to the great amount of activities as boats and ship transportation it caused to release the oil into the sea water and sand coast on surrounded area which is effected on the chemical properties [9].

2. Materials and methodology

To determine the concentrations of heavy metals, three stations fisheries port, namely Posht e Shahr (Ps), Sayadan (Sa) and Shilat (Sh), were selected to collect the water and sediment samples. Table 1 shows the geographic coordinates of all three stations and Fig. 1 shows the stations location on the map.

Table 1: Sampling stations GIS, Study Location

Number	Station	E	N
1	Ps	56°15'3.11"	27° 9'57.46"
2	Sa	56°15'55.45"	27°10'3.17"
3	Sh	56°19'9.29"	27°10'51.33"

Field studies and sampling were conducted in two period of time: first in June and the second in November 2017. The samples were collected from the beach and surface sediment and water. Sampling was performed three times at each station. Each samples is collected by core grab and put into the PVC containers. The samples were transferred to the lab then freeze and prepared for the analysis. According to MOOPAM instruction in 1983 which is used for similar studies in this area, after drying the sediment, 0.2% of each bottle content was digested with hydrofluoric acid (HF) and nitric acid-chloride acid (1.4%) solution in teflon containers then homogenized and filtered [10]. Finally, 50 ml distilled water was added to them. The absorption of each metal was measured by using of the Flame Atomic absorption Spectrometer (M5, manufactured by Thermo Company).

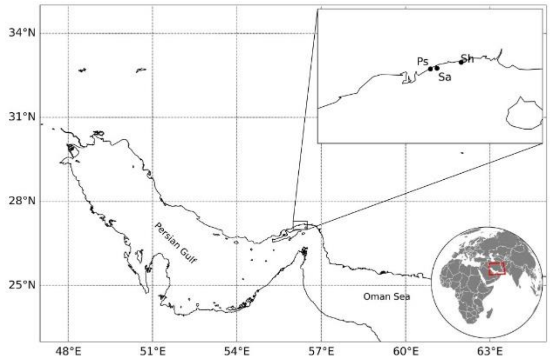

Figure. 1. Stations Location in Persian Gulf, Bandar Abbas coastline, south of Iran

Finally, the samples were distilled in 50 m of water [11] then extracted. The obtained values were analyzed by Minitab software. Moreover, One Way ANOVA test was used to compare the amount of different metals in the studied area [12]. Afterward, the Cluster K-Means technique is applied and the general statuses of the first metals were compared base on the clustering of each station, finally the heavy metals are classified. The dendrogram diagram was drawn according to the Cluster output that indicated which metals or stations had the same status or the same origin [13]. The Principal Component Analysis (PCA) was used to determine the first and second main components. The correlation coefficients between metals were defined by Pierson Coefficient and finally, the toxicity and the concentrations were compared according to the international standards [14].

3. Results

The analysis of the sediment samples data which obtained from the two sampling stages of the three coastal stations are shown in Tables 2, 3. Cadmium, lead, copper, zinc and nickel extracted.

Table 2:Heavy metals concentration (g/Kg Dry weight) for the three stations, June 2017

Station/Sample No		Cd	Pb	Cu	Zn	Ni
Ps	1	0.95	15.46	10.34	35.1	51.24
	2	1.09	17.76	8.48	29.73	44.22
	3	1.13	18.22	9.09	27.63	41.04
Sa	1	0.66	10.37	6.4	19.45	19.95
	2	0.79	6.65	7.98	37.13	19.97
	3	0.68	11.65	8.9	25.31	24.52
Sh	1	1.36	16.01	16.55	48.57	70.96
	2	1.64	16.75	19.16	51.4	66.17
	3	1.74	15.06	16.09	47.82	62.01
Maximum		0.66	6.65	6.4	19.45	19.95
Minimum		1.74	18.22	19.16	51.4	70.96
Average	**St.1**	1.06	17.15	9.3	30.82	45.5
	St.2	0.71	9.56	7.76	27.3	21.48
	St.3	1.58	15.94	17.27	49.26	66.38

Table 3:Heavy metals concentration (g/Kg Dry weight) for the three stations, November 2017

Station/Sample No		Cd	Pb	Cu	Zn	Ni
	1	1.03	17.02	9.33	25.46	48.07
Ps	2	0.91	18.21	9.12	27.31	51.23
	3	0.98	15.23	8.56	24.13	40.98
	1	0.58	9.89	7.02	26.13	23.06
Sa	2	0.88	8.24	7.11	24.03	21.25
	3	0.73	6.89	6.14	22.12	26.34
	1	0.98	14.12	13.21	39.89	68.76
Sh	2	0.95	13.69	18.14	41.06	65.89
	3	1.01	15.01	14.12	38.88	71.16
Maximum		0.58	6.89	6.14	22.12	21.25
Minimum		1.03	18.21	18.14	41.06	71.16
	St.1	0.97	16.82	9	25.63	46.76
Average	**St.2**	0.73	8.34	6.76	24.09	23.55
	St.3	0.98	14.27	15.16	39.94	68.6

3.1. One-way analysis of variance (One Way ANOVA)

The P-Value obtained for One Way ANOVA test related to the collected samples of June (R-sq = 72.42) and November (R-sq = 75.16) was 0.000. The results indicated that the concentrations of various metals were not the same. The results of Tukey's test showed that in both samples of Ps station in the June and November, Ni and Zn were placed in the first and Pb, Cu and Cd were in the second class. It should be noted that in one-way analysis of variance, those elements with similar behavior and source were in the same class.

Clustering

In terms of station

As shown in Figure 2, about the samples that collected in June, three repetitions of Sh and Ps stations were placed in the same cluster, but three repetitions of Sa Fish quay station were placed in a separate cluster. It indicated that Shilat (Sh) and Posht e Shahr (Ps) stations had the same statuses but Sayadan (Sa) had a different status.

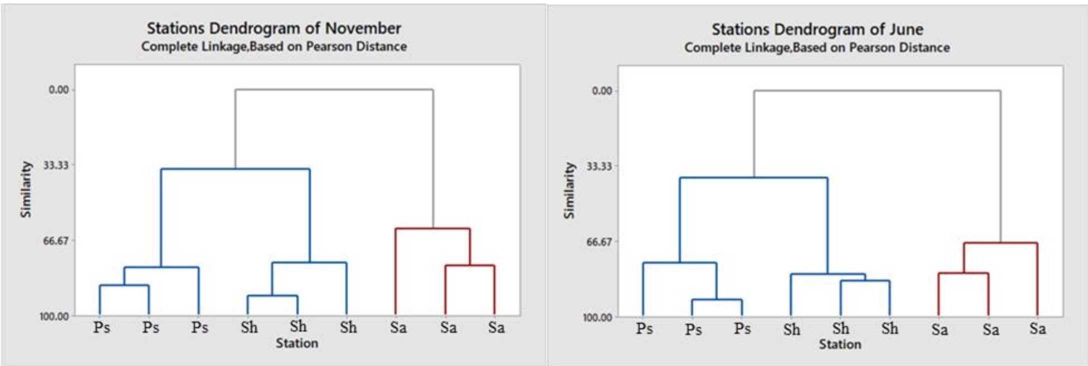

Figure. 2. Dendrogram of the Stations (Similar Data are in the Same Group)

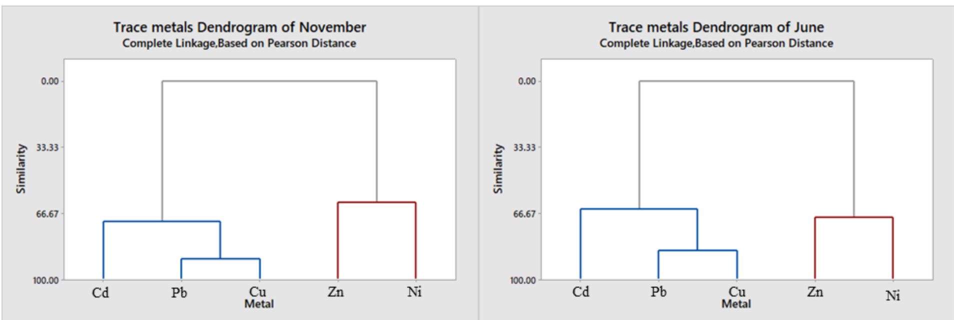

Figure. 3. Dendogram of the Metals (Similar Data are in the Same Group)

In terms of metal type

The results of the sample extract was consistent and compatible with the results of the Anova one-way analysis, represented by a dendrogram (Figure 3). The elements represented in one cluster are due to the same source.

Principal Component Analysis (PCA) chart:

The PCA graph, shown in Figure 4, illustrated which metals play a more important role, as well as the metals classification.

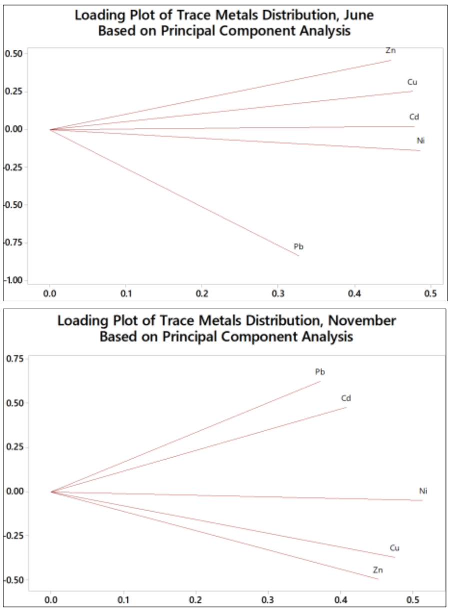

Figure. 4. Loading plot of Principal component for June and Nov samples

Correlation between metals using Pearson correlation coefficient

This coefficient is used to represent the correlation between the elements, the greater coefficient, and the stronger correlation. The correlation had a direct relation if the coefficient value is positive and negative for versa (table 4). In June the positive correlated is between Ni and Pb, Cu and Zn. The Negative correlated is between Cu and Cd, Zn and Cd, Pb. In November Cd with Cu, Zinc and Ni as well Ni with Zn are positive correlated and negative correlated with Pb and Cd.

Table 4: Correlation Coefficient of Pearson

Correlation: Cd, Pb, Cu, Zn, Ni, June

Correlations

	Cd	Pb	Cu	Zn
Pb	0.604			
Cu	0.895	0.450		
Zn	0.847	0.277	0.925	
Ni	0.884	0.723	0.892	0.827

Correlation: Cd, Pb, Cu, Zn, Ni, November

Correlations

	Cd	Pb	Cu	Zn
Pb	0.694			
Cu	0.545	0.423		
Zn	0.430	0.330	0.940	
Ni	0.712	0.681	0.876	0.876

Ecological Impact

Metal contamination in sediments may cause toxicity in sediment-dwelling organisms [15,16]. The effects-range low (ERL) and effects-range median (ERM) sediment quality guidelines [15] were used to characterize the potential toxicity of sediments due to their metal (Cd, Cu, Pb, Ni and Zn) contamination. Metal concentrations below the ERL, at or above the ERL but below the ERM, and at or above the ERM are associated with, respectively, Rare, occasional, and frequent occurrence of toxic effects. For each metal, two quotients namely the effects-range low quotient (ERLQ) and effects-range median quotient (ERMQ) were derived by dividing the measured metal concentration by its corresponding ERL and ERM concentrations, respectively. Within this approach, an ERLQ <1 indicated that toxic effects would Rarely occur; an ERLQ > 1 but ERMQ<1 indicated that toxic effects would occur occasionally; whereas an ERMQ > 1 indicated that toxic effects would occur frequently (Table 5-8) [17].

Table 5: Sediment quality, values of ERL, ERM (Lang et al., 1995), ISQG and PEL (CCME, 2002) (ppm in dry weight) and the relative percentages of biological (ERL: Effect Range Low& ERM: Effect Range Medium)

Substance	ISQG	ERL	PEL	ERM	%<=ISQ	<ERL	ISQ<%<PEL	ERL-ERM	%>=PEL	>ERM
Cd	0.7	1	4	10	6	7	20	37	66	71
Cu	18.7	34	108	270	9	9	22	29	56	84
Ni		21		52		2		17		17
Pb	30.2	47	112	218	6	8	26	36	58	90
Zn	124.0	150	271	410	4	6	27	47	65	70

Table 6: ERLQ values of metals for sediment of three stations, June 2017

Station/Sample No		ERLQ (Cd)	ERLQ (Cu)	ERLQ (Pb)	ERLQ (Ni)	ERLQ (Zn)
PS	1-1	0.8583333	0.2744118	0.362128	2.289048	0.169733
	1-2	0.7583333	0.2682353	0.387447	2.439524	0.182067
	1-3	0.8166667	0.2517647	0.324043	1.951429	0.160867
SA	2-1	0.4833333	0.2064706	0.210426	1.098095	0.1742
	2-2	0.7333333	0.2091176	0.175319	1.011905	0.1602
	2-3	0.6083333	0.1805882	0.146596	1.254286	0.147467
SH	3-1	0.8166667	0.3885294	0.300426	3.274286	0.265933
	3-2	0.7916667	0.5335294	0.291277	3.137619	0.273733
	3-3	0.8416667	0.4152941	0.319362	3.388571	0.2592
Average		0.7453704	0.3031046	0.279669	2.204974	0.199267
Total Average		0.7464768				

Table 7: ERLQ values of metals for sediment of three stations, November 2017

Station/Sample No		ERLQ (Cd)	ERLQ (Cu)	ERLQ (Pb)	ERLQ (Ni)	ERLQ (Zn)
PS	1-1	0.7916667	0.3041176	0.328936	2.44	0.234
	1-2	0.9083333	0.2494118	0.377872	2.105714	0.1982
	1-3	0.9416667	0.2673529	0.38766	1.954286	0.1842
Sa	2-1	0.55	0.1882353	0.220638	0.95	0.129667
	2-2	0.6583333	0.2347059	0.141489	0.950952	0.247533
	2-3	0.5666667	0.2617647	0.247872	1.167619	0.168733
Sh	3-1	1.1333333	0.4867647	0.340638	3.379048	0.3238
	3-2	1.3666667	0.5635294	0.356383	3.150952	0.342667
	3-3	1.45	0.4732353	0.320426	2.952857	0.3188
Average		0.9296296	0.3365686	0.302435	2.116825	0.238622
Total Average		0.7848162				

Table 85: ERMQ values of heavy metals, for sediment of three station, June 2017

Station/Sample No		ERMQ (Cd)	ERMQ (Cu)	ERMQ (Pb)	ERMQ (Ni)	ERMQ (Zn)
Ps	1-1	0.107292	0.034556	0.077364	0.924423	0.062098
	1-2	0.094792	0.033778	0.082773	0.985192	0.06661
	1-3	0.102083	0.031704	0.069227	0.788077	0.058854
Sa	2-1	0.060417	0.026	0.044955	0.443462	0.063732
	2-2	0.091667	0.026333	0.037455	0.408654	0.05861
	2-3	0.076042	0.022741	0.031318	0.506538	0.053951
S	3-1	0.102083	0.048926	0.064182	1.322308	0.097293
	3-2	0.098958	0.067185	0.062227	1.267115	0.100146
	3-3	0.105208	0.052296	0.068227	1.368462	0.094829
Average		0.093171	0.038169	0.059747	0.89047	0.072902
Total Average		0.230892				

Table 9: ERMQ values of heavy metals, for sediment of three station, November 2017

Station/Sample No		ERMQ (Cd)	ERMQ (Cu)	ERMQ (Pb)	ERMQ (Ni)	ERMQ (Zn)
Ps	1-1	0.0989583	0.0382963	0.070273	0.985385	0.08561
	1-2	0.1135417	0.0314074	0.080727	0.850385	0.072512
	1-3	0.1177083	0.0336667	0.082818	0.789231	0.06739
Sa	2-1	0.06875	0.0237037	0.047136	0.383654	0.047439
	2-2	0.0822917	0.0295556	0.030227	0.384038	0.090561
	2-3	0.0708333	0.032963	0.052955	0.471538	0.061732
Sh	3-1	0.1416667	0.0612963	0.072773	1.364615	0.118463
	3-2	0.1708333	0.070963	0.076136	1.2725	0.125366
	3-3	0.18125	0.0595926	0.068455	1.1925	0.116634
Average		0.1162037	0.0423827	0.064611	0.854872	0.087301
Total Average		0.233074				

4. Discussion and Conclusion

The result of one-way analysis of variance and Dendrogram (Fig. 3) of the cluster are indicated that Ni and Zn had the same sources but the Pb, Cu and Cd had different sources. It seems that Ni and Zn entered the environment due to the dispersed fishing tools, repairment and harbor construction. The Pb, Cu and Cd entered this area through oil spills release from fishing boats. According to the obtained clustering results in (Fig. 2), it seems that Posht e Shahr and Shilat stations were more impacted by similar activates as fishing, but Sayadan station was affected by various sources in addition to fishing boats, maintenances, dyeing, refueling and coastal construction. According to the results of the Principal Component Analysis (Fig. 10), it is observed that in the in June, Cu, Ni, and Zn are placed in the first principal component group (PCA1). Hence Pb and Cd are placed in the second principal component group (PCA2), and in the samples of November, all elements, except Pb, are placed in the first principal component group (PCA1) and Pb is placed in the second principal component group (PCA2). The results of Pearson correlation coefficient, clarified the highest correlation between Cu and Zn. As well as Cu with Cd in the samples of November were (0.925 and 0.895, respectively). This indicated a close relative between Cd and Zn with Cu which was again consistent with the results of one-way analysis and clustering. The ERLQ and ERMQ toxicity values indicated that in both sampling series, Ni pollution at Ps and Sa stations was at the occasional level and at station Sh, it was at the frequent occurrence level. Moreover, in November, Cd toxicity was at the occasional level at Sh station. Pollutions of all other elements were at the rare level, which proved that there was no risk. Only Ni toxicity was at the occasional level, and the average toxicity of other metals were at the rare level. Based on the results and local observations, it is clear that the fishing boat activities, which cause to release oil and gasoline spills are the main source of the dispersion of heavy metals as Ni and Pb in these three stations. Additionally, various fishing tools and equipment as well as metal wastes are also the sources of Fe and Cd in such ports. Moreover, due to the direction of prevailing wind in this region which is from south west, the floated oil spills on the water surface were transferred to the eastern coast of Bandar Abbas. The weathered spills are trapped within sand and increased the concentration of heavy metals in the coastal port sediment in this area [18]. In general, it is necessary to develop more rules by local law enforcement agencies and prevent of oil release through boats. As well making a suitable place regarding to the environmental protection issues for the solid wastes and unused instruments in these areas would reduce the leave or accumulation of these substances in the sea and coast. A new standard instruction according to the environment is very effective for the ships and boats discharge.

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