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Article *in* Research Journal of Pharmaceutical, Biological and Chemical Sciences · November 2016

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Journal of Pharmaceutical, Chemical and Biological Sciences
ISSN: 2348-7658
Impact Factor (GIF): 0.701
Impact Factor (SJIF): 2.092
September-November 2016; 4(3): 440-449
Published on: 28th November 2016

Original Research Article

Heavy Metals in Residual Sediments Core Along Shatt AL-Arab Estuary

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Received: 19 October 2016 Revised: 02 November 2016 Accepted: 04 November 2016

ABSTRACT
In This study we have calculated the concentrations of some heavy metals (Pb, Ni, Cu, Cr, Zn, Co, Cd and Fe) in residual phase by using Flame Atomic Absorption Spectrophotometer (FAAS) for sediment core at six stations along Shatt Al-Arab estuary they are: (Al-Qurna, Al-Deer, Al-Qarma, Al-Ashar, Abu-Alkasib and Al-Fao). The Grain Size and Total Organic Carbon (TOC%) were also analyzed. Higher concentrations of some heavy metals in sediments indicated that the sediments acted as a sink and source for these metals. Also we observed decreasing values with increasing depth because these layers are oldest age so the decomposition processes took place for a long time as compared with the layers above it. The lowest mean concentration in some stations because of the fewness sources of pollution in this region whereas the highest mean concentration in other stations such as Al-Ashar and Al-Fao station because of there are a lot of pollution sources such as : Oil Pollution (Al-Muftia oil refineries) Industrial wastes, Municipal Wastes (Al-Ashar river) and Sewage pollutants. The results obtained for the sediment samples were high except for Cd and Co which were relatively low. They were followed in order as: Fe > Cr > Ni > Zn > Pb > Cu > Co > Cd. The increasing in some Heavy metals concentrations are due to Iraq –Iran war and the Gulf war 1and 2 a lot of shooting and military actions were done during these times which release Heavy metals to the environments. The highest rate of Total Organic Carbon recorded in Al-Qarma amounted to (1.67%) while the lowest rate recorded in Al-Fao (0.049%) due to the lack of pollution sources in this region. The Grain Size of sediment were also analyzed, the silt and clay was predominate in most of the study stations. There is mainly a significant Correlation between metals and Total Organic Carbon and there is no significant Correlation with grain size.

Keyword: Heavy metals; resiual; sediment core; Shatt AL-Arab estuary

INTRODUCTION
The Shatt Al-Arab River forms the main source of freshwater for the Arabian Gulf and plays an important role for marine habitats in the Gulf's north-eastern coastal areas. However, the large-scale development of upstream water regulation and dam structures, together with the drainage of the Mesopotamian Marshes

have caused severe salinization of the river. This not only threatens marine ecosystems in the Gulf, but also jeopardizes agricultural activity along the Shatt Al-Arab. The southern part of the Shatt Al-Arab constitutes the border between Iran and Iraq until it discharges into the Arabian Gulf, with a total length of 192 km, the Shatt al Arab widens over its course, expanding from a width of (250-300)m near the Euphrates-Tigris confluence to almost 700 m near the city of Basrah and more than 800 m as it approaches the river mouth An area of 145,190 km2 drains directly to the Shatt Al-Arab region downstream of the Euphrates-Tigris confluence (excluding the Euphrates and Tigris Basin areas). The Shatt Al-Arab Delta area is classified as estuarine-deltaic because the river's sediment seeps into a shallow, narrow part of the Arabian Gulf. The Shatt al Arab Delta is 140 km wide and splits into more than 10 branches. The landscape is characterized by green marshy areas, lakes, lagoons and estuaries, bordered by irrigated lands and date palm plantations and surrounded by desert [1]. The most important Heavy Metals from the point of view of water pollution are zinc, copper, lead, cadmium, iron, ,nickel and manganese . Some of these metals (e.g. copper, zinc and iron) are essential Heavy Metals to living organisms and play irreplaceable roles in the functioning of critical enzyme systems , but become toxic at higher concentrations. Others, such as lead and cadmium, have no known biological function, and may be toxic even at Heavy levels to exposure [2] .

MATERIALS AND METHODS

The sediment core samples were taken from six sampling stations which represent different sector of Shatt Al-Arab estuary for analysis and estimation the concentration of some heavy Metals (Cr, Co, Cd, Cu, Pb, Ni, Fe and Zn) in residual phase in these sediment core. GPS instrument is used to fix the positions of these stations. They are : Al-Deer , Al-Qarma , Al-Qurna , Al-Ashar , Abo-Alkasib and Al-Faw as shown in Fig(1) . Sediment cores (Acid washed PVC pipe of 1m lengthX10 cm diameter) were collected from six stations. The cores were inserted into the water-sediment interface and pushed to ensure that it reached maximum depth. The cores were slowly retrieved back, closed with its cover immediately and marked as to which is the upward direction .

Fig. No. 1: The study stations

The residual heavy metals were extracted according to [3] concentrated HCl and HNO_3(1:1) were added to each sample and evaporated to near dryness on a hotplate at 80°C, then a mixture of concentrated $HClO_4$ and HF (1:1) were added. After heating to near dryness, 20 ml of 0.5 HCl were added and cooled for 10 min. The extraction was decanted into 25 ml plastic volumetric flask. This step was repeated twice and all supernatant were combined. Samples were stored in tight stopper polyethylene vials to be ready for analysis by Flame Atomic Absorption Spectrophotometer (FAAS).To check for contamination of the digestion procedure and sample manipulation, a blank solution was prepared and carried through each set of the analysis. The Total Organic Carbon content in the sediment samples was determined according to the method of [4]. Mean grain size were analyzed by using Sedigraph and the grain size (sand , silt , and clay) was determined as percentage of sediments.

RESULTS AND DISCUSSION

Result of the present study are shown in Table (1) to (6) show that the concentrations of lead in the residual phase inversely proportional with the depth for all stations, whereas the concentrations of lead in the residual phase inversely proportional with the depth for all stations, whereas the highest value of concentrations of lead in the residual phase was (73.19 µg/g dry weight) at (0-5 cm) depth in Al-Qarma station and the lowest value was (25.61 µg/g dry weight) at (45-50 cm) depth in Al-Qurna station , the highest mean value (58.44 µg/g dry weight) in Al-Fao station and the lowest mean value (51.29 µg/g dry weight) in Al-Qurna station. The lowest mean concentration observed in Al-Qarma and Al-Qurna station because of the fewness sources of pollution in this region whereas the highest mean concentration observed in Al-Ashar and Al-Fao station because of there are a lot of pollution sources such as : Sewage pollutants, Industrial wastes, Oil Pollution (Al-Muftia oil refineries) and Municipal Wastes (Al-Ashar river) .The increasing in Pb concentrations are due to Iraq –Iran war and the Gulf war 1and 2 a lot of shooting and military actions were done during these times which release Pb to the environments. The concentrations of Nickel inversely proportional with the depth for all stations, whereas the highest value of concentrations of Nickel in the residual phase was (85.42 µg/g dry weight) at (0-5 cm) depth in Al-Qurna station and the lowest value was (50.47 µg/g dry weight) at (45-50 cm) depth in Al-Qarma station, the highest mean value (74.90 µg/g dry weight) in Al-Qurna station and the lowest mean value (66.36 µg/g dry weight) in Al-Qarma station. The increasing in Ni concentrations are due to the oil refinery of Abadan discharge [5]. The concentrations of Copper inversely proportional with the depth for all stations, whereas the highest value of concentrations of Copper in the residual phase was (54.52 µg/g dry weight) at (0-5 cm) depth in Al-shar station and the lowest value was (18.47 µg/g dry weight) at (45-50 cm) depth in Al-Qarma station, the highest mean value (38.21 µg/g dry weight) in Al-Ashar station and the lowest mean value (28.34 µg/g dry weight) in Al-Fao station.This fluctuation in Cu concentrations is mainly due to the different source of pollution in these stations such as the discharge of Industrial wastes, Oil refinery, sewage pollution [5]. The concentrations of Chrome inversely proportional with the depth for all stations, whereas the highest value of concentrations of Chrome in the residual phase was (102.87 µg/g dry weight) at (0-5 cm) depth in Al-Fao station and the lowest value was (55.11 µg/g dry weight) at (45-50 cm) depth in Al-Qurna station, the highest mean value (86.40 µg/g dry weight) in Al-Fao station due to the oil terminals in the area and the fish boats in the area which discharge waste oil and the lowest mean value (74.32 µg/g dry weight) in Al-Qurna station. the concentrations of Zinc inversely proportional with the depth for all stations, whereas the highest value of concentrations of Zinc in the residual phase was (65.89 µg/g dry weight) at (0-5 cm) depth in Al-Ashar station and the lowest value was (44.79 µg/g dry weight) at (45-50 cm) depth in Abu-Alkasib station, the highest mean value (58.30 µg/g dry weight) in Al-Fao station and the lowest mean value (55.34µg/g dry weight) in Al-Deer station.The high concentration of Zn because of the high population compared with other areas and launch high organic wastes. The concentrations of Cobalt inversely proportional with the depth for all stations, whereas the highest value of concentrations of Cobalt in the residual phase was (18.99µg/g dry weight) at (5-10 cm) depth in Al-Qarma station and the lowest value was (8.3 µg/g dry weight) at (45-50 cm) depth in Al-Qurna station, the highest mean value (15.65 µg/g dry weight) in Al-Deer station and the lowest mean value (12.04 µg/g dry weight) in Al-Qurna station. The concentrations of Cadmium inversely proportional with the depth for all stations, whereas the highest value of concentrations of Cadmium in the residual phase was (15.98 µg/g dry weight) at (0-5 cm) depth in Abu-Alkasib station and the lowest value was (6.49µg/g dry weight) at (40-45 cm) depth in Al-Fao station, the highest mean value (13.57 µg/g dry weight) in Abu-Alkasib station and the lowest mean value (9.50µg/g dry weight) in Al-Fao station. The increasing of Cd due to increased human activities and continued launch of pollutants without treatment. the highest value of concentrations of Iron in the residual phase was (20,158.26 µg/g dry weight) at (5-10cm) depth in Al-Ashar station and the lowest value was (770.15 µg/g dry weight) at (45-50 cm) depth in Abu-Alkasib station, the highest mean value (12,710.76 µg/g dry weight) in Al-Ashar station and the lowest mean value (1,412.01 µg/g dry weight) in Abu-Alkasib station. This fluctuation in concentration of Fe due to the seasonal changes and weather conditions of heat, light, wind speed and erosion and sedimentation processes which effect the sedimentation or supareat of Iron as a result of oxidation and reduction processes. In this study there is mainly a Significant Correlation between metals at ($p > 0.05$) as shown as table (9) .

Table 1: Concentration of Residual Heavy Metals (µg/g) dry weight in sediment core from Al-Qurna station

Depth cm	pb	Ni	Cu	Cr	Zn	Co	Cd	Fe
0-5	71.54	85.42	45.15	99.98	62.01	15.09	15.95	2785.99
5-10	70.77	82.55	44.39	94.59	61.94	14.87	15.64	2531.01
10-15	67.11	79.83	34.47	88.56	60.1	14.36	14.35	2152.17
15-20	62.31	77.11	30.3	81.25	58.39	12.63	14.27	1598.45
20-25	55.57	75.24	29.29	73.91	57.87	12.39	13.62	1254.71
25-30	52.33	75.13	29.19	70.34	57.47	12.1	13.27	1875.22
30-35	44.24	75.08	27.35	60.49	57.15	10.42	13.22	1957.52
35-40	32.56	66.85	21.71	60.23	55.7	10.16	12.22	1584.56
40-45	30.87	66.47	21.22	58.77	55.11	10.07	12.15	1632.71
45-50	25.61	65.3	20.29	55.11	50.74	8.3	9.05	1284.88
Total	512.91	748.98	303.36	743.23	576.48	120.39	133.74	18657.22
Mean	51.29	74.90	30.34	74.32	57.65	12.04	13.37	1865.72
±SD	17.18	6.88	8.84	16.11	3.37	2.29	1.98	505.03

Table 2: Concentration of Residual heavy metals (µg /g) dry weight in sediment core from Al- Deer station

Depth (cm)	pb	Ni	Cu	Cr	Zn	Co	Cd	Fe
0-5	70.33	80.97	40.65	100.37	60.81	18.82	12.81	5120.25
5-10	68.34	78.46	39.77	98.28	60.31	18.05	12.64	4356.29
10-15	68.71	74.91	37.64	98.03	58.62	17.61	12.11	3635.62
15-20	57.92	71.7	31.64	82.61	58.48	17.22	11.37	3599.32
20-25	57.26	69.63	31.24	82.24	58.12	17.03	11.06	3226.62
25-30	50.27	67.31	26.42	72.63	53.24	16.73	9.52	3231.27
30-35	44.92	66.92	22.61	72.32	51.61	16.32	9.32	2619.63
35-40	41.62	62.76	22.52	68.67	51.16	12.24	9.15	1923.62
40-45	41.31	62.39	22.02	63.64	51	12.11	9.07	1692.43
45-50	40.66	62.33	20.77	60.18	50.03	10.37	8.24	1670.42
Total	541.34	697.38	295.28	798.97	553.38	156.5	105.29	31075.47
Mean	54.13	69.74	29.53	79.90	55.34	15.65	10.53	3107.55
±SD	12.03	6.70	7.76	14.86	4.30	2.94	1.66	1148.34

Table 3: Concentration of Residual heavy metals (µg /g) dry weight in sediment core from Al- Qarma

Depth (cm)	pb	Ni	Cu	Cr	Zn	Co	Cd	Fe
0-5	73.19	80.19	42.37	100.47	60.3	18.68	13.62	5535.59
5-10	70.59	79.27	42.33	94.46	59.78	18.99	13.3	5985.66
10-15	70.16	70.02	41.72	94.19	58.95	15.2	12.49	5635.51
15-20	66.2	69.72	41.41	86.12	58.13	15.12	12.38	4253.12
20-25	62.37	69.12	31.38	80.05	55.95	15.08	10.92	4002.67
25-30	59.15	62.98	26.38	77.21	55.61	14.92	10.56	3856.21
30-35	51.67	62.53	26.19	77.12	53.56	12.6	10.34	3122.94
35-40	40.61	60.16	22.64	69.35	53.26	12.18	9.73	3522.17
40-45	42.57	59.29	19.01	60.65	50.88	12.03	8.27	3994.27
45-50	42.86	50.47	18.47	59.99	48.7	11.87	6.78	2642.61
Total	579.37	663.75	311.9	799.61	555.12	146.67	108.39	42550.75
Mean	57.94	66.36	31.19	79.96	55.51	14.67	10.84	4255.08
±SD	12.63	9.17	9.98	14.03	3.90	2.60	2.20	1118.03

Table 4: Concentration of Residual heavy metals (µg /g) dry weight in sediment core from Al-Ashar

Depth (cm)	pb	Ni	Cu	Cr	Zn	Co	Cd	Fe
0-5	69.63	81.03	45.52	98.56	65.89	17.83	11.74	20,158.26
5-10	68.77	80.9	45.15	93.56	64.83	16.07	11.26	19,854.26
10-15	65.75	75.52	44.47	87.6	63.78	15.76	10.61	17,521.23
15-20	60.54	72.59	42.12	84.1	60.7	14.99	10.75	15,672.31
20-25	58.97	71.86	41.46	81.3	59.14	14.06	10.18	12,548.10
25-30	57.65	69.23	40.03	76.07	57.07	13	9.84	10,775.16
30-35	54.77	69.17	37.22	73.89	55.49	12.63	9.19	8,759.23
35-40	46.24	68.47	32.46	71	54.8	12.05	8.58	7,819.24
40-45	43.64	66.05	28.52	69.1	45.19	11.99	8.28	7,024.18
45-50	41.11	63.32	25.19	68	53.79	11.07	7.97	6,975.64
Total	567.07	718.14	382.14	803.18	580.68	139.45	98.4	127107.6
Mean	56.71	71.81	38.21	80.32	58.07	13.95	9.84	12710.76
±SD	10.23	5.89	7.21	10.54	6.24	2.17	1.30	5238.21

Table 5: Concentration of Residual heavy metals (µg /g) dry weight in sediment core from Abu-Alkasib

Depth (cm)	pb	Ni	Cu	Cr	Zn	Co	Cd	Fe
0-5	69.63	81.03	38.52	98.56	64.89	17.83	15.98	2295.49
5-10	68.77	76.9	35.52	93.52	63.83	17.07	15.78	2021.49
10-15	68.75	76.52	32.47	90.6	63.78	16.96	15.32	1885.52
15-20	68.54	64.59	30.56	80.44	63.7	16.49	15.25	1782.26
20-25	58.97	61.86	30.46	80.26	60.14	16.06	13.92	1525.18
25-30	57.65	58.83	30.03	80.07	50.07	14.8	13.75	1125.65
30-35	50.77	58.57	27.82	72.89	57.49	14.63	11.95	925.57
35-40	46.24	60.47	27.46	64.73	54.8	10.95	11.87	915.97
40-45	43.64	65.05	22.52	64.1	54.19	10.2	11.2	872.83
45-50	41.11	65.32	21.89	62	44.79	10.07	10.64	770.15
Total	574.07	669.14	297.25	787.17	577.68	145.06	135.66	14120.11
Mean	57.41	66.91	29.73	78.72	57.77	14.51	13.57	1412.01
±SD	11.34	8.20	5.18	12.84	6.78	2.99	2.01	557.12

Table 6: Concentration of Residual heavy metals (µg /g) dry weight in sediment core from Al-Fao station

Depth (cm)	pb	Ni	Cu	Cr	Zn	Co	Cd	Fe
0-5	68.95	82.07	34.37	102.87	63.06	16.72	11.88	4651.72
5-10	68.42	81.77	32.37	102.07	62.47	15.27	11.53	4351.72
10-15	66.14	78.77	32.01	98.83	60.51	14.48	10.74	3263.28
15-20	64.79	75.32	30.49	98.04	60.36	14.17	10.27	3152.16
20-25	57.95	75.21	30.21	80.16	58.58	13.74	10.07	3525.04
25-30	57.55	74.55	27.99	80.06	58.27	13.52	9.58	2996.61
30-35	56.93	73.15	24.95	81.27	55.89	13.04	9.27	2959.73
35-40	56.76	66.26	24.91	77.48	55.48	11.61	6.96	2982.53
40-45	46.31	62.55	24.07	75.26	55.16	11.18	6.49	2425.07
45-50	40.63	60.03	22.06	67.99	53.25	10.75	8.24	2119.47
Total	584.43	729.68	283.43	864.03	583.03	134.48	95.03	32427.33
Mean	58.44	72.97	28.34	86.40	58.30	13.45	9.50	3242.73
±SD	9.31	7.66	4.15	12.71	3.31	1.86	1.81	777.61

Table 7 show that the concentrations of Total Organic Carbon(TOC%) inversely proportional with the depth for all stations, whereas the highest value of concentrations of Total Organic Carbon (TOC%) was (1.67µg/g dry weight) at (0-5) in Al-Qarma station, the lowest value was (0.049 µg/g dry weight) at (45-50cm) in Al-Fao station, the highest mean value (0.89 µg/g dry weight) in Abu-Alkasib station and the lowest mean value (0.36 µg/g dry weight) in Al-Fao station. There is mainly a significant Correlation between metals and TOC% as shown as table 9 .

Table 7: Concentration of Total Organic Carbon (TOC%)

Depth (cm)	Al-Qurna	Al-Deer	Al-Qarma	Al-Ashar	Abu-Alkasib	Al-Fao
0-5	1.176	0.5145	1.67	1.176	1.056	0.7595
5-10	0.931	0.441	1.61	0.816	1.008	0.686
15-20	0.588	0.441	1.32	0.792	0.984	0.6125
20-25	0.539	0.4165	1.27	0.744	0.936	0.49
25-30	0.441	0.392	1.26	0.696	0.912	0.343
30-35	0.367	0.3675	1.15	0.48	0.912	0.2695
35-40	0.269	0.343	0.98	0.456	0.84	0.1715
40-45	0.196	0.319	0.94	0.336	0.768	0.098
45-45	0.147	0.269	0.9	0.216	0.768	0.098
45-50	0.12	0.25	0.82	0.144	0.72	0.049
Total	4.78	3.75	11.92	5.86	8.90	3.58
Mean	0.48	0.37	1.19	0.59	0.89	0.36
±SD	0.35	0.08	0.29	0.32	0.11	0.26

Table 8 shows the percentage of sand, silt, and clay is descried in the grain size analysis. The dominant of silt and clay in all the sediments in the study stations with little share of sand fraction between (1-18%) except in Al-Qurna station sediments where the sand content increase to (23%) in (30-50cm) depth, Al-Deer station sediments where the sand content increase to (36%) in (0-15cm) depth, and Al-Qarma station sediments where the sand content increase to (38%) in (0-25cm) depth and in (35-50cm). There is no significant Correlation between metals and grain size as shown as Table 9 .

Table 8: Grain Size Analysis of Sediment Core Samples in Study Stations.

	Al-Qurna				Al-Deer				Al-Qarma			
Depth(cm)	**Sand**	**Silt**	**Clay**	**Texture**	**Sand**	**Silt**	**Clay**	**Texture**	**Sand**	**Silt**	**Clay**	**Texture**
0-5	%10	%74	%16	Silty clay	%35	%55	%10	Silty sand	%38	%54	%8	Silty sand
5-10	%12	%71	%17	Silty clay	%36	%56	%8	Silty sand	%36	%54	%10	Silty sand
10-15	%11	%64	%25	Silty clay	%27	%59	%14	Silty sand	%33	%55	%12	Silty sand
15-20	%12	%61	%27	Silty clay	%12	%72	%16	Silty clay	%27	%55	%18	Silty sand
20-25	%12	%63	%25	Silty clay	%9	%72	%19	Silty clay	%26	%54	%20	Silty sand
25-30	%18	%63	%19	Silty clay	%6	%74	%20	Silty clay	%0	%58	%42	Silty clay
30.35	%22	%58	%20	Silty sand	%6	%70	%24	Silty clay	%0	%60	%40	Silty clay
35-40	%22	%60	%18	Silty sand	%8	%72	%20	Silty clay	%23	%62	%15	Silty sand
40.45	%23	%63	%14	Silty sand	%6	%76	%18	Silty clay	%20	%66	%14	Silty sand
45-50	%18	%65	%17	Silty sand	%6	%76	%18	Silty clay	%21	%69	%10	Silty sand

	Al-Ashar				Abo-Alkasib				Al-Fao			
Depth(cm)	**Sand**	**Silt**	**Clay**	**Texture**	**Sand**	**Silt**	**Clay**	**Texture**	**Sand**	**Silt**	**Clay**	**Texture**
0-5	%10	%64	%26	Silty clay	%0	%91	%9	Silty clay	%1	%64	%35	Silty clay
5-10	%17	%64	%28	Silty clay	%0	%90	%10	Silty clay	%1	%64	%35	Silty clay
10-15	%11	%64	%25	Silty clay	%0	%80	%20	Silty clay	%3	%64	%33	Silty clay
15-20	%10	%64	%26	Silty clay	%1	%62	%37	Silty clay	%4	%64	%32	Silty clay
20-25	%8	%62	%30	Silty clay	%1	%62	%37	Silty clay	%2	%69	%29	Silty clay
25-30	%7	%63	%30	Silty clay	%5	%66	%29	Silty clay	%2	%70	%28	Silty clay
30.35	%9	%60	%31	Silty clay	%9	%69	%22	Silty clay	%7	%71	%22	Silty clay
35-40	%11	%61	%28	Silty clay	%9	%71	%20	Silty clay	%6	%75	%19	Silty clay
40.45	%11	%63	%26	Silty clay	%12	%70	%18	Silty clay	%8	%72	%20	Silty clay
45-50	%5	%69	%26	Silty clay	%12	%70	%18	Silty clay	%9	%69	%22	Silty clay

***Adopted from [6]**

Table 9: Correlation coefficient

	pb 1	Ni 1	Cu1	Cr1	Zn 1	Co1	Cd1	Fe1	pb 2	Ni 2	Cu2	Cr2	Zn2	Co2	Cd2	Fe2	toc	Sand	silt	Clay
pb 1	1	.754**	.573**	.657**	.757**	.699**	.542**	.203	.681**	.730**	.817**	.705**	.754**	.654**	.520**	.551**	.238	.210	-.255-*	.013
Ni 1	.754**	1	.802**	.903**	.856**	.748**	.719**	.588**	.911**	.721**	.870**	.877**	.820**	.837**	.616**	.412**	.551**	.038	-.055	.032
Cu1	.573**	.802**	1	.884**	.745**	.820**	.884**	.837**	.858**	.508**	.729**	.801**	.706**	.721**	.503**	.366**	.703**	-.005	-.119	.137
Cr1	.657**	.903**	.884**	1	.858**	.815**	.815**	.690**	.871**	.685**	.806**	.882**	.778**	.769**	.442**	.479**	.532**	-.056	-.045	.138
Zn 1	.757**	.856**	.745**	.858**	1	.765**	.782**	.544**	.882**	.843**	.848**	.907**	.814**	.776**	.453**	.463**	.408**	.077	-.084	.009
Co1	.699**	.748**	.820**	.815**	.765**	1	.825**	.703**	.727**	.597**	.788**	.709**	.698**	.613**	.376**	.644**	.632**	.238	-.382-**	.098
Cd1	.542**	.719**	.884**	.815**	.782**	.825**	1	.828**	.816**	.518**	.724**	.805**	.664**	.723**	.317*	.428**	.633**	.087	-.250	.144
Fe1	.203	.588**	.837**	.690**	.544**	.703**	.828**	1	.688**	.279*	.496**	.628**	.486**	.553**	.335**	.172	.815**	.057	-.146	.072
pb 2	.681**	.911**	.858**	.871**	.882**	.727**	.816**	.688**	1	.730**	.830**	.937**	.801**	.831**	.592**	.308*	.591**	.049	-.120	.072
Ni 2	.730**	.721**	.508**	.685**	.843**	.597**	.518**	.279*	.730**	1	.730**	.783**	.757**	.559**	.571**	.301*	.231	.118	-.066	-.059
Cu2	.817**	.870**	.729**	.806**	.848**	.788**	.724**	.496**	.830**	.730**	1	.796**	.743**	.696**	.521**	.611**	.531**	.233	-.243	-.028
Cr2	.705**	.877**	.801**	.882**	.907**	.709**	.805**	.628**	.937**	.783**	.796**	1	.791**	.825**	.516**	.306*	.489**	.059	-.093	.032
Zn2	.754**	.820**	.706**	.778**	.814**	.698**	.664**	.486**	.801**	.757**	.743**	.791**	1	.669**	.628**	.370**	.396**	-.035	-.015	.087
Co2	.654**	.837**	.721**	.769**	.776**	.613**	.723**	.553**	.831**	.559**	.696**	.825**	.669**	1	.506**	.285*	.553**	.132	-.071	-.082
Cd2	.520**	.616**	.503**	.442**	.453**	.376**	.317*	.335**	.592**	.571**	.521**	.516**	.628**	.506**	1	-.143	.523**	.100	.007	-.129
Fe2	.551**	.412**	.366**	.479**	.463**	.644**	.428**	.172	.308*	.301*	.611**	.306*	.370**	.285*	-.143	1	.186	.076	-.247	.201
toc	.238	.551**	.703**	.532**	.408**	.632**	.633**	.815**	.591**	.231	.531**	.489**	.396**	.553**	.523**	.186	1	.244	-.215	-.092
Sand	.210	.038	-.005	-.056	.077	.238	.087	.057	.049	.118	.233	.059	-.035	.132	.100	.076	.244	1	-.608-**	-.656-**
silt	-.255-*	-.055	-.119	-.045	-.084	-.382-**	-.250	-.146	-.120	-.066	-.243	-.093	-.015	-.071	.007	-.247	-.215	-.608-**	1	-.190
Clay	.013	.032	.137	.138	.009	.098	.144	.072	.072	-.059	-.028	.032	.087	-.082	-.129	.201	-.092	-.656-**	-.190	1

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

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

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Cite this article as:
Zahra'a Salih Radi Al-Shamsi, Abbas H. Mohammed, Hamid T. Al-Saad. Heavy Metals in Residual Sediments Core Along Shatt AL-Arab Estuary. J Pharm Chem Biol Sci 2016; 4(3): 440-449.