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Concentration of Some Heavy Metals in Short Cores in the Nearshore Sediments of Alexandria , Egypt

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تركيزات بعض العناصر الثقيلة فى تثقيبات قصيرة فى الرواسب القاعية القريبة من شاطئ الإسكندرية – مصر

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تعتبر كل من الميناء الغربية والميناء الشرقية وخليج أبى قير على امتداد ساحل مدينة الإسكندرية مناطق ذات نشاط بحرى وصناعى مكثف. وقد تم عمل تثقيبات قصيرة فى الرواسب المتاخمة لسواحل هذه الأماكن لتتبع الإنتشار الرأسى لكل من تركيزات العناصر الثقيلة : الكادميوم، الكوبالت، النحاس، الكروم، النيكل، الزنك، المنجنيز والحديد بالاضافة إلى محتوى الرواسب من المياه البينية، الكربونات والكربون العضوى.بينت نتائج التحليل أن الطبقة الأعلى فى التثقيبات بها أعلى التركيزات وأن تثقيبات الميناء الغربية تحتوى أعلى التركيزات نسبيا إلى كل من الميناء الشرقية وخليج أبى قير.

Key words: *Carbonate, Grain-size, Heavy metals, Organic carbon.*

ABSTRAC

The Western Harbor, Eastern Harbor and Abu Qir Bay are three sites located along the Alexandria coast. These sites are characterized by extensive maritime and industrial activities. To investigate the penetration of heavy metals into the bottom sediments, some short cores were collected from the three sites.

Every core interval was analyzed for granulometric characteristics, water content, organic carbon, carbonate, Cd, Co, Cu, Cr, Ni, Zn, Mn and Fe concentrations.

The upper most layers of the cores show the highest heavy metal accumulations with the maximum levels in the Western Harbor.

Introduction

The marine pollution by heavy metals is a severe problem that threatens our aquatic planet. It has begun and has been observed in the coastal waters where the highest rate of soiling takes place across some hot spots such as rivers, industrial and agricultural activities and domestic sewage discharges. In other words it is the day to day interaction between human and natural systems.

The coastal area under study covers three regions, which lie in the very near shore-zone. These sites are affected by very dense navigational routes, which include commercial, fishing, tourist and sporting vessels.

The Alexandria seaport (known as the Western Harbor; WH) and its navigational channel represent the first site. Commercial ships mainly occupy this site. The second site is represented by the Eastern Harbor(EH)and is mostly occupied by fishing machine boats, yachts and sporting sharpies. The third site is represented by a location in the extreme west of Abu Qir Bay(AQB)and is mainly occupied by service tugs and fishing boats(Table 1 & Fig.1).

The aim of this work is to evaluate the levels of heavy metals contents of the bottom sediments and the extent to which these metals penetrate through the sea bed layers. The differentiation between natural and anthropogenic sources is in consideration.

Previous Work

As stated before the near shore zone of Alexandria is occupied by relatively dense navigational activities. Alexandria city and its neighborhood is the commercial hub with more than third of the whole industries of Egypt in addition to its reputation as a summer resort. It has put the area under continuous stress and close environmental observations are needed. Several studies dealt with the coastal area of Alexandria as [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 and 13].

Materials And Methods

The three sites along the shallow coastal zone of Alexandria were sampled by short cores. The stations were located in very crowded marine routes and docking area. Sample collection was carried out using simple gravity corer and diving in case of coarser sediments. The water depth at the stations varied from 4 to 17 m while the length of the collected sediment cores ranged between 12.5 and 30 cm.

Table 1. Locations, water depths and core lengths of the collected samples

Site	Sample No.	Latitude N Deg. Min. Sec.	Longitude E Deg. Min. Sec.	Water Depth (m)	Core length (cm)
Western Harbor (WH)	W - 1	31 09 49.5	29 50 25.5	13	22.5
	W - 2	31 10 26.7	30 52 12.9	6.25	12.5
	W - 3	31 11 26.4	29 52 21.2	13.5	27
	W - 4	31 11 38.3	29 52 39.7	10	24
	W - 5	31 11 54.2	29 52 48.1	4.5	12
	W - 6	31 10 33.5	29 49 26.2	17	18
Eastern Harbor (EH)	E - 7	31 12 53.2	29 54 12.5	9	18
	E - 8	31 12 40.9	29 53 08.2	4	16
	E - 9	31 12 37.5	29 53 01.5	3	18.5
Abu-Qir Bay (AQ)	AQ - 10	31 19 04.4	30 04 28.8	8.75	30
	AQ - 11	31 19 18.1	30 04 35.0	10.5	28
	AQ - 12	31 16 24.4	30 09 27.8	7.5	18

Soon after reaching the laboratory, every core was divided into 5 cm segments. Each segment was labeled and sub-sampled to meet the requirements of : water contents (heating to 105° C), organic carbon contents (heating to 550° C), carbonate contents [14], grain-size

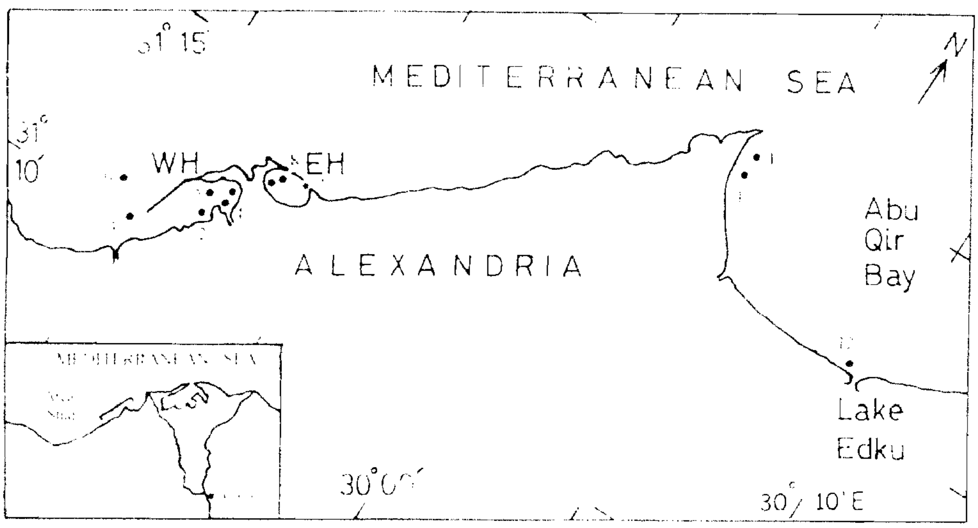

Fig. 1. Area of study and core stations

composition [15], and the total contents of the heavy metals; Cd, Co, Cu, Cr, Ni, Zn, Mn and Fe were measured using AAS. All the parameters are presented in Table 2.

Results And Discussion

Grain-Size Composition

In a coastal shallow marine zone it is expected to find variable coarse-size sediments. This is the case in the study area but all the size variations lie in the sand range with very narrow exceptions. The first site –the Western Harbor-, which was sampled by six short cores (ranged from 12, 12.5, 18, 22.5, 24 and 27 cm length), has a vertically homogenous mean size and sorting except very few substrata. This site has sediments confined between fine sands and coarse silts.

Being a closed basin surrounded with platforms, it receives its input via El-Mahmodeya and El-Nobareya channels and some industrial sewers.

The sorting of these sediments vibrates between well, moderate and poorly sorted. The second site –the Eastern Harbor- was sampled by three short cores (16, 18 and 18.5 cm). Every core sediment has the same vertical size characteristics indicating homogenous sediment supply.

Some exceptions appeared at the base of cores, where a change in the mean size took place. This site has sediments that vary between very coarse and fine sands. The wide variation in sand size refers to the high carbonate fraction introduced here.

However, these sediments have moderate or poorly sorting. The latter site -Abu Qir Bay- was sampled by three short cores (18, 28 and 30 cm). Like the other cores, the vertical sediment succession is homogenous in regard to both the mean size and sorting. This site has the narrower grain-size range; only very fine sand and coarse silt.

Although Abu Qir Bay is bottomed by very wide range of grain size, but the sample location lies inside very low-energy and protected basin. Therefore this basin has moderately sorted sediments in general.

Water Contents

The water contents of the core sediments under study are affected by the grain size of these sediments, where smaller the grain size, the higher is the water content. The core sediments of the WH have water contents

Table 2. Results of the measured physical and chemical parameters.

Core No.	Segment	Sample	Mean size Φ	Sorting Φ	Sand %	Silt %	H_2O %	OC %	CO_3 %
W - 1	0 - 5 cm	10	2.48	0.98	94.04	5.96	31.43	1.85	66.14
	5 - 10	11	2.33	0.95	96.16	3.84	31.75	1.38	69.03
	10 -15	12	2.42	0.83	97.46	2.54	39.38	1.88	84.17
	15 - 20	13	2.23	0.92	96.15	3.85	38.10	1.77	95.39
	20 - 22.5	14	1.90	0.95	98.25	1.75	33.30	1.87	89.82
W - 2	0 - 5 cm	20	2.53	1.51	84.55	15.45	65.78	6.61	67.81
	5 - 10	21	3.81	1.03	77.50	22.50	67.25	5.98	69.85
	10 -12.5	22	3.02	1.48	73.00	27.00	59.35	7.48	69.39
W - 3	0 - 5 cm	30	0.58	1.59	92.91	7.09	50.36	3.37	86.86
	5 - 10	31	4.41	0.77	14.82	85.18	47.98	4.08	71.08
	10 -15	32	4.50	0.31	0.00	100.00	44.89	4.08	34.87
	15 - 20	33	4.50	0.31	100.00	0.00	46.68	4.21	26.31
	20 - 25	34	4.44	0.86	10.00	90.00	49.04	4.15	45.71
	25 - 27	35	4.50	0.31	100.00	0.00	45.66	3.82	84.37
W - 4	0 - 5 cm	40	3.45	1.48	44.79	55.21	46.56	4.44	37.26
	5 - 10	41	2.86	1.70	57.24	42.76	43.68	4.43	33.51
	10 -15	42	3.23	1.50	51.53	48.47	48.68	5.22	61.27
	15 - 20	743	2.66	1.60	57.89	42.11	33.18	2.76	58.86
	20 - 24	44	2.89	1.44	44.32	55.68	35.41	3.66	69.89
W - 5	0 - 5 cm	50	2.84	1.38	78.57	21.43	67.34	8.72	74.88
	5 - 10	51	2.66	1.42	82.86	17.14	59.98	6.86	70.42
	10 -12	52	2.48	1.46	83.01	16.99	64.22	8.86	85.26
W - 6	0 - 5 cm	60	0.72	0.65	100.00	0.00	13.93	1.46	41.63
	5 - 10	61	0.54	0.63	100.00	0.00	15.42	1.69	90.02
	10 -15	62	0.50	0.69	100.00	0.00	13.57	2.69	31.88
	15 - 18	63	0.65	0.70	100.00	0.00	11.10	2.01	88.11
E - 7	0 - 5 cm	70	-0.32	0.52	100.00	0.00	12.27	1.88	93.19
	5 - 10	71	0.00	0.78	100.00	0.00	16.25	1.86	92.29
	10 -15	72	-0.06	0.75	100.00	0.00	18.93	1.70	91.06
	15 - 18	73	0.07	0.77	100.00	0.00	20.16	1.74	97.24
E - 8	0 - 5 cm	80	1.22	1.53	96.55	3.45	25.49	2.32	91.40
	5 - 10	81	1.77	1.39	94.23	5.77	27.95	1.99	91.53
	10 -15	82	0.77	1.51	96.63	3.37	25.73	2.24	88.71
E - 9	0 - 5 cm	90	2.76	1.21	85.56	14.44	37.58	2.53	22.39
	5 - 10	91	2.58	1.14	90.00	10.00	26.35	1.77	12.66
	10 -15	92	2.55	1.32	86.50	13.50	19.75	1.12	22.39
	15 - 18.5	93	1.73	1.55	89.45	10.55	17.27	1.81	12.66
AQ - 10	0 - 5 cm	100	4.20	0.73	19.75	80.25	50.96	3.96	12.92
	5 - 10	101	1.07	2.15	76.00	24.00	50.02	4.18	32.42
	10 -15	102	4.49	0.31	2.18	97.82	52.11	4.52	27.17
	15 - 20	103	4.43	0.46	12.50	87.50	50.99	3.89	38.27
	20 - 25	104	3.81	0.66	13.21	86.79	52.20	3.76	44.29
	25 - 30	105	4.60	0.61	11.72	88.28	43.66	3.70	28.33
AQ - 11	0 - 5 cm	110	3.45	0.94	67.89	32.11	44.49	4.53	32.56
	5 - 10	111	3.66	0.88	61.03	38.97	61.80	7.07	32.44
	10 -15	112	3.43	0.93	69.68	30.32	43.95	3.59	65.00
	15 - 20	113	3.47	0.92	67.78	32.22	35.56	3.49	17.60
	20 - 25	114	2.50	0.47	99.50	0.50	30.53	3.48	6.12
	25 - 28	115	2.76	0.60	96.67	3.33	21.37	1.58	4.57
AQ - 12	0 - 5 cm	120	3.38	0.87	82.22	17.78	22.96	1.38	8.93
	5 - 10	121	3.36	0.82	85.57	14.43	21.64	1.37	12.80
	10 -15	122	3.61	0.76	78.59	21.41	24.22	1.61	11.79

Table 2. Results of the measured physical and chemical parameters (continued).

Core No.	Segment	Sample	Cd	Co	Ni	Cu	Cr	Zn	Mn	Fe
	0 - 5 cm	10	1.48	11.26	33.12	35.95	15.34	32.90	88.17	414.94
	5 - 10	11	0.56	4.67	18.53	27.94	14.14	29.33	74.77	210.30
W - 1	10 -15	12	0.59	2.05	40.30	32.75	17.69	35.14	68.85	497.50
	15 - 20	13	0.21	7.52	38.05	32.62	15.45	43.66	45.86	94.77
	20 - 22.5	14	0.73	8.18	44.65	29.82	12.91	26.76	38.83	78.44
	0 - 5 cm	20	3.33	18.93	62.53	388.27	5.86	580.12	144.05	3069.84
W - 2	5 - 10	21	1.21	12.73	67.21	361.25	6.82	505.96	164.99	4683.00
	10 -12.5	22	1.09	15.03	79.40	269.97	7.12	535.65	157.33	3935.74
	0 - 5 cm	30	0.58	22.62	82.28	58.67	21.90	130.95	133.59	1618.80
	5 - 10	31	0.72	12.81	58.22	53.80	11.73	141.87	121.92	1164.41
W - 3	10 -15	32	0.81	17.32	58.76	56.42	24.93	83.55	105.26	1000.47
	15 - 20	33	0.76	15.28	84.07	48.37	13.12	78.58	122.50	1155.20
	20 - 25	34	0.59	6.86	65.89	52.35	15.90	103.02	82.98	964.65
	25 - 27	35	0.65	6.39	33.52	46.29	17.90	66.60	81.64	925.87
	0 - 5 cm	40	1.48	11.26	33.12	85.28	24.11	162.23	109.85	1600.27
	5 - 10	41	0.56	4.67	18.53	68.46	34.82	91.05	129.37	891.58
W - 4	10 -15	42	0.21	2.05	40.30	72.19	33.58	69.33	171.78	1840.35
	15 - 20	743	0.18	7.52	38.05	51.29	31.40	95.12	128.12	807.80
	20 - 24	44	0.73	8.18	44.65	68.37	32.92	111.53	145.03	1351.50
	0 - 5 cm	50	2.89	21.25	82.24	278.87	8.44	615.54	215.70	7381.63
W - 5	5 - 10	51	0.66	10.95	68.34	225.75	5.90	621.53	204.27	4933.75
	10 -12	52	--	7.54	64.75	278.79	4.36	592.97	218.65	4368.15
	0 - 5 cm	60	0.82	6.75	27.80	14.53	9.03	238.04	133.45	234.12
W - 6	5 - 10	61	0.09	6.60	24.32	15.19	8.36	178.24	173.87	531.31
	10 -15	62	0.53	9.65	17.85	18.46	9.49	91.59	82.73	217.46
	15 - 18	63	--	8.27	4.14	17.30	3.56	100.61	21.59	395.91
	0 - 5 cm	70	0.74	10.16	70.80	21.05	2.39	16.28	55.44	825.42
E - 7	5 - 10	71	--	6.36	54.32	19.68	1.47	10.56	26.95	110.10
	10 -15	72	--	25.28	17.85	24.57	--	26.77	106.65	74.79
	15 - 18	73	--	7.48	27.34	20.99	--	12.39	35.86	49.46
	0 - 5 cm	80	1.04	9.24	40.08	46.46	6.72	107.04	89.20	814.20
E - 8	5 - 10	81	0.12	6.74	29.75	41.86	4.07	204.00	203.62	541.85
	10 -15	82	0.44	9.94	20.74	28.54	0.46	216.57	92.85	347.31
	0 - 5 cm	90	0.55	9.88	88.99	22.06	9.03	238.32	204.73	1718.61
E - 9	5 - 10	91	0.61	10.18	40.69	18.62	8.36	194.76	216.75	885.68
	10 -15	92	0.99	5.40	47.43	19.84	9.49	79.34	166.02	1733.11
	15 - 18.5	93	0.95	6.19	58.14	16.33	3.56	194.22	15.92	1494.00
	0 - 5 cm	100	2.09	24.07	72.83	44.34	7.27	106.48	444.98	8194.96
	5 - 10	101	1.37	23.00	70.19	39.98	7.00	101.94	413.82	7949.34
AQ - 10	10 -15	102	0.44	22.43	89.09	35.61	1.03	126.60	401.25	8972.27
	15 - 20	103	1.00	21.19	91.26	28.72	1.16	113.51	415.83	10494.50
	20 - 25	104	0.53	20.95	78.17	18.12	0.64	95.04	366.47	8003.64
	25 - 30	105	0.53	18.73	65.67	9.79	0.60	67.15	361.59	6062.93
	0 - 5 cm	110	0.37	23.71	52.06	42.25	19.05	131.90	309.90	8675.03
	5 - 10	111	0.18	20.65	67.11	43.67	17.85	133.99	342.15	8241.67
AQ - 11	10 -15	112	--	16.53	54.24	38.22	18.48	114.26	291.37	7281.16
	15 - 20	113	--	17.78	46.56	37.61	15.48	111.18	257.72	7269.84
	20 - 25	114	--	2.30	12.10	15.98	3.57	17.35	111.32	1940.26
	25 - 28	115	--	7.08	26.61	16.85	0.78	35.03	155.77	4123.00
	0 - 5 cm	120	0.63	18.60	40.69	27.30	6.83	79.55	228.67	7513.04
AQ - 12	5 - 10	121	0.80	21.72	38.43	25.96	12.13	74.73	352.79	7734.70
	10 -15	122	0.72	29.18	42.19	27.50	13.52	79.41	366.08	8296.75

that range between 34.79, 64.12, 47.44, 41.50, 63.85 and 13.50 %, and those of the EH have water contents around 16.90, 26.39 and 25.24 %, while the core sediments of the AQB have water contents from 49.99, 39.62 to 22.94 %. The equivalent mean grain sizes are fine sands, sands and fine sands for the WH, EH and AQB, consequently.

Generally there is a vertical trend, and the water contents of the core sediments get lower values from top to bottom. This indicates that lower sub-layer are more compressed.

Organic Carbon

The core sediments collected from the WH have organic carbon contents vary between 1.75, 6.69, 3.91, 4.10, 8.15 and 1.96 %. The vertical distribution of OC among the core sediments is more or less constant. The horizontal distribution among this cored region is very wide and variable.

The organic carbon contents of the EH are more or less constant between 1.80, 2.18 and1.81 %. The same constant trend was traced vertically as well. In regard to the third region -AQB-, its core sediments have organic carbon contents that range between 4.00, 3.96 and 1.45 %.

When these organic carbon contents were encountered vertically, a random pattern was obtained. Generally the organic carbon contents does not show a clear down or up ward trend but a random one.

Carbonates

The carbonate contents of the core sediments in the WH range between 80.91, 69.02, 58.20, 52.16, 76.86 and 62.91 %. At this site the carbonate percentage increases from top to base in every core.

The core sediments of the EH region have carbonate contents that vary between 93.45, 90.55 and 17.53 %. These shallow cores do not show any vertical ascending or descending trends. The carbonate contents of the core sediments of AQB being 30.57, 26.38 and 11.17 % have the lower percentages and show random vertical trends.

Heavy Metals

The group of heavy metals (Cd, Co, Cr, Cu, Ni, Zn, Mn and Fe) attains the concentrations in both the aquatic and sediment media. Their chemical forms crossing the water column and reaching the seabed and their sedimentary phases (reducible, oxidizable or resistant) depend on the specific character of each element.

An organism or authigenic mineral may accumulate one form of a metal rather than another form. Consequently, this affects metal concentration in the dissolved state and in sediments. For example Zn is distributed among forms as 10 – 20% ionic, 30 – 50% particulate and 40 –50% complex forms [16]. Both the second and third forms can be transformed into the first ionic form by lowering the pH.

Generally, all the studied core sediments have concentration values, which decrease from top to bottom in a downward direction with some exceptions. This indicates that the underwater surficial sediments still are active recipients for anthropogenic compounds including heavy metals.

The upper most sub-layers of the six shallow cores sampled from the WH have the highest concentrations of the heavy metals (Cd, Co, Cr, Cu, Ni, Fe, Mn & Zn) except Ni & Cr in Core W2, and Cd in core W3. The maximum average concentration of Ni, Zn, Mn & Fe lie in Core

W5, and those of Cd, Co & Cu lie in core W2. Regarding the EH, with the exception of Cu in core W6 and Cd & Co in core E9 the metal concentrations keep their downward decreasing trends.However, core E9 has the highest averages of Cd, Ni, Cr, Zn, Mn &Fe concentrations. The sediments of core AQ10 in AQB have the highest average concentrations of Cd, Ni, Zn, Mn & Fe.

Contrary to the general view, the concentration trends of Cd, Co, Ni, Cu & Cr are increasing downward in core AQ12. However, lowest concentrations were encountered in core AQ11 in this area.

Applying the equation of the Index of Geoaccumulation I_{geo}:

$$I_{geo} = \log_2 \; C_n / \; 1.5 \, B_n \qquad [17]$$

Where C_n is the measured concentration of the element "n", B_n is the geochemical background value, which measures the metal pollution in the aquatic sediments. It reveals that the highest enrichment by heavy metals takes place by Zn in the WH, in the sequence Zn > Cd > Cu > Ni, while both the EH and AQB have bottom sediments enriched only by Cd. From another side the application of the same equation but only on the surficial layer puts Cd as a major and primer pollutant followed by Ni in the sequence Cd > Ni >Zn > Cu, Cd >> Ni >> Zn and Cd > Ni > Co in the WH, EH and AQB, respectively.

Statistical Treatment

The correlation matrix (Table 3) of the fifteen parameters indicates that one feature which is the mean size has one major influence on the granulometrical characters; sorting, and both sand and silt fractions from one side and another one minor influence on both the Ni & Fe concentrations. As the grain size decreases : sorting gets worse degree, and each of silt fraction, water content (interstitial water), Ni and Fe increase. The physical feature represented by the water content shows that as the water content increases all the investigated heavy metals except Co, Cr & Mn have more accumulation among the bottom marine sediments. The carbonate fraction of the studied sediments has an inverse proportionality with concentrations of Co, Mn & Fe indicating to their siliciclastic source. The Cd is well related to Cu and Zn but with less degree.Both Co and Ni correlate with each other and with Mn & Fe but Co has favorable relation with them than Ni. The highest correlation coefficient was recorded between Mn & Fe and between Cu and Zn as well. The most unexpected observation among this correlation matrix is the absence of any significant relation with the organic carbon content of the studied sediments. This refers to being its source is an anthropogenic origin and not a natural one.

Table 3. Correlation matrix of the determined parameters. (significant values are greater than 0.33 when N=35)

	Mean size	Sorting	Sand	Silt	H_2O	OC	CO_3	Cd	Co	Ni	Cu	Cr	Zn	Mn	Fe
Mean size	1.00	-0.44	-0.66	0.66	0.53	-0.14	-0.29	0.12	0.30	0.34	0.13	0.22	0.04	0.33	0.41
Sorting	-0.44	1.00	0.27	-0.27	0.14	0.09	0.32	0.25	-0.08	-0.12	0.30	0.04	0.38	-0.05	-0.10
Sand	-0.66	0.27	1.00	-1.00	-0.45	0.26	0.37	-0.13	-0.37	-0.42	0.00	-0.11	0.03	-0.41	-0.41
Silt	0.66	-0.27	-1.00	1.00	0.45	-0.26	-0.37	0.13	0.37	0.42	0.00	0.11	-0.03	0.41	0.41
H_2O	0.53	0.14	-0.45	0.45	1.00	0.07	0.10	0.38	0.31	0.59	0.64	0.14	0.55	0.22	0.33
OC	-0.14	0.09	0.26	-0.26	0.07	1.00	0.04	0.13	0.22	0.00	0.17	-0.08	0.20	0.18	0.18
CO_3	-0.29	0.32	0.37	-0.37	0.10	0.04	1.00	-0.10	-0.51	-0.13	0.18	-0.07	0.25	-0.57	-0.58
Cd	0.12	0.25	-0.13	0.13	0.38	0.13	-0.10	1.00	0.28	0.22	0.58	-0.13	0.38	0.12	0.15
Co	0.30	-0.08	-0.37	0.37	0.31	0.22	-0.51	0.28	1.00	0.51	0.08	-0.13	0.07	0.77	0.82
Ni	0.34	-0.12	-0.42	0.42	0.59	0.00	-0.13	0.22	0.51	1.00	0.26	-0.28	0.29	0.37	0.46
Cu	0.13	0.30	0.00	0.00	0.64	0.17	0.18	0.58	0.08	0.26	1.00	-0.14	0.88	-0.07	0.08
Cr	0.22	0.04	-0.11	0.11	0.14	-0.08	-0.07	-0.13	-0.13	-0.28	-0.14	1.00	-0.32	-0.27	-0.25
Zn	0.04	0.38	0.03	-0.03	0.55	0.20	0.25	0.38	0.07	0.29	0.88	-0.32	1.00	0.03	0.11
Mn	0.33	-0.05	-0.41	0.41	0.22	0.18	-0.27	0.12	0.77	0.37	-0.07	-0.27	0.03	1.00	0.92
Fe	0.41	-0.10	-0.41	0.41	0.33	0.18	-0.58	0.15	0.82	0.46	0.08	-0.25	0.11	0.92	1.00

Summary And Conclusion

The Western Harbor serves about 70% of the foreign trade of Egypt. Handling, transportation and storage of different goods are the main current activities carried out now. Waste materials reach the WH. environment via routine activities such as ship cleaning and discharging, improper handling of solid wastes from ships, sunken vessels, industrial and agricultural drains. All these reasons multiply the heavy metal concentrations and cause deficiency of dissolved oxygen, complete depletion and evolving hydrogen sulphide in some regions as well. Consequently, no benthic life was encountered in the WH. The EH. which is a semi-enclosed basin connected to the open sea via two openings shares the WH. part of its loadings and suffers originally from permanent maintenance operations of machine fishing boats all over the year in addition to some illegal dumping from land-based sources. Although ABQ is widely connected to the open water of the Mediterranean, it is subjected to dense contamination from the dry docks and industrial sewage at several scattered areas.

The uncontrolled discharging and overloaded operations have influenced the marine environments of the areas under investigation. For example the waters of the WH –as a transporting medium- have higher concentrations of heavy metals in comparison to the background values or even to those of the Alexandria coastal waters. Comparing the heavy metals contents reported by [18]: Cu= 344.81 ppm, Cd= 25.37 ppm, Zn= 231.96 ppm, Mn= 274.70 ppm and Fe= 1.35 % illustrates that these very high levels are confined to the upper layer of the sea bed sediments of the WH. This is confirmed by the present work, which deals with a vertical succession of sediments. In contrast to either [19] or [20] averages of Cd, Co, Cu, Cr, Ni, Zn, Mn and Fe contents in the mean sandy and carbonatic sediments, it is concluded that: there is a multiplication factor specific for each element; for example the concentration of Cd in normal silicates lies below the detection limit of simple spectrographic or spectrophotometric instruments, but its concentration in the sediments under study proves a factor of about 5. The highest multiplication factor was obtained for Co where its accumulation is in the order AQB > WH > EH. Unexpectedly, Cr concentration remains unchanged. This refers to being the sources of Cr are out of reach of these areas.

From the aforementioned results and discussion it is clear that:

- although all the pathways of pollutants reaching the sea water are vertically downloading in regard to the sea bed, generally the highest concentrations occupy the upper most surface layer of the studied core sediments,
- the highest concentrations of the heavy metals are encountered in the sediments of the Western Harbor relative to the other areas, and
- the highest levels of the metals are concentrated in the area of the old dry dock.

This clearly necessitates managing, controlling and applying the rules and measures to protect our marine environment particularly in hot spot provinces.

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