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ENVIRONMENTAL RISK ASSESSMENT AND CHEMICAL CONTAMINATION WITH HEAVY METALS IN THE SEDIMENTS OF THREE DRAINS, SOUTH OF MANZALA LAKE (EGYPT)

Yasser El-Amier*, Samia Haroun, Amr Mowafy and Mottia Abd-Elwahed

Botany Department, Faculty of Science, Mansoura University, Mansoura, Egypt

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ABSTRACT. Six heavy metals (Fe, Cd, Co, Cr, Ni, and Pb) were measured in all 15 sediment samples collected from three drains south of Manzala Lake (Egypt). The possible environmental risks of heavy metals in the sediment of the three drains were investigated using soil indices and risk assessment. Results showed that heavy metal contamination was found at the studied sites along the three drains, and pollution levels varied depending on metals and sites. The mean concentration ($mgkg^{-1}$) ranked in the order of Fe (3950) > Cd (22.36) > Cr (21.15) > Co (19.01) > Pb (14.16) > Ni (10.40) for Faraskour drain, Fe (5068) > Cd (30.29) > Co (18.97) > Cr (16.90) > Ni (15.03) > Pb (12.16) for Al-Etaiwy drain and Fe (56.12) > Cd (19.60) > Co (17.15) > Ni (14.88) > Cr (10.10) > Pb (10.03) for Ramsis drain. The mean ranges of enrichment factor for Cd, Co, Pb, Ni and Cr were 167.5-3858, 6.11-51.78, 4.38-31.20, 1.07-11.84 and 0.61-7.43, respectively. The average degree of contamination revealed that the majority of the sites had reached very high levels of pollution, with the exception of site 1, which had reached a moderate level of contamination. The ecological risk of heavy metals can be ranked as follows: Cd > Co > Pb > Ni > Cr, and the potential ecological risk index (PERI) were 931.0, 1173 and 818.5 in the Faraskour, Al-Etaiwy and Ramsis drains, respectively. To decrease pollution in these drains, it was determined that more effective restrictions on Cd and Co were needed. In general, the mean levels of Cr, Ni, and Pb in sediments from the three drains are within the European Union (EU) and Canadian Soil Quality Guidelines (CSQGD), Cd higher than EU and CSQGD, and Co higher than EU but lower than CSQGD.

KEY WORDS: Heavy metals, Pollution indices, Environmental risk assessment, Drains, Nile Delta

INTRODUCTION

Water is a vital for life on this planet. Water covers roughly 71% of the Earth's surface, and the oceans store about 97% of all water on the globe, while freshwater accounts for only a tiny percentage of all water on the world. Only 3% of it is fresh water. Even then, just 1% of our freshwater is easily accessible, with much of it trapped in glaciers and snowfields [1, 2].

Today, pollution is occurring on a vast and unprecedented scale around the globe. Pollution is not only bad for the environment, but it is also bad for people. Pollution is defined as the introduction of pollutants into the natural environment that have a negative impact [3, 4]. This pollution has the potential to harm our wildlife, plants, and trees, as well as taint our drinking water. To put it another way, pollution is hazardous to all of us. In 2015, pollution claimed the lives of 9 million people throughout the world [5, 6].

Heavy metals (HMs), which have an atomic density of more than 6 g/cm^3, are one of the most persistent contaminants in wastewater [7]. Arsenic, cadmium, chromium, lead, mercury, copper, nickel, and zinc are the most frequent hazardous heavy metals found in wastewater. High levels of heavy metals in water bodies cause significant health and environmental issues, as well as an increase in wastewater treatment costs [8, 9]. Human activities such as rapid industrialization, urbanization, and anthropogenic causes contribute to the existence and accumulation of HMs in the environment. Because HMs are non-biodegradable and toxic, they remain in wastewater [10-12].

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*Corresponding author. E-mail: yasran@mans.edu.eg

Egypt's total canal and drain length is about 4700 km [13]. Aquatic weeds have infested these canals and drains, and environmental factors such as water clarity, depth of water, physico-chemical properties, water quality, water currents, and air temperature affect the degree of the infection. Problems with Egyptian irrigation canals have risen since the building of the Aswan High Dam in 1965 [14]. El-Gharably *et al.* [15] and El-Amier *et al.* [9], on the other hand, blamed other ecological factors for the development of aquatic weeds in the Nile Delta's irrigation and drainage canals. Aquatic ecosystems are progressively being threatened as the populations grow and rising water demand in agricultural, domestic and industrial affairs [16, 17]. Egypt is the most populous country in the Middle East and North Africa region, with approximately 100 million inhabitants. Because Egypt's geography is mostly desert, 43.1% of the population lives in towns on the Nile or the Mediterranean Sea, such as Cairo, Alexandria, or Aswan [18]. The objectives of this study were: i) to determine the level of pollution of six heavy metals (Ni, Cr, Fe, Co, Cd, and Pb) in three main drains that debouched into the Lake Manzala and (ii) to apply some pollutant indices to estimate the environmental risk.

EXPERIMENTAL

Study area

The coastal lakes of northern Egypt (Bardawil, Manzala, Burullus, Idku and Mariout) are one of Egypt's most valuable natural systems, with abundant birds and fish. There is a considerable amount of lake water pollution as a result of industrial, agricultural, and sewage pollutants spilling into the lakes through drains [19, 20]. The Nashart drain, El-Gharbia drain, Elhoks drain, El Shakhlouba drain, Elkashaa drain, Hadous drain, Faraskour drain, Al-Etaiwy drain, Ramsis drain, and Bahr El-Baqar drain are just a few of the main drains in the Nile Delta, which serve 64% of Egypt's total agricultural land area of 29,600 km^2. The Nile Delta might benefit from the reuse of drainage water or the specific use of treated wastewater [21].

One of these coastal lakes is Manzala Lake, located at the north-eastern part of Nile Delta, Egypt. Manzala Lake receiving huge amounts of wastewater from the nearby provinces through many inlets drains found along its south and west coasts. There are different drains in the southern part of the lake. The studied three drains are distributed as Figure (1); Faraskour and Al-Etaiwy drains are located at the south-western part of lake and Ramsis drain in the south-eastern part of the lake.

Metal analysis in sediment samples

Along three drains south of Manzala Lake, fifteen geo-referenced sediment samples were collected. The sampling locations were chosen to be 5–10 km apart (Figure 1). A composite sediment sample was obtained at each location by combining three subsamples collected with a stainless hand auger. To eliminate stones and trash, the sediment samples were air-dried for several days at room temperature before being crushed and sieved with a 2 mm sieve. They were then placed in plastic bags to be examined chemically and physically. As reported by Oregioni and Astone [22]. Soil samples were digested for roughly two hours in a combination of nitric acid, perchloric acid, and hydrochloric acid. The concentrations of Ni, Cd, Fe, Co, Cr, and Pb in the investigated heavy metals (mg kg^{-1}) were determined using an atomic absorption-spectrophotometer (ASSU, Buck Scientific Aceusys 211).

Metal pollution indices

To compute pollution quantification for each metal (Co, Cd, Ni, Fe, Cr, and Pb) along the drains, the enrichment factor (Ef), contamination factor (Cf), geo-accumulation index (I*geo*), ecological risk factor (Er), degree of contamination (Dc), and prospective ecological risk index (PERI) were employed. Table 1 shows the classes of pollution indicators as well as the sediment quality associated with them.

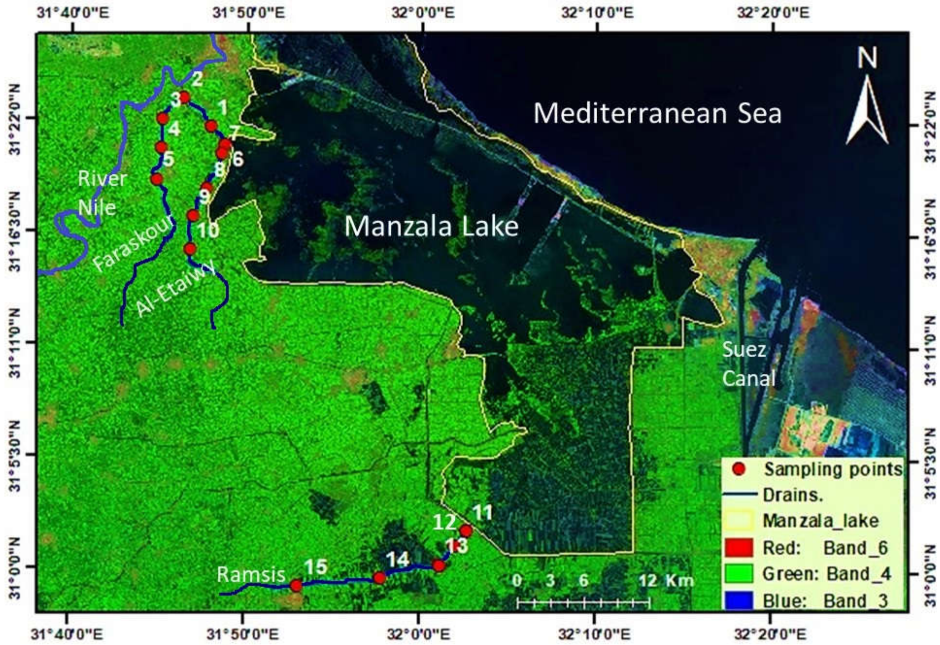

Figure 1. Location map showing studied sites (1-15) along the three drains, south Manzala Lake.

Enrichment factor (Ef)

The probable sources (natural or anthropogenic) of elements in sediments were determine by enrichment factor (E*f*). The Ef of elements is express by the equation of Turekian and Wedepohl [23].

$$\mathrm{E}f = \frac{\left(\frac{\mathrm{C_{sample}}}{\mathrm{Fe_{sample}}}\right)}{\left(\frac{\mathrm{C_{ref}}}{\mathrm{Fe_{ref}}}\right)} \tag{1}$$

C_{sample}: concentration of element in the soil sample that was analysed; Fe_{sample}: in the soil sample under study, the concentration of the reference metal; C_{ref}: the reference environment's element content (background); Fe_{ref} (background), reference element content in the reference environment. Iron (Fe) is considered a normalization element for the following reasons: Fe is connected to fine to medium solid elements, has a geochemistry comparable to many heavy metals, and has a steady natural concentration in the investigated area [24].

Contamination factor (Cf) and degree of contamination (Dc)

The contamination status of the sediment was determined using the contamination factor and degree of contamination [25, 26].

$$\mathrm{Cf} = C_{sample} \,/\, C_{ref} \tag{2}$$

$$\mathrm{Dc} = \sum_{\mathrm{i}=1}^{\mathrm{n}} \mathrm{Cfi} \tag{3}$$

Geo-accumulation index (Igeo)

The geo-accumulation index is used to assess the present state of the environment and metal pollution in relation to natural environments. To assess the degree of pollution, it uses chemical data. The I_{geo} values were determined according to the equation of Muller [27] and Lu and Bai [28].

$$Igeo = Log2\ (C_{Sample}/1.5Bn) \tag{4}$$

C_{sample} represents the metal content in the sediment, *Bn* denotes the geochemical background value in average shale of element *n*, and 1.5 is the background matrix correction due to terrigenous effects.

Ecological risk assessment of tested heavy metal

The ecological risk index (Er) of single heavy metals in the sediments was used to characterize the potential ecological risk index (PERI). The PERI was used to determine the ecological sensitivity of heavy metal contamination in stream sediments based on heavy metal toxicity and environmental responses [25, 29].

$$RI = \sum_1^n Er \tag{5}$$

$$Er = Ti\ \times Cf \tag{6}$$

C*f*: the contamination factor; T*i*: the toxic-response factor for a specific metal.

Table 1. Classes of used indices and ecological risk for metals in the present study.

Ef		*Igeo*	
Classes	Sediment quality	Classes	Sediment quality
EF < 2 = natural		*Igeo* ≤ 0	Uncontaminated
EF > 2 = anthropogenic		0 < *Igeo* < 1	Uncontaminated to moderately contaminated
Ef < 1	Depletion or no enrichment	1 < *Igeo* < 2	Moderately to heavily contaminated
Ef < 2	Minor enrichment	2 < *Igeo* < 3	Moderately to strongly contaminated
Ef = 2-5	Moderate enrichment	3 < *Igeo* < 4	Strongly contaminated
Ef = 5-10	Moderately severe enrichment	4 < *Igeo* < 5	Strongly to extremely contaminated
Ef = 10-25	Severe enrichment	*Igeo* > 5	Extremely high contaminated
Ef = 25-50	Very severe enrichment		
Ef > 50	Extremely severe enrichment		
C*f*		D*c*	
CF < 1	Low contamination factor	DC < 8	Low DC
1 ≤ CF ≤ 3	Moderate contamination factor	8 ≤ Dc< 16	Moderate DC
3 ≤ CF ≤ 6	Considerable contamination factor	16 ≤ Dc< 32	Considerable DC
6 ≤ CF	Very high contamination factor	Dc> 32	Very high
E*r*		PERI	
Er < 40	Low ecological risk	PERI < 150	Low risk
40 ≤ Er < 80	Moderate ecological risk	150 ≤ PERI < 300	Moderate
80 ≤ Er < 160	Considerable ecological risk	300 ≤ PERI < 600	Considerable
160 ≤ Er < 320	High ecological risk	PERI ≥ 600	Very high.
Er ≥ 320	Very high ecological risk		

Abbrivation: Enrichment factor (EF), contamination factor (CF), degree of contamination (Dc), geoaccumulation index (I*geo*), ecological risk factor (Er) and potential ecological risk index (PERI).

RESULTS AND DISCUSSION

Heavy metals concentration in sediment samples

Heavy metal concentrations and bioavailabilities in sediments are not fixed in time; they are influenced by a variety of factors [30, 31]. Table 2 shows the typical amounts of HMs (Fe, Cd, Cr, Co, Ni, and Pb) in surface sediments from 15 sites throughout the three drains. We found significant differences in Fe and Pb concentrations between the various streams (Faraskour, Al-Etaiwy, and Ramsis drains) in our study, but no significant differences in Cd, Cr, Co, or Ni. Generally, the mean concentration (mg kg^{-1}) ranked in the order of Fe (3950) > Cd (22.36) > Cr (21.15) > Co (19.01) > Pb (14.16) > Ni (10.40) for Faraskour drain, Fe (5068) > Cd (30.29) > Co (18.97) > Cr (16.90) > Ni (15.03) > Pb (12.16) for Al-Etaiwy drain and Fe (56.12) > Cd (19.60) > Co (17.15) > Ni (14.88) > Cr (10.10) > Pb (10.03) for Ramsis drain. The concentration of heavy metals in the sediment of the three drains is higher than that of the River Nile (Damietta branches) as a background and reference point, thus indicating significant pollution. In particular, Cd, Cr, and Co concentrations are greater than other heavy metals, which is consistent with discharge and human activities along the three drains. The lower concentrations of other heavy metals are most likely due to less discharge.

Table 2. Descriptive data of heavy metal (mg/kg) in the sediment samples from different sites of the three drains.

Drain	Statistic	Heavy metals (mg/kg)					
		Fe	Cr	Co	Cd	Ni	Pb
Faraskour drain (n=5)	Min	2746	3.84	8.38	3.30	5.03	11.62
	Max	5812	44.04	28.78	45.08	17.18	17.14
	Mean	3950^{a}	21.15^{a}	19.01^{a}	22.36^{a}	10.40^{a}	14.16^{a}
	±SD	1348	18.32	7.51	18.50	4.40	2.27
	Median	3150	16.48	19.46	12.25	10.02	14.65
	%CV	34.12	86.59	39.52	82.73	42.32	16.05
Al-Etaiwy drain (n=5)	Min	3819	6.45	13.36	15.72	8.36	10.01
	Max	7238	41.52	26.57	43.09	24.51	14.41
	Mean	5068^{a}	16.90^{a}	18.97^{a}	30.29^{a}	15.03^{a}	12.16^{ab}
	±SD	1381	14.10	5.02	11.96	7.38	1.78
	Median	4882	11.51	17.79	34.47	12.21	11.96
	%CV	27.26	83.47	26.45	39.50	49.12	14.66
Ramsis drain (n=5)	Min	1093	1.40	8.93	11.74	5.55	6.52
	Max	1597	17.61	25.91	30.49	21.20	16.44
	Mean	1256^{b}	10.10^{a}	17.15^{a}	19.60^{a}	14.88^{a}	10.03^{b}
	±SD	199.0	6.71	7.20	7.07	5.87	4.06
	Median	1206	12.53	15.95	18.02	15.90	8.51
	%CV	15.84	66.48	41.99	36.05	39.47	40.50
p-value		0.0005***	0.47ns	0.88ns	0.45ns	0.41ns	0.04*
Permissible limits worldwide							
EU (2002)		-	150	11.6	3	75	300
CSQGD (2007)		-	64	40	1.4	50	70
Average Shale		47200	90	19	0.3	68	20
Toxic response factor		-	2	5	30	5	5

CV: Coefficient of variation, SD: standard deviation, (CSQGD): Canadian soil quality guidelines for the protection of environmental and human health document (2007); EU: European Union Standard (2002); Average shale, after Turekian and Wedepohl (1961); ***: significant at $p \leq 0.001$, **: significant at $p \leq 0.01$, *: significant at $p \leq 0.05$, ns: non-significance.

Spatial distribution of heavy metals

The total content of heavy metals concentration fluctuations at sites 1-15 but middle stream in Faraskour and Ramsis drains (sites 3 and 13), and downstream in Al-Etaiwy drain (site 6) attained the highest content (Figure 2). The observation from the obtained data of all the measured heavy metals that cadmium, as it showed higher values other than the rest of the measured elements (Table 2). Our findings revealed that iron is the most prevalent element in the sediments, with concentrations ranging from 1093 mg/kg in Ramsis drain to 7238 mg/kg in Al-Etaiwy drain (Table 2). Fe is a prevalent element in all environments, and after oxygen and silicon, it is the third most plentiful element in the Earth's crust [32]. Anthropogenic activities have an impact on Fe distribution in the water stream (steel industry, sewage, etc.) [33]. Farhat [32] who claimed that iron and manganese are intimately linked in a geochemical cycle, agreed with El-Alfy *et al.* [34] and Bessa *et al.* [35].

For the Faraskour and Al-Etaiwy drains, the distribution of Cd, Cr, Co, Ni, and Pb showed an incremental rise in concentrations from downstream to middle stream, while the distribution of heavy metals fluctuated across five sites in the Ramsis drain (Figure 2). Because the cadmium background levels were low, any increased Cd concentrations were likely due to runoff from agricultural area that employed fertilizers, herbicides, and pesticides. Agricultural activities, notably the use of ammonium fertilizers, as well as industrial processes such as chromium plating, metal finishing, leather tanning, and paint manufacturing, might have contaminated the environment with Cr in the studied areas [36, 37]. Organic substances, carbonates, and Fe/Mn oxides account for the majority of Co and Ni metal measurements [38]. In soils, Co has a poor mobility and a high adsorption; however, its mobility improves in wet, acidic soils [39]. The sites along three drains, which received significant amounts of sewage effluent and agricultural runoff, are mostly blocked.

The greatest Pb concentration (17.14 mg/kg) was found in the middle stream of the Faraskour drain, while the lowest concentration (6.52 mg/kg) was found downstream of the Ramsis drain. The major source of Pb has been recognized as anthropogenic output, such as automobile exhaust and car batteries, industrial effluents, sewage sludge, fertilizer, and pesticide application, according to several studies [40]. Generally, the mean values of Cr, Ni and Pb in sediments of the three drains are within EU [41] and CSQGD [42], Cd higher than EU [41] and CSQGD [42], and Co higher than EU [41] but lower than CSQGD [42] (Table 2).

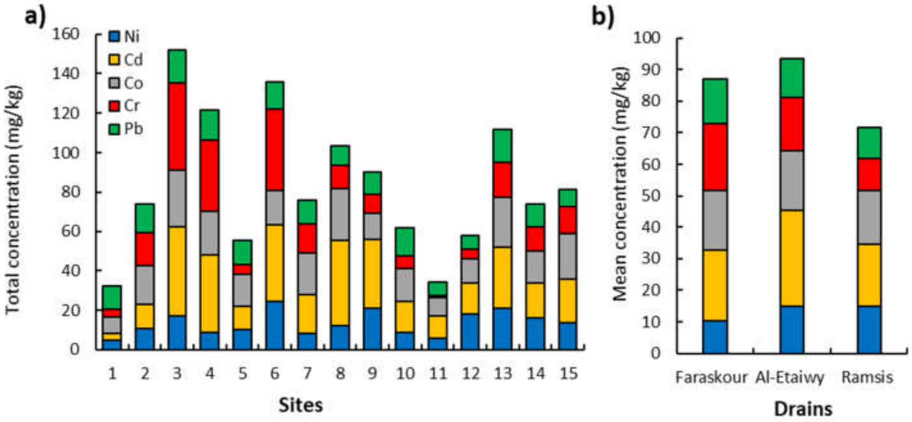

Figure 2. Spatial distribution of heavy metals in the sediment of the three drains **a)** different sites and **b)** three drains.

Correlation matrix between heavy metals

Table 3 displays the correlation coefficients as a linear correlation matrix. Cr was positively correlated ($p \leq 0.05$) with Co, Cd, and Pb ($r = 0.610$, 0.743, and 0.641, respectively) in a Pearson correlation coefficient (r) analysis of heavy metals (Table 3). Zhang *et al*. [43] and El-Amier *et al*. [31] reported the positive correlation of Cr with Co, Cd, Zn, Pb and Cu contents. El-Amier *et al*. [31] and Alhassan *et al*. [44], in contrast to our findings, found that Cr is negatively correlated with Ni. Cobalt had a strong positive linear correlation with Cd and Pb ($r = 0.707$ and 0.562, respectively), while cadmium had a weak positive linear correlation with Ni ($r = 0.566$). El-Amier *et al*. [31] reported that Ni presence is not linked with Pb, Cr, Fe and Co in the sediment of drains.

The positive correlations among metals may reflect the fact that these metals had similar pollution levels, the same behavior during transport, and common sources or at least one major source [45].

Table 3. Pearson correlation matrix of heavy metals from the three drains.

Heavy metals	Fe	Cr	Co	Cd	Ni	Pb
Fe	1					
Cr	0.512	1				
Co	0.238	0.610*	1			
Cd	0.312	0.743**	0.707**	1		
Ni	0.108	0.443	0.291	0.566*	1	
Pb	0.478	0.641*	0.762**	0.389	0.201	1

**,*: correlation is significant at the 0.01 level or 0.05 (2-tailed), respectively.

Assessment of heavy metal pollution

Enrichment factor (Ef)

The EF was used to assess the impact of anthropogenic contamination on sediment heavy metal concentrations. In this work, iron was utilized as a reference element to calculate EF values [46]. The examined metal mean values were ranked in descending order for their EF values, as follows: Cd > Co > Pb> Ni > Cr (Figure 3). The measured ranges of EF for Cd, Co, Pb, Ni and Cr were 167.5-3858, 6.11-51.78, 4.38-31.20, 1.07-11.84 and 0.61-7.43, respectively. In the present study, the Ef fluctuation from depletion to extremely severe enrichment along the three drains. A heavy metal with an EF between 0.05 and 1.50 is entirely derived from crustal materials and natural processes, according to Liu *et al*. [46]. Whereas a heavy metal with an Ef more than 1.50 is totally derived from non-crustal materials, such as direct and indirect anthropogenic sources. On this basis, the heavy metals analyzed were most likely delivered to the three drains by anthropogenic sources (Figure 3). Metals' bioavailability and toxicity in sediment samples are determined not only by their quantities, but also by their chemical forms [47].

Contamination factor (Cf) and degree of contamination (DC)

By comparing the metal content in the sediment to the metal concentration in the unpolluted sediment, the contamination factor (Cf) is used to assess sediment contamination. For measuring heavy metal contamination in soil, the quantity of metals in the Earth's crust is utilized as a reference value [25]. The current findings show that the mean Cf values for Cr, Co, Pb, and Ni at all sites are less than one (low contamination). On the other hand, Cd showed very high contamination factor ($6 \leq Cf$) at all sites (mean $Cf = 80.27$), with the highest concentrations at sites 3 and 8 in Faraskour and Al-Etaiwy drains, respectively. Meanwhile, the Cf values of metals varied dramatically between the sites investigated (Figure 4).

Furthermore, the average degree of contamination (Dc) revealed that the majority of the sites had Dc > 32 (i.e., very high degree of contamination), with the exception of site 1, which had Dc = 11.89 (moderate degree of contamination) (Figure 4). According to Hakanson [25] and Caeiro *et al*. [26], the results pointed to significant anthropogenic contamination. Contaminants are transported downstream from upstream sources and deposited (such as agricultural land, sewage, and tributaries).

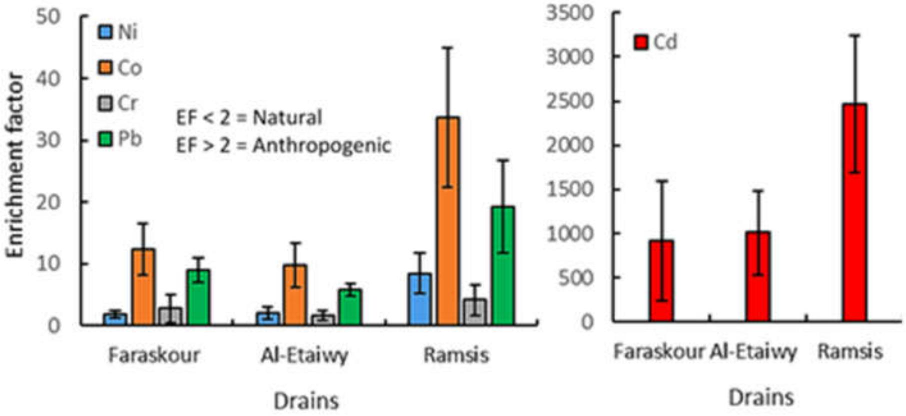

Figure 3. The enrichment factor of the heavy metals in the sediment samples collected from the three drains.

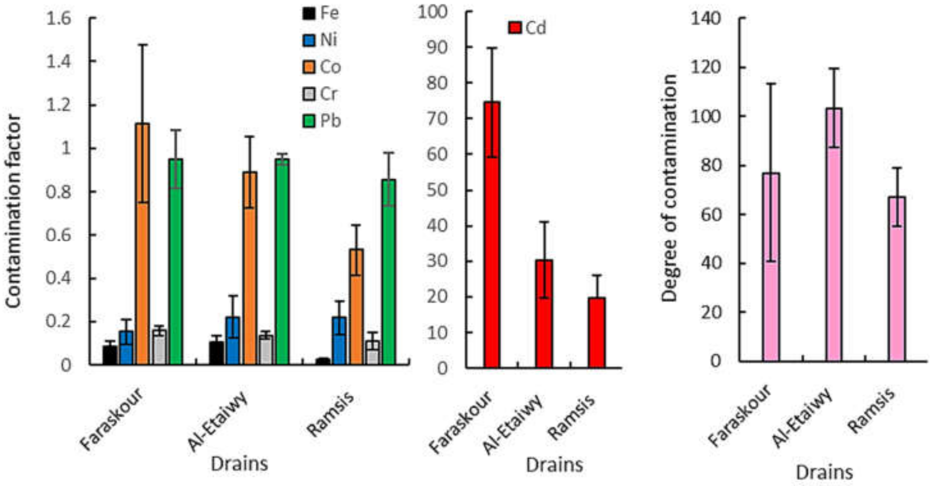

Figure 4. Heavy metal contamination factors and degree of contamination in sediment samples collected from the three drains

Geo-accumulation Index (Igeo)

The I*geo* is the most reliable and widely used index for determining heavy metal accumulations in aquatic sediments. The I*geo* was computed using the element's geochemical background value in the average shale [29]. According to the current I*geo* findings for the examined metals, the sediments in the studied drain can be classified as class 0 (I*geo*< 1; i.e., uncontaminated; Fe, Ni, Cr, Co and Pb). Meanwhile, the I*geo* value for Cd fall into class 2 (1 < I*geo* < 2; i.e., moderately to heavily contaminated) in all sites, except site 1 at Faraskour drain fall into class 1 (0 < I*geo* < 1; uncontaminated to moderately contaminated). These groups denote various levels of sediment quality and pollution in certain areas. As a result, according to Muller [27], the Manzala Lake drains are free of Fe, Cr, Co, Ni, and Pb, but moderately to heavily polluted with Cd, in the sequence Cd > Pb > Co > Cr > Ni > Fe (Figure 5).

We can see from the above pollution indices that I*geo* has the similar trend as Ef and Cf, implying that the drains emptying into Manzala Lake are largely uncontaminated (i.e., of natural origin), with the exception of moderate to high Cd contamination (i.e., anthropogenic origin).

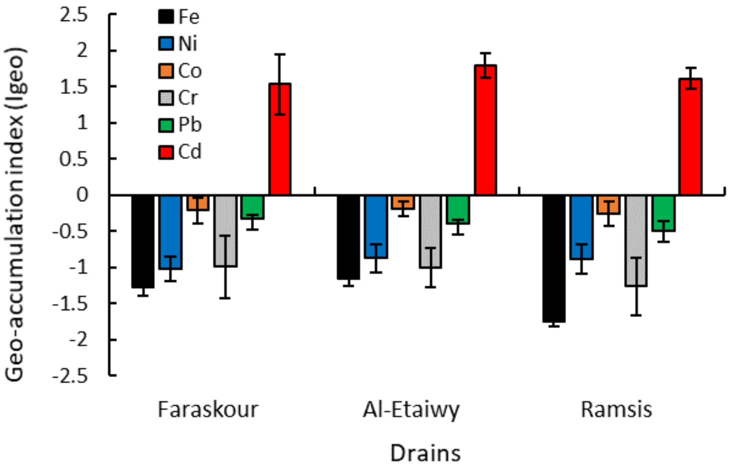

Figure 5. I_{geo} of heavy metals in the sediment samples from the studied three drains.

Ecological risk assessment

The potential ecological risk index (PERI) was used to characterize the ecological risk index (Er) of single heavy metals in sediments. The PERI was used to determine the ecological sensitivity of heavy metal contamination in stream sediments based on heavy metal toxicity and environmental responses [25]. Figure 6 depicts the results of the Er and PERI evaluations. The following is a ranking of the Er of heavy metals in drain sediments: Co > Pb > Ni > Cr > Cd (Figure 6). The Er index for Cr had a mean value of less than 40 (Er 40; i.e., low ecological risk). The mean Er values of Ni and Pb were 52.03, 75.14, 74.40 and 70.80, 60.78, 50.13 for Faraskour, Al-Etaiwy and Ramsis drains, respectively (i.e., moderate ecological risk (40 < Er < 80)) (Figure 6). The mean values of the Er index for Co was higher than 80 (80 ≤ Er< 160; i.e. considerable ecological risk). Furthermore, Cd is one of the most dangerous heavy metals, surpassing the geochemical background value in the average shale. As a result, the toxicity levels for Cd in the middle Nile Delta required to be investigated further in order to assess their distribution on a larger scale, evaluate their possible consequences, and devise a plan for controlling these pollutants.

The PERI values in the Faraskour, Al-Etaiwy, and Ramsis drains were 931.0, 1173, and 818.5, respectively. The three drains investigated in the middle Nile Delta have extremely high levels of sediment ecological damage. When comparing the Al-Etaiwy drain to the others, we observed that the potential ecological risk is higher [31].

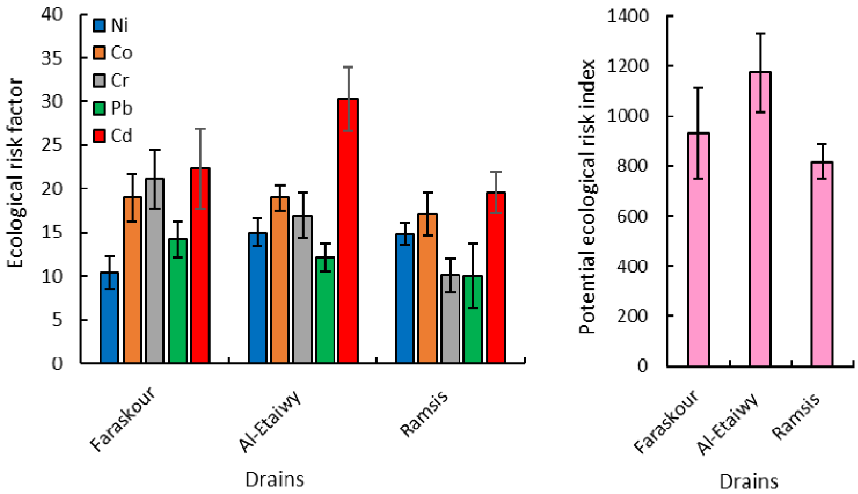

Figure 6. Ecological risk factor and potential ecological risk index of heavy metals in the sediment samples from the studied three drains.

CONCLUSION

The degree of heavy metal pollution varies depending on the metal species and the site. For the Faraskour and Al-Etaiwy drains, the distribution of Cd, Cr, Co, Ni, and Pb showed an incremental rise in concentrations from downstream to middle stream, while the distribution of heavy metals fluctuated across five sites in the Ramsis drain. As a result, effective measures to limit Cd, Co, and Cr pollution in the study area should be implemented. In comparison to the others, the Al-Etaiwy drain poses a significant risk to the environment. Thus, it is recommended to conduct an urgent and systematic study of heavy metals in the sediments of drains in the Nile Delta and to assess the source of pollution because it can significantly reduce the toxicity of these elements, and thus contribute to improving the environmental risks of the local residents in the Nile Delta.

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