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Risk Evaluation of Heavy Metals in Sediments of the Fish Farming Area in the Mediterranean Section of Lake Manzala

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Abstract

To reveal the potential pollution characteristics of heavy metals in sediment of the fish farming area in the Mediterranean section of Lake Manzala, three indices of Enrichment factor (EF), Nemerow multi-factor, and Hakanson potential ecological risk factor have been used. The reference values for calculating these indices were the background levels in the same area. The averages of EF values are in the following order: Cu>Zn>Cd>Pb. The average of pollution indices (PI) and Contamination Factor ($C^i f$) descended in the order of Fe > Cu > Zn > Pb > Cd. The NIPI values in sediments ranged from 0.36 to 15.57 indicating lightly polluted to severe or high level of pollution with an average of 6.68 (severe or high level of sediment pollution). The average contamination value (Cd) was 28.12, reflecting relatively high contamination degree. In terms of the mean potential ecological risk indices of the four types of heavy metals, the Eif arrayed is in the order of Cu > (Cd > Pb) > Zn. Cu was the key influence factor to cause the potential ecological risk, and its Eif mean value was up to 37.63 with risk grade (medium). The scope of RI range was 36.25 and 92.96 with ecological risk levels slight and strong respectively.

Keywords: Enrichment Factor, Ecological Risk, Fish Farming, Mediterranean, Lake Manzala, Heavy Metals.

Introduction

Heavy metals are the most important pollutants that affect the ecosystem as they are persistent and resist degradation in normal conditions. Their toxicity appears after accumulating and exceeding level of indispensability and when they are not metabolized by the body and accumulate in the soft tissues. Metals are absorbed and accumulated on bottom sediments because of low solubility in water (Jain *et al*., 2008). Thus, the sediment can be a potential source of heavy metals launched in under water by natural and anthropogenic processes, where benthic biota or other organisms can ingest metal particles or contaminated water. This resulted in metals accumulating in their tissues and ultimately entering the food chain. Consequently, this could have a negative impact on human health (Yin *et al*., 2011). In addition to this, bottom sediments are sensitive indicators to monitor contaminants as they can act as a sink and a carrier of pollutants in the aquatic environment (Bai *et al*., 2011). For that, the sediment analysis plays an important role in assessing the state of pollution in the aquatic environment (Suresh *et al*., and Liang *et al*., 2012).

Indices of Pollution are a beneficial tool for analyzing, implementing, and transforming the environmentally raw information to authority and the public (Caeiro *et al*., 2005, and Qingjie *et al*., 2008). For these reasons, Enrichment Factor (EF), Hakanson (1980) ecological risk and the Nemerow multi-factor methods were used to evaluate the ecological hazards related to the five heavy metals analyzed in the contaminated sediments collected from the fish farms located in the Mediterranean section of Manzala Lake (Wang *et al*., 2013). In aquatic ecosystems, several environmental factors must be considered as chemical, physico-chemical, biological, and eco-toxicological parameters. All these variables must integrate and these indices must be applied to do it (Fiori *et al*., 3013).

Statistics have been used to evaluate the referenced and man-made influence of trace elements in lake sediments (Li *et al*., 2013).
The present work aims to determine the heavy metals concentrations (Cd, Fe, Cu, Pb and Zn) in sediments of the fish farms in the Mediterranean section of Manzala Lake and to evaluate the contamination degree of heavy-metal using the pollution indices (PI & NIPI) and Enrichment Factor (EF). Also we aim to assess the sediments' toxicity using the single and integrated ecological risk indices.

Methodology

Area of study

The study fish farming is located in the eastern part of Lake Manzala in the Mediterranean section. Sampling sites are displayed in Figure 1. The lake is a shallow aquatic brackish system with depth ranged from 0.5 and 1.0 m (Shaheen & Yosef, 1979). The study area receives its feeding from the Mediterranean through El-Gamil and El Mussallas inlets (Rasmussen *et al*., 2009). The area was isolated from the main lake by the construction of a new coastal road. The area is now subdivided into small ponds for fish farming which is also practiced elsewhere within Lake Manzala (El Banna & Frihy, 2008; and Ahmed *et al*., 2009). Other parts of this area have been developed for other uses including building and refuse disposals.

Sampling

Sediments were collected from 16 sites at El Mussallas area - the fish farming area in the Mediterranean section of Lake Manzala (Fig. 1). Sampling Locations were identified using GPS as described in Table 1. The sediment samples were oven dried, grounded, homogenized and sealed in clean polythene bags stored in a fridge till processing.

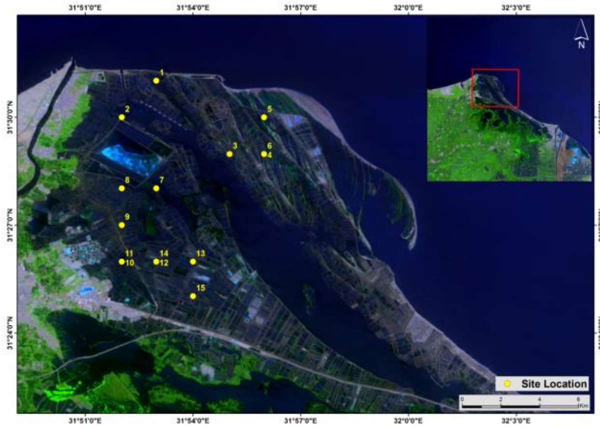

Fig. 1 Sampling sites from Lake Manzala.

Heavy metal analysis

Finding out the total heavy metals in sediments was measured according to UNEP/IAEA (1986). An exact weight of dry sample (about 0.5g) of sediment was completely digested in Teflon vessels using a mixture of HNO_3, HF and $HClO_4$ (3:2:1 V/V). The final solution was diluted to 10 ml with distilled de-ionized water. All digested solutions were analyzed for heavy metals (Cu, Cd, Pb, Zn, and Fe) by using atomic absorption spectrophotometer (Shimadzu AA-6800) and results expressed as mg/kg^{-1} dry wt.

Methods of heavy-metal pollution assessment

Enrichment factor (EF)

Enrichment factor (EF) was developed by Taylor (1964). It is one of the indicators most often used for estimating anthropogenic inputs (Gonzáles-Macías *et al*,. 2006, Çevik *et al*., 2009, and Louri˜no-Cabana *et al*., 2011). This technique based on the hypothesis that, in the natural sedimentation conditions, there is a linear relationship between the reference elements (RE) and other elements if RE concentration changed with a factor the concentration of the other elements change also with the same factor (El-

Gharabawy *et al*., 2011). The EF ratio can be used as an indicator of pollution by comparing the concentrations of identified metals with the reference levels of these metals in sediments from local or worldwide lakes. It's important to use the background or reference values of a local sediments as it can be better for comparison. The commonly used metals for are Al (Kwokal *et al*., 2002, and Zhang *et al*., 2009) and Fe (Ghrefat *et al*., 2006 and Çevik *et al*., 2009). We use Fe as a reference element to identify natural from anthropogenic components. The reference values were obtained from site 16 (Fig. 1). The concentrations of various elements in this site were nearly the lowest among those sampling sites. The EF is defined as follows (Li *et al*., 2013 and Ra *et al*. 2014):

$$\mathrm{EF} = \frac{\mathrm{M_s}/\mathrm{Fe_s}}{\mathrm{M_r}/\mathrm{Fe_r}}$$

Where M_s and Fe_s is the measured value of a metal and its Fe value for each site, M_r and Fe_r is the measured value of a metal and its Fe value for site 16 (reference site). The EF value was differentiated to seven classes according to Taylor (1964) in Table 2.

Nemerow multi-factor index method

The sub-index can be used to calculate the single factor and multi-factor comprehensive pollution indices of sediment heavy metals. The situation at Manzala Lake was analyzed based on the sub-index, the single factor contamination index, and multi-factor comprehensive contamination index (Soldecilla *et al*., 1992, and Li *et al*., 2003). The comprehensive contamination index is able to highlight the effects of high concentrations of contaminants on environmental sediment quality. Therefore, the comprehensive pollution index provides a more scientific representation of sediment contaminants and sediment environmental quality. Nemerow integrated pollution index (Yang *et al*., 2011) was attributed to each sample (Wang *et al*., 2013).

Table 1. The sampling sites description and its GPS locations.

sites	locations E		locations N		elevation(m)	Description of the sampling sites
1	31°	52. 92′	31°	30.980′	8	Near the new harbor that feeding the lake from the Mediterranean se) within 2 km away from ezbet elborg.
2	31°	52.33′	31°	30.249′	7	Open area near to the farm own to the governorate.
3	31°	54.972′	31°	28.750′	7	The beginning of the government channel (feed opening 6 km from ezbet elborg.
4	31°	55.543′	31°	29.393′	6	Middle of the government Channel.
5	31°	55.717′	31°	30.255′	4	The beginning of El karaka feeding channel (privet farm own to mohammed shetta).
6	31°	55.718′	31°	30.257′	4	Middle of El karaka feeding channel. The feeding stop as result of siltation processes.
7	31°	53. 242′	31°	28.269′	7	Privet farm own to Mohammed hamdy.
8	31°	52.105′	31°	27.674′	2	Middle of el arbeen channel (linked between government channel and el rattama channel)
9	31°	51.693′	31°	27.313′	5	The connection between el arbeen channel and el rattama channel.
10	31°	52.27′	31°	26.472′	1	Middle of el rattama channel.
11	31°	52.274′	31°	26.287′	6	The beginning of the young graduates' channel.
12	31°	53.239′	31°	26.350′	3	Middle of The young graduates channel
13	31°	53.8′	31°	25.844′	9	Private farm own to Hassan saqr.
14	31°	52.927′	31°	25.614′	10	Private farm own to El beheary.
15	31°	53.59′	31°	24.858′	7	End of The young graduates' channel.
16	31°	52.813′	31°	24.528′	8	Feeding channel from the southern part of Lake Manzala.

The single contamination index (PI) was defined as follows:

$$\mathrm{PI} = C_s/S_r$$

where C_s is the measured value for one metal, and S_r is the background or reference value. The sediment is not contaminated when PI≤1 but is contaminated when PI>1, and the higher the PI the more serious the sediment contamination.

The Nemerow multi-factor index for a site is defined as follows:

$$NIPI= (PI^2_{i\ ave}+PI^2_{i\ max}/2)^{1/2}$$

Where $PI^2_{i\ max}$ and $PI^2_{i\ ave}$ are the maximum and mean contamination factor (PI) value of each heavy metal (Wang *et al*., 2013 and Jiang, 2014). The NIPI is classified as in Table 3.

Table 2. The classification of EF value was defined in seven classes according to (Taylor, 1964 and Ra *et al*. 2014).

EF classes	Sediment quality
EF<1	No enrichment
1-3	Minor
3-5	Moderate
5-10	Moderately severe
10-25	Severe
25-50	Very severe
>50	Extremely severe

Table 3. Classification criteria for the comprehensive soil sediment assessment (Yang *et al*., 2010, and Jiang, 2014).

Grade division	NIPI	Contamination level
1	NIPI≤0.7	non-pollution
2	0.7<NIPI≤1	warning line of pollution
3	1<NIPI≤2	low
4	2<NIPI ≤3	moderate
5	NIPI>3	sever or high level

Potential Ecological Risk Index (PERI)

The environmental behavior of heavy metal contaminants in sediments was assessed by risk index method. The assessment was able to reflect the effects of various contaminants and to reveal the comprehensive influence of multiple contaminants in a particular environment. At present, the Hakanson method is the most scientific and comprehensive approach to assessing heavy metal contamination in sediments. This index was widely used and had great influence at international level (Fan *et al*., 2002 and Guo *et al*., 2010). The method was defined as follows:

Contamination Factor (C^i_f)

Contamination Factor C^i_f is defined as follows

$$C^i_f = C^i_{sample} / C^i_{reference}$$

Where C^i_f is contamination coefficient of a certain metal in sediment, which can display the contamination modality in the studied area, but cannot determine the extent of environmental and biological risks in the region. C^i_{smple} is the concentration of metals in sediment samples. $C^i_{reference}$ is the background or reference values of metals goatherd from previous research (Abdel-Baky *et al*., 1998, Madkour 2005, Saeed *et al*., 2008, and El-Serehy *et al*., 2012). The classifications according to C^i_f results were summarized in Table 4.

The comprehensive contamination measure (C_d) for one area is the summation of all C^i_f

$$C_d=\sum C^i_f$$

Five heavy metals (Fe, Pb, Cu, Zn, and Cd) are investigated. C_d classification was summarized in Table 5.

Table 4. Classification criteria for the contamination coefficient (C^i_f) (Yang *et al*., 2010, and Jiang *et al*., 2014).

Contamination Factor	Classification
C^i_f<1	Low
1≤C^i_f<2	light
2≤C^i_f<3	Moderate
C^i_f ≥3	heavy

Table 5. Classification criteria for the integrated pollution degree (C_d) (Fu *et al*., 2009 and Jiang *et al*., 2014).

Degree of contamination Factor	Classification
C_d<5	Low
5≤C_d<10	Moderate
10≤C_d<20	relatively high
C_d≥20	Very high

The single ecological risk index (E^i_f)

The formula for potential ecological risk index for the single heavy metal pollution:

$$E^i_f=C^i_f\times T^i_f$$

Where T^i_f is the toxic response factor of the single heavy metal. The toxic response factor represents the potential hazard of heavy metal contamination by indicating the toxicity of particular heavy metal and the environmental sensitivity to contamination. The toxic response factor was determined according to the "elements abundance principle" and the "elements release principle". According to the standardized toxic response factor proposed by Hakanson (1980) Cd, Hg, As, Pb, Cr, Cu, Zn, and Ni have toxic response factors of 30, 40, 10, 5, 2, 5, 1, and 5, respectively.

The potential ecological risk index (RI)

The formula for the ecological risk index for multi heavy metals:

$$RI=\sum E^i_f$$

Due to the difference in pollutant types and quantity, the present study adjusted the grading standard of heavy metals' ecological risk indices based on the types and quantity of pollutants (Li *et al*., 2012). The standards of potential risk index of metals in sediment were displayed in Table 6.

Table 6. The corresponding grading standards for ecological risk index (Fu *et al*., 2009 and Jiang *et al*., 2014)

E^i_f	Classification	RI	Classification
E^i_f <30	slight	RI<40	slight
30 ≤ E^i_f < 60	medium	40 ≤RI< 80	medium
60 ≤ E^i_f < 120	strong	80 ≤RI< 160	strong
120 ≤ E^i_f < 240	Very strong	160 ≤RI< 320	Very strong
E^i_f ≥ 240	Extremely strong	RI≥ 320	-

Data analysis

Descriptive statistics e.g. standard deviation, maximum, minimum, average and Pearson correlation coefficient are performed using SPSS version 18.

Results and Discussion

Comparison of heavy-metal concentrations in sediments of Manzala Lake with background values

The concentrations of heavy metals in the lake sediments, the background, and the international guidelines values are listed in Table 7. The mean concentrations of Cu, Cd, Pb and Zn were lower than the PLE and ERM international guidelines. The mean values of Cd were lower than the background values that recorded by Madkour (2005), El-Serehy *et al*., (2012), Abdel-Baky *et al*. (1998), and Saeed *et al*., (2008). The mean concentrations of Cu were higher than the background values recorded by Madkour (2005), El-Serehy *et al*., (2012), and Abdel-Baky *et al*. (1998) and lower than the values recorded by Saeed *et al*., (2008). The recorded values for Zn were the same as Cu except that Zn was nearly equal to the values recorded by Abdel-Baky *et al*. (1998). While, the mean values of Pb was higher than the background values recorded by Madkour (2005) and Abdel-Baky *et al*. (1998), it was lower than the values recorded by El-Serehy, *et al*., (2012), and Saeed *et al*., (2008). The mean concentrations of Fe were higher than that recorded by Saeed *et al*., (2008) and lower than that recorded by El-Serehy, *et al*., (2012).

The enrichment factor (EF)

The enrichment factor (EF) for the four metals (Cd, Cu, Zn, Pb) was calculated based on the five element (Fe) to evaluate the anthropogenic contribution to heavy metals in sediments and is shown in Figure 2. The average of EF values for Cd (1.22), Cu (1.92) and Zn (1.62) were in the range of 1-3(minor enrichment) and the average EF value for pb (0.99) was in the range of EF <1 (No enrichment).The EF values for Cd ranged from 0.88 (No enrichment) at site (13) to1.55 (minor enrichment) at site (8). The EF values for Cu were highly variable at sampling sites, ranging from1.21 to 3.44 indicating a minor enrichment (EF class 1-3) to moderate enrichment (EF class 3-5). Zn ranged from 1.06 to 2.41 indicating minor enrichment (EF class 1-3). The highest EF value for Pb (1.79) was observed at site (2) indicating minor enrichment (EF classes 1-3). Metal contamination level is arranged as follow: Cu>Zn>Cd>Pb.

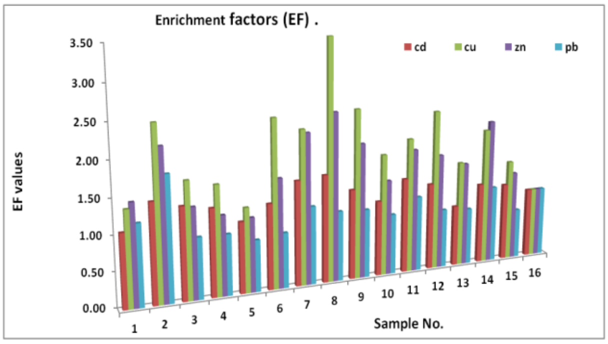

Fig. 2 EF calculated for some heavy metals in polluted sediments of Manzala Lake.

Table 7. Heavy metal (mg kg^{-1} dry wt.) with the range of reference and the International guidelines values.

Sites	Concentration in sediments (mg kg^{-1} dry wt.)				
	Cd	Cu	Zn	Pb	Fe
1	0.88	15	43.28	21.06	516
2	1.2	27.38	64.84	32.5	520.8
3	1.1	18.28	38.68	15.84	515.2
4	1.04	17.2	33.94	15.72	514.8
5	0.84	13.16	31.38	13.26	511.8
6	1.02	26.4	46.74	14.34	517
7	1.26	24.44	64.72	20.4	520
8	1.3	38.24	72.72	18.42	523.4
9	1.08	26.76	57.96	17.92	519.8
10	0.9	19.18	40.8	15.72	517.2
11	1.14	21.34	53.12	19.68	519.4
12	1.04	25.26	49.56	15.38	518.6
13	0.72	16.44	44	14.6	510.8
14	0.96	21.38	61.54	19.76	514.8
15	0.92	15.82	37.82	12.82	512.8
16	0.82	10.84	29.4	17.84	510.4
Max	1.3	38.24	72.72	32.5	523.4
Min	0.72	10.84	29.4	12.82	510.4
Average± SD	1.01±0.16	21.07±6.85	48.16±13.13	17.83±4.67	516.43±3.79
Reference values / mg kg^{-1} dry wt.					
Madkour, (2005).	3.2	2.8	14.2	2.5	-
El-Serehy, *et al*., (2012)	1.9	7	32.5	21	1918.7
Saeed *et al*., (2008).	84.8	315.36	432.16	134.6	33.39
Abdel-Baky *et al*. (1998).	1.36	7.89	48.42	14.05	-
International guidelines (µg/g dry wt.):					
Persaud *et al*. 1990.	0.6-10	16-110	120-820	31-250	-
Canadian TLE-PLE.	0.7-4.2	18.7-108	124-271	30.2-112	-
Wisconsin TLE-PLE.	0.99-5.0	32-150	120-460	36-130	-
FlemishTarget value–Limit value.	2.5-7	20-100	160-500	70-350	-
NOAA guidelines ERL- ERM.	1.2-9.6	34-270	150-410	46.7-218	-

ERL: Effects Range-Low; ERM: Effects Range-Median; TEL: Threshold Effect Level; PEL: Probable Effect Level.

Nemerow integrated pollution index (NIPI)

The single contamination index (IP) varied greatly among heavy metals. The PI values for Cd ranged from 0.23 at site (13) to 0.41 at site (8) indicating that the sediment was uncontaminated by Cd. The sediment was strong to very strongly contaminated with Cu, as PI values were ranged from 3.87 (site 16) to 13.66 (site 8). While, the maximum PI value of Zn (5.12) was recorded at site (8) indicating strongly contaminated sediment, the lowest (2.07) were recorded at site (16) indicating moderately contaminated sediments. The range of IP value for Pb were 1.03 (site 15) to 2.60 (site 2) indicating low to moderately contaminated sediment. Also, The PI values for Fe were ranged from 15.29 at site (16) to 15.68 at site (8) indicating very strong level of sediment pollution. As a result, site (8) show the highest PI values among all sites for the all measured elements while, site 16 is the lowest. The results showed that the average of PI descended in the order of Fe (15.47) > cu (7.53) > Zn (3.39) > Pb (1.43) > Cd (0.32).The NIPI values in the lake sediments ranged from 0.36 to 15.57 indicating slightly polluted (NIPI≤0.7) to sever or high level of pollution (NIPI>3) with an average of 6.68 (sever or high level of sediment pollution). The results of PI and NIPI of heavy metals in sediment of Manzala Lake are expressed in Figures 3 and 4.

Contamination coefficient analysis of heavy metals in the sediments

According to Hakanson's method, degree of pollution and ecological risk are analyzed by the use of potent ecological risk index method (Puente *et al*., 2008 and Fu *et al*., 2009). The contamination coefficient (C^i_f) has the same values of PI calculated above. The order of C^i_f for the 5 heavy metals was Fe＞Cu＞Zn＞Pb＞Cd (Fig. 5). The (C_d) value was determined as the sum of all C^i_f of one site. The C_d ranged from 22.91 at site (16) to 36.33 at site (8) indicating relatively high to very high contamination (Fu *et al*., 2009). The average value of C_d were 28.12, reflecting relatively high contamination degree (Fig. 6).

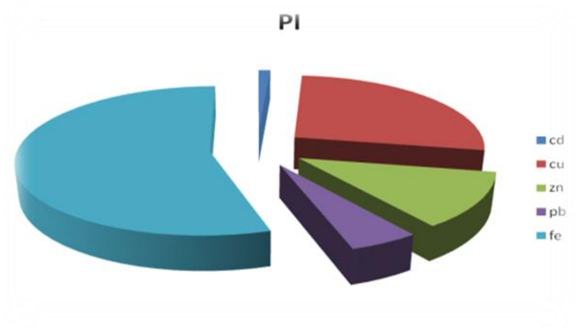

Fig. 3 Sediment contamination index (PI).

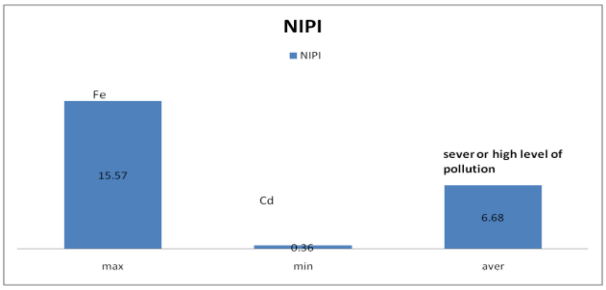

Fig. *4 Integrated pollution index of pollutants in the study area.*

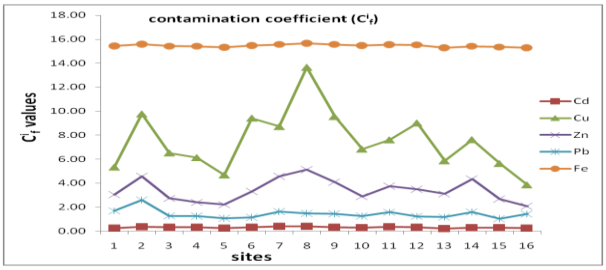

Fig. 5 Sediment contamination coefficient (Cif) in the study sites.

Single and comprehensive potential ecological risk assessment of heavy metals

From the results, we can observe that the scope of the potential ecological risk indices of the four types of heavy metals are E^i_f (Cd) 6.75-12.19, E^i_f (Cu)19.36-68.29, E^i_f (Zn) 2.07-5.12, and E^i_f (Pb) 5.13-13. In terms of the mean potential ecological risk indices of the four types of heavy metals, the E^i_f arrayed is in the order of (Cu) > (Cd) > (Pb) > (Zn). Cu was the key influence factor to cause the potential ecological risk, and its mean value of E^i_f was up to 37.63 with Risk grade (medium). The mean E^i_f values of Cd, Zn, and Pb were 9.47, 3.39, and 7.13 respectively indicating risk grade (slight) (Fig. 7). The scope of RI was 36.25-92.96 with ecological risk levels slight and strong respectively (Fig. 8). High ecological risks have been estimated to exist in site (8), while the slight ecological risk exists at site (16).

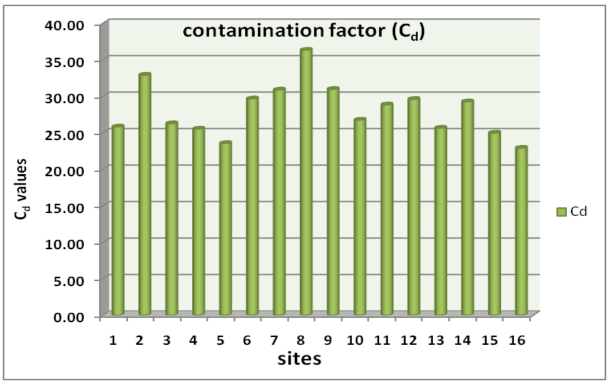

Fig. 6 The degree of pollution (Cd) in the study sites.

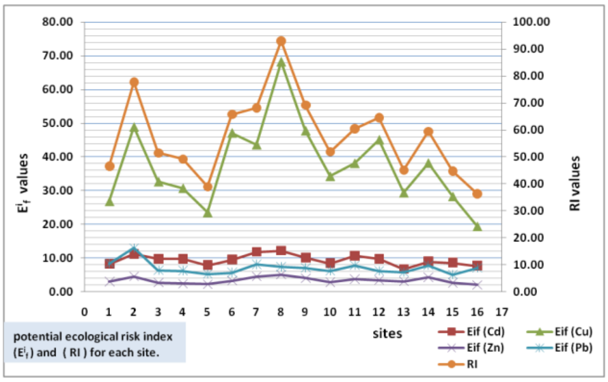

Fig. 7 Single & comprehensive risk index (E^i_R, RI) for each site.

Pearson correlation analysis

Usually the content of heavy-metal elements originated from the same or similar source tend to have a significant correlation (Hirschfeld, 1935; Rodríguez *et al*., 2008), so the correlation between the heavy-metal content in sediment can be considered as an indicator of whether the source of heavy metal was the same or not. Positive correlation between heavy metals suggests that these heavy metals have common sources, mutual dependence and identical behavior during transport. Negative correlations suggest that they do not share the above-mentioned metal traits with each other's (Jiang *et al*., 2014). The analysis results are listed in Table 8.

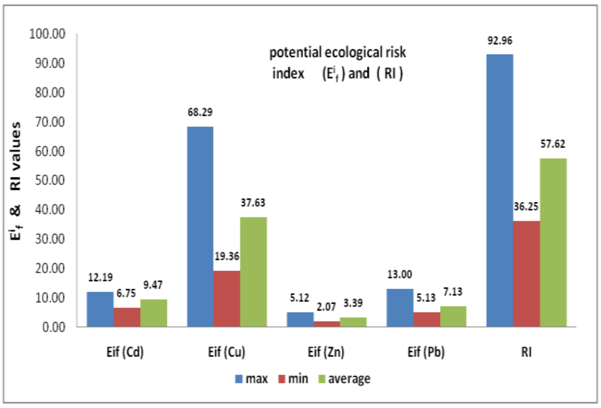

Fig. 8 Min , Max, and Average of the Single & comprehensive risk index (E^i_R, RI).

Table 8. Pearson's multiple correlations of some heavy metals in sediments of the study area.

Elements	Cd	Cu	Zn	Pb	Fe
Cd	1.000				
Cu	0.793**	1.000			
Zn	0.738**	0.864**	1.000		
Pb	0.468	0.332	0.576*	1.000	
Fe	0.882**	0.886**	0.822**	0.501*	1.000

*=P<0.05, **=P<0.01

The results of Pearson correlation analysis indicated that the heavy metals in the sediment are highly correlated with each other, where Cd is highly correlated with Cu, Zn and Fe (P<0.01); Cu with Zn and Fe (P<0.01) and Zn with Fe (P<0.01). Pb showed low correlation with Zn and Fe in the sediment (P<0.05).

Conclusions

The averages of EF were in the range of minor enrichment for Cd (1.22), Cu (1.92) and Zn (1.62) to no enrichment for pb (0.99) and arranged in order: Cu>Zn>Cd>Pb. The NIPI values in sediments ranged from lightly polluted to severe or high level of pollution with an average of 6.68 (severe or high level of sediment pollution). In terms of the mean potential ecological risk indices of the four types of heavy metals, the E^i_f arrayed is in the order of Cu > Cd > Pb > Zn. Cu was the key influence factor to cause the potential ecological risk, and its E^i_f mean value was up to 37.63 with Risk grade (medium**)**. The scope of RI range was 36.25-92.96 with ecological risk levels slight and strong respectively. Strong ecological risk have been estimated to exist in site (8), while the slight ecological risk exists at site (16). The three indices revealed similar levels of heavy metal pollution, indicating that the sites are contaminated by the heavy metals to varying degrees compared to the background values.

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الملخص العربي

تقييم مخاطر التلوث بالمعادن الثقيلة فى رواسب منطقة الاستزراع السمكى بالقطاع الشمالى لبحيرة المنزلة على البحر المتوسط.

مختار سامى بحيرى[1] ، فاطمة عادل المطرى[2]
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تم تعيين تركيز بعض العناصر الثقيلة (النحاس, الكادميوم, الرصاص, الزنك و الحديد) فى رسوبيات منطقة المزارع السمكية الواقعة بالجزء الشمالى من بحيرة المنزلة. وقد تم استخدام ثلاثة معاملات وهى معامل التغذية EF , معامل حمل التلوث NIPI ومعامل المخاطر الايكولوجية RI, وذلك دراسة خصائص التلوث بالمعادن الثقيلة في عينات الرواسب و تحديد مستوى التلوث بمنطقة الدراسة ككل. وكانت القيم المرجعية لحساب هذه المعاملات هى نتائج لدراسات سابقة على نفس المنطقة. و بحساب متوسطات القيم لمعامل التغذية EF اعطت النتائج الترتيب التالي: النحاس> الزنك> الكادميوم> الرصاص. وتراوحت قيم معامل حمل التلوث NIPI في الرواسب من 36 الى 57,15 والتى تشير الى رواسب طفيفة التلوث إلى مستوى شديد التلوث وذلك بمتوسط 6.68 (رواسب ذات مستوى شديد التلوث). كان متوسط قيمة التلوث (Cd) لمنطقة الدراسة 28.12، مما يعكس درجة عالية نسبيا من التلوث. سجل المعامل الفردى للمخاطر الإيكولوجية المحتملة للتلوث بأحد المعادن الثقيلة (Eif) ترتيب كالتالى: النحاس> الكادميوم> الرصاص> الزنك. وكان النحاس هو عامل التأثير الكبير للتسبب في مخاطر بيئية محتمله حيث وصلت قيمة (Eif) إلى 37.63 بدرجة مخاطر متوسطة. كما تراوح معامل المخاطر الايكولوجية RI للمنطقة ككل من مخاطر بيئية طفيفة الى قوية.