Survey of Modified Hazard Quotient, Potential Ecological Risk Factor and Toxicity Units of Heavy Metals in Surface Sediments of Some Wetlands of Iran

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Background & Aims of the Study: The present research aims to use sediment quality indices in the assessment of toxicity and ecological risk factors of heavy metals Pb, Cu and Zn in Anzali, Meighan, Shadegan and Hashilan wetlands.

Material & Methods: Given the environmental conditions, surface sediments in 71 diverse stations were sampled in three replications. Having preparation and subjected to acid digestion of sediment samples, 0.5 g of each sample was digested with a mixture of nitric acid and super-pure ratio of 4 to 1 perchloric acid. Finally the concentration of these metals was determined using the contrAA 700 Analytic Jena Atomic absorption spectroscopy.

Results: The results of the potential acute toxicity and the ecological risk of the considered metals indicated low toxicity and risk. Also, the outcomes of Modified Hazard Quotient (mHQ) indicated a low to moderate pollution risk in Anzali wetland, very low pollution in Shadegan wetland, and in Meighan wetland for Pb and Cu, low pollution to very low and for Zn metal it showed low to high pollution. In Hashilan wetland Modified Hazard Quotient for Pb and Zn showed very low pollution and for Cu it was negligible to moderate among others.

Conclusion: However, the growth of urbanization and the increase of various anthropogenic activities such as agriculture, urban, industrial ... within the wetland basin (draining area) and entry of untreated urban and rural sewage requires urgently continuous monitoring of wetlands as well as the assessment of their health risks and ecological risk among others.

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Background

Heavy metals are found to be the most important and most hazardous pollutants in Ecotoxicologic researches (1) and due to some properties such as toxicity, carcinogenicity, mutagenicity, long half-life and high stability, accumulation and biomagnification in the trophic levels are measured as one of the major threats to human health and other living organisms (2,3). This calls for extensive scientific research into the assessment of concentration, toxicity, ecological risk, the risks and natural and human threats posed by the entry of heavy metals and other toxic and dangerous pollutants into the environment. The toxicity and dangers of pollutants, such as heavy metals, for living organisms depend on various factors such as concentration, mode and duration of exposure to the substance (1).

Heavy metals come in two directions of direct consumption of water and food, and the other non-digestive pathway through the passage of permeable membranes such as skin, muscle, and lung main substances into the human food chain and living organisms of the aquatic ecosystem (4). The accumulation of heavy metals in possible living beings it is either active or selective or resulting from the absorption and disposing of them or both (5). Some metals such as Cd, Hg and Pb have no important physiological roles and functions for living organisms, and even at low concentrations produce toxicities or effects such as mutagenicity, carcinogenicity, and teratogenicity and ... in organisms. Toxic effects of metals happen when the detoxification, storage, metabolism and excretion mechanisms cannot decrease the amount of intake for a long time and consequence in their accumulation in the body (6). Heavy metals can naturally flow into the environment, including water, soil and air, as a result of numerous chemical and physical processes such as volcanic motion, weathering, and soil erosion or from human resources such as agricultural, industrial, urban development in the creation environment, distributed and dispersed (7,8). These elements can be accumulated and kept in sediments due to their facility to bind and react with various components and compounds of various aqueous environments and different geochemical phases (3). Sediments are the main reservoir of heavy metals due to absorption, deposition, propagation process, chemical reactions and biological activity, and can effectively be used as a reservoir to store and stabilize heavy metals through adsorption processes, hydrolysis and simultaneous deposition in aqueous media or as a heavy metals production source during the process of changing environmental situations such as changing pH or oxidation potential and restoring the environment (9,10). Hence, sediments can be considered as one of the poles or sources of threats to human health and aquatic organisms. Moving and transporting heavy metals in the water and sediment matrix is influenced by the size of the particles and the chemical composition of the sediments and is significant for the overall concentration of heavy metals. (3,11). There are several methods for monitoring and monitoring Potential Ecological Risk Factor of heavy metals in the environment, especially in sediments and aquatic environments, including Pollution Load Index (PLI), Potential Ecological Risk Factor (Er) Risk Index (RI), Acute Metabolism Evaluation and Modified Hazard Quotient Index (mHQ). Due to the negative effects of heavy metals on Zn organisms and the health of natural ecosystems, their occurrence in the environment is a worldwide concern (8,12). In this regard, assessment, concentration and ecological damage are considered by several researchers. Following the rapid population growth, urban development and extensive human actions such as agriculture, industry and transportation around the wetlands and watershed, these areas are heavily affected by many contaminants, including heavy metals. The introduction of pollutants into aquatic ecosystems, while aggregating in the sediments of the region, creates many ecological threats and ecological hazards for living organisms, especially humans.

Aims of the study:

The purpose of this study was to assess the ecological risk and toxicity of heavy metals in surface sediments of Anzali, Meighan, Shadegan and Hashilan wetland wetlands using sediment quality index in different areas of Iran. The results of this study, by presenting a picture of the state of pollution of heavy metals in the sediments of the region, the calculation of acute toxicity and the risks to them from living organisms and consumers of wetland products can be a means of managing and conserving the important ecosystems of the country.

Materials & Methods

Study area

The studied areas include some of the internationally important wetlands and are at risk and threats from anthropogenic activities in Iran including Anzali, Shadegan, Meighan and Hashilan wetlands.

- Anzali Wetland is one of the most important international wetlands in Iran. This wetland is the most important source for the breeding and production of sturgeon and bony fish of the Caspian Sea, with an estimated area 193 km^2 in 28 and 37 N, and 25 and 49 E in the south of the Caspian Sea in Gilan province, whose average length 30 kilometers and its average width is approximately 3 kilometers and its current area is more than 100 km^2.

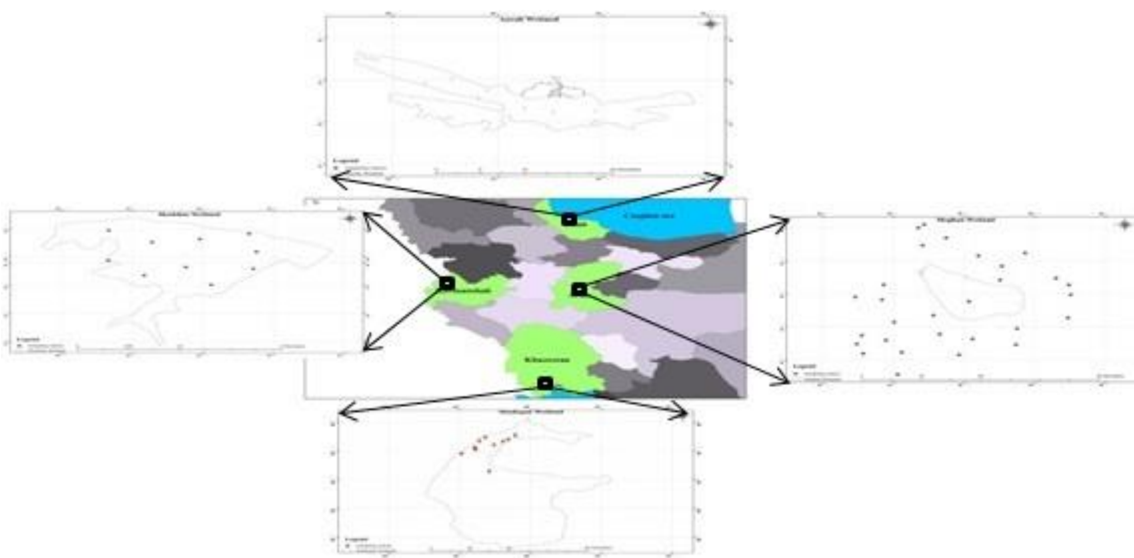

Figure 1) Geographical position of studied wetlands and sampling stations

-Shadegan wetland is an important international wetland with an area of about 400,000 hectares in the coordinate range of '17 and 48' to 50 'and 48' E, and '17, 30' to 57 'and' 37 N in Khuzestan province (13). About 296,000 hectares of this wetland are located as a wildlife refuge in the mainland of the wetland (14)

-The Meighan Wetland is also one of the important international and regional wetlands of the IBA birds, located 15 kilometers northeast of Arak. The wetland has an area of more than 50,000 hectares, the 12,000 hectare pond of the reservoir is located in the geographical coordinates of 56'40° 49' to 26'04° 50' E and '17'06° 34 'to 05'19° 34' N is elevation area between 1650 and 1750 meters and has a gradient of 0-5 percent (15). This Meighan wetland is a seasonal saline lake at the end of the Arak plain, which is dry in the warm seasons due to high evaporation. The Meighan wetland is rich in biodiversity due to its location in the center of the country and the angle of the collision between the two Alborz and Zagros Mountains and the semi-arid and semi-arid region of the country. In the autumn and winter seasons, Meighan is home to a large number of migratory birds.

- Hashilan wetland is located 36 km in northwest of Kermanshah city with coordinates "54", "15", "46" E, "34" 34 "to 35" 34 "N. Due to the favorable conditions of this habitat, this wetland is a habitat for many native and migratory birds in the region. Figure 1 shows the location of the studied area and the sampling points.

Sample collection

After field study of Anzali, Shadegan, Meighan and Hashilan wetlands, and survey of the dispersion and pollution status of urban, industrial and agricultural resources in different and accessible parts of each wetland, sampling stations were selected and at each station 3 samples at different points concurrently, surface sediments (depth 0 to 5 cm) were removed. The stations and samples were selected in such a way as to be able to access and index in the region, to show the possible entry of heavy metal pollutants and their sources (Figure 1). After recording the station's geographic location, the sample in special plastic bags, they were collected and coded in ice cologne and moved to the laboratory and stored at 4 ° C until the experiments.

Sample preparation and Analysis

To prepare the samples, the sediment was first placed in an oven at 70 °C for 24 hours to be dried completely. One gram of each dried sample was poured into PTFE digestive tubes (Polytetrafluoroe thylene) and 10 ml of 65% nitric acid (Merck, Germany) and 70% perchloric acid (Merck, Germany) in 1: 4 ratios was added. The PTFE tubes were placed on a heater at 40 °C for one hour and then the temperature increased to 140 °C for 3 hours. The contents of each tube were transferred from Watman No. 1 paper to a 25 ml volume of deionized water. To analysis control the quality; three blank samples were digested with the samples. Finally, the samples were measured by the atomic absorption device 797 VA Computrace, manufactured by Metrohm, Switzerland (16). To analyze the data, all of the data obtained using SPSS 21 and 2010 Office Excel software were used.

Data analysis and Risk Indices

A) Potential ecological risk factor of heavy metals in the study area

The ecological risk assessment index was used by Hankanson (1980) (17) to assess the risk of heavy metal pollution in sediments for the first time. This index is based on the toxicity of metals by modified methods by different researchers such as Yi et al. (2011) and Wang et al. (2013) (18,19). According to Hakanson (1980) (17), the toxicity response factor for Cu, Pb, and Zn is 5, 2 and 1, respectively. In this study, the ecological risk potential was calculated based on the following equation (6).

$$E_r^i = \frac{C^i}{C_0^i} \times T_r^i$$

$$RI = \sum_{i=1}^{7} E_r^i$$

Where E_r^i: Ecological hazard index, C^i and C_0^i iare the measured values and background value, T_r^i: is equal to the metal toxicity response factor.

If the risk index (RI) is less than or equal to 150; low risk; if 300≥RI≥150 average risk; if 600≥RI≥300 significant risk (high) and if 600≤RI is very high risk assessment It's all about Also, if the ecological hazard of any metal (E_r^i) is less than or equal to 40, the lower risk is 80≤ E_r^i ≥40; average risk; 160≤ E_r^i ≥80; significant risk; 320≤ E_r^i ≥160 A high risk is 320≤E_r^i. The risk level is considered very high.

B) Metals toxicity assessment

To assess the toxicity of heavy metals in sediments, the acute toxicity of metals was used. Acute toxicity potential index the sediment sample can be evaluated and assessed as total toxicity units. In this index, the Toxicity Unit (TU) is calculated as the ratio of the concentration of the metal to the PEL value of the metal (Equation 6). The amount of PEL indicates a high concentration of chemicals that can cause undesirable effects in the sediments of the area. PEL values for Pb, Zn and Cu are 112, 271 and 108, respectively (20).

$$TU = \frac{\text{Metals}}{\text{PEL}}$$

It is worth noting that Σ TU can be used to evaluate the acute toxicity of several metals in the sample. If ΣΣTU is greater than 4, there is acute toxicity, and if ΣâTU is less than 4, there is no toxicity (20).

C) Modified Hazard Quotient (mHQ)

Modified Hazard Quotient is a tool that determines the degree and risk of any metal for aquatic organisms and living organisms. This indicator is obtained from the evaluation of the concentration of metals in the sediments by the distribution of undesirable ecological synoptic effects for the quantitative thresholds TEL (PEL and SEL) and from equation (5) (TEL) for Pb, Cu and zinc was 35, 35.7 and 125, respectively) (21).

$$mHQ = \left[C_i\left(\frac{1}{TEL_i} + \frac{1}{PEL_i} + \frac{1}{SEL_i}\right)\right]^{\frac{1}{2}}$$

C_i is the measured metal concentration of the in the sediment sample, TEL (Threshold Effect Level), PEL (Probable Effect Level), and SEL (Sever Effect Level).

Based on quantitative results if the modified Hazard Quotient (mHQ) is higher than 3.5 or Cu is 3.5. Severely contaminated (very severe) sediments; 3.5 mHQ≥3 Very high pollution; 3> mHQ≥2.5; High pollution; 5.2> mHQ≥2 Significant pollution; 2>mHQ≥1.5; medium pollution; 1.5> mHQ ≥ 1 low pollution; 0>mHQ 0.5; very low pollution; if it is >0.5 mHQ the absence of pollution or minor pollution of sediments in the region (22).

E) Estimation of ecotoxicology.

Different amounts of pollutants can have various effects on Zn organisms that are exposed to it. In this regard, since aquatic ecosystems are abundant in interaction with or live in bed sediments, sediments can act as an important source of exposure to aquatic organisms to pollutants. In this regard, standards such as Sediment Quality Guidelines (SQGs) and the National Oceanic and Atmospheric Administration (NOAA) for sediment have been developed, which can be used to classify contaminated sediments and to predict the risk of adverse effects Use in aquatic animals in contact with these sediments (23). In the NOAA standard, there is a twofold risk of pollution of metals in sediments that have been presented as ERL (Effect Range Low) to the extent that less than 10% of the biological communities are at risk and ERM (Effect Range Medium) provided that less than 50% of the biological communities are at risk. The SQGs with two Threshold Effectiveness (TEC) and PEC (Probable Effect Concentration) measures the effect threshold of effective concentration. In the Canadian Sediment Quality Standard, two levels of LEL (Lowest Effect Level) indicate a level of pollution that is tolerable to most large animals and has no specific effect on biological communities, and SEL (Sever Effect Level) indicates severe pollution Which threatens the health of benthic organisms and if the infection is higher than this. Precise sediment toxicity tests should be performed (24). In addition, in order to find out more realistic values of the effect of sediment toxicity on living organisms, the probable effective coefficient of PELQ and average effective coefficient (ERMQ) is calculated according to the following equations (25,26).

$$PELQ = \frac{\sum_{i=1}^{n} \frac{Mi}{PELi}}{n}$$

$$ERMQ = \frac{\sum_{i=1}^{n} \frac{Mi}{ERMi}}{n}$$

Where Mi is metal concentration in sediment i; PELi and ERMi is probable effect level and Effect Range Median in the sediment i; n: the number of metal examined in each sample. The classification of the sediment pollution level and the effect of sediment toxicity on the basis of the quantitative values of the probable effect level (PELQ) quotients (PELQ) and the Effect Range Median (ERMQ) are existing in Table 1. The ERM for Pb, Cu and Zn is equal to 218, 270 and 410.

Table1) Relationship between sediment toxicity value of ERMQ and PELQ (25,26)

Sediment toxicity		
Sediment toxicity	ERMQ	PELQ
Non Toxic	0.1>	1.0>
Slightly Toxic	0.1-0.5	0.1-1.5
Moderately Toxic	0.5-1.5	1.5-2.3

Results

The results of the study of variations in the concentration (minimum and maximum concentration) of the three heavy metals measured in the sediments of Anzali, Shadegan, Meighan and Hashilan wetlands in different regions of Iran were given in mg/kg (Table 2).

Table 2) Mean concentrations of Pb, Cu and Zn in sediments of Anzali, Shadegan, Meighan and Hashilan wetlands (mg/kg dry weight)

Station	Hashilan			Mighan			Shadegan			Anzali		
	Cu	Zn	Pb	Cu	Zn	Pb	Cu		Pb	Cu	Zn	Pb
1	29.1	28.82	9.76	17.53	6.65	9.8	19.26	1	20.01	43.07	275.5	24.75
2	23.48	23.72	8.10	17.03	9.63	9.1	19.65	2	24.16	42.02	305.5	54.5
3	17.8	18.62	6.44	30.32	9.51	5.13	17.45	3	23.11	29.82	133.75	32.75
4	19.3	35.26	6.69	138.35	7.63	12.86	18.11	4	24.13	27.07	128.75	38.75
5	17.5	29.84	6.50	17.57	7.06	10.44	19.53	5	22.83	29.9	138.75	39.5
6	15.6	24.42	6.30	18.12	28.95	8.52	20.26	6	23.10	29.5	159.5	42.75
7	10.9	13.93	5.55	23.89	7.72	7.64	17.87	7	24.19	19.5	114.75	26.5
8	13.3	19.18	5.93	16.77	6.88	18.36	19.38	8	20.81	17.92	106.5	23.25
9	18.5	24.21	6.95	19.77	9.26	8.36	21.17	9	19.20	24.67	137.75	23.25
10				50.6	7.61	12.57	21.77	10	20.92	18.42	167.5	18.25
22				32.08	7.14	7.85		22		30.5	196	27
12				21.12	8.05	11.23		12		29.77	209	21.5
13				11.66	8.31	6.57		13		12.7	166.75	13.5
14				23.37	8.15	7.49		14		32.37	226.75	3.5
15				14.46	8.62	8.4		15		34.62	177.5	21.25
16				20.83	9.01	12.96		16		35.92	176.5	16.75
17				22.87	9.74	11.01		17		31.7	169.5	14.5
18				197.56	9.6	18.45		18		37.85	216.25	22
19				25.93	7.35	5.05		19		50.97	297.5	21.25
20				49.87	6.57	11.88		20		81.92	381.5	34.75
21				152.11	19.97	5.6		21		8.75	66.75	20.5
22				32.61	10.93	15.23		22		34.72	229.75	31.75
23				22.28	1.98	8.63		23		12.87	259	22.5
24				17.65	3.93	10.44		24		15.22	83.5	17.5
25				15.28	2.13	7.66		25		18.55	70.5	13.5
26				15.5	6.62	4.12		26		17.1	143.5	14.75
28				33.48	20.28	9.14		27		16.22	107.25	29.5
29				31.76	24.14	7.44		28		33.82	131.25	17.5
30				16.84	27.98	14.04		29		11.55	176.5	14.75
Mean				39.73	41.16	11.82		30		13.25	64.5	11
1	18.4	24.22	6.91	38.23	11.41	9.92	19.44	Station	22.8	28.7	173.93	23.78

The mean concentration of Pb, Cu and Zn in Anzali wetland was 23.87±10.5, 28.7±14.75 and 173.93±13.11, Shadegan wetland, 22.83±58.5, 28.1±0.5 and 44.9±48.2, Meighan wetland 92.9±5.3, 38.23±8.03 and 11.44±8.8, Hashilan wetland, 6.6±0.94±0.49, 24.22±16.2 and 18.41±1.8 mg/kg dry weight of the sediment.

Ecological potential risk assessment of heavy metals in the study area

The results of ecological risk and environmental risk assessment of heavy metals in the wetlands of the studied wetlands are presented in Table (3). In general, these results show that most of the studied stations are in the low risk category due to the ecological risk of heavy metals. Furthermore, the trend of total hazard of metals in Anzali and Shadegan wetlands is evaluated as (Zn>Cu>Pb) and for two Meighan and Hashilan wetlands (Zn>Pb>Cu) (Table 3).

Table 3) Results of Ecological and Environmental Risk Indices of Metals Measured in Surface Sediments of the Wetlands

Station	Hashilan				Mighan				Shadegan				Anzali			
	∑TU	mHQ			∑TU	mHQ			∑TU	mHQ			∑TU	mHQ		
		Cu	Zn	Pb		Cu	Zn	Pb		Cu	Zn	Pb		Cu	Zn	Pb
1	0.46	1.16	0.61	0.64	0.27	0.90	0.29	0.64	0.47	0.94	0.62	0.91	1.64	1.41	1.89	1.01
2	0.38	1.04	0.55	0.58	0.27	0.89	0.35	0.61	0.50	0.95	0.59	1.00	2.00	1.40	1.99	1.50
3	0.29	0.91	0.49	0.52	0.36	1.19	0.35	0.46	0.46	0.90	0.56	0.98	1.06	1.18	1.32	1.17
4	0.37	0.95	0.68	0.53	1.42	2.53	0.31	0.73	0.49	0.92	0.60	1.00	1.07	1.12	1.29	1.27
5	0.33	0.90	0.62	0.52	0.28	0.90	0.30	0.66	0.49	0.95	0.61	0.97	1.14	1.18	1.34	1.28
6	0.29	0.85	0.56	0.51	0.35	0.92	0.61	0.59	0.50	0.97	0.61	0.98	1.24	1.17	1.44	1.33
7	0.20	0.71	0.43	0.48	0.32	1.05	0.32	0.56	0.48	0.91	0.59	1.00	0.84	0.95	1.22	1.05
8	0.25	0.78	0.50	0.50	0.34	0.88	0.30	0.87	0.47	0.95	0.61	0.93	0.77	0.91	1.18	0.98
9	0.32	0.93	0.56	0.54	0.29	0.96	0.35	0.59	0.47	0.99	0.61	0.89	0.94	1.07	1.34	0.98
10					0.61	1.53	0.31	0.72	0.49	1.00	0.61	0.93	0.95	0.92	1.47	0.87
22					0.39	1.22	0.30	0.57					1.25	1.19	1.59	1.06
12					0.33	0.99	0.32	0.68					1.24	1.17	1.65	0.94
13					0.20	0.74	0.33	0.52					0.85	0.77	1.47	0.75
14					0.31	1.04	0.33	0.56					1.17	1.23	1.72	0.38
15					0.24	0.82	0.33	0.59					1.17	1.27	1.52	0.94
16					0.34	0.98	0.34	0.73					1.13	1.29	1.51	0.83
17					0.35	1.03	0.36	0.68					1.05	1.21	1.48	0.78
18					2.03	3.03	0.35	0.88					1.34	1.32	1.68	0.96
19					0.31	1.10	0.31	0.46					1.76	1.54	1.96	0.94
20					0.59	1.52	0.29	0.70					2.48	1.95	2.22	1.20
21					1.53	2.66	0.51	0.48					0.51	0.64	0.93	0.92
22					0.48	1.23	0.38	0.80					1.45	1.27	1.73	1.15
23					0.29	1.02	0.16	0.60					1.28	0.77	1.83	0.97
24					0.27	0.90	0.23	0.66					0.61	0.84	1.04	0.85
25					0.22	0.84	0.17	0.56					0.55	0.93	0.96	0.75
26					0.20	0.85	0.29	0.41					0.82	0.89	1.36	0.78
27					0.47	1.25	0.51	0.62					0.81	0.87	1.18	1.11
28					0.45	1.21	0.56	0.56					0.95	1.25	1.30	0.85
29					0.38	0.88	0.60	0.76					0.89	0.73	1.51	0.78
30					0.63	1.36	0.73	0.70					0.46	0.78	0.91	0.68

Acute toxicity of metals and Modified Hazard Quotient (mHQ)

The results of Modified Hazard Quotient mHQ metals in Anzali wetland showed that the rate of Pb pollution was low to moderate (mHQ values in the range of less than 0.5 to 2); for Zn metal, the risk of significant pollution (mHQ value less than 0.5 to 2.5); and for Cu, the risk of pollution is very low to moderate (mHQ value is between 0.5 and 2). In Shadegan wetland, since Modified Hazard Quotient for all three Pb, Cu and Zn metals are in the range of 0.5-0.46 The state of pollution of very low sediments; In Meighan Modified Hazard Quotient wetland for Pb and Cu at different stations in the range of 1-0 (low or very low pollution), the Zn concentration in the range of 3.5-5.0 indicates that the different pollution levels in different stations are insignificant to high pollution. Also, in Hashilan Modified Hazard Quotient wetland for Pb and Zn at different stations in the range of 1-0 (low or very low pollution), but for Cu metal, in the range of 0.5-1.5, the pollution situation at the station Various variables range from low to low pollution (Table 4).

Table 4) values of the acute toxicity of metals and Modified Hazard Quotient (mHQ) in surface sediments of studied wetlands

Station	**Hashilan**				**Mighan**				**Shadegan**				**Anzali**			
	∑TU	**mHQ**			∑TU	**mHQ**			∑TU	**mHQ**			∑TU	Mhq		
		Cu	Zn	Pb		Cu	Zn	Pb		Cu	Zn	Pb		Cu	Zn	**Pb**
1	0.46	1.16	0.61	0.64	0.27	0.90	0.29	0.64	0.47	0.94	0.62	0.91	1.64	1.41	1.89	1.01
2	0.38	1.04	0.55	0.58	0.27	0.89	0.35	0.61	0.50	0.95	0.59	1.00	2.00	1.40	1.99	1.50
3	0.29	0.91	0.49	0.52	0.36	1.19	0.35	0.46	0.46	0.90	0.56	0.98	1.06	1.18	1.32	1.17
4	0.37	0.95	0.68	0.53	1.42	2.53	0.31	0.73	0.49	0.92	0.60	1.00	1.07	1.12	1.29	1.27
5	0.33	0.90	0.62	0.52	0.28	0.90	0.30	0.66	0.49	0.95	0.61	0.97	1.14	1.18	1.34	1.28
6	0.29	0.85	0.56	0.51	0.35	0.92	0.61	0.59	0.50	0.97	0.61	0.98	1.24	1.17	1.44	1.33
7	0.20	0.71	0.43	0.48	0.32	1.05	0.32	0.56	0.48	0.91	0.59	1.00	0.84	0.95	1.22	1.05
8	0.25	0.78	0.50	0.50	0.34	0.88	0.30	0.87	0.47	0.95	0.61	0.93	0.77	0.91	1.18	0.98
9	0.32	0.93	0.56	0.54	0.29	0.96	0.35	0.59	0.47	0.99	0.61	0.89	0.94	1.07	1.34	0.98
10					0.61	1.53	0.31	0.72	0.49	1.00	0.61	0.93	0.95	0.92	1.47	0.87
22					0.39	1.22	0.30	0.57					1.25	1.19	1.59	1.06
12					0.33	0.99	0.32	0.68					1.24	1.17	1.65	0.94
13					0.20	0.74	0.33	0.52					0.85	0.77	1.47	0.75
14					0.31	1.04	0.33	0.56					1.17	1.23	1.72	0.38
15					0.24	0.82	0.33	0.59					1.17	1.27	1.52	0.94
16					0.34	0.98	0.34	0.73					1.13	1.29	1.51	0.83
17					0.35	1.03	0.36	0.68					1.05	1.21	1.48	0.78
18					2.03	3.03	0.35	0.88					1.34	1.32	1.68	0.96
19					0.31	1.10	0.31	0.46					1.76	1.54	1.96	0.94
20					0.59	1.52	0.29	0.70					2.48	1.95	2.22	1.20
21					1.53	2.66	0.51	0.48					0.51	0.64	0.93	0.92
22					0.48	1.23	0.38	0.80					1.45	1.27	1.73	1.15
23					0.29	1.02	0.16	0.60					1.28	0.77	1.83	0.97
24					0.27	0.90	0.23	0.66					0.61	0.84	1.04	0.85
25					0.22	0.84	0.17	0.56					0.55	0.93	0.96	0.75
26					0.20	0.85	0.29	0.41					0.82	0.89	1.36	0.78
27					0.47	1.25	0.51	0.62					0.81	0.87	1.18	1.11
28					0.45	1.21	0.56	0.56					0.95	1.25	1.30	0.85
29					0.38	0.88	0.60	0.76					0.89	0.73	1.51	0.78
30					0.63	1.36	0.73	0.70					0.46	0.78	0.91	0.68

Ecotoxicology Estimation

The findings of the investigation of the strength and the probability of the effect of heavy metals on the Zn of organisms using two, probable effect level (PELQ) and Effect range median (ERMQ) showed that the ERMQ index in Shadegan and Hashilan wetlands stations less than 0.1. Also, in these wetlands, the PELQ index was in the low toxicity and low toxicity class (less than 0.1 and 0.5-0.0), which indicates the low toxicity of wetland sediments for living organisms. Ecological toxicity at all stations, the Anzali wetland, with the exception of Station 20 (Cu Avi 0.59) was ranged from 0.1 to 0.5 with a low risk of pollution. In addition, the results of calculating the PELQ index in the Anzali wetland showed that the rate for the stations is in the range of 0.1 to 1.5, which indicates low to medium heavy metals for living organisms in the wetland. In the Meighan wetland, the ERMQ index is in the low toxicity and low toxicity class (less than 0.1 and 0.5-0.0). The PELQ index at all stations was between 0.1-0.5 and less than 0.1, indicating low toxicity of sediment for living organisms (Table 5).

Table 5) the results of the toxicity of the Anzali, Shadegan, Meighan and Hashilan wetlands sediments using two, probable effect level (PELQ) and Effect range median (ERMQ)

Station	PELQ				ERMQ			
	Hashilan	Mighan	Shadegan	Anzali	Hashilan	Mighan	Shadegan	**Anzali**
	0.15	0.07	0.18	0.98	0.09	0.04	0.08	0.41
1	0.13	0.08	0.18	1.16	0.08	0.04	0.09	0.49
2	0.10	0.08	0.17	0.55	0.06	0.04	0.08	0.24
3	0.15	0.23	0.18	0.55	0.08	0.14	0.09	0.24
4	0.13	0.07	0.18	0.58	0.07	0.04	0.09	0.26
5	0.11	0.14	0.18	0.66	0.06	0.06	0.09	0.29
6	0.07	0.08	0.18	0.46	0.04	0.04	0.08	0.20
7	0.09	0.10	0.17	0.42	0.05	0.05	0.08	0.18
8	0.12	0.08	0.17	0.52	0.07	0.04	0.08	0.23
9		0.12	0.18	0.59		0.07	0.08	0.25
10		0.08		0.72		0.05		0.31
22		0.08		0.75		0.04		0.32
12		0.06		0.57		0.03		0.24
13		0.08		0.75		0.04		0.31
14		0.07		0.65		0.04		0.28
15		0.09		0.64		0.05		0.27
16		0.09		0.61		0.05		0.26
17		0.33		0.78		0.20		0.33
18		0.07		1.04		0.04		0.44
19		0.12		1.38		0.07		0.59
20		0.27		0.28		0.16		0.12
21		0.12		0.85		0.06		0.36
22		0.06		0.88		0.03		0.36
23		0.06		0.33		0.04		0.14
24		0.05		0.28		0.03		0.12
25		0.05		0.51		0.03		0.21
26		0.13		0.44		0.07		0.19
27		0.14		0.50		0.07		0.22
28		0.15		0.60		0.07		0.25
29		0.21		0.25		0.10		0.11

Discussion

Considering the importance of the health and ecological hazards of heavy metals in the environment and the impact of various organisms in various aquatic environments, their concentration in various levels of aquatic ecosystems, in order to evaluate the human and environmental hazards and threats Environmental considerations are considered. Since sediments are constantly absorbing pollutants and have the ability to deposit metal pollutants transported from drought environments in the water column, they are very good environmental indicators that are powerfully influenced by human and human pollution. It's even natural (27).

In general, the average total concentration of heavy metals in the sediments is different in the Anzali, Shadegan, Meighan and Hashilan wetlands in the Anzali and Hashilan wetlands: Zn>Cu>Pb; Shadegan: Zn>Pb>Cu and Meighan: Cu>Zn>Pb. Pb, Cu and Zn elements are important environmental pollutants that enter natural and abnormal natural, non-point sources such as oil and petrochemical industries, urban and rural sewage into aquatic ecosystems (28,29). In this study, due to the average total concentration obtained and its comparison with the mean Earth crust, sediments of wetlands are of low or moderate pollution. Considering the results of other studies and environmental evidence, it is likely that the high amounts of some of the metals in

Shadegan's wetland are of widespread human activities, such as oil and petrochemical extraction, sewage entering, and urban and rural runoffs. In Meighan wetland, high concentrations of Cu compared to other studied metals could be due to the presence of Iran's salary plant, Arak urban wastewater treatment plant, Arak airport, existing industrial sectors and agricultural land in the neighboring areas. Also, according to available evidence, the expansion of human activities such as construction, agricultural and industrial activities, fishing and tourism are factors that affect the environment, and as a result, the entry of heavy metals into the Anzali and Hashilan wetlands. the amount of phenol at different times and (30) is difficult and needs of these assessments and comparisons cautious, but the results of concentrations of metals wetlands Anzali, Shadegan, Meighan and Hashilan other aquatic ecosystems Shows that the concentration of metals in sediments of these wetlands is less or less dependent on the type of metal and place of measurement than elsewhere in the world. (Table 6).

Table 6) Comparison of mean concentrations of Pb, Cu and Zn (mg/kg) in the present study with some Iranian and world wetlands

Location		Zn	Cu	Pb	Reference
Taranto Gulf (Ionian Sea, Southern Italy)		102.3	47	59	(31)
plateau lake China		86.82	31.4	43.19	(32)
Al Hawizah Iran		61.25	67.44	-	(33)
Yunxiao, Fujian, China		83.4	25.4	64.4	(34)
Lake Bourget, France		42.89	3.86	4.47	(35)
Beihai, Guangxi, China		9	3	7	(36)
This study	Anzali	173.93	28.07	23.78	-
	Shadegan	28.01	19.44	22.83	-
	Mighan	11.41	38.23	9.91	-
	Hashilan	24.22	18.40	6.91	-

Risk Indices

The results of calculating the environmental risk index of heavy metals in surface sediments of the studied wetlands showed that the environmental hazard of these metals in sediments of the wetlands is less than 150 (below 150), which indicates a low risk of metals in sediments. Mortazavi and Hatami (2018) evaluated the ecological risk of heavy metals in the Bashar River, which is consistent with these findings (37). In addition, the trend of total hazard of metals in Anzali and Shadegan wetlands was evaluated as (Zn>Cu>Pb) and for two Meighan and Hashilan wetlands (Zn>Pb>Cu). The quality indices of pollution are good indicators for assessing the pollution of heavy metals in sediments (8).

The results of the study of the acute toxicity potential of heavy metals in the sediments of the studied wetlands in all studied stations were less than 4 bustards, which indicate that there is no acute toxicity in the sediments of each wetland.

The results of biosynthesis of sediments of wetlands showed that ERMQ index in Anzali and Meighan wetlands was found in low toxicity and low toxicity and in Shadegan and Hashilan wetlands in non-toxic level. In addition, the results of the calculation of the PELQ index of Anzali wetland suggesting a low to moderate toxicity of heavy metals in the Shadegan wetland showed low toxicity and also

in the two Meighan and Hashilan wetlands, indicating the lack of toxicity and toxicity of the wetland sediments for living organisms.
Investigation of Sucrose Biomechanical Properties Using SQGs of Canada Sediment Quality Standards and US NOAA Quality Guideline showed that the average concentrations of Pb, Cu and Zn in Anzali wetland deposits were higher than Cu, LEL, and Zn, respectively, according to ERL, TEC, and LEL standards. It shows the presence of pollution of these two metals and their negative impact on living organisms. In Shadegan and Hashilan wetlands, the levels of Pb and Zn are lower than the mentioned standards, but the Cu metal in Shadegan and Hashilan wetlands has a value of LEL and average earth crust. On the other hand, Cu values in the Meighan wetland were higher than LEL, TEC and ERL values. The high Cu values in comparison to the standards expressed in this ecosystem indicate potential negative effects on bird fauna of these ecosystems and, consequently, the food chain (Table 7). Considering the position of the wetland and the presence of extensive human activities in the area and areas around the wetlands, it is essential to adopt appropriate measures that can help to reduce pollutants.

Table 7) Comparison of mean total concentrations of Pb, Cu and Zn, (mg/kg) with NOAA and SQGs standards

Standard		Zn	Cu	Pb	Reference
Metal background guidelines		100	15	5	(24)
ERL		150	34	47	(23)
ERM		410	270	218	(23)
TEC		121	31.6	38.8	(23)
PEC		459	149	128	(38)
LEL		120	16	31	(38,39)
SEL		820	110	250	(24)
This study	**Anzali**	173.93	28.07	23.78	
	Shadegan	28.01	19.44	22.83	
	Mighan	11.41	38.23	9.91	
	Hashilan	24.22	18.40	6.91	

Conclusion

The present research was aimed to shed lights on shed lights on Modified Hazard Quotient (mHQ), acute toxicity and ecological risk of heavy metals Pb, Cu and Zn by using sediment quality indices in surface sediments of Anzali, Shadegan, Meighan and Hashilan wetlands. Based on the findings, it can be determined that although the amount of heavy metals present in these wetlands is in the low and moderate pollution potential in terms of acute toxicity, ecological risk and Modified Hazard Quotient (MHQ), the development of urbanization is a growing trend for various industries, of the industries related with oil and petrochemicals, agriculture, industry and settlement in the area of these wetlands and the entry of untreated urban and rural waste, they are worrying. Also, based on estimating and predicting the probability of adverse effects of these pollutants on living organisms using SQGs and NOAA sediment quality indices, it can be concluded that the high Cu values equated to the ERL standard in Anzali, Shadegan and Hashilan wetlands, as well as more The average concentration of Cu and Zn metals from the ERL, TEC, and LEL standards in Meighan and Anzali wetlands respectively, along with the pollution of these metals and the presence of large sources of pollution in these ecosystems, shows the potential for its negative impact on the bird fauna of these ecosystems and as a consequence of the food chain, this canvas will be constructed. Finally, the need for continuous monitoring of surface sediments of these wetlands and living organisms is emphasized in order to evaluate the ecological risk of wetlands.

Footnotes

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