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Assessment of Sediment Quality Collected from AL-Hawizeh Marsh, Southern Iraq

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Abstract

A study was carried out to investigate the concentrations and spatial distribution of trace metals in the sediments of AL-Hawizeh Marsh in the southern part of Iraq . Sediment samples were taken from five sampling stations (Al-Adaim-1, Al-Adaim-11, Um El-Nia'j , Al-Soudah , Al-Baida).

Mean of concentrations of metals in the sediments ranged from 1365 to 3735 for Fe, 4.50 to 10.50 for Zn, 4.15 to 8.15 for Cu and 6.00 to 7.70 $mgkg^{-1}$ for Pb . The degree of contamination in the sediments has been evaluated using Enrichment factor (EF), Geoaccumulation index (I_{geo}), Contamination factor (CF) and pollution load index (PLI) . EF indicates that Fe, Zn, Cu and Pb in sediments ranged from depletion to significantly enrichment while at station 1 Pb are very highly enriched. Igeo values showed that the sediments were background contamination ($I_{geo}<1$) for all stations . CF also show that the sediments have low contamination (CF<1) .PLI of the studied area ranged from 0.107 to 0.163 which indicated that the Marsh sediments were unpolluted (PLI=0-1).

Key words: AL-Hawizeh Marsh; heavy metal concentration; enrichment factor; geoaccumulation index; pollution load index

1- Introduction

The Iraqi Marshlands are one of the finest and most extensive natural wetland ecosystems (Evans, 2002). The Mesopotamian marshlands are located mostly in south-eastern Iraq but also extend across the border into Iran. They once covered an area 20000 km^2 between the three Iraqi cities of Amarah in the north, Basrah in the south, Naseriyah in the west and the Iranian town of Hawizeh in the east. The marshlands straddled the Euphrates and Tigris rivers and part of the Shatt Al-Arab which forms when these two rivers join together. The area consisted of interconnected lakes, mudflats and wetlands, and supported an indigenous population of 500,000 as well as numerous endemic species of birds, mammals, amphibians, reptiles, fish and invertebrates (Dehghanp-isheh, 2003).

The Mesopotamian marshlands compr-ised of three major wetland areas; the Al-Hawizeh, Al-Hammar and Central marshes. All three were connected by the Tigris and Euphrates rivers from Iraq and the Karkeh River from Iran which converged to form the Shatt Al-Arab waterway in the centre of the three marshes (Ghadiri and Afkhami, 2005a). Around 85% of the Mesopotamian Marshlands have been lost mainly as a result of drainage and damming, (UNEP, 2002), restoration by reflooding of drained Marshes is proceeding, and the ecological effects of this massive water diversion need elaborated research. Hence, the reflooding of southern Iraq's Mesopotamian Marshes is a giant ecosystem-level experiment (Richardson & Hussain, 2006).

Sediments are important carriers of trace metals in the environment and reflect the current quality of the system, sediments usually provide a record of catchments inputs into aquatic ecosystems, natural sediment formed during weathering process might be modified markedly during transportation and deposition by chemical of anthropogenic origin (Chapmann, 1992).

Trace metals are among the most common environmental pollutants and their occurrence in waters, sediments and biota indicate the presence of natural or anthropogenic sources. The existence of trace metals in aquatic environments has led to serious concerns about their influence on plants and animals life (Sheikh et al., 2007 ; Zvinowanda *et al.,* 2009).

The behavior of metals in natural waters is a function of the substrate sediment composition, the suspended sediment composition and the water chemistry (Shrestha *et al.,* 2007 ; Harikumar *et al.,* 2009). Recent studies reveal that the accumulation and distribution of hydrocarbons, trace metals and chlorinated compounds in soil, water and environment are increasing at an alarming rate causing deposition and sedimentation in water reservoirs and affecting aquatic organisms (Hobbelen *et al.,* 2004).

To assess the environmental impact of contaminated sediments, information on total concentrations is not sufficient and particular interest is the fraction of the total trace metal content that may take part in further biological processes (Al-Haidarey, 2009).The overall behavior of trace metals in an aquatic environment is strongly influenced by the associations of metals with various geochemical phases in sediments (Forstner and Wittmann, 1983 ; Horowitz, 1991).

The aim of this study is measure the concentration of trace metals and their association with various geochemical substrates in sediments of Ai-Hawizeh Marsh and to assess the contribution of anthropogenic activities in sediment pollution .

Study area

Al-Hawizeh Marsh lies between 31°00’-31°45’ N, 47°25’-47°50’ E (Figure 1). The Iranian section of the Marshes is known as Al-Azim Marsh , were it is fed primarily by the Karkeh River. In Iraq, this Marsh is largely fed by two main distributaries departing from the Tigris River near Amarah city, known as Al-Musharah and Al-Kahla.

2- Materials and Methods

Sediment sampling

Five stations in Al-Hawizeh Marsh were selected in this study. Two stations in Al-Adaim, one station in Um El-Nia’j, one station in Al-Soudah and one station in Al-Baida (Figure 1). Sediment samples were collected on February, 2009. The sample mass collected by hand in each case was about 500gm. Samples were air dried in the laboratory at room temperature, ground in fine mixture using mortar and pestle before sieved under 2 mm mesh. The samples were then stored in a polyethylene container ready for digestion and analysis (Jose *et al.,* 2005).

Analysis of sediments

One gram of dried sediment sample was transferred to 100 mL quartz tube and digested in concentrated HNO_3 and HCL (1:3 v/v) on a hot plate . The tubes were cooled and volumes prepared with double distilled water in volumetric flask. The digested samples were analyzed for Fe, Zn, Cu and Pb according to APHA (1998) on Atomic Absorption spectrophotometer Technique .

Determination of enrichment factor

To evaluate the magnitude of source material to that found in the Earth's crust (Huheey, 1983) and following equation was used to calculate the EF_C as contaminants in the environment, the enrichment factors (EF) were computed relative to the abundance of species in proposed by Atgin *et al.,* (2000) .

$$\mathbf{EF = (C_M / C_{Fe})_{sample} / (C_M / C_{Fe})_{Earth's\ crust}}$$

Were, $(C_M / C_{Fe})_{sample}$ is the ratio of concentration of trace metal (C_M) to that of Fe (C_{Fe}) in the sediment sample and $(C_M / C_{Fe})_{Earth's\ crust}$ is the same reference ratio in the Earth's crust. The average abundance of Zn, Cu and Pb (70 , 55 and 12.5 µg /g, respectively) and the reference value of Fe is 5.2% was selected as the reference element, due to its crustal dominance and its high immobility (Huheey, 1983).

Determination of geoaccumulation index

The geoaccumulation index I_{geo} values were calculated for different metals as introduced by Muller (1969) is as follows :

$I_{\mathbf{geo}} = \log_2 C_{\mathbf{n}} / 1.5\, B_{\mathbf{n}}$

Where, C_n is the measured concentration of element n in the sediment and B_n is the geoaccumulation background for the element n which is either directly measured in precivilization sediments of the area or taken from the literature (average shale value described by Turekian and Wedepohl , 1961) . The factor 1.5 is introduced to include possible variation of the background values that are due to lithologic variations.

Determination of pollution load index

The pollution load index (PLI) proposed by Tomlinson *et al.,* (1980) has been used in this study to measure PLI in sediments of AL-Hawizeh Marsh. The PLI for a single site is *n*th root of n number multiplying the contamination factors (CF values) together . The CF is the quotient obtained as follows :

$CF = C_{\text{Metal concentration}} / C_{\text{Background concentration of the same metal}}$ and ***LI for site*** $= {}_{\mathbf{n}}\text{th}\sqrt{CF_1 \times CF_2 \ldots\ldots \times CF_n}$

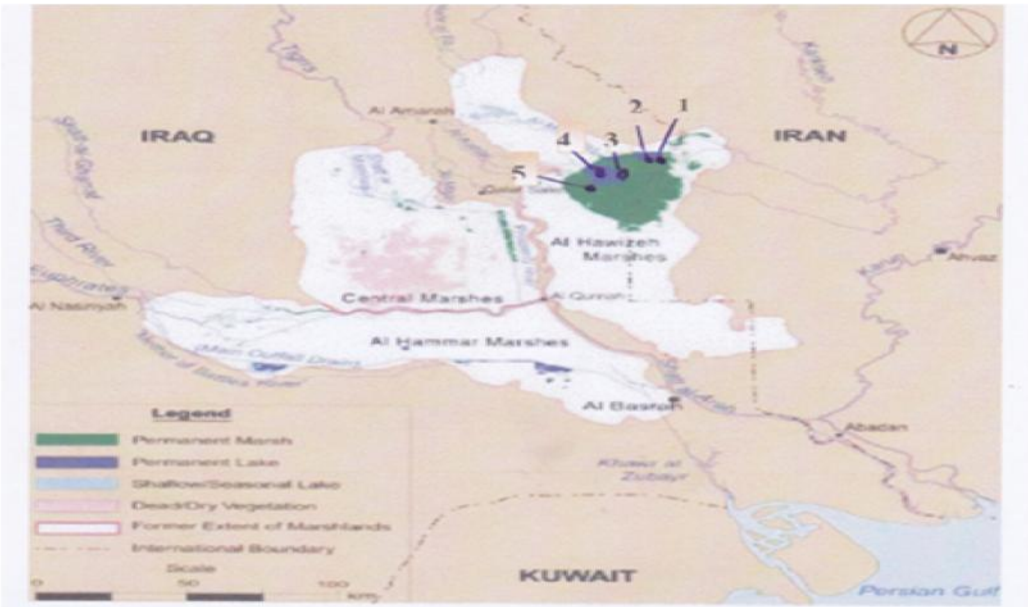

Figure 1. The studied stations in Al-Hawizeh Marsh. Al-Adaim-I & II (1 and 2), Al-Soudah(3), Um-El-Nia'i(4) and Al-Baida (5)

3- Results and Discussion

In order to asses the metals content in AL-Hawizeh Marsh sediments, it is important to establish the allowable levels of these metals, heavy metals may be incorporated in to the aquatic system from anthropogenic sources. However, knowledge of the distribution and concentrations of the heavy metals in the sediments will help to detect the source of pollution in the aquatic systems (Elias *et al*., 2011) .

The total concentration of heavy metals in sediments for each station in this study were shown in Table 1. Metal contents were ranging over following intervals: Fe: (1365–3735) ; Zn: (4.50–10.50) ; Cu: (4.15–8.15) and Pb: (6.00–7.70) mg kg^{-1} respectively. Mean contents of this metals were : Fe (2465) ; Zn (7.10) ; Cu (5.79) and Pb (7.06) mg kg^{-1} respectively, allowing to arrange the metals from higher to lower mean content in this area as : Fe > Zn > Pb > Cu .

The background value gives the normal abundance of an element. The mean concentration of Fe, Zn, Cu and Pb in sediments of all the stations are lower than the background values (Table 1) (Martin and Meybeck, 1979). This may be attributed to the removing of these metals by many ways such as adsorption by particulate matter, precipitation deposition and removal by organism (Mohiuddin *et al.,* 2010). On the other hands, sediments of marshes containing high amount of organic materials are be complex compound with elements by exchangeable and chemical reactions (Al-Haidarey *et al.,* 2009).

From the EF values in tables 2&3, EF value of Zn was ranged from depletion to minimally enriched at Um El-Nia'j station (1.72) and Al-Baida station (0.89) while other stations, AL-Adaim-1 (4.35), AL-Adaim-11 (3.22) and Al-Soudah (2.33) tends towards moderately enriched . Cu at all stations tends towards moderately enriched . EF value of Pb at AL-Adaim-1 station (22.85) is very highly enriched while others, AL-Adaim-11(14.42), Um El-Nia'j (13.67), Al-Soudah (8.73) and Al-Baida (8.57) tends towards significantly enriched.

Elements which are naturally derived have an EF value of nearly unity while elements of anthropogenic origin have EF values of several orders of magnitude (Sekabira *et al.,* 2010). According to Harikumar and Jisha (2010), EF values greater than 1.5 have such heavy metals derived from other sources suggesting environmental contamination by those particular heavy metals. It is presumed that high EF values indicates an anthropogenic source of trace metals mainly from activities such as accumulation of organic materials , decompositions, and export of particulate organic matter (Al-Saffar, 2006). Science the bioavailability and toxicity of any heavy metal in sediment depend on chemical from and concentration of the metal (Kwon *et al*., 2001), it can be inferred that trace metals in sediments samples with high EF values, along with higher labile fractions in sediments are potential sources for mobility and bioavailability in the aquatic ecosystems (Ameh et al., 2011).

The high concentrations of EF values in some locations above may be attributed to the land base activities, sewage wastes and also from the erosion of
soil (Al-Haidarey et al., 2009).

Geoaccumulation index (I_{geo}) values were shown in Table 4. The negative I_{geo} values are indicating that there are no significant contaminations or background level of element in sediments of AL-Hawizeh Marsh, base on Muller (1981) classification (Table 5). All stations can be categories as background concentration with Fe, Zn, Cu, and Pb (I_{geo} values < 0).
The I_{geo} values for Fe, Zn, Cu and Pb fall in class ″0″ in all the five stations indicating that there is no pollution from these metals in sediments of AL- Hawizeh marsh because all values were below 0 (Table 4).

Contamination factor (CF) and pollution load index (PLI) values was shown in Table 6a&b . The concentration of metals Fe, Zn, Cu and Pb were present at much lesser concentrations. From the contamination factor calculations, it was found that all stations were low contamination (CF < 1).
PLI values were ranged from 0.107 – 0.163 clearly indicated that the overall sediments of AL-Hawizeh Marsh can be classified as unpolluted sediments (PLI= 0-1).The PLI value of >1 is polluted whereas <1 indicates no pollution. Lower values of PLI imply no appreciable input from anthropogenic sources. There is, in general, a decrease in PLI values at all stations indicating dilution and dispersion of metal content with increasing distance from pollution sources (Ameh et al., 2011 ; Chakravarty and Patgiri , 2009).

Table (1): Total concentration of heavy metals (mg kg^{-1} dry weight) in sediment samples collected from AL-Hawizeh Marsh

Stations	Fe	Zn	Cu	Pb
AL-Adaim-1	1365	8.00	4.15	7.50
AL-Adaim-11	1730	7.50	4.40	6.00
Um El-Nia'j	2160	5.00	5.00	7.10
Al-Soudah	3335	10.50	7.25	7.00
Al-Baida	3735	4.50	8.15	7.70
Mean	2465	7.10	5.79	7.06
Maximum	3735	10.50	8.15	7.70
Minimum	1365	4 .50	4.15	6.00
Background	35900	129	32	20

Table (2): Enrichment Factor (EF) of heavy metals in sediments of AL-Hawizeh Marsh .

Heavy metals	**Sample stations**				
	AL-Adaim-1	**AL-Adaim-11**	**Um El-Nia'j**	**Al-Soudah**	**Al-Baida**
Zn	**4.35**	**3.22**	**1.72**	**2.33**	**0.89**
Cu	**2.87**	**2.40**	**2.18**	**2.05**	**2.06**
Pb	**22.85**	**14.42**	**13.67**	**8.73**	**8.57**

Table(3): Enrichment Factor (EF) of heavy metals with respect to each location and class classification (Sutherland *et al.,* 2000).

EF Indices	**Degree of Enrichment**	**Heavy metals**
EF < 2	**Depletion to minimal enrichment**	**Zn**
2 < EF < 5	**Moderate enrichment**	**Zn, Cu**
5 < EF < 20	**Significant enrichment**	**Pb**
20 < EF < 40	**Very high enrichment**	**Pb**
EF > 40	**Extremely high enrichment**	

Table(4): Geoaccumulation index (I_{geo}) of heavy metals in sediments of studied stations.

Stations	I_{geo} Fe	I_{geo} Zn	I_{geo} Cu	I_{geo} Pb
AL-Adaim-1	- 5.83	- 3.71	- 4.31	- 1.32
AL-Adaim-11	- 5.49	- 3.81	- 4.23	- 1.64
Um El-Nia'j	- 3.58	- 4.39	- 4.04	- 1.40
Al-Soudah	- 4.55	- 3.32	- 3.51	- 1.42
Al-Baida	- 4.38	- 4.54	- 3.34	- 1.28

Table (5): The seven classes of the Geoaccumulation index (Muller, 1981)

Class	Range	Interpretation (Quality)	Heavy metals
0	Igeo≤ 0	Practically uncontaminated	Fe,Zn,Cu,Pb
1	0 <Igeo< 1	Uncontaminatedto moderately contaminated	
2	1 <Igeo< 2	Moderately contaminated	
3	2 <Igeo< 3	Moderately to heavily contaminated	
4	3 <Igeo< 4	Heavily contaminated	
5	4 <Igeo< 5	Heavily to very heavily(extremely)contaminated	
6	Igeo> 5	Very heavily (extremely) contaminated	

Table 6 a&b : Contamination factor (CF), pollution load index (PLI) of heavy metals in sediments and classes (Hakanson , 1980)

Heavy metals	Stations				
	AL-Adaim-1	AL-Adaim-11	Um El-Nia'j	Al-Soudah	Al-Baida
Fe	0.026	0.033	0.041	0.064	0.072
Zn	0.114	0.107	0.071	0.150	0.064
Cu	0.075	0.080	0.091	0.132	0.148
Pb	0.600	0.480	0.568	0.560	0.616
PLI	0.107	0.108	0.111	0.163	0.143

Contamination Factor (CF) Indices	Degree of contamination	Heavy metals
CF< 1 1 ≤ CF < 3 3 ≤ CF < 6 6 ≤ CF	Low contamination Moderate contamination Considerable contamination Very high contamination	Fe, Zn, Cu , Pb

4- Conclusion

This study revealed that the enhanced concentration of some trace metals in wetlands areas like AL-Hawizeh Marsh is due to anthropogenic influences. Distribution pattern of trace metals in the sediments according to EF were ranged from minimally to significantly polluted with Zn, Cu and Pb at all stations, while was very high polluted with Pb at AL-Adaim-1 station, Geoaccumulation index (I_{geo}) of all sediments can be classified as background polluted (I_{geo}< 0). Contamination factor (CF) of sediments can be classified as low contamination (CF< 1). However, the PLI values can be classified as unpolluted (PLI=0-1).

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تقييم نوعية رواسب مختارة من هور الحويزة ، جنوب العراق

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الخلاصة

أجريت الدراسة لفحص توزيع تراكيز بعض العناصر النادرة (Pb , Cu , Zn , Fe) في رواسب هور الحويزة في الجزء الجنوبي من العراق . أخذت العينات من خمس محطات (العظيم-1 ، العظيم-11 ، السودة ، أم النعاج ، البيضة) . تراوح معدل تركيز هذه العناصر من 1365 إلى 3735 ملغم/كغم حديد ، ومن 4.50 إلى 10.50 ملغم/كغم زنك ، ومن 4.15 إلى 8.15 ملغم/كغم نحاس ، ومن 6.00 إلى 7.70 ملغم/كغم رصاص . قُيِّمَت درجة تلوث الرواسب باستعمال معامل الأغناء Enrichment Factor (EF) ودليل التجمع الجيولوجي Geoaccumulation index (I_{geo}) ومعامل التلوث Contamination Factor (CF) ودليل التلوث Pollution Load Index (PLI) . تراوحت درجة تلوث الرواسب بالعناصر المدروسة من الضئيلة جداً إلى المعنوية وفقاً إلى معامل الأغناء لجميع المحطات عدا المحطة الأولى كانت عالية التلوث جداً بالرصاص . أما قيم دليل التجمع الجيولوجي فقد أظهرت عدم تلوث الرواسب في جميع محطات الدراسة (Igeo<1) . في حين أظهرت الرواسب درجة تلوث واطئة وفقاً إلى قيم معامل التلوث (CF<1) . أما قيم دليل التلوث PLI فقد تراوحت بين 0.107 إلى 0.163 حيث بينت النتائج عدم تلوث الرواسب بالعناصر النادرة قيد الدراسة . (PLI=0-1)