Original Article

Analysis of Heavy Metals in Surface Sediments from Agh Gel Wetland, Iran

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ABSTRACT

Background: Soil and sediment serve as major reservoir for contaminants as they possess ability to bind various chemicals together. In this study the concentrations of heavy metals Cd, Cr and Cu were analyzed in surface sediments of Agh Gel Wetland in west of Iran.

Methods: The sediment samples were taken from 10 stations. The samples were subjected to bulk digestion and chemical partitioning and Cd, Cr and Cu concentrations of the sediments were determined by ICP-OES. Geo-accumulation index (I-geo), Contamination factor (CF) and Pollution load index (PLI) were used to evaluate the magnitude of contaminants in the sediment profile.

Results: The mean sediment concentrations (mg kg^{-1} dry weight) ranged within 0.20-0.29 (Cd), 58-71 (Cr) and 23-36 (Cu). According to the I-geo values, the sediments' qualities are classified as unpolluted to moderately polluted category. According to the CF values, the sediments' qualities are classified as low to moderate contamination. Furthermore, the PLI values indicated that there were no metal pollution exists for all sampling stations.

Conclusion: The Agh Gel Wetland is potential to be threatened by chemical pollutants such as agricultural effluent. So to preserve the environment of the Agh Gel Wetland from deterioration, periodically monitoring of the water and sediment qualities is recommended.

Keywords: Agh Gel Wetland, Anthropogenic, Geochemical Indices, Heavy Metals, Sediment.

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INTRODUCTION

The clay, sand, silt, and organic particles deposited at the bottom of a water body as sediments come from soil erosion and decay of plants and animals; wind, rain, and anthropogenic activities may carry these particles into aquatic ecosystems especially rivers, lakes, and streams. Once inorganic and organic particulate are in the aquatic environment, heavy metals are adsorbed onto them and are incorporated into sediment resulting in raised levels of heavy metals in bottom sediment [1, 2].

Due to rapid urbanization and industrialization, heavy metals were continuously introduced into the aquatic environment [3-5]. Because the most of the aquatic organisms are not adapted to deal with trace elements, they are some of the main sources of metal toxicity problems in the aquatic environment especially when toxic metals occur above threshold concentrations [6].

However, heavy metals are natural components of natural waters and some of them such as Co, Fe, Mn, Mo, Se and Zn are present at low contents and are biologically important in the aquatic environment. Heavy metals enter natural waters from various sources. In this regard, the natural geological weathering of rocks and soil, is usually the largest natural source. The other main source of heavy metals is anthropogenic input from domestic, mining, farming, and other industrial manufacturing activities such as discharge from waste water from smelting and metal engraving industries. Once inorganic and organic particulate are in the aquatic environment, metals are adsorbed onto they and are incorporated into sediment resulting in elevated levels of heavy metals in bottom sediment [6-8].

From four decades ago, many efforts around the world have been undertaken to assessment the behavior and distribution of heavy metals in sediments from the aquatic ecosystems [2]. In this regards, geochemical study has been used widely to estimate the impact of human activities and the degree of metal pollution on sediment quality [9-11].

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Therefore the aim of this study is assessing the level of heavy metal concentrations (Cd, Cr and Cu) in surface sediments of Agh Gel Wetland and investigation of geochemical indices including Sediment contamination factor (CF), Pollution load index (PLI) and Geo-accumulation index (I-geo) in sediment samples.

MATERIALS AND METHODS

Study Area and Sample Sites

Agh Gel Wetland is located between Hamadan and Markazi Provinces, Iran (49˚ 15´E; 34˚ 32´ 34´´ N) with an area of approximate 17.5 km^2 and 0.5 m deep [12].

Chemical and Reagents

All chemical reagents were purchased from Merck and Sigma-Aldrich (Germany). All solutions were prepared with doubly distilled water. Stock standard solution of metals (Cd (II), Cr (VI) and Cu (II)) were prepared by dissolving the adequate amount of metal salts in doubly distilled water and diluting to 1000 ml in the volumetric flask.

Sediment Sampling and Metal Analysis

Sediment specimens were collected at 10 sampling station from Agh Gel Wetland using a modified Peterson dredge sampler from November 2012 to January 2013 in 3 replicates. Sediment samples put inside polyethylene bags and stored under 4 °C. Each sediment sample was dried in an oven at 105 °C and sieved through a 2mm sieve. Figure 1 shows the sampling stations in the study area

Total concentrations of heavy metals in specimens were measured using acid digestion method. For this purpose 5 ml of mixed acid (nitric acid: perchloric acid:hydrofluoric acid = 4:1:4) was added to 0.1 g of dried sediment samples in a Teflon Digestion Vessel and heated in a sand for one day. Element analyses were performed using the ICP-OES (710-ES, Varian, Australia) [13].

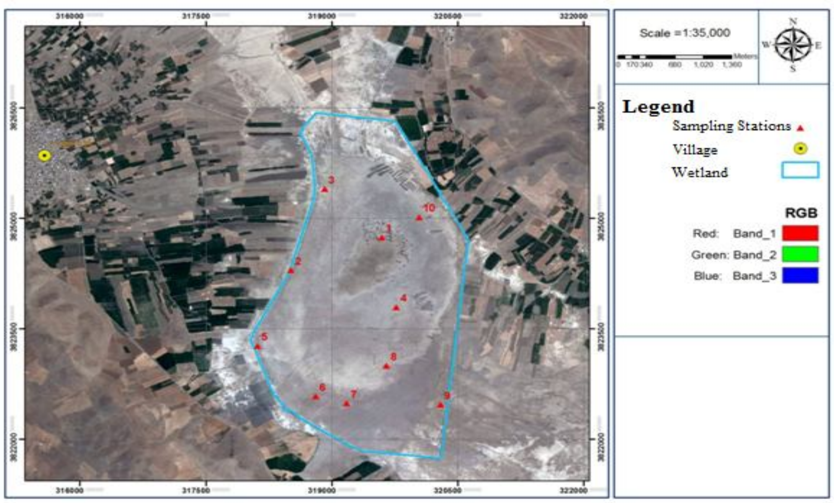

Figure1. Map of sampling stations.

Assessment of Sediments Contamination

Geo-Accumulation Index (I-Geo)

The geo-accumulation index (I-geo) that introduced by Muller (1981), has been used to evaluate the degree of metal contamination and calculated according to the following equation [14]:

$$I_{geo} = \frac{log_2(Cn)}{1.5(Bn)}$$

where Cn indicative the concentration of metals measured in sediment samples; Bn indicative the geochemical baseline concentration of the metal and factor 1.5 indicative the background matrix correction factor due tolithogenic effects [14].

The geo-accumulation index classified to seven grades. I-geo≤0 indicative unpolluted sediment quality (Class 0); 0<I-geo<1 indicative unpolluted to moderately polluted (Class 1); 1<I-geo<2 indicative moderately polluted (Class 2); 2<I-geo<3 indicative moderately to strongly polluted (Class 3); 3<I-geo<4 indicative strongly polluted (Class 4); 4<I-geo<5 indicative strongly to very strongly polluted (Class 5); and 5<I-geo indicative very strongly polluted (Class 6) [15].

Contamination Factor (Cf)

The CF is the parameter obtained by dividing the concentration of each metal in the sediment by background value:

$$CF = \frac{C_{heavy\,metal}}{C_{background}}$$

CF values were suggested by Hakanson [16], where: CF<1= low contamination; 1<CF<3= moderate contamination; 3<CF<6= considerable contamination; and CF> 6= very high contamination [14].

Pollution Load Index (Pli)

This index assessed the level of metal pollution and calculated according to the following equation:

$PLI = \sqrt[n]{(CF_1 x CF_2 x CF_3 x \ldots x CF_n)}$

If PLI>1, it means that a pollution exists; and if PLI<1 it means no metal pollution exist [17].

RESULTS

The descriptive statistics of heavy metals concentration in the sediment samples from Agh Gel Wetland are shown in Table 1.

Pearson correlation coefficient between the elements and the I-geo, CF and PLI values are presented in Tables 2 and 3, respectively.

Table 1. Heavy metals concentration (mg kg^{-1}) in the sediment samples of Agh Gel Wetland.

Sampling station Metal	Cd	Cr	Cu
1	0.27^{d*}	66^{e}	28^{c}
2	0.27^{d}	58^{a}	23^{a}
3	0.27^{d}	67^{e}	24^{ab}
4	0.20^{a}	63^{d}	31^{e}
5	0.24^{bc}	71^{g}	28^{c}
6	0.29^{e}	69^{f}	35^{f}
7	0.23^{b}	62^{cd}	25^{b}
8	0.23^{b}	62^{cd}	29^{cd}
9	0.25^{c}	60^{b}	30^{de}
10	0.21^{a}	61^{bc}	36^{f}
Min	0.20	58	23
Max	0.29	71	36
Mean	0.25	63.90	28.90
SD	0.03	4.17	4.33
Background[18]	1.1	31	25

*a, b, c… – the letters represent the statistical differences between mean values of heavy metal contents among the different sampling stations according to Duncan Multiple Range Test (p= 0.05).

Table 2. Pearson correlation coefficient matrix for heavy metals.

Element	Cd	Cr	Cu
Cd	1	0.325	-0.259
Cr		1	0.141
Cu			1

* Correlation is significant at the 0.05 level (2-tailed).

Table 3. Geo-accumulation index, Contamination factor and Pollution load index for sediments from Agh Gel Wetland.

Sampling Station	Cd		Cr		Cu		PLI
	I-geo	CF	I-geo	CF	I-geo	CF	
1	-2.61	0.24	0.50	2.13	-0.42	1.12	0.83
2	-2.61	0.24	0.32	1.87	-0.71	0.92	0.74
3	-2.61	0.24	0.53	2.16	-0.64	0.96	0.79
4	-3.04	0.18	0.43	2.03	-0.27	1.24	0.77
5	-2.78	0.22	0.61	2.29	-0.43	1.12	0.83
6	-2.51	0.26	0.56	2.22	-0.10	1.40	0.93
7	-2.84	0.21	0.41	2.0	-0.58	1.0	0.75
8	-2.84	0.21	0.41	2.0	-0.38	1.16	0.79
9	-2.72	0.23	0.37	1.93	-0.32	1.20	0.81
10	-2.97	0.19	0.40	1.97	-0.06	1.44	0.81
Mean	**-2.74**	**0.2**	**0.32**	**2.06**	**-0.38**	**1.16**	**0.81**

DISCUSSION

The results show that mean value of the metals concentration (mg kg^{-1}, means±S.D.) in specimens were Cd 0.25±0.03, Cr 63.90±4.17 and Cu 28.90±4.33, respectively.

Pearson correlation coefficient between the elements indicated that there were no significant correlations between Cd/Cr, Cd/Cu and Cr/Cu. According to the mean I-geo values, the sediments' qualities are classified as unpolluted category for Cd and Cu. Furthermore, the sediments' quality is classified as unpolluted to moderately polluted for Cr. The CF values for Cr and Cu elements are classified as low contamination. The mean CF value for Cd is classified as moderate contamination. The PLI values indicated that there were no metal pollution exists for all sampling stations.

Cluster analysis was performed in order to assess heavy metal interactions between water and sediment. Accordingly, Cr is heavily contaminated metal drived from anthropogenic sources. Cu is moderate contamination deriving from both natural and anthropogenic sources. While Cd indicated the lower contamination which came from the natural source.

The comparison of mean concentration of the metals with sediment quality guideline proposed by USEPA (Table 4) [19-21] indicated that Cr and Cu are classified in moderately polluted category. Comparison of the results of this study with other studies is showed in Table5.

Table 4. U.S.EPA sediment quality guidelines (mg kg^{-1}, dry weight).

Metal	Not Polluted	Moderately Polluted	Heavily Polluted	Present Study
Cd	.....	…..	>6	0.25±0.03
Cr	<25	25-75	>75	63.90±4.17
Cu	<25	25-50	>50	28.90±4.33

Table 5. Comparison of present average values in sediment samples (mg kg^{-1}) with other studies.

Study Area	Cd	Cr	Cu	References
Agh Gel Wetland	0.25±0.03	63.90±4.17	28.90±4.33	this study
Kowsar Dam reservoir (Iran)	5	-	19.70	[22]
Anzali wetland (Iran)	457.50	126.73	-	[23]
Mighan Wetland (Iran)	0.27±0.08	-	17±2.68	[15, 24]
Shirin Su Wetland (Iran)	0.10±0.03	23.08±2.83	10.63±9.89	[25]
Shefa-Rud (Iran)	-	-	35.25±2.50	[26]
Bushehr (Iran)	-	130.50±15.69	20.97±3.22	[27]
Bamdezh Wetland (Iran)	14.20±2.58	-	-	[28]

CONCLUSION

The content of metals in sediments can be a secondary source of water pollution, once the environmental situation is changed. Therefore, evaluation of metal contamination in sediments is an essential tool to assess the risk in an aquatic ecosystem [15]. According to the I-geo values, the sediments' qualities are classified as unpolluted to moderately polluted category. According to the CF values, the sediments' qualities are classified as low to moderate contamination. The sediments in constructed (artificial) wetlands were contaminated with toxic heavy metals due to the vehicle emissions, agricultural and industrial effluents, urban and rural domestic wastewaters and atmospheric sources compared to natural lakes. Therefore, periodically monitoring of the water and sediment qualities is recommended.

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