Environmental Assessment of Heavy Metals in Soil of West Quarna -2 Oil field at Basrah-Southern Iraq

دراسة الاثر البيئي للعناصر الثقيلة في ترب حقل نفط غرب القرنة-2 في البصرة-جنوب العراق

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Abstract

In this study, concentrations of eight heavy metals (Pb, Ni, Cu, Cr, Zn, Co, Cd and Fe) were investigated during 2016 in ten stations at West Qurna-2 oil field in Basra city Southern of Iraq. These metals were analyzed by using Atomic absorption spectrometry. The mean values of the metals in the soil range for : pb (18.23 -39.15), Ni (28.34-46.35), Cu (10.12-18.22), Cr (50.64-59.23), Zn (25.23-40.48), Co (5.34-11.27), Cd (5.99-10.23) and Fe (1150.12-2185.83) ug/g dry weight. Contamination Factor (CF), Enrichment factor (EF) and Geo accumulation index (I-geo) were computed and compared in different stations of the soil oil field. Total concentration of metals in soil samples found to be in this order: Fe>Cr> Ni >Zn> Pb>Cu> Co>Cd. The main reason for different in concentration could be due to the effects of contamination caused by various activities in the oil field and the urban .Total organic carbons and grain size analysis were also determined, and there is a good correlation between TOC and Heavy metals. These data are a first of its kind in this important area and could be used as a baseline for coming study in the futures.

The purpose of this study were to determine the spatial distribution of trace metals in the soil of the West Qurna-2 oil field, and to quantify potentially ecological risk of trace metal pollution.

Keywords West Qurna-2 oil field, Heavy metals, soil, Basrah

الخلاصة:

تناولت الدراسة الحالية قياس تراكيز العناصر الثقيلة (الرصاص، النيكل، النحاس، الكروم، الزنك،الكوبلت، الكادميوم والحديد) بإستخدام جهاز مطياف الإمتصاص الذري اللهبي للترب المأخوذه من عشر محطات موزعة في حقل نفط غرب القرنة-2 في مدينة البصرة جنوب العراق.كانت معدلات قيم التراكيز في الترب pb (18.23 -39.15)، Ni (28.34-46.35)، Cu (10.12-18.22) ، Cr (50.64-59.23)، Zn (25.23-40.48)، Co (5.34-11.27)، Cd (5.99-10.23) و Fe (1150.12-2185.83). تم حساب معامل التلوث (CF)، معامل الأغناء (EF) ومعامل التجمع الجيوكيميائي (I-geo) ومقارنته في المحطات المختلفة لتربة الحقل.

توزعت تركيز المعادن في عينات التربة على هذا النمط: Fe>Cr> Ni >Zn> Pb>Cu> Co>Cd، يمكن أن يكون السبب الرئيسي للأختلاف في التراكيز هو التلوث الناجم عن الأنشطة المختلفة في حقل النفط والانشطة الحضرية. كما تم قياس الكربون العضوي الكلي والتحليل الحجمي الحبيبي، وقد وجد ان هنالك علاقة جيدة بين الكربون العضوي الكلي والعناصر الثقيلة. هذه البيانات هي الأولى من نوعها في هذة المنطقة ويمكن استخدامها كدراسة مرجعية للدراسات المستقبلية.

والغرض من هذه الدراسة هو تحديد التوزيع المكاني للمعادن الثقيلة في تربة حقل غرب القرنة -2 النفطي، وتحديد المخاطر البيئية المحتملة للتلوث بالعناصر الثقيلة.

الكلمات الدالة حقل غرب القرنة-2 ، العناصر الثقيلة ، التربة، البصرة.

Introduction

Metals, especially the ones called ‘trace metals’ are among the most common environmental pollutants and their occurrence in waters and biota indicate the presence of natural or anthropogenic sources. Natural processes (including erosion of ore-bearing rocks, wind-blown dust, volcanic activity and forest fires); and processes derived from human activities by means of atmospheric deposition, rivers, and direct discharges or dumping [1]. Coastal and estuarine regions are the important sinks for many persistent pollutants and they accumulate in organisms and bottom sediments [2]. Moreover, the majority of pollution occurs in the most seas arise from the land namely waste that comes from large cities (sewage, industrial waste and hydrocarbons) and agricultural runoff (nutrients, pesticides and fertilizers). The major sources of metal pollution in marine and freshwater systems come from domestic wastewater effluents (especially Cr, Cu, Mn and Ni), coal-burning power plants, power plants (Hg and Se in particular), non-ferrous metal smelteries (Cd, Ni, Pb), iron and steel plants (Cr, Mo, Sb and Zn) and dumping of sewage sludge (Mn and Pb) [3]. It is known that when low quality lignite is burned, its fly ash contains several toxic elements, such as Cd, Co, Pb and Zn which can leach out and contaminate soils as well as surface water and groundwater [4].

Sediments and soils have a high storage capacity for contaminants. In the hydrological cycle, less than 0.1% of the metals are actually dissolved in the water, and more than 99.9% are stored in sediments and soils [5]. The distribution and accumulation of trace metals is influenced by sediment texture, mineralogical composition, reduction/oxidation state, adsorption and desorption processes, and physical transport [6].

Rapid urbanization due to the anthropogenic activities by humans has increased the amount of pollutants, such as dioxins, persistent organic pollutants (POPs), and heavy metals, in urban soil [7]. In urban soil, heavy metals can be present in both natural and anthropogenic forms. The natural forms of heavy metals due to the weathering of rock minerals are present at relatively low concentrations [8, 9].

The purpose of this study were to determine the spatial distribution of trace metals in the soil of the West Qurna-2 oil field which large amounts of contaminated waste from agricultural, domestic and industrial activities are discharged, and to quantify potentially ecological risk of trace metal pollution.

Materials and Methods

Soil samples were collected from ten stations in West Qurna-2 oil field at Basrah city during 2016, samples were warped with aluminum foil then transferred to the laboratory for analysis (Fig.1).

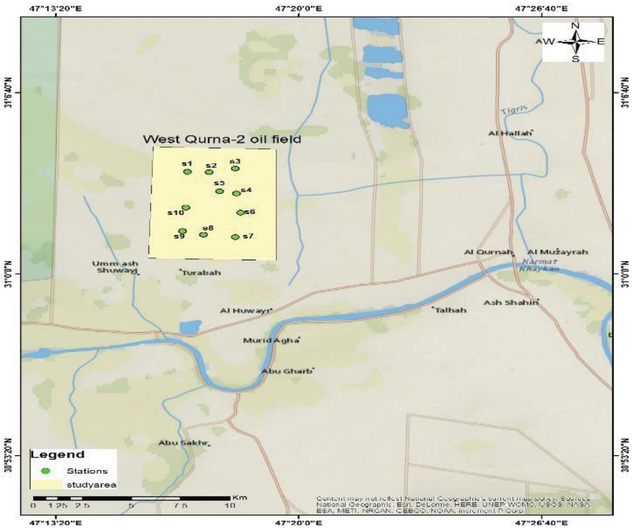

Fig. (1) The study area.

Trace metals analysis was performed on the <63 μm fraction of the soil which has been separated by sieving after drying and grinding. The method of [10] was used in this study to determination of trace metals in soil samples. Concentrated HCl and HNO3 (1:1) were added to each sample and evaporated to near dryness on a hotplate at 80 °C, then a mixture of concentrated HCLO4 and HF (1:1) were added. After heating to near dryness, 20 ml of 0.5 HCL were added and cooled for 10 min. The extraction was decanted into 25 ml plastic volumetric flask. This step was repeated twice and all supernatant were combined. Finally samples were stored prior to trace metals analysis using a Pye-Unicam Atomic Absorption.

Grain size analysis of the soil samples was done according to [11], Total Organic Carbon (TOC) content in the soil samples is determined according to [12] using the exothermic heating and oxidation of (0.3 g) grind dry sample with chromic acid.

Result and Discussion

Analysis values of heavy metals with the mean value, range and SD are given in Table (1and 2), the order of the mean concentrations of examined heavy metals are arranged as fellow: Fe>Cr> Ni >Zn> Pb>Cu> Co>Cd.

The mean values of the element in the soil range for : pb (18.23 -39.15), Ni (28.34-46.35), Cu (10.12-18.22), Cr (50.64-59.23), Zn (25.23-40.48), Co (5.34-11.27), Cd (5.99-10.23) and Fe (1150.12-2185.83) ug/g dry weight (Table 1) respectively.

The results show that there is a variation in the recorded of trace metal pollutants. They gradually increased starting from the sampling at station 1 until station 5, and then significantly decreased at station 6 and then increased to station 10. This is due to the distance from the flame of flare. In general, station10 records the higher concentrations when compared to the other studied stations. This is due to the location of its existing near the flame.

The level of contamination expressed by the contamination factor (CF) [13] was calculated as follows:

Cf= (metal content into the soil) /(metal content in the natural reference soil).

The contamination factors was classified into four groups [13]. Cf < 1 refer to the low contamination factors 1< Cf<3 refers to the moderate contamination factors, 3 < Cf < 6 refers to the considerable contamination factors and Cf > 6 refers to the very high contamination factors.

The values of contamination factors (CF) were shown in Table (3). It is noted that the contamination factors in the investigated soil were pb (1.302-2.796), Ni (0.337-0.551), Cu (0.168-0.303), Cr (0.496-0.580), Zn (0.360-0.578), Co (0.213-0.450), Cd (39.933-68.200) and Fe (0.020-0.038) In general, the contamination factors of trace metals in the present study were refer to the low contamination factors in Ni, Cu, Cr, Zn, Co and Fe. While Pb was moderate contamination factors and Cd very high contamination factors.

According to [14], the Enrichment Factor (EF) is defined as follows:

EF = (M/Fe sample)/ (M/Fe background)

Where (M/Fe) sample is the ratio of metal and Fe concentration of the sample and (M/Fe) background is the ratio of metals and Fe concentration of a background. The values of EF <1 no enrichment, EF = 1-3 minor enrichment, EF = 3-5 moderate enrichment, EF = 5-10 moderate to severe enrichment, EF = 10-25 severe enrichment, EF 25-50 very severe enrichment, EF >50 extremely severe enrichment. The values of enrichment factors (EF) were shown in Table (4). It is noted that the enrichment factors in the investigated soil were pb (63.741-81.875), Ni (14.212-18.560), Cu (7.821-

10.287), Cr (14.956-24.302), Zn (14.741-18.050), Co (10.456-12.483), Cd (1691.465-1954.793) and Fe (1-1) In general, the enrichment factors of trace metals in the present study were refer to the minor enrichment factors in Fe. While Cu was moderate to severe, and a severe enrichment factors in Zn, Co, Cr, Ni, whereas pb and Cd extremely severe enrichment factors.

The geo accumulation index I*geo* values were calculated for different metals, as introduced by [15] as follows:

$$I\text{-}geo = \log_2 (Cn / 1.5\, Bn)$$

Where, Cn: is the measured concentration of element n in the soil ; Bn: is the geo accumulation background for the element n which is either directly measured in precivilization soil of the area or taken from the literature average shale value, described by [16]. If I-geo <1 practically unpolluted-Background sample, 1-2 unpolluted to moderately polluted, 2-3 moderately polluted to polluted 3-4 strongly polluted, 4-5 strongly to extremely polluted, >5 extremely polluted.

The values of Geoaccumulation (I-geo) index were shown in Table (5). It is noted in the investigated soil were pb (-0.204-0.898), Ni (-2.152--1.442), Cu (-3.152-2.304), Cr (-1.595-1.369), Zn (-2.057-1.375), Co (-2.811-1.734), Cd (4.734-5.506) and Fe (-6.198--5.271) In general, the (I-geo) index of trace metals in the present study were refer to practically unpolluted in pb, Ni, Cu, Cr, Zn, Co and Fe. Whereas Cd were strongly to extremely polluted.

Analysis of Total Organic Carbon (TOC %) show high values in station 10 while lower values at station 1 (Table 6), and there is a good correlation between metals and TOC.

If we compared our date with other as shown in Table (7) we found its lies within these data in other study in the region.

As a conclusion there is a considerable amount of Heavy metals in west Qurna-2 oil field, and these data could be represented as a baseline for coming study in the future.

Table (1) Concentrations of trace elements in soil samples (ug/g dry weight) in West Qurna-2 oil field.

Stations	pb	range	mean	±SD	Ni	range	mean	±SD	Cu	range	mean	±SD	Cr	range	mean	±SD
1	18.11	18.11-18.37	18.23	0.131	28.29	28.29-28.41	28.34	0.062	10.07	10.07-10.18	10.12	0.055	50.58	50.58-50.73	50.64	0.079
	18.21				28.32				10.11				50.61			
	18.37				28.41				10.18				50.73			
2	20.39	20.39-20.53	20.45	0.072	30.09	30.09-30.19	30.13	0.052	12.63	12.63-12.76	12.68	0.07	53.41	53.41-53.52	53.45	0.060
	20.43				30.11				12.65				53.42			
	20.53				30.19				12.76				53.52			
3	26.09	26.09-26.3	26.19	0.105	35.19	35.19-35.24	35.21	0.026	14.68	14.68-14.85	14.75	0.088	55.37	55.37-55.53	55.43	0.087
	26.18				35.2				14.72				55.39			
	26.3				35.24				14.85				55.53			
4	27.81	27.81-28	27.89	0.098	40.29		40.33	0.045	14.92	14.92-15.1	14.99	0.096	55.97	55.97-56.07	56.01	0.052
	27.86				40.32	40.29-40.38			14.95				55.99			
	28				40.38				15.1				56.07			
5	30.84	30.84-30.94	30.89	0.05	44.23	44.23-44.31	44.26	0.043	15.12	15.1-15.27	15.19	0.075	58.01	58.01-58.24	58.09	0.13
	30.89				44.24				15.18				58.02			
	30.94				44.31				15.27				58.24			
6	32.28	32.28-32.37	32.32	0.045	41.48	41.48-41.57	41.52	0.045	14.96	14.96-15.08	15.01	0.062	57.71	57.71-57.84	57.76	0.07
	32.31				41.51				14.99				57.73			
	32.37				41.57				15.08				57.84			
7	36.11	36.11-36.22	36.17	0.055	42.21	42.21-42.24	42.23	0.017	16.19	16.19-16.23	16.21	0.02	58.29	58.29-58.36	58.32	0.036
	36.18				42.24				16.21				58.31			
	36.22				42.24				16.23				58.36			
8	36.71	36.71-36.73	36.72	0.01	45.25	45.25-45.33	45.28	0.043589	16.79	16.79-16.89	16.83	0.052915	58.51	58.51-58.59	58.54	0.043589
	36.72				45.26				16.81				58.52			
	36.73				45.33				16.89				58.59			
9	37.85	37.85-37.94	37.89	0.045	45.71	45.71-45.85	45.77	0.072	17.18	17.18-17.3	17.23	0.062	59.08	59.08-59.17	59.12	0.045
	37.88				45.75				17.21				59.11			

	37.94				45.85				17.3				59.17			
10	39.12	39.12-39.19	39.15	0.036	46.32	46.32-46.39	46.35	0.036	18.18	18.18-18.29	18.22	0.060	59.19	59.19-59.29	59.23	0.052
	39.14				46.34				18.19				59.21			
	39.19				46.39				18.29				59.29			

Table (2) Concentrations of trace elements in soil samples (ug/g dry weight) in West Qurna-2 oil field.

Stations	Zn	ZN range	mean	±SD	Co	range	mean	±SD	Cd	range	mean	±SD	Fe	range	mean	±SD
1	25.18	25.18-25.3	25.23	0.062	5.31	5.31-5.38	5.34	0.036	5.95	5.95-6.04	5.99	0.045	1150.09	1150.09-1150.16	1150.12	0.036
	25.21				5.33				5.98				1150.11			
	25.3				5.38				6.04				1150.16			
2	27.41	27.41-27.52	27.45	0.060	6.73	6.73-6.84	6.78	0.055	6.09	6.09-6.16	6.12	0.036	1223.04	1223.04-1223.17	1223.1	0.065
	27.42				6.77				6.11				1223.09			
	27.52				6.84				6.16				1223.17			
3	29.45	29.45-29.65	29.53	0.105	7.83	7.83-7.96	7.89	0.065	6.85	6.85-6.94	6.89	0.045	1345.31	1345.31-1345.51	1345.4	0.101
	29.49				7.88				6.88				1345.38			
	29.65				7.96				6.94				1345.51			
4	30.51	30.51-30.58	30.54	0.036	7.94	7.94-8.06	7.99	0.062	7.29	7.29-7.42	7.34	0.07	1456.31	1456.31-1456.38	1456.34	0.036
	30.53				7.97				7.31				1456.33			
	30.58				8.06				7.42				1456.38			
5	33.32	33.32-33.47	33.38	0.079	8.84	8.84-8.92	8.87	0.043	8.86	8.86-8.95	8.9	0.045	1821.21	1821.21-1821.25	1821.23	0.02
	33.35				8.85				8.89				1821.23			
	33.47				8.92				8.95				1821.25			
6	32.91	32.91-33	32.95	0.045	8.21	8.21-8.28	8.24	0.036	8.03	8.03-8.26	8.11	0.13	1587.41	1587.41-1587.5	1587.45	0.045
	32.94				8.23				8.04				1587.44			
	33				8.28				8.26				1587.5			
7	34.51	34.51-34.68	34.58	0.088	9.19	9.19-9.24	9.21	0.026	8.93	8.93-9.01	8.97	0.04	1823.2	1823.21-1823.28	1823.23	0.043
	34.55				9.2				8.97				1823.21			
	34.68				9.24				9.01				1823.28			

8	36.41	36.41-36.93	36.43	0.02	9.83	9.83-9.96	9.89	0.065	9.03	9.03-9.23	9.12	0.101	1975.34	1975.34-1975.45	1975.39	0.055
	36.43				9.88				9.1				1975.38			
	36.45				9.96				9.23				1975.45			
9	38.93	38.93-39.04	38.98	0.055	10.08	10.08-10.14	10.11	0.03	9.21	9.21-9.3	9.25	0.045	2052.51	2052.51-2052.63	2052.56	0.062
	38.97				10.11				9.24				2052.54			
	39.04				10.14				9.3				2052.63			
10	40.43	40.43-40.54	40.48	0.055	11.23	11.23-11.32	11.27	0.045	10.21	10.21-10.25	10.23	0.02	2185.81	2185.81-2185.85	2185.83	0.02
	40.47				11.26				10.23				2185.83			
	40.54				11.32				10.25				2185.85			

Fig (2) Mean concentrations of metals in different station in soil of West Qurna-2 oil field.

Table (3) Contamination Factor (CF) of heavy metal in soil of West Qurna-2 oil field.

Stations	CF							
	pb	Ni	Cu	Cr	Zn	Co	Cd	Fe
1	1.302	0.337	0.168	0.496	0.360	0.213	39.933	0.020
2	1.460	0.358	0.211	0.524	0.392	0.271	40.800	0.021
3	1.870	0.419	0.245	0.543	0.421	0.315	45.933	0.023
4	1.992	0.480	0.249	0.549	0.436	0.319	48.933	0.025
5	2.206	0.526	0.253	0.569	0.476	0.354	59.333	0.032
6	2.308	0.494	0.250	0.566	0.470	0.329	54.066	0.028
7	2.583	0.502	0.270	0.571	0.494	0.368	59.800	0.032
8	2.622	0.539	0.280	0.573	0.520	0.395	60.800	0.035
9	2.706	0.544	0.287	0.579	0.556	0.404	61.666	0.036
10	2.796	0.551	0.303	0.580	0.578	0.450	68.200	0.038

Table (4) Enrichment Factor (EF) of heavy metal in soil of West Qurna-2 oil field.

Stations	EF							
	pb	Ni	Cu	Cr	Zn	Co	Cd	Fe
1	63.741	16.515	8.256	24.302	17.643	10.456	1954.793	1
2	67.237	16.510	9.727	24.120	18.050	12.483	1878.048	1
3	78.282	17.540	10.287	22.740	17.653	13.206	1922.140	1
4	77.013	18.560	9.658	21.228	16.866	12.355	1891.692	1
5	68.207	16.288	7.826	17.605	14.741	10.967	1834.182	1
6	81.875	17.530	8.872	20.083	16.694	11.689	1917.511	1
7	79.778	15.524	8.342	17.655	15.254	11.375	1846.580	1
8	74.753	15.363	7.994	16.357	14.832	11.274	1732.843	1
9	74.235	14.945	7.876	15.898	15.274	11.092	1691.465	1
10	72.027	14.212	7.821	14.956	14.894	11.611	1756.614	1

Table (5) Geoaccumulation (I-geo) index of heavy metal in soil of West Qurna-2 oil field.

Stations	I-geo							
	pb	Ni	Cu	Cr	Zn	Co	Cd	Fe
1	-0.204	-2.152	-3.152	-1.595	-2.057	-2.811	4.734	-6.198
2	-0.038	-2.064	-2.827	-1.517	-1.935	-2.467	4.765	-6.109
3	0.318	-1.839	-2.609	-1.464	-1.830	-2.248	4.936	-5.971
4	0.409	-1.643	-2.585	-1.449	-1.781	-2.230	5.027	-5.857
5	0.556	-1.509	-2.566	-1.397	-1.653	-2.079	5.305	-5.535
6	0.622	-1.601	-2.584	-1.405	-1.672	-2.186	5.171	-5.733
7	0.784	-1.577	-2.473	-1.391	-1.602	-2.025	5.317	-5.533
8	0.806	-1.476	-2.418	-1.386	-1.527	-1.922	5.341	-5.417
9	0.851	-1.460	-2.385	-1.371	-1.429	-1.891	5.361	-5.362
10	0.898	-1.442	-2.304	-1.369	-1.375	-1.734	5.506	-5.271

Table (6) TOC% and Grain size in the soil of West Qurna-2 oil field.

Station	TOC%	Clay%	Silt%	Sand%	Clay%
1	0.762	2	70	28	2
2	0.833	1	41	58	1
3	1.034	3	68	29	3
4	1.175	1	47	52	1
5	1.558	1	76	23	1
6	1.326	2	32	66	2
7	1.621	1	42	57	1
8	1.717	1	56	43	1
9	1.891	1	39	60	1
10	2.187	2	73	25	2

Table (7): Heavy metals concentrations in total sediments (μ g/g dry weight) in the present study as compared with the other previous studies.

Studied Area	Cu	Zn	Cd	Pb	Ni	Cr	Co	Fe	Reference
Shatt Al Arab Estuary	29.24	31.99	0.27	17.74	104.2	404.10		5210.50	[17]
Shatt Al-Arab river	61.3	235.4	6.39	116.6	-	-		4119.55	[18]
Shatt Al-Arab river	5.9-81.3	24.8-112.4	2.0-7.8	27.6-96.2	57.3-512.1	93.6-757.1		4700-23700	[19]
Some wetlands in south of Iraq	3.21-48.69	9.15-539.8	2.52-35.92	26.54-543.75	95.67-486.95	157-3548.22		148.37-18435.5	[20]
Shatt Al-Arab river and Shatt Al Basrah	30.15	-	5.81	40.13	53.80	-		4170.33	[21]
Euphrates river	14.14	67.66	11.22	0.59	0.37	37.70		661.70	[22]
Euphrates river	30.40	24.05	0.30	11.17	-	-		2034	[23]
Al-Chibayish marsh	2.25	109.47	2.32	5.1	81.25	-		-	[24]
Shatt Al-Arab river	26.69	75.56	-	83.78	-	528.77		1911.03	[25]
Shatt Al-Hilla river	8.21-21.8	-	-	18.5-27.06	114.5-140.5	-		629.0-1228.9	[26]
Shatt Al-Arab river	44.11	106.21	13.08	104.97	234.64	992.09		20485.79	[27]
Shatt Al-Arab river	-	-	-	-	40.942-134.375	-		1159.254-693.245	[28]
Shatt Al-Arab river	E:26.49-9.17 R:54.52-18.47	E:43.13-23.34 R:65.89-44.79	E:13.32-5.01 R:15.98-6.49	E:37.54-20.15 R:73.19-25.61	E:65.93-30.07 R:85.42- 50.47	E:65.91-50.88 R:102.87-55.11	E:15.85-4.46 R:18.00-8.3	E:4987.92-950.78 R:20158.26-770.15	[29]
West Qurna-2 oil field	10.12-18.22	25.23-40.48	5.99-10.23	18.23 -39.15	28.34-46.35	50.64-59.23	5.34-11.27	1150.12-2185.83	The present study

Conclusion

The results show that there is a variation in the recorded of trace metal pollutants. They gradually increased starting from the sampling at station 1 until station 5, and then significantly decreased at station 6 and then increased to station 10. This is due to the distance from the flame of flare. In general, station10 records the higher concentrations when compared to the other studied stations. This is due to the location of its existing near the flame.

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