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ASSESSMENT OF HEAVY METALS POLLUTION IN THE SEDIMENTS SURROUNDING OF BADRA OIL FIELD, WASIT, IRAQ

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Abstract

Ten samples were collected from the sediments around Badra Oil field area, Wasit governorate, eastern Iraq. The collected samples have been analyzed for Fe, Co, Zn, Cu, Ni and Pb heavy metals to detect the sediment pollution in the study area by using three main indices; "geo- accumulation (I- geo), pollution load index (PLI) and contamination factor (CF)".

I-Geo shows that the Pb and CO were found negative in all the sites, ranging from -0.72 to -0.51 and -1.26 to -0.12 respectively, these results are of (class 0) which indicates that the concentrations of Pb and CO in the sediments of these sites are unpolluted. The Ni and Fe, O*f* were found positive in all the sites, ranging from 0.87 to 1.05 and 0.37 to 1.3 respectively, these results are of (class 1) to (class 2) which indicates that the concentrations of Niand Fe, O*f* in the sediments of these sites are slightly polluted to moderately pollute. The Cu was found positive in the all sites, ranging from 0.42 to 2.29, these results are of (class 1) to (class 3), which indicates that the concentrations of Cu in the sediments of these sites are slightly polluted to moderately severely polluted. The Zn had positive values in the all sites, ranging between 0.21 to 0.76. These results are of (class 1) which indicates that the concentrations of Zn in the sediments of these sites are slightly polluted.

The contamination factor (CF) for Lead (Pb), Fe_2O_3 and Co in all sites classified as "class 1" representing a low contamination, to ''class 2'' representing moderate contamination, Cu in all sites classified as "class 1" representing a low contamination, to class 4 Very high contamination. The (CF) Contamination factor for Zn in all the studied sites classified as "class 2" Moderate contamination. The CF for Ni classified as class 2 which indicate moderately contamination to Considerable contamination "class 3".

PLI values in the studied sites are ranging from 1.55 to 2.59 classified as class 2 (Deterioration on site quality) indicating local pollution. The indication of slightly to moderately polluted of sediments in the studied area may be as a result of anthropogenic activities, oil spilling, and daily toxic wastes.

Key words : Pollution Load Index, geo-accumulation index, heavy metals, contamination factor, Badra oil field, Wasit, Iraq.

Introduction

The area around theBadra oil field, Was it governorate, eastern Iraq occupies an area of (1868 km^2), between latitudes (32° 55'–33° 20') N and longitudes (45° 50' – 46° 15') E (Al-Shammary, 2008) (table 1 and fig. 1).

These components of heavy metals are set up at a few ratios in natural soil, their concentration has been increasing in the environment due to human activities including oil and gas production, which may reach in some cases to fatal levels to humans and other living beings, and the due to their toxic properties, mineral contamination is considered continuous (Bonito, 2005).

Heavy metals contamination in soil is a major concern because of their toxicity and threat to human life and the environment (Begum *et al*., 2009). The soil receives pollutants from several sources, the most important including emissions of factory chimneys, automobile exhaust gases, dust storm and household electric power generators. Soil is a crucial component of rural and urban environments, and in both places land management is the key to soil quality, Pollution is a global environmental problem. Toxic heavy metals entering the ecosystems may lead to geo- accumulation, bio-accumulative and bio-magnification. Pollutants enter the soil environment by three ways; first by direct discharge of effluents and solid wastes (industrial discharge, municipal waste discharge, sewage and others); Second, by land runoff in the earth zone, mainly by rivers, and third by the atmospheric fallout of pollutants transferred by the air mass, quantitative estimates of these processes are

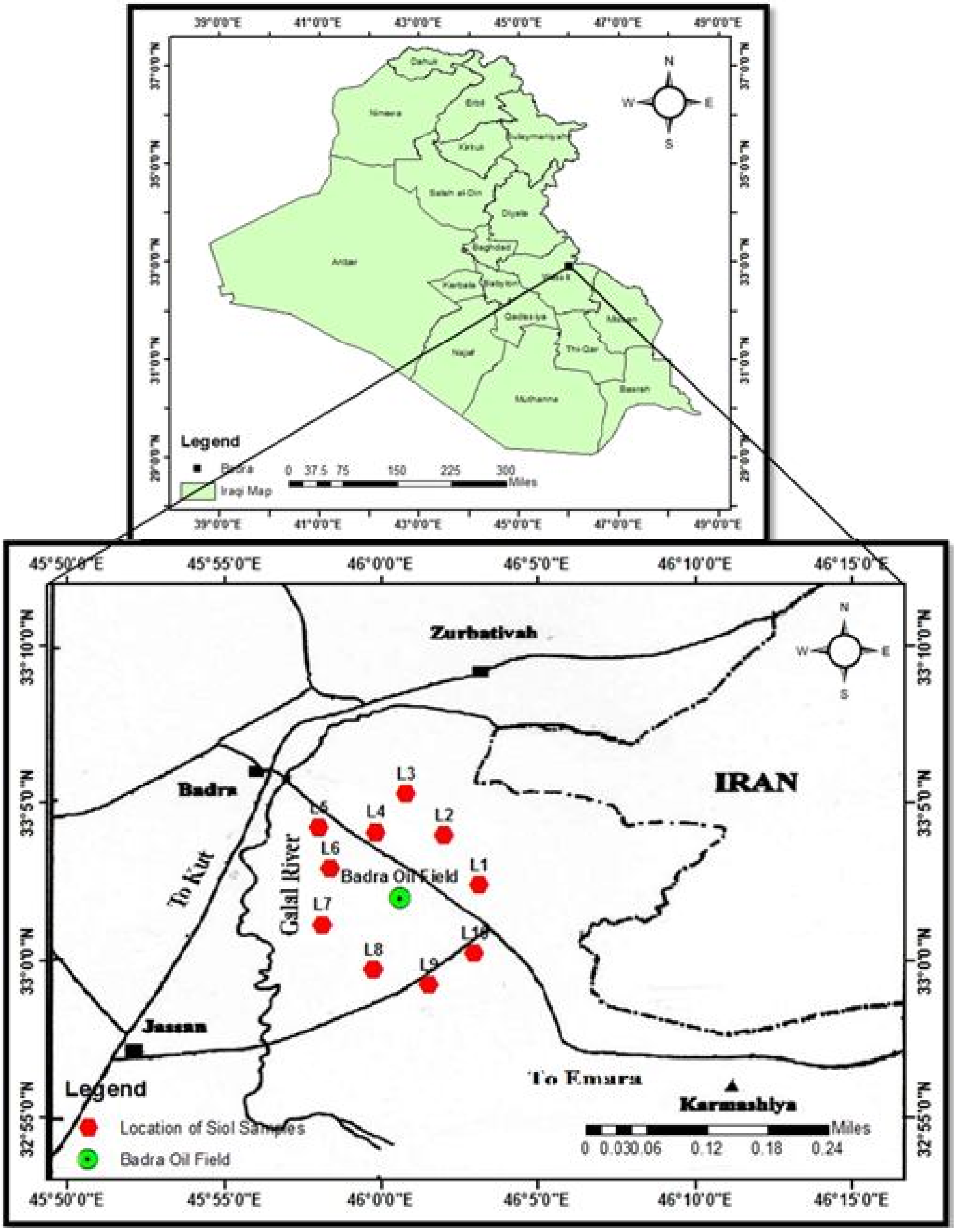

Fig. 1 : Location map and samples.

difficult because of the lack of reliable data and the extreme complexity of the natural processes, (Al-Saad *et al*., 2009). Chandrajith *et al*. (2005) pointed out that the trace elements in the soil are one of the important elements in terrestrial ecosystems, which play a key role in the cycle of the elements and determine the quality of the environment and micronutrients that are essential to the soil. The concentration levels of the trace elements depend on environmental factors which may enhance or reduce trace-metal concentrations through soil pH, redox potential (Eh) and organic matter content (Alloway, 1995). Trace elements can be good when taken at suitable quantities through the food chain, where can occur both the insufficiency and toxicity (Keller, 1970). To assess soil contamination, we must monitor heavy metals and chemical components., many researchers had been studied the heavy metals as a polluted indicator in this area and surrounding areas using the traditional analytical methods, but no one uses the contamination factor (CF), geo- accumulation (I-geo) and Pollution load index (PLI) as indicators of pollution (Khwedim *et al.*, 2009). Therefore, the objective of this study is to elucidate the distribution of heavy metals (Fe, Zn, Cu, Co, Pb, Ni) and the sediment contamination in the area around Badra oil field by using the geo- accumulation (I-geo), contamination factor (CF) and Pollution load index (PLI) a first attempt to evaluate the heavy metals pollution in the sediments.

Materials and Methods

Ten samples were collected from the sediments from the study area (table 1 and fig. 1). These sediments are quaternary sediment, the Mesopotamian plain formed from sediment mainly from floods sediment and river sediments (silt, clay and sand), (Jassim and Goff, 2006). The collected samples have been assessed for Fe, Co, Zn, Cu, Ni and Pb heavy metals to detected the sediment pollution in the study area by used three of main indices; contamination factor (CF), Geo-accumulation (I-Geo), and pollution load index (PLI). All samples were transferred to the XRD and XRF in the laboratory of Baghdad University, College of Science, Department of Geology and the soil samples are subjected to oven drying at a temperature of 60°C, thereafter, 10 g of the sample, in powder form, to detect the Fe, Co, Zn, Ni, Cu and Pb elements by using XRD and XRF method.

Results and Discussion

A. Heavy metals

Determination of the natural levels of heavy metals in sediments is very important in order to determine the mineral content in the sediments of the study area. In addition to natural contribution, heavy metals may be incorporated into the system from anthropogenic source such as oil spills, liquid and solid waste of industries in the surrounded Badra oil field. The range of the measured heavy metals concentrations (Co, Zn, Fe, Pb, Ni and Cu) in the sediment at depths 0-15 cm of the studied area in 2017 (table 2).

The maximum concentration area is the (L.6) site which shows high concentrations of the measured heavy metals Co, Zn, Cu, Ni, and Pb, with concentration of 18.5, 180.4, 183.8, 137.3 and 17.8 ppm. While the lowest concentration is present in a (L.1) site, where the heavy metals Co, Zn, Cu, Ni, and Pb, have the average concentration of 10.5, 123.4, 50.3, 121.5 and 15.5 ppm respectively (table 2). Discussion of these heavy metals is as follows:

1. Iron (Fe_2O_3) : Iron is present in the opaque minerals and as the presence of iron in the structure of clay minerals such as chlorite, montmorillonite and kaolinite minerals and in the iron minerals (Eslinger and Peaver, 1988). Such high values of the studied heavy metals are believed may be due to high contamination of clay percentages in the studied sediments as well as may be due to the oil and gasoline spill in the studied areas. Iron was found in this study that the maximum was 7.8 % in (L.6) site and the minimum Fe_2O_3 % was 5.4 % in (L.10) site.

Table 1 : Location of all Stations samples in study area.

Sediment samples	Longitude	Latitude
L1	46º 03' 06.6" E	33º 02' 27.9" N
L2	46º 01' 59.9" E	33º 04' 0.8" N
L3	46º 00' 47.1" E	33º 05' 21.7" N
L4	45º 59' 52.5" E	33º 04' 6.9" N
L5	45º 58' 1.4" E	33º 04' 12.9" N
L6	45º 58' 19.6" E	33º 02' 58.2" N
L7	45º 58' 7.4" E	33º 01' 09" N
L8	45º 59' 44.6" E	32º 59' 46.2" N
L9	46º 01' 29.5" E	32º 59' 15.9" N
L.10	46º 02' 56.5" E	33º 00' 16.5" N
Badra Oil Field	46º 00' 35" E	33º 02' 1.6" N

Table 2 : Values of heavy metals in the sediments of study area, 2017.

Sample No.	Fe_2O_3 %	Co ppm	Zn ppm	Cu ppm	Ni ppm	Pb ppm
L.1	5.5	10.5	123.4	50.3	121.5	15.5
L.2	5.6	11.5	125.5	51.5	122.9	15.6
L.3	6.2	16.4	166.3	160.8	136.2	17.6
L.4	7.1	17.2	177.4	177.2	136.7	17.5
L.5	7.7	18.4	180.1	183.6	136.8	17.7
L.6	7.8	18.5	180.4	183.8	137.3	17.8
L.7	7.2	17.4	177.8	178.4	137.7	17.7
L.8	6.3	16.7	167.2	160.5	137.6	17.9
L.9	5.5	11.6	125.4	51.3	122.7	15.5
L.10	5.4	11.1	124.2	51.1	122.5	15.4
Mean	6.4	14.9	154.7	124.8	131.2	16.8

2. Cobalt (Co) : The cobalt is a significant and essential factor for living beings, flora and animal nutrition, the Cobalt (Co) is connected with clay minerals and organic matter, even though Cobalt is present at lower trace level (Hem, 1985). The uses of clays are of significance because of their great absorption capacity and their relatively easy exit of the Cobalt (Co), (Pendias and Pendias, 2001). Cobalt was found in Surrounding of Badra oil field that the maximum was 18.5 ppm in (L.6) site and minimum average Cobalt concentration was 10.5 ppm in (L.1) site.

3-Zinc (Zn) : The zinc concentration in arid to semi-dry areas ranging from 900 ppm in alkaline soils to the little occurrence in the semi-desert soils, as in the river sediments, the zinc concentration rate can be up to (90 ppm) (Aubert and Pinta, 1977). Zinc (Zn) was found in Surrounding of Badra oil field that the maximum was 180.4 ppm in (L.6) site and minimum Zinc concentration was 123.4 ppm in the (L.1) site.

4. Nickel (Ni) : Nickel is found widely in nature, nickel occurrence within the earth's crust is up to (80 ppm) and it has very minor amounts in all types of coal (Venugopal and Luckey, 1978). Nickel is present in Carniorite, millerite, nicolite and pentlandite minerals (Rankama and Sahama, 1950).

The highest concentration of nickel found in the ultrabasic rocks like Dunite and Peridotite. It is characterized by a wide change in various sediments and soils its concentration depends on the abundance of clay minerals and organic material as well as aluminum and iron hydroxides (Aubert and Pinta, 1977). Nickel content was found in Surrounding of Badra oil fieldthat the maximum was 137.7 ppm in (L.7) site and minimum Ni concentration was about 121.5 ppm in (L.1) site.

5. Copper (Cu) : Copper found in all crustal rocks with various content depending on the nature of the rocks, Copper is relatively common compared with other heavy elements (Aubert and Pinta, 1977). Copper has a high transition at (pH <5.5) and the transition becomes less in neutral or basic solution, this means that the transition is determined by pH, as well as by adsorption of organic matter and clay minerals (Hawkes, 1997).

Copper is found in nature as free or it relates to other elements in host minerals, it is compatible with sulfur in most rocks such as his occurrence in a copper sulfate within igneous rocks (basic and ultrabasic) (Fairbrige, 1972). Copper (Cu) content in soil at a rate (20 ppm) and its absorption depends on source of rocks, especially basic volcanic rocks, Humus, organic thing, clay concentration and pH (Aubert and Pinta, 1977). Copper was found in Surrounding of Badra oil field that the maximum was 183.8 ppm in (L.6) site and minimum Copper concentration was 50.3 ppm in the (L.1) site.

6. Lead (Pb) : Lead is one of the elements (Chalcophile) found in soil rich in organic matter and iron. It tends to the formation of high concentrations of sulfides in the environment containing chloride, especially in semi-arid areas (Hawkes and Webb, 1962). Iraqi soil are with little content of the lead element, in general, concentrations of lead in soils of the Mesopotamian plain ranging between (17) to (5) ppm (Al-Qaraghouli, 1987). The concentration of Lead in the sediments of the study area that the maximum was 17.9 ppm in (L.8) site and minimum Pb concentration was 15.4 ppm in the (L.10) site.

B. Assessment of contamination

There are many sediments pollution indices that can be used to assess the level of contamination by heavy metals. For this purpose and to meet the objectives of this study, three indices were selected to evaluate the contamination level of Fe, Co, Zn, Cu, Ni, and Pb in the sediments of the study area. These are geo accumulation indexI- geo, contamination factorCF and Pollution Load Index PLI (tables 3 and 4).

1. Geo- accumulation index (I-geo)

The index of The index of I-Geo (geo accumulation) Means the assessment of contamination by comparing the levels of heavy metals in soil samples with the background level used with bottom sediments (Muller, 1969). Geo-accumulation index (I- Geo) was determined by the following equation according to (Muller,1969) which was described by Rabee *et al*. (2011).

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

Where,

Cn = the concentration measured of the heavy metals in the sediments, Bn = the geochemical background concentration (crustal average) of the heavy metals, (Taylor and McLennan, 1985). The constant 1.5 as a constant introduced to minimize the effect of possible variations in the background values, which may be attributed to lithologic variations in the sediments (Lu *et al.*, 2009). Muller (1969) designed a classification for the Geoaccumulation index. Table 3 shows the values of this index vary from subzero to more than 5 having 7 grades. The lower grade (0) reflects the background concentration and the highest grade (6) reflects a 100-fold enrichment.

The Pb was found negative in all the sites, ranging from -0.72 to -0.51 (table 4). These results are of (class 0) which indicates that the concentrations of Pb in the sediments of these sites are unpolluted and lower than the background (table 3). The Ni was found positive in all the sites, ranging from 0.87 to 1.05. These results are of (class 1) to (class 2), which indicates that the concentrations of Ni in the sediments of these sites are slightly polluted to moderately polluted (table 3). The Cu was found positive in the all sites, ranging from 0.42 to 2.29, these results are of (class 1) to (class 3) which indicates that the concentrations of Cu in the sediments of these sites are slightly polluted to moderately severely polluted (table 3). The Zn had positive values in the all sites, ranging between 0.21 to 0.76. These results are of (class 1), which indicates that the concentrations of Zn in the sediments of these sites are slightly polluted (table 3). The Co was found negative in all the sites, ranging from -1.26 to -0.12. These results are of (class 0) which indicates that the concentrations of Co in the sediments of all sites are unpolluted and lower than the background (table 4). The Fe_2O_3 was found positive in the all sites, ranging from 0.37 to 1.3, these results are of (class 1) to

Table 3 : Classified grades of I- geo, CF and PLI indices,after (Thomilson *et al*., 1980 in Rabee *et al*., 2011).

I-geo	CF contamination factor	PLI
≤ 0 Practically unpolluted, (class 0)		<1 Perfection (class 0)
0 < to ≤ 1slightly polluted, (class 1).	<1 Low contamination (class 1).	=1 Baseline Level (class 1).
1< to ≤ 2 Moderately polluted, (class 2).	1≤ CF< 3 (class 2), Moderate contamination.	>1 Deterioration on site quality (class 2)
2< to ≤ 3 moderately, severelypolluted (class 3).	3≤ CF ≤6 (class 3), Considerable contamination.	
3< to ≤ 4 Severely polluted, (class 4).	>6 Very high contamination (class 4).	
4< to ≤ 5 Severely extremely polluted (class 5).		
> 5 Extremely polluted (class 6).		

Table 4 : CF, I-Geo and PLI index for the sediments in the study area.

Sampe no.	Fe_2O_3%		Co ppm		Zn ppm		Cu ppm		Ni ppm		Pb Ppm		
	CF	I-geo	CF	I-geo	CF	I-geo	CF	I-geo	CF	I-geo	CF	I-geo	PLI
L.1	2.62	0.80	0.62	-1.26	1.73	0.21	2.01	0.42	2.75	0.87	0.91	-0.71	1.55
L.2	2.66	0.83	0.68	-1.13	1.76	0.23	2.06	0.45	2.78	0.89	0.91	-0.70	1.59
L.3	2.95	0.97	0.97	-0.62	2.34	0.69	6.43	2.10	3.08	1.04	1.03	-0.53	2.26
L.4	3.38	1.17	1.02	-0.55	2.49	0.73	7.08	2.24	3.19	1.04	1.03	-0.54	2.41
L.5	3.66	1.28	1.09	-0.45	2.53	0.75	7.34	2.29	3.10	1.04	1.04	-0.52	2.49
L.6	3.71	1.30	1.10	-0.44	2.54	0.76	7.35	2.29	3.11	1.05	1.04	-0.51	2.50
L.7	3.42	1.19	1.03	-0.53	2.50	0.74	7.13	2.25	3.12	1.05	1.04	-0.52	2.42
L.8	3.00	1.00	0.99	-0.62	2.35	0.65	6.42	2.09	3.12	1.05	1.05	-0.51	2.29
L.9	2.62	0.80	0.69	-0.12	1.76	0.23	2.05	0.45	2.78	0.89	0.91	-0.71	1.59
L.10	2.57	0.37	0.66	-0.18	1.74	0.22	2.04	0.44	2.77	0.88	0.90	-0.72	1.57
Mean	3.09	0.97	0.88	-0.59	2.17	0.52	4.99	1.50	2.98	0.90	0.98	-0.59	2.06

(class 2), which indicates that the concentrations of Fe_2O_3 in the sediments of all sites are slightly polluted to moderately pollute (table 3).

2. Contamination factor (CF)

Contamination factor (CF) was determined following equation according to Thomilson *et al*. (1980). The level of contamination by metals was established by applying the CF that can be calculated as follows:

CF = Cm Sample/ Cm Background (table 3).

The contamination factor (CF) for Fe, Co, Zn, Ni, Cu and Pb was calculated in the surrounded by Badra oil field and the results are presented in table 4. Lead (Pb) in (L.1, L.2, L.9 and L.10) sites classified as (class 1), representing a low contamination, while in other sites which classified as class 2 representing moderate contamination (table 3). The Contamination factor (CF) for Cu in (L.1, L.2, L.9 and L.10) sites classified as (class 1), representing a low contamination, but at other sites are classified as class 4 Very high contamination. The Contamination factor (CF) for Zn in all the studied sites classified as class 2 Moderate contamination. Zn comes from toxic waste from industrial sources (Thorpe and Harrison, 2008).

The Contamination factor (CF) for (Co) in (L.1, L.2, L.3, L.8, L.9 and L.10) sites classified as (class 1), representing a low contamination, except in the sample (L.4, L.5, L.6 and L.7) classified as class 2 (moderate contamination).

The Contamination factor (CF) for Fe in the in the surrounded by Badra oil field is classified as (class 2), Moderate contamination at (L.1, L.2, L.3, L.9 and L.10) sites, but other sites Considerable contamination (class 3). The CF for Ni classified as class 2 which indicate moderately contamination in (L.1, L.2, L.9 and L.10) sites, but at other sites is Considerable contamination (class 3). It is believed that considerable part of nickel and iron finds its way into the environment as a result of the burning of diesel oil and oil spilling from the oil field or from the pipes carried Oil that spread in this area caused to increase both of nickel and iron in the sediments.

3. Pollution load index (PLI)

The PLI provides a simple but comparative means for assessing a site quality. Pollution load index (PLI) was determined following equation according to (Thomilson *et al*., 1980), where (PLI) is expressed as follows:

$$PLI = \sqrt[n]{CF1 \times CF2 \times CF3 \times ..... \times CFn}$$

Where,

n = the number of study metals at each site (table 3).

The Pollution Load Index (PLI) for Fe, Co, Zn, Ni, Cu and Pb was calculated in the surrounded by Badra oil field and the results are present in the table 4. PLI values in the studied sites are ranging from 1.55 to 2.50 classified as class 2 (Deterioration on site quality) indicating local pollution. Higher values of PLI factor may be result from the effect of the sediments in the studied area of oil spilling, in addition to effects of un-treatment toxic waste that discharge to the main rivers in the study area from the industries and some anthropogenic activities caused to contaminated the soil by zinc, copper and lead.

Conclusion

The concentration of heavy metals (Fe, Co, Zn, Ni, Cu and Pb) in the surrounded by Badra oil field can mainly be attributed to due to high contamination of clay percentages in the studied sediments as well as may be due to the oil, gasoline spill and Volatile gases from oil wells in the region. It is clear from this that the pollution impacted on the (L.4, L.5, L.6 and L.7) sites that have a relatively high Clay% of the sediment more than the other sites that have a relatively high S and % of the sediment. As well as the effect of volatile gases from the field where these areas are in the direction of the wind that transport pollutants to it concluded that the sediment pollution with these heavy metals thought to be due to different sources such as urban wastes, oil, industrial effluents, land washout.

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