RESEARCH ARTICLE

Use Geo Accumulation Index and Enrichment Factor in Assessing Pollution in Iraqi Tidal Flats of Some Heavy Metals

Donia K. Kassaf Al-Khuzie[2], Wesal Fakhri Hassan*[1], Zahraa Al-Hatem[2], Zuhair Ali Abdulnabi[2], AlaaAdilMizhir[2] and Hala Ali Shabar[2]

[1]Department of Science Application, Marine Science Faculty, University of Basra, Basra, Iraq.
[2]Department of Marin Environment Chemistry, Marin Science Center, University of Basra, Basra, Iraq.

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***Address for correspondence**
Wesal Fakhri Hassan
Department of Science Application,
Marine Science Faculty, University of Basra,
Basra, Iraq.
Email: dr.wesalhassan@gmail.com

ABSTRACT

Assessment of heavy metals as toxic pollutants has significant importance in environmental pollution studies. Surficial sediments of water resources have a high potential in releasing heavy metals to the upper water environment, hence sediment analysis presents guidelines to the establishment for monitoring the environmental systems. In this study, total concentrations of four heavy metals (Cd, Cu, Fe and Pb) were investigated along different sites of tidal flats in Basra South Iraq using Atomic absorption for analysis. Geo accumulation index (Igeo) and Enrichment Factor (EF) were computed and compared in different sites in this study too. The range of the concentration in the sediments areas as follows :(Cd: 7.05-15.98 mg/kg), (Cu: 21.07-109.2 mg/kg), (Fe: 1103.32-1147.38 mg/kg) and (Pb: 31.31-125.24 mg/kg). Total concentration of metals in sediment samples found to be in this order: Fe>Pb>Cu> Cd. The guidelines results show that the coastal is high to very high degree of Cd contamination on the other hand unpolluted to moderately polluted degree of Pb but unpolluted for the other studied metals.

Keywords : Heavy Metals, Pollution, Igeo., EF., Iraqi Tidal Flats.

INTRODUCTION

Pollution of the natural environment by heavy metals is a worldwide problem as these metals are indestructible and have toxic effects on living organisms when they exceed a certain concentration limit [MacFarlane and Burchett

2000]. The impact of anthropogenic alarm is most strongly felt by estuarine and coastal environments adjacent to bans areas [Nouri et al., 2008].Sediments are a mixture of several components including different mineral species and organic debris. It represents one of the final sinks for heavy metals discharged into the environment [Hassan,2007,Hassan, et al.,2010, Bettinetti et al., 2003, Hollert et al., 2003].Over the last decades, the study of assessment sediment has shown to be an excellent tool for establishing the effects of anthropogenic and natural processes on depositional environments [Vinodhini and Narayanan, 2008, Nadia, 2009].The assessment of sediment enrichment with elements can be carried out in many ways. The most common ones are the index of geo-accumulation index (Igeo).

Concentrations of metals in sediment of Iraqi costal have been documented by [Hassan, 2007, Al-Sabah, 2007, Al-jaberi, 2013, Al-Kuziea, 2015, Abdulnabi et al.,2016]. Al-Jaberi and Al-Dabbas (2014) shows that the Igeo in the studied of heavy metals have relatively values of (class 0 and 1) in the studied sites reflect unpolluted to slightly polluted with Cd and Pb. The indication of slightly to moderately pollution of sediments in the studied area may be as a result of anthropogenic activities, oil spilling and daily toxicity wastes that flow from the main rivers in Basra city[Abdulnabi,2016].In recent years, human impacts on the environment have been leading to eutrophication in coastal and marine areas, and interaction between human activities and natural force has had a major impact on the entire ecosystem. In this work Cd, Cu, Fe and Pb, total concentrations were determined for the surface sediment of 16 stations of Iraqi tidal flats, to do a field survey and a database on the concentrations of elements in these areas, which is not studied very much. Index of geo-accumulation and Enrichment factor was calculated to assess sediment contamination and determine if the concentrations of metals represent background levels for the North West of the Arabian Gulf.

MATERIALS AND METHODS

Samples were taken from 16 typical sections of the Surface sediment sample from tidal flats at the depth of 20 -30cm on July 2015(Fig.1).The samples were collected from each site using a plastic spade and put into an auto sealed polyethylene plastic bag. After sampling, sediments were transported to the laboratory for analysis. Samples were air dried and sieved to prepare for analysis. The dried sediments were digested in a mixture of HF,$HClO_4$,HNO3 [Sparks, 1996] and brought into solution in 0.5M HCl (50 ml). Total concentration in samples was analyzed for four heavy metals (Cd, Cu, Fe and Pb) on an AAS [Phonex, 985]. The data were statistically analyzed using the software SPSS v-19.0.

RESULTS AND DISCUSSION

Metal Concentration

In order to assess the metal content in the sediments, it's important to establish the natural levels of these metals. Apart from natural contribution, heavy metals may be released into the system from anthropogenic sources such as solid and liquid waste of industries, the oil spill in to the sea water in the studied areas that are considered as important commercial lines of the world oil transportation [Abdulnabi,2016].The data in mean table (1) show the mean, mini., maxi., Std. Deviation and median of the measured heavy metals concentrations (Cd, Cu, Fe and Pb) in the surface sediment of the studied area.

Cadmium

Cadmium is a non-essential element that causes kidney damage in humans and negatively affects plant growth and development. It is released into the environment by power stations, heating systems and metal working industries or urban traffic. It is also used in electroplating, pigment, plastic stabilizers, and Nickel- Cadmium batteries. The common source of contaminants is due to corrosion of galvanized pipes, erosion of natural deposits, discharge from metal refineries, run-off from waste batteries and paints. The mean value of Cd in sediments was 9.09 mg/kg ranged between 7.63 mg/kg in station 9 and 12.69 mg/kg in station 7 (Fig 2). This was above the probable effect level of 0.15 mg/kg (0.1-0.2) [Kabata Pendias,2011].

Copper

Copper reaches the aquatic environment through wet and dry depositions, mining activities, and storm water run-offs, industrial, domestic, and agricultural waste disposal. Among industrial sources include copper plating, pulp and paper mills, e-waste, sewage and other forms of waste waters. In this study it was found that the mini. Cu concentration was 23.46 mg/kg in station 10 and the maxi. was 83.3 mg/kg in station 3 Fig.3.Copper (Cu) forms several minerals of which the common primary minerals are simple and complex sulfides. These minerals are quite easily soluble in weathering processes and release Cu ions, especially in acid environments [Hawks and Web, 1962]. The mean Cu in the sediment was 38.24 mg/kg, this value is above the mean Cu concentration in crust 26 mg/kg. The Cu concentration in surface sediment reflects the bioaccumulation of the metal and also recent anthropogenic sources of the element, the relative enrichment in copper content that could be due to environmental contamination, [Kabta Pendias, 2011].

Iron (Fe)

It was found in this study that the mini. Fe concentration was 1112.46 mg/kg in station 9 and the maxi. was 1143.58 mg/kg in Station 1 (Fig4). Such high values of the studied heavy metals is 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 to the sea water in the studied areas that are considered as important commercial lines to the world ships that are passing in the north and Northwest of the Arabian Gulf [Al- Khion 2012]. This finding is in accordance with Al-Jaberi (2013) results.

Lead (Pb)

The principal source of Pb in the marine environment appears to be the exhaust of vehicles which run with leaded fuels [Heba, et al., 2004]. Also, lead reaches the sea by rain and wind blowing dust [Williams et al., 1978,Hassan et al.2016]. As a natural source for trace metals introduction to the Northern Arabian Gulf there are airborne and waterborne particulates. Dissolved and absorbed metal pollutants derived from the urban, industrial and agricultural centers of Iraq, Iran and Kuwait may be entering to the Northern Arabian Gulf [Abdulnabi,2016]. The majority of the suspended particulate load of Shatt Al-Arab is expected to be deposited in its estuary before they reach the Gulf in which absorbed trace metals are released there [Al-Khafaji, 1996, Abdulnabi,2016]. The high concentration of trace metals in the sediments of areas close to highly dense cities could be arising from sewage discharge as well as industrial pollution, ship wrecks, oil enrichment and transportation, Moreover, high concentrations of lead (Pb) is found everywhere which associated with high traffic density of automobile running by leaded gasoline [Al-Khafaji,1996, Riley and Chester, 1981].

It was found in this study that the mini. Pb concentration was 31.31 mg/kg in station 16 and the maxi. was 109.58 mg/kg in station 3 (Fig5). The anthropogenic source of Pb is leaded gasoline. The average abundance of Pb in the earth's crust is 14.5 (14-15) mg/kg. The accumulation of Pb in the aqueous environments is exposed to various pollution sources and it is of great ecological significance because this metal is known to greatly affect the biological activity in aqueous environments, [Kabta Pendias, 2011]. Lead is positively correlated with Fe, Zn, and Ni probably suggesting some association with the fertilizers, clay and heavy minerals [Hassan 2007, Al-Jaberi, 2013].

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, two indices were selected to evaluate the contamination level of Cd, Cu, Fe and Pb, in the sediments of Iraqi coastline. These are Geo accumulation index (Igeo) and Enrichment factor (E.F) (Tables 2 and 3).

Geo- Accumulation Index (Igeo)

The index of Geo accumulation (Igeo) means the assessment of contamination by comparing the levels of heavy metal obtained to a background level originally used with bottom sediments [Müller, 1969]. It was widely used by many authors [Gowd et al., 2010, Al-Kuziea, 2015, Hussan, 2007, Al-Sabah, 2007] in Iraqi sediment.The I geo for the metals studied were calculated using the Müller (1979)
I geo = log2 [Cn/1.5Bn]

Where: Cn is the measured concentration of the examined metal 'n' in sediments and
Bn is the background concentration of the same metal.

It is very difficult to establish Bn values for sediments in the Iraqi tidal flat owing to geochemical variability of various areas and different anthropogenic impacts [Al-Sultan et al., 2013]. In this work, Bn value has been taken equal to metal concentrations determined by Kabta Pandieas (2011). Based on the I-geo data and Müller's I -geo, the contamination level with respect to each metal at 16 stations is ranged in Table (3). Lu et al (2007) defined the constant 1.5 as a constant introduced to minimize the effect of possible variations in the background values which may be attributed to litho logic variations in the sediments. Müller (1969) designed a classification for the Igeo. This application was considered by many researchers like Hussan (2007), Al-Sabaah (2007), Huu et al. (2010) Al-kuziea 2015 and Al-Hujaaj (2016).The Igeo of Cd was found positive in all the stations, ranging from 5.085 to 5.817.with the mean value 5.322 ± 0.223 These results are of (class 6) which indicates that the concentrations of Cd in the sediments of these sites are extremely contaminated (Fig 6).

The Igeo of Cu concentrations was found positive in the stations 1, 2, 3, 4, 13, 15 ranging between (0.010-1.103), these results are of (class 1and 2) which indicates that the concentrations of Cu in the sediments of this sites are uncontaminated to moderately contaminated. While Cu in the other sites of the study area had negative values ranging between -0.732 to -0.099 with the mean value -0.410± 0.528 .These results are of (class 0) which indicates that the concentrations of Cu in the sediments of these sites are unpolluted and lower than the background (Fig 7).The Igeo of Fe was found negative in all station ranging from -6.075 to –6.035 , with the mean value –6.05± 0.015 these results are of (class 0) which indicates that the concentrations of Fe in the sediments of these sites are unpolluted and lower than the background (Fig 8).The Igeo of Pb had positive values in all station ranging between 0.476 to 2.284. These results are of (class 1, 2 and 3) which indicates that the concentrations of Pb in the sediments of these sites are (uncontaminated to moderately contaminated) to moderately contaminated and moderately to strongly contaminated. (Fig 9).

Enrichment Factor (EF)

Enrichment factor (EF) was calculated to determine if levels of metals in sediments of Iraq and its surrounding marine environment were of anthropogenic origins (e.g., contamination). To identify abnormal metal concentration, geochemical normalization of the heavy metals data to a conservative element, such as Al, Fe, and Si was employed. Several authors have successfully used iron to normalize heavy metals contaminants [Schiff and Weisberg, 1999, Baptista Neto et al., 2000, Mucha et al., 2003, Hussan 2010, Al-Kuziea 2015]. In this study, iron was also used as a conservative tracer to differentiate natural from anthropogenic components. According to Ergin et al., (1991), the metal EF is defined as follows:
EF = (X/Fe) sediment/(X/Fe) crust
Where, X/Fe is the ratio of the concentration heavy metal (X) to the Fe concentration.

EF values were taken as suggested by Sutherland (2000) for the metals studied with respect to crust average 5% [Kabta pandieas 2011]. EF < 1 indicates no enrichment, EF < 3 is minor enrichment, EF = 3–5 is moderate enrichment, EF = 5–10 is moderate to severe enrichment, EF = 10–25 is severe enrichment, EF = 25–50 is very severe enrichment, and EF > 50 is extremely severe enrichment. The mean mini. and maxi., std. deviation EF were calculated for all analyzed metals in this study(Table 4).

The EF values for Cd were fill in >50 (2288.44 to 3698.88) in all stations (Fig .10)With mean value 2670.63 (EF)which indicates the extremely severe enrichment degree of Cd contamination (very severe enrichment). These high values may revert to the low iron concentration in the study areas, compared with its concentration in the Earth's crust so it's better to choose another element for comparison instead of iron. The extremely severe enrichment cadmium content in the sediments may be due to the disposal of cadmium containing wastewater from factories and hospitals in Basra city to Shatt Al-Arab and Shatt Al Basra rivers caused to increase of cadmium content in the sediments especially in station 7. Increase in Cd concentration in the recent few years due to the close proximity of this site to industrial discharges.

Copper showing E.F ranging from very severe enrichment, to extremely severe enrichment (40.56 to 140.94) With mean value 64.50± 0.289 (at all station, as shown in Fig 11). In all the studied sites classified as class 5 and 6 representing is very severe enrichment, and is extremely severe enrichment. Pb had the second highest EF values 46.90 to 159.70 with mean value 81.70 ± 0.636 suggesting very severe enrichment, to extremely severe enrichment among the metals studied. Lead is known to come from the use of leaded gasoline .The principal source of Pb in the marine environment appears to be the exhaust of vehicles which run with leaded fuels (Heba, et al., 2004). Also, lead reaches the sea by rain and wind blow dust (Williams, et al., 1978). As a natural sources for trace metals introduction to Northern Arabian Gulf are airborne and waterborne particulates. Dissolved and adsorbed metal pollutants derived from the urban, industrial and agricultural centers of Iraq, Iran and Kuwait may be entering to the Northern Arabian Gulf.

CONCLUSION

Among four metals studied, the I-geo of Cd was ranged from strong to very strong class (I geo class = 4-5) for sediments in all stations. Whereas I geo of Pb (second abundance metal in the tidal flat of Iraqi sediment) was ranged from (0.476-2.284) for sediments in all stations .Practically Uncontaminated to moderately contaminated, moderately contaminated and moderately to strongly contaminated.While the tidal flat of Iraqi sediment where practically unpolluted- Background sample with Cu Uncontaminated to moderately contaminated, moderately contaminated and Uncontaminated with Fe. This might indicate that the tidal flat of Iraqi sediment has heavy accumulations of Cd and Pb metals, which apparently come from sewers that include industrial wastes in addition to the outside source.

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Table1: The mean, mini., maxi., Std. Deviation and median of the measured heavy metals concentrations(mg/kg)

Element	Mean	Mini.	Maxi.	Std.Deviation	Median
Cd	9.09	7.05	15.98	0.813	4.465
Cu	38.254	21.074	109.198	8.633	17.721
Fe	1132.2	1100.33	1147.38	5.702	569.138
Pb	56.308	31.31	125.24	10.856	27.396

Table 2: Igeo Classification [Müller 1979]

I geo	Class geo	Description of sediment quality
<0	0	Uncontaminated
0-1	1	Uncontaminated to moderately contaminated
1-2	2	Moderately contaminated
2-3	3	Moderately to strongly contaminated
3-4	4	Strongly contaminated
4-5	5	Strongly to extremely strongly contaminated
>5	6	Extremely contaminated

Table 3: The I geo values in the sediments of study area

Element	Mean	Mini.	Maxi.	Std.Deviation	Median
Cd	5.322	5.085	5.817	0.223	4.311
Cu	-0.12	-1.103	-0.732	0.528	-1.138
Fe	-6.05	-6.075	-6.035	0.015	-0.398
Pb	1.233	0.476	2.284	0.507	0.284

Table 4: Heavy metal enrichment factor (EF)in Iraqi sediments

Element	Mean	Mini.	Maxi.	Std.Deviation	Median
Cd	2670.63	2288.44	3698.88	4.779	26.151
Cu	64.50	40.56	140.94	.289	.599
Pb	81.704	46.9	159.709	.636	1.600

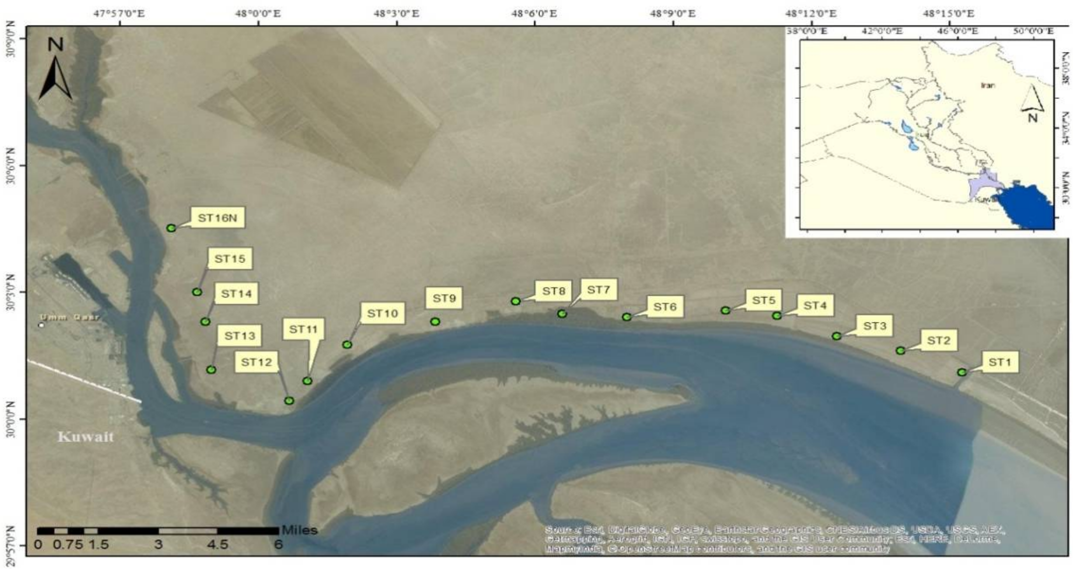

Fig. 1: Map showing the sampling station

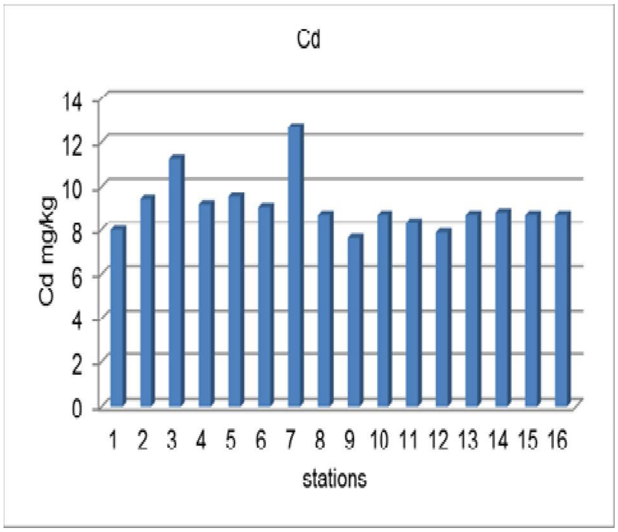

Fig.(2): The mean value of Cd in sediments stations

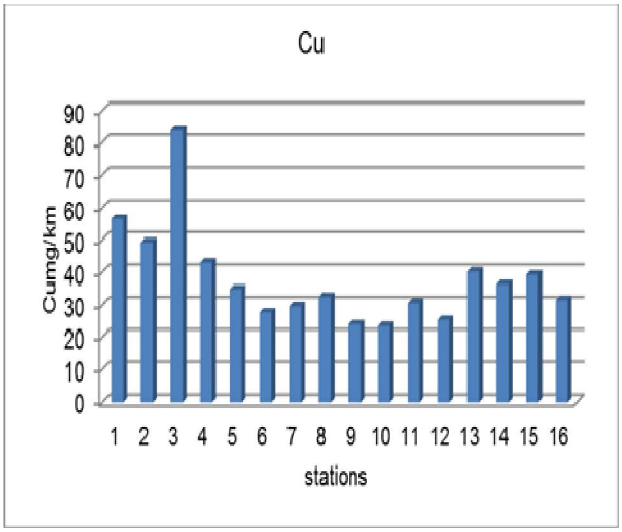

Fig.(3): The mean value of Cu in sediments stations

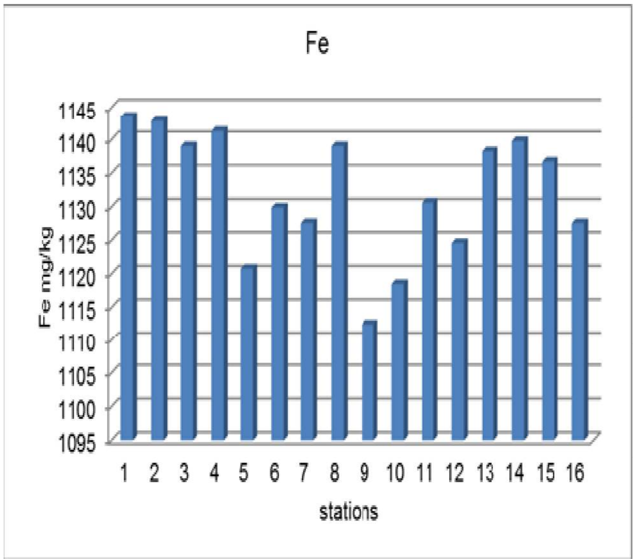

Fig.(4): The mean value of Fe in sediments stations

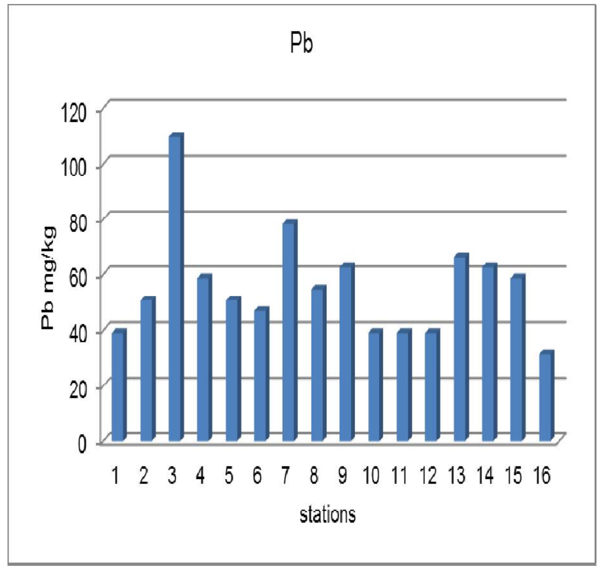

Fig.(5): The mean value of Pb in sediments stations

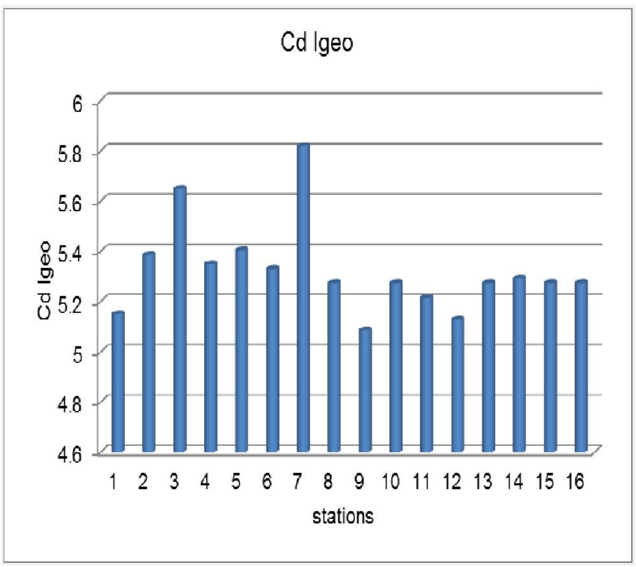

Fig.6: the value of Cd Igeo in the sediments stations

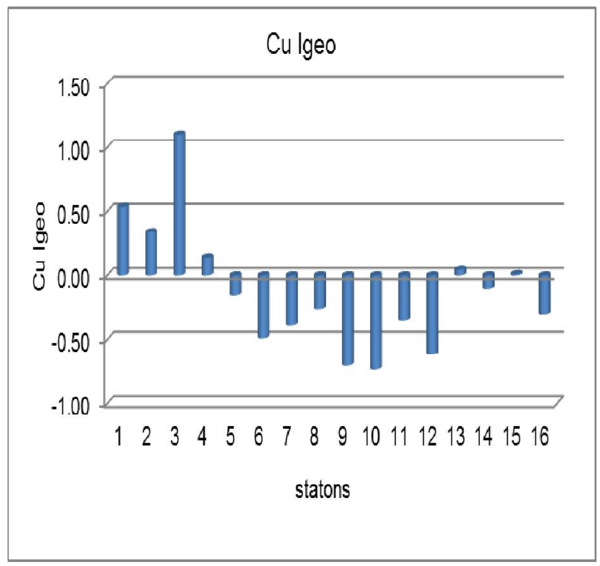

Fig.7: the value of Cu I geo in the sediments stations

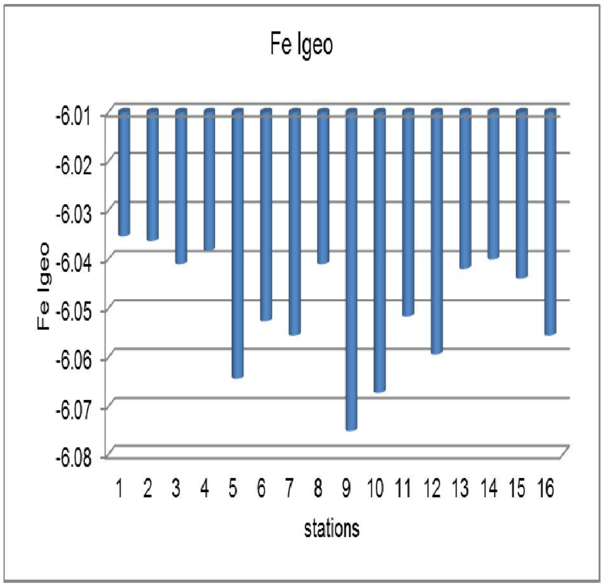

Fig.8: the value of Fe Igeo in the sediments stations

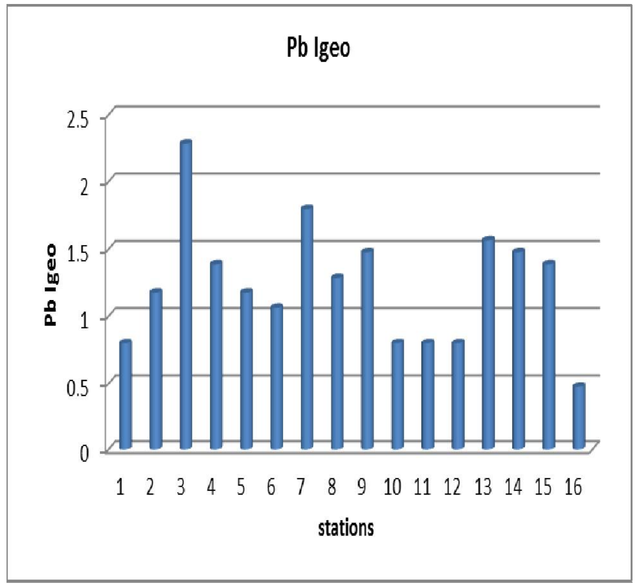

Fig.9: The value of Pb Igeo in the sediments stations

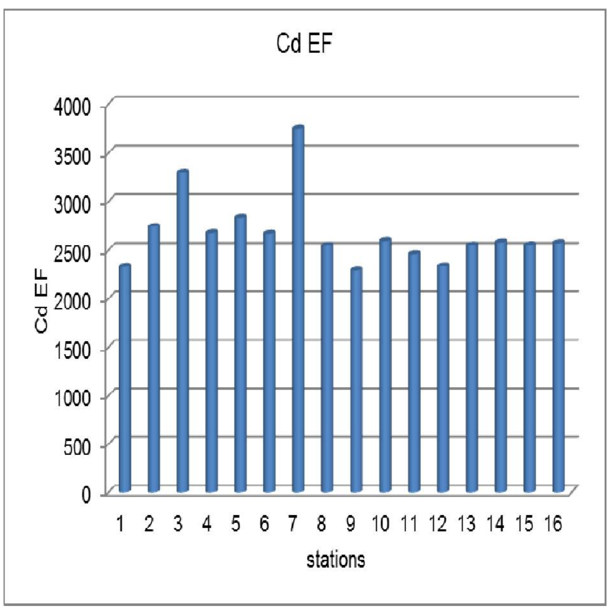

Fig.10:The value of Cd EF in the sediments stations

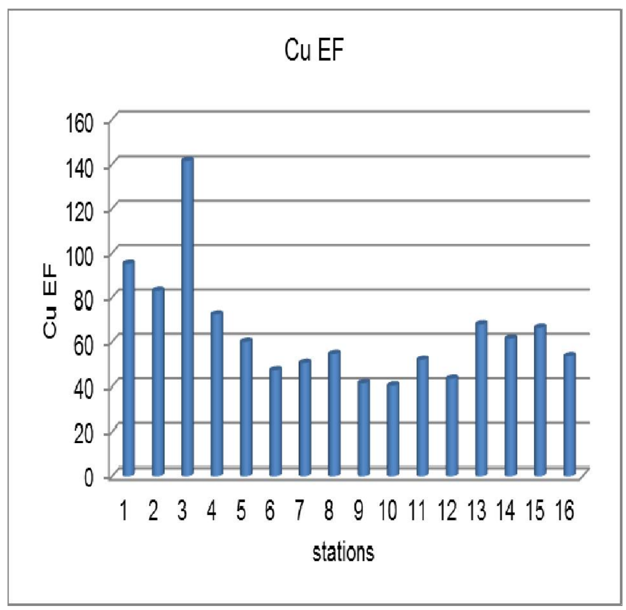

Fig.11:The value of Cu EF in the sediments stations

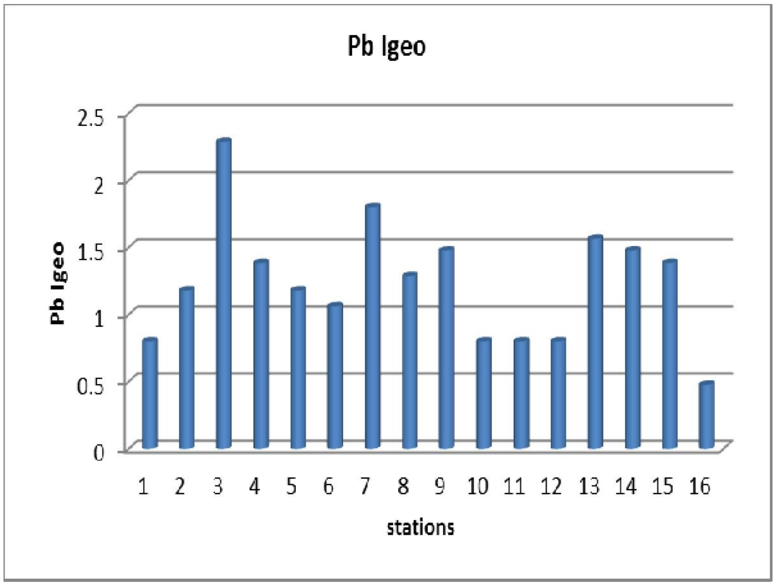

Fig.12 :The value of Pb EF in the sediments stations