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ANALYTICAL STUDY FOR HEAVY METALS POLLUTION IN SURFACE WATER AND SEDIMENT FOR SELECTED RIVERS OF BASRAH GOVERNORATE

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ABSTRACT

Concentration of 2 heavy metals; lead and mercury (Pb and Hg) in rivers and sediments soil were studied at different sites in Basrah. In this study, the effect of lead and mercury pollutions is studied together with determining their locations in the surface water and sediments at some areas in the South of Iraq (Basrah Governorate) particularly in the upper areas of the Arabian Gulf and in its northern part. These seven locations are: Qurnah, Madinah, Deir, Ashar, Abo Al–Khasib, Zubair and Um Qasir. The effect of the lead and mercury concentration on surface water and sediments analysed during 2014–2015 quarterly. Standardized method have been followed in analysing and comparison the surface water standards and sediment soil just to determine the percentage of lead and mercury pollution and assesse the values with standard pollution index.

Overall concentrations of Pb in the rivers ranged from 0.44-4.5 mg/l for surface water and soil sediment samples ranged from 0.0-7.36 mg/kg, and for Hg in the rivers from 0.0003-0.006 mg/l and soil sediment samples ranged from 0.0005-0.009 mg/kg. The concentration of heavy metals in the surface water and soil display the following decreasing trend: Pb>Hg. From this result, found that levels of heavy metal in surface water and soil near industrial areas give higher value compared with other locations in Basrah. The Pollution index revealed that Pb and Hg give low contamination. The highest concentrations values are recorded in Abo Al–Khasib (7.63 ppm) for the underground sediments, the lowest concentrations values are recorded in Madina for the depth sediments. The highest concentrations are recorded in Al-Deer (0.009 ppm) for the mercury pollution. Results of combined heavy metal concentration and heavy metal assessment indicate that industrial activities and traffic emission represent most important sources for Hg and Pb. The pollution Index were calculated for the two pollutants concentrations at the rivers and soils.

KEYWORDS: Pollution, Lead, Basrah Government, South of Iraq, Surface water, Mercury

دراسة تحليلية لنسب التلوث بالعناصر الثقيلة فـي المياه السطحية والرواسب لبعض الانـهر في محافظة البصرة

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الخلاصـــة

درس تأثير التلوث بعنصري الرصاص والزئبق وتحديد مواقع التلوث للمياه السطحية وللرواسب القاعية في مناطق من أنهر جنوب العراق في محافظة البصرة على وجه الخصوص في أعلى الخليج العربي عند قمته الشمالية وهي سبعة مواقع: القرنة، المدينه، الدير، العشار، أبو الخصيب، الزبير وأم قصر خلال الفترة من 2014- 2015 على أساس فصلي. اعتمدت الطرق القياسية لتحليل الرواسب القاعية وتم تقييم النتائج ومقارنتها مع القيم المثالية والمحددات البيئية لمياه الري وللتربة والتلوث. تراوحت قيم التراكيز للرصاص والزئبق ما بين 0.44-4.5 ملغم/لتر للمياه السطحية لمعدن الرصاص و 0-7.63 ملغم/كغم للرواسب وللزئبق كانت القيم 0.0003-0.006 ملغم/لتر للمياه السطحية و0.0005-0.009 ملغم/كغم للرواسب وكانت قيم التراكيز بمستويات اعلى من غيرها في المناطق القريبة من الصناعات الثقيلة في البصرة. كذلك بينت نتائج التقييم بأن مؤشر التلوث يشير الى قيم واطئة لمستويات التلوث بالمعادن الثقيلة في البصرة. حيث سجلت أعلى قيمة معدل لتركيز الرصاص في منطقة ابي الخصيب حيث بلغت (7.63 PPM) للرواسب القاعية، في حين اعلى قيمة للزئبق مسجلة هي (0.009 PPM) في منطقة الدير ولم تسجل أي قيمة للرواسب القاعيـــة للرصاص في منطقـــة المدينة.كما أنه ظهرت قيمة للزئبق قليلة نسبيا مقارنة بالرصاص حيث كانت اعلى قيمة بحدود (0.009 PPM) في منطقة الدير. وتم حساب دليل التلوث (POLLUTION INDEX) لهذين العنصرين وكانت النتائج اقل من واحد وهذا مؤشر على عدم وجود تلوث لهذين العنصرين في مياه ورواسب محافظة البصرة.

1. INTRODUCTION

Aquatic environment with its water quality is considered the main factor controlling the state of health. Pollution of the aquatic environment by inorganic or organic chemicals is a major factors posing serious threat to the survival of aquatic organisms. In the sixties of this century the pollution problems began to appear at the world and is today at the important issues that take a premium of attention of governments, and pollution does not recognize political boundaries of states and geographical considerations because of the rapid spreading of contamination as a result of activity of economic development being done by human such as manufacturing intensive growing and overuse of natural resources which has led to air, water and soil pollution (Khan et al., 2002) and (Al-Saad et al., 2003).

The trace elements represent within the environmental pollutants which can be defined as inorganic elements estimated by parts per million in water and sediments because it is small quantities, they are heavy elements because of its high specific density (greater than $5g/cm^3$). This elements characterized by negative effects on the life because of its high toxicity and effectiveness compared to the other natural elements and their survival for a long time in the environment without decomposition (Kuwait Institute for Scientific Research, 1986).

Many studies are estimated the trace elements in the water, sediment samples and living organism in Iraqi water bodies have been conducted to evaluate the possibility of contamination of these metals and identifying the most pollution sites (Al-Imara, 1996), (Al-Imara, 1998) and (Al-Khafagi, 1996). Lead and mercury represent the most influential heavy elements, toxic for humans at even low-lying concentrations, where lead is found in air, water, food and there is also in soil and in water reservoirs and in the rivers that are supply drinking water for the cities (Layla, 1990).

On the other hand, in seas and oceans, lead source comes from rivers estuary, which are the other (80%) from their sources comes from atmospheric deposition and direct discharge of waste, and waters bodies at coastal cities have high values in the proportion of lead, especially at rivers estuary (Niragu, 1980). The combustion of gasoline containing lead compounds represents the main source of pollution of the environment by lead, where lead compounds product with the resulting gases and deposited in the water bodies by gravity due to its weight causing pollution of soil, water, plants, food and the human body nearby from busy streets (Al-Niaami, 1984).

There are also other sources of lead contamination in Iraq, where lead enters in many industrials such as batteries, printing and paints where this contributed to increased pollution but also less

than what is released by cars (Saeed, 1984). The World Health Organization (WHO) adopted concentration limits of lead and mercury in drinking water element at 100 micrograms / liter for Pb and as 0.001 mg/l for Hg, while the European Assembly considered as 50 micrograms / liter is the highest limit for Pb (Anarez et al., 1982) and (Geneva et al., 2002). Also lead pollutants reach to surface water through several sources of pollutants such as oil and sewage tanks and precipitation and soil inorganic materials (Al-Shakhli, 2003). Leachate pollution should get appropriate attention as it may be a source of heavy and toxic metal in soil and it is possible to percolate and may lead to water pollution in the surroundings water sources.

The main objective of this study is to determine and evaluate the lead and mercury pollution ratio in surface water at some selected points in Basrah Governorate southern of Iraq. The result can then be used as a basis for improving the situation and as a guide for environmental planners and government in reducing pollution in Basrah.

2. THE STUDY AREA AND DESCRIPTION

The study area is represented by Basrah Governorate, Fig. 1. Basrah Governorate is the third largest urban centre in Iraq. It is locate in the south east of Iraq between (28º. 0\. 0\\\ and 32º. 0\.0\\\) N and (46º. 0\. 0\\\ and 49º. 0\. 0\\\) E, with area of (19,070 km^2) and with population more than 3.0 million (NGO coordination committee for Iraq, 2015). The governorate of Basrah is subdivided into seven main districts: Abu Al-Khaseeb, Al-Midaina, Al-Qurna, Al-Zubair, Basrah, Fao, and Shatt Al-Arab. Basrah is Iraq's third largest urban center. The main surface water rivers in the study area are Tigris, Euphrates, Sahtt Al-Arab and Al Basrah rivers. In Basra Governorate the Tigris River extends from the boundaries of Maysan Governorate from the north, reaching its confluence with the Euphrates River in Al Qurnah District 47km downstream. About 24 subsidiary rivers feed into the Tigris for a combined total length of approximately 69,500 km. The Euphrates River currently has two riverbeds in Basra Governorate. One is the old north riverbed, which enters the Governorate coming from Dhi Qar Governorate. It then flows eastwards, parallel with the east bank of Al Hammar Marsh, 40 km. inside Basra Governorate, until it meets the Tigris river in Al Qurnah district. The river width varies from 50 m when it enters the Governorate to around 200 min Al Qurnah. The length of Shatt Al-Arab River; from Al Qurnah City to where it flows into the Arabian Gulf, is around 95 km. Its width expands to be 25m, 305m, 457m, 805m, 1600m and 2500m at Al Qurnah City, Al Ma'qil quarter, Ashar area, Muhammara City, Al Fao City and its final flow to the Gulf sequently. Al Basra river extends to the west side of the Shatt Al-Arab river. It starts from Hareer Village and connects to Garmat Ali River in the north until it ends with the Khor Al

Zubair water surface in the south. Its length is around 42 km. Through this river, water of Al Hammar Marsh flows directly into the Arabian Gulf (Persian Gulf). This study select seven areas in Basrah with varies conditions in geographic, surface water, land use, and agriculture.

Fig. 1. Location of study area.

3. METHODOLOGY AND SAMPLING STRATEGY

The field and sampling works conducted in this study includes detailed field surveys to investigate all study area and surface water characteristics. Many samples from rivers and sediment soils samples were collected to measure the heavy metal pollutants concentrations. Different tools were used to sampling through four season periods at one years for the period (Oct 2014; Sep 2015). Fig. 2 shows a map for the study area, where the number of sampling point was 4 samples for each water and sediment (Table 1), where the sediment soil samples were collected from seven sampling site (1 to 7), distributed at main rivers in Basrah and selected to be near main streets and disposal sites of wastes and urban movement.

The rivers and sediment soil samples were mainly taken from a depth of 10 cm to 20 cm from rivers beds near edge and roadside of the cities. A total 28 samples for surface water and 28 samples for sediments were collected from the seven selected sites. Water samples were taken

at different places at each station by a plastic bottles sampler at depth of half meter from the water surface. Five grab water samples were collected from each site and stored in washed plastic containers. The samples were preserved with 4 ml concentrated nitric acid and stored in freezer at about 4^{o}C so as to prevent adsorption and precipitation of metals. The stored samples were sent back and processed in laboratory within 24 hours of sampling. Sediments samples collected by sweeping an area of about one square meter (1 m^2) from river bed to a depth of 10-20cm using hand auger, stored in plastic polyethylene bags with 1.5 to 2 kg for each. In the laboratory, the samples were oven dried at 60°C for 2 days, followed by grinding with mortar and pestle and sieved using a 2 mm sieve. The sediment soil samples were digested and the concentrations of lead (Pb) and mercury (Hg) were determined by standards test methods (American Public Health Association, 2005).

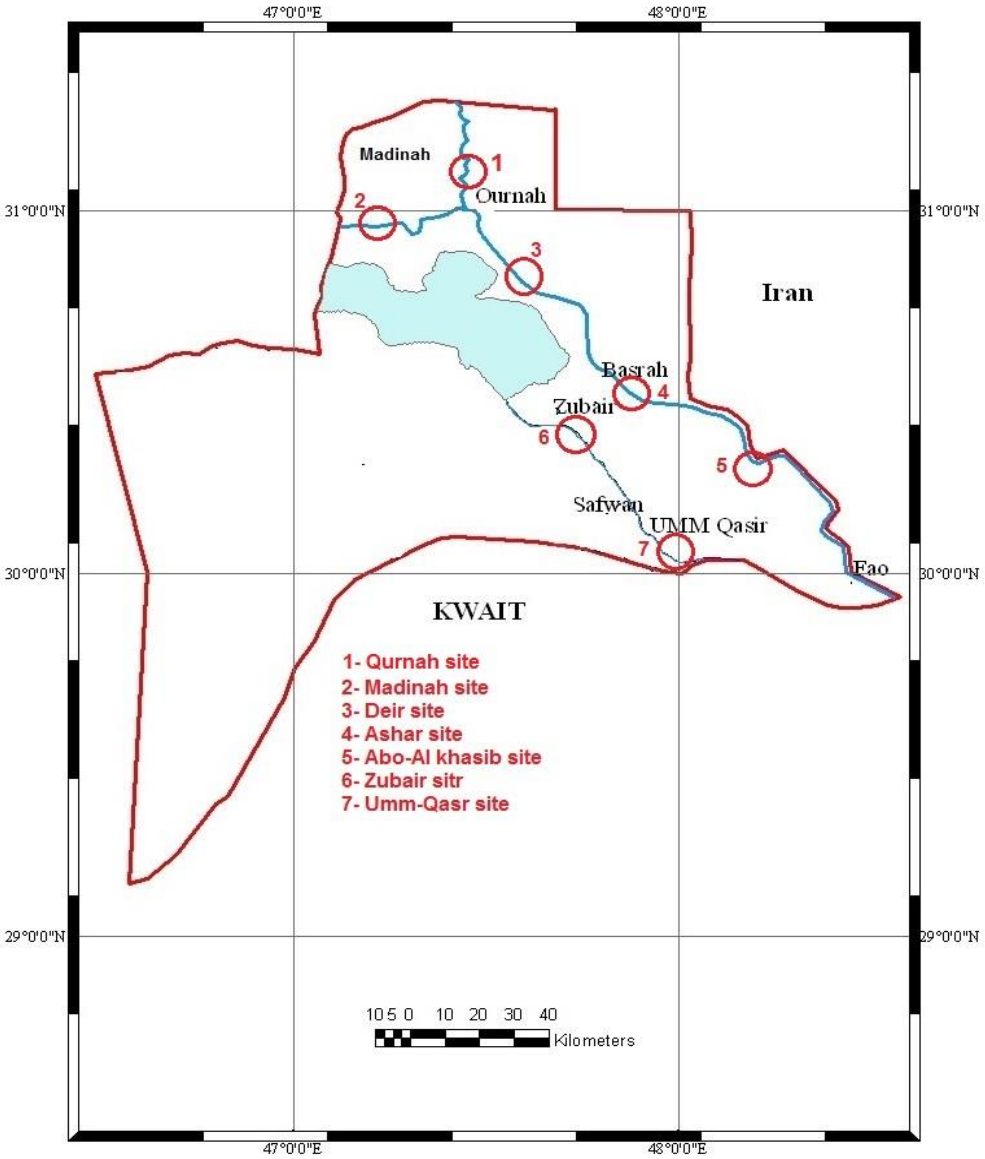

Fig. 2. Location sampling site of sediment soil.

Table 1. The selected seven district and samples numbers in the study area for one-year period.

No.	Site	No. of water samples	No. of sediments samples
1	Qurnah site	4	4
2	Madinah site	4	4
3	Deir site	4	4
4	Ashar site	4	4
5	Abo Al–Khasib site	4	4
6	Zubair site	4	4
7	Um Qasir site	4	4
Total samples		56	

4. RESULTS AND DISCUSSION

- The seasonal concentration of heavy metals in the Basrah river water and sediment soil are listed in Tables 2-5 for the four season periods (Oct, 2014; Sep, 2015) and showed at graphical charts at Figs. 3-6.

Table 2. Heavy metal concentration in surface water and sediment soil for the period (Oct: 2014 to Dec: 2014).

No.	Site	Heavy metal concentration in sediments (mg/kg)		Heavy metal concentration in surface water (mg/l)	
		Pb	Hg	Pb	Hg
1	Qurnah site	0.66	0.0008	0.5	0.0006
2	Madinah site	ND	0.0005	0.9	0.0003
3	Deir site	1.01	0.006	2.5	0.005
4	Ashar site	3.17	0.0009	1.5	0.0008
5	Abo Al–Khasib site	6.23	0.005	1.6	0.004
6	Zubair site	4.41	0.001	4.2	0.0009
7	Um Qasir site	4.91	0.003	1.4	0.002

ND: not detected

Table 3. Heavy metal concentration in surface water and sediment soil for the period (Jan: 2015 to Mar: 2015).

No.	Site	Heavy metal concentration in sediments (mg/kg)		Heavy metal concentration in surface water (mg/l)	
		Pb	Hg	Pb	Hg
1	Qurnah site	0.71	0.0007	0.65	0.0004
2	Madinah site	ND	0.0006	0.6	0.0004
3	Deir site	1.22	0.0083	2.0	0.0045
4	Ashar site	3.37	0.001	1.85	0.0009
5	Abo Al–Khasib site	6.85	0.008	2.1	0.005
6	Zubair site	4.84	0.0014	3.95	0.0011
7	Um Qasir site	5.22	0.007	2.75	0.0015

Table 4. Heavy metal concentration in surface water and sediment soil for the period (Apr: 2015 to Jun: 2015).

No.	Site	Heavy metal concentration in sediments (mg/kg)		Heavy metal concentration in surface water (mg/l)	
		Pb	Hg	Pb	Hg
1	Qurnah site	0.92	0.0012	0.75	0.0008
2	Madinah site	0.002	0.001	0.68	0.0005
3	Deir site	1.83	0.009	1.85	0.0065
4	Ashar site	3.88	0.0018	2.64	0.0012
5	Abo Al–Khasib site	7.35	0.008	1.88	0.006
6	Zubair site	5.95	0.002	3.67	0.0018
7	Um Qasir site	6.72	0.008	1.99	0.002

Table 5. Heavy metal concentration in surface water and sediment soil for the period (Jul: 2015 to Sep: 2015).

No.	Site	Heavy metal concentration in sediments (mg/kg)		Heavy metal concentration in surface water (mg/l)	
		Pb	Hg	Pb	Hg
1	Qurnah site	0.85	0.0015	0.68	0.0011
2	Madinah site	0.001	0.0015	0.85	0.0008
3	Deir site	2.05	0.008	1.98	0.006
4	Ashar site	4.18	0.0011	2.5	0.001
5	Abo Al–Khasib site	7.63	0.006	2.55	0.0055
6	Zubair site	6.08	0.0017	4.5	0.0016
7	Um Qasir site	5.81	0.007	2.15	0.0035

- (Table 6) shows the allowable standards limits of heavy metal concentrations in irrigation water and soils.
- All data in Tables 2-5 were compared with allowable standards limits at (Table 6) (Siti Norbaya Mat Ripin, 2014) and (Watershed Management Section, 2012).
- The maximum concentration of Pb was (7.63 mg/kg) in sediment and (4.5 mg/l) in water and Hg was (0.009 mg/kg) in sediment and (0.006 mg/l) in water.
- The two concentrations levels of Pb and Hg were smaller than maximum standard limits. Thus, there are acceptable limits for soil and surface water pollution in rivers i.e. Pb, and Hg relatively below limit from standards (Table 6).
- Thus, we can summarized that most of the Basrah rivers is still in save level from these two heavy metal effects.
- The concentrations results showed that (Pb) was highly distributed in surface water at Zubair site and in sediment on Abo Al–Khasib site. This mean these sites have a source of this metal compared with others because these sites near of Abu-Floos port and fertilizers plant and were located near the industrial areas and near major road that loads a heavy traffic. On the other hand, the (Hg) was at high concentration for sediment and surface water in Deir site in at station 3 because this site was near to oil fields and some industrial plants such as electrical and papers plants.

- Thus from the overall result, we can state that contamination level in Basrah is still in low levels, just on certain location that located near industrial areas and major road that produce high level of heavy metal.
- For seasonal variation of metals concentrations we show that the concentration levels increase at dry season compared with wet seasons. This decreasing at wet weather due to the dilution effect by rain and most of heavy metals transport to the rivers by dusts during dry weather with wind action during hot season. It is observed from above analysis that after rain seasons the heavy metals may be transported or diluted by rain water and thus concentration of metals is less.
- From concentration data for the seven sites we show high levels in heavy metals at Um-Qasr, Abo Al-Khaseeb and Al-Zubair sites compared with others, this due to the largest industrial activities in Basrah at high levels at these sites.
- For further view on contamination level in this study area, heavy metal assessment index will be carried out and explain further detail below.

Table 6. Allowable limits of heavy metal concentrations in irrigation water and soil (Siti Norbaya Mat Ripin, 2014) and (Watershed Management Section, 2012).

Heavy metal	Environmental Quality Std of Soils (mg/kg)	This study	Environmental Quality Std of irrigation water (mg/l)	This study
Pb	100	7.63	5	4.5
Hg	0.1	0.009	0.01	0.006

5. HEAVY METAL POLLUTION ASSESSMENT

To assess contamination level of heavy metals, a pollution index (PI) of each metal was attributed to each metal using equation 1 (Siti Norbaya Mat Ripin, 2014) below:

$$PI = Cn/ Bn \quad (1)$$

where Cn (mg/kg) is the measured concentration of each heavy metal and Bn is background value for each metal. The PI of each metal was classified as either low ($PI \leq 1$), moderate ($1 < PI \leq 3$) or high contamination ($PI > 3$).

The concentration of heavy metal of soil in each station is influence by various sources such as anthropogenic and naturally. Thus, a pollution index (PI) was applied to the data set to discover possible sources that might influence different distribution of elements over study area around

Basrah. The pollution index was calculated relative to the background values of heavy metals in the soils and the result as shown in Tables 7 and 8.

The PI value of Pb and Hg ranged from 0 to 0.07 and 0.005 to 0.09 respectively for soil and ranged from 0.08 to 0.37 and 0.03 to 0.24 respectively for surface water.

From this assessment show that, Pb and Hg are 100% at low contamination level, this indicating no obvious pollution for Pb and Hg. From this, generally majority of study area is still in secure state where the seven sites in study area for each elements give PI≤ 1 indicate low contamination.

Table 7. Heavy metal concentrations (mg/kg) Pollution index (PI) of soil.

Heavy metal	No. of samples	Background values [18]	Concentration			Pollution index values		
			Min	Max	Mean	Min	Max	Mean
Pb	28	100	0	7.63	3.45	0	0.07	0.03
Hg	28	0.1	0.0005	0.009	0.004	0.005	0.09	0.05

Table 8. Heavy metal concentrations (mg/l) Pollution index (PI) of surface water.

Heavy metal	No. of samples	Background values [18]	Concentration			Pollution index values		
			Min	Max	Mean	Min	Max	Mean
Pb	28	5	0.44	4.5	1.87	0.088	0.9	0.374
Hg	28	0.01	0.0003	0.006	0.0024	0.03	0.6	0.24

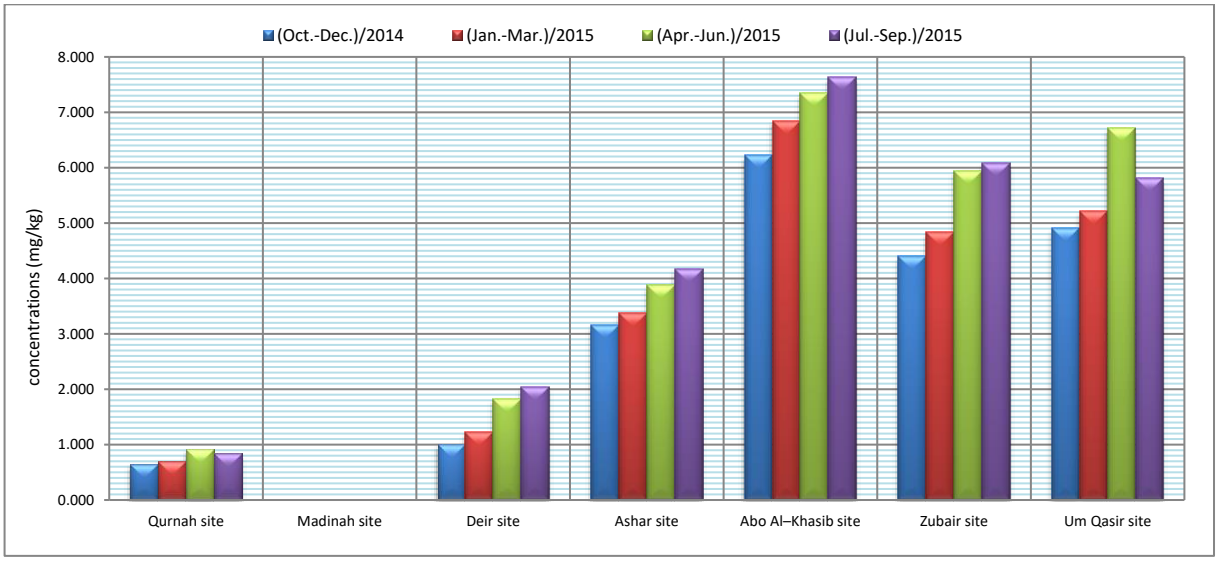

Fig. 3. Seasonal concentration of Pb (mg/kg) in sediment soil for selected Basrah sites.

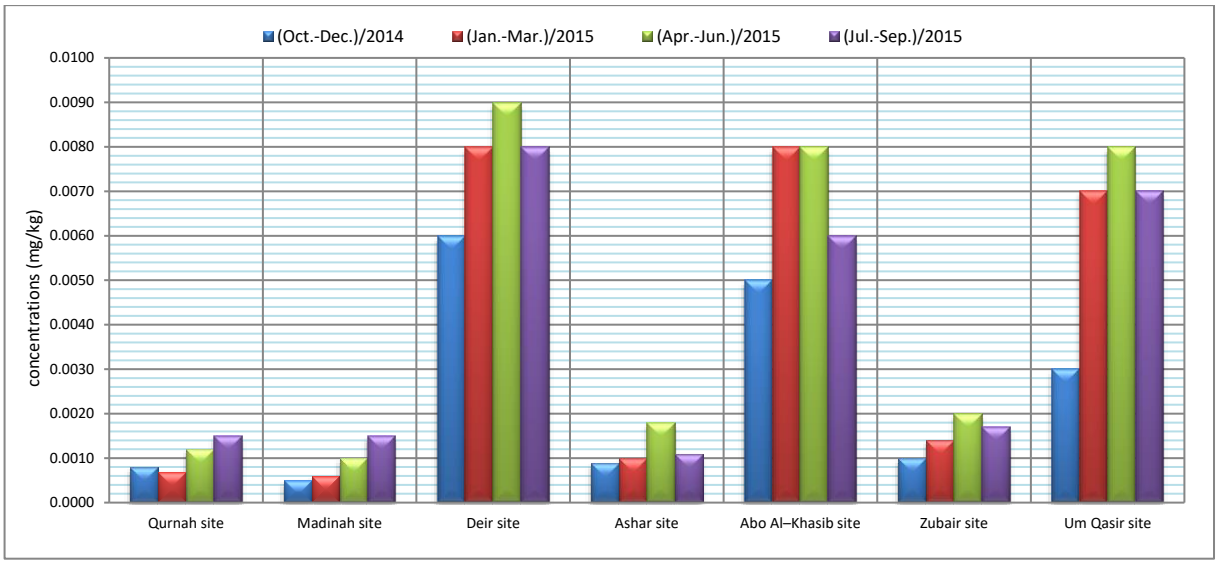

Fig. 4. Seasonal concentration of Hg (mg/kg) in sediment soil for selected Basrah sites.

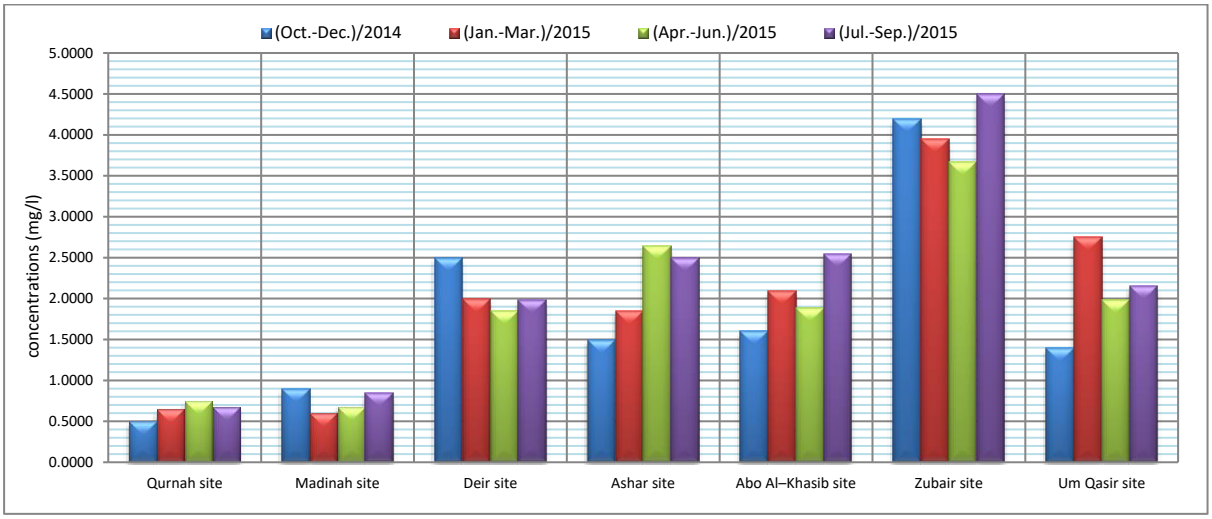

Fig. 5. Seasonal concentration of Pb (mg/l) in surface water for selected Basrah sites.

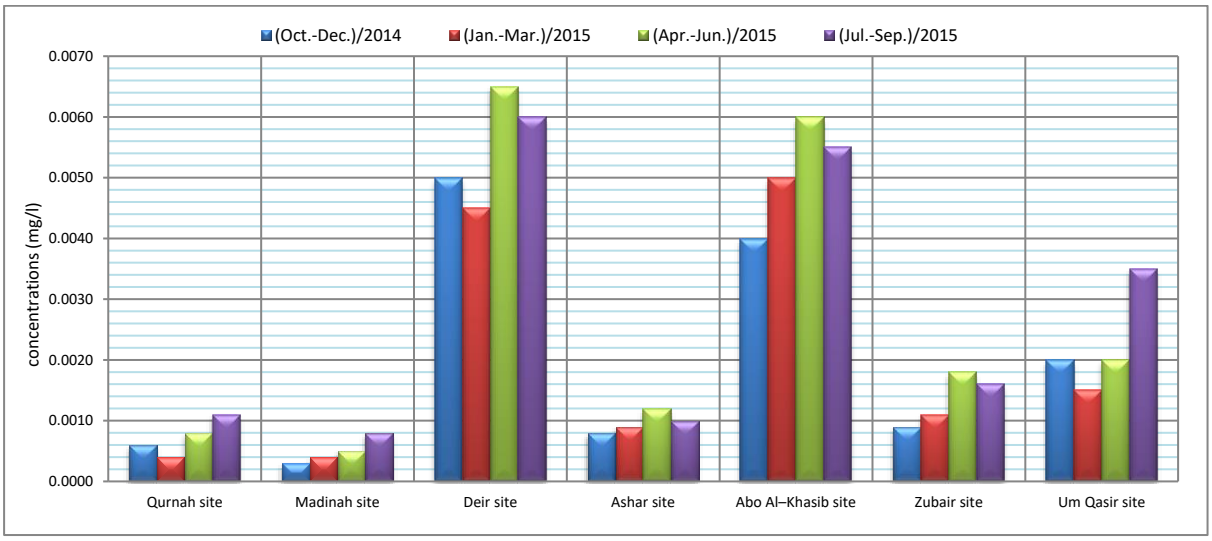

Fig. 6. Seasonal concentration of Hg (mg/l) in surface water for selected Basrah sites.

6. CONCLUSION

Soil and water are essential for the earth's living skin directly sustains life. many water and soil samples collected from varies sites in Basrah were analyzed for Hg and Pb. Hg and Pb concentrations in surface water and soil sediments were lower than allowable limits. After the analysis of samples, a general conclusion that could be reached is that the concentrations of heavy metals in soil sediment and rivers is low. The results of selected heavy metal concentrations of samples shows that the total concentrations of the heavy metals vary seasonally in small variation. Also it was observed that the concentrations of Pb are not detected or at very small levels in Madina site.

Heavy metal concentrations were assessed using pollution index (PI) and the selected elements give low contamination. From this result, found that level of heavy metal in rivers and sediment soil near industrial areas give high value compared with other location in Basrah. Results of combined heavy metal concentration and heavy metal assessment indicate that industrial activities and traffic emission represent most important sources for Hg and Pb.

Heavy metal contamination resulted from the human activities especially the agriculture processes, decomposition of the garbage, sewage, and polluted air. The contamination of Pb and Hg is caused by agriculture operations : (fertilizers, pesticides and herbicides), sewage, and polluted air. Regarding to agriculture operations, domestic sewage effluents, the human activities especially agriculture, sewage, garbage, and desalination plants and waste water represent the main sources of the contamination with contribution from the natural sources in the study area.

7. ACKNOWLEDGEMENT

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