Spatiotemporal variations in the heavy metal pollution index (HPI) values southern Iraq.

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Abstract

All previous researches on heavy metals pollution southern Iraq were studied and reviewed to evaluate the heavy metal pollution in water bodies of this region. The review included three major marshes, Shatt Al-Arab and Shatt Al-Basrah rivers, the main drainage system, and the Euphrates in Nassiriyah city. The concentrations of heavy metals through the period 1985 to 2016 changed in both dissolved and particulate phase spatially and temporally, most of these changes weren't significant. The HPI calculations for these researches shows no pollution in the region, except for Shatt Al-Arab in 2007 and 2014 which reached 576.34 and 163.91 respectively, and for the upper and lower part of Shatt Al-Basrah in 2002 which reached 337.46 and 447.09 respectively. Pollution began to appear in 2002 and subsequent years.

Introduction:

Trace metals are the sort of pollutants that seriously affect all kinds of life in ecosystem, they could be a source of risk for the ecosystem because of their ability to accumulate in living organisms which may lead to bio-magnifications, and geo-accumulation, on the other hand their compounds cannot be degrade to a simple harmless components (Duruibe *et.al*, 2007; Woody, 2007; Bharti, 2012).

Zinc, copper, iron, cadmium, nickel, lead, and manganese are the most important metals from the water pollution point of view. Some of these metals are very important for growth and metabolism of the living organisms such as zinc, copper, and iron, others like lead have no significant importance for life, but in fact it is toxic even in its low concentrations (Al-Hejuje 2014).

There are two main sources of metals in the Iraqi waters; first is natural, include storm dust falls, crustal weathering or erosion and decomposition of biota in water (Al-Juboury, 2009). And secondly the anthropogenic, which include sewage and municipal wastes, industrial effluent, fuel combustion, fertilizer industry effluent, as well as heavy metal related to oil spill and petroleum industry effluent (Al- Haidary, 2009; Eqal, 2015 and Mustafa *et al*., 2015). Military stocks from the Iraqi-Iranian war may contributed in additional amounts of trace metals in southern Iraqi waters (Kubba, 2011; Al-Baidany, 2013).

The southern region of Iraq includes marshes and rivers. These water bodies derives its water mainly from Tigris and Euphrates which meet to form Shatt Al-Arab river in Qarmat-Ali, this river has one tributary from Iran discharge in the left bank of the southern part of the river named Karron. Other sources for its water are Al-Hammar, Al-Hewiza, and Al-Qourna marshes (Hussein *et al*., 1991).

The presence of trace metals in water sources lead to increase the risks of human exposure through direct or indirect ingestion. The aim of this study is to summarize the result of all previous studies on heavy metal in water of southern Iraq to recognize the temporal and spatial distribution of these metals, and evaluating the contamination level of trace metals in water.

Methods and data processing

In this paper most of the studies on heavy metals pollution in southern Iraq have been reviewed to determine their average concentration of trace metals during each study year, starting since 1985 to 2016. The methodological approaches employed in these studies were almost the same; include

sampling methods, and samples digestion for dissolved and particulate water samples.

Study area

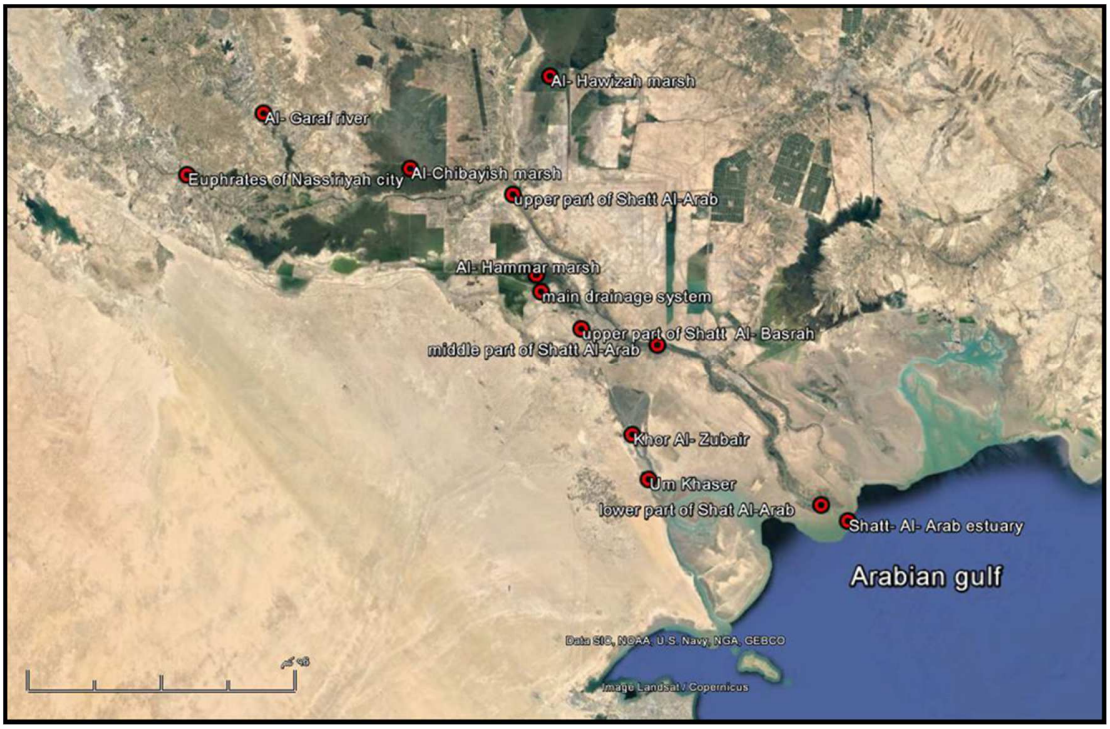

Figure 1: map of the study area

Data processing

1- Trace metals concentration

The average values of eight trace metals (Zn, Pb, Cu, Cd, Ni, Co, V, and Fe) in southern Iraq were calculated to obtain a bulk sample for each trace metal in the study. The concentration, spatial and temporal distribution, and contamination levels of these metals were compared to provide a consistent overview of the contamination with trace metals in water sources southern Iraq. All the data were analyzed using SPSS statistics version 22, under 5% significant degree.

2- Heavy metal pollution index (HPI)

The HPI, which represents the total water quality, is calculated taking into account the amount of heavy metals in it according to the following three steps:

1-Caulculating the weightage for the elements; $W_i=K\backslash S_i$, Wi (weight unit), K represents the relative constant, where S_i is the recommended standard of the relevant metal.

2-Quality rating for each metal; $Q_i=100\times V_i/S_i$ where V_i is the metal concentration in the environment.

3-Collect these two secondary indices to find the overall HPI, $HPI=\Sigma W_i\times Q_i/W_i$. the water considered polluted if the HPI value passed 100 (Prasad& Bose, 2001).

Results

trace metals concentration varied in the southern area of Iraq throughout the years as shown in table (1-6) , The spss test showed that there is no significant spatial differences between the dissolved trace metals concentrations in the studied areas exept for Ni and Co. For Co all Shatt Al-Arab river was significantly different than other areas, while the temporal differences wasn't significant for Fe, V, Co, and Ni.

Table (1) : Spatiotemporal variations of some heavy metals in particulate phase of water (µg/l) in the middle part of Shatt Al – Arab and Shatt - Arab estuary.

location	Fe	V	Co	Ni	Cd	Cu	Pb	Zn	source
middle part of Shatt Al-Arab	-	-	-	-	84.08	489.04	8.72	161.3	Mustafa 1985
middle part of Shatt Al-Arab	31.47	207	6	3807	55	77	93	77.2	Abaychi&Douabul 1985
middle part of Shatt Al-Arab	-	-	-	-	7.45	16.85	53.2	38.6	Abaychi& Mustafa 1988
middle part of Shatt Al-Arab	-	-	-	543.5	23.89	43.4	169.3	227	Atte 2004
middle part of Shatt Al-Arab	-	24.13	-	37.65	11.25	-	13.6	24.45	Awad et.al, 2004
middle part of Shatt Al-Arab	30540.5	-	-	283.53	106.15	141.9	659.96	462.58	Al-Hejuje 2014
Shatt Al-Arab	-	104.15	3.43	326	14.6	26.06	62.76	69.23	AL-Khafaji 2005
Shatt Al-Arab estuary	2466		22.5	193.4	10.04	35.7	18.9	112.3	Al-Saad and Al-Khafaji 1996
Shatt Al-Arab estuary	7104	-	6.3	223.3	33.11	52.25	30.7	32.75	AL-Khafaji et.al, 1997

Table (2) : Spatiotemporal variations of some heavy metals in particulate phase of water (µg/l) in the middle part of the upper part of Shatt Al – Basrah and Basrah Chanal.

Location	Fe	V	Co	Ni	Cd	Cu	Pb	Zn	Source
upper part of Shatt Al-Basrah	-	144.673	20.387	189.416	29.109	6.645	22.713	-	AL-Saadon 2002
upper part of Shatt Al-Basrah	-	-	-	-	-	20.12	13.35	34.46	Aziz et al 2006
lower part of Shatt Al-Basrah	-	280.78	20.34	355.83	60.97	14.04	48.45	-	AL-Saadon 2002
Basrah chanals	-	-	-	-	55.84	108.38	519.12	15.95	Al-Hejuje 1997
Basrah chanals	-	-	18.89	72.127	-	167.37	-	389.937	Al-Imarah et.al, 2008

Table (3) : Spatiotemporal variations of some heavy metals in particulate phase of water (µg/l) in southern marshes and different locations south of Iraq.

Location	Fe	V	Co	Ni	Cd	Cu	Pb	Zn	Source
Al-Chibayish marsh	-	-	-	-	13.5	14.25	20	610	AL-Khafaji et.al, 2015
Al-Chibayish marsh	-	-	-	110.8	3.16	11.57	13.1	550.5	Al-Kahafaji 2015
Al-Hammar marsh	-	-	-	-	15.25	28.73	19.31	83.82	Qazar 2009
Euphrates at Nassiriya city	909.4	-	-	-	16.13	24.48	49.95	35.62	AL-Khafaji 2011
Nassiriya city	-	93.46	-	106.87	-	-	-	-	Maktoof et.al, 2014
Euphrates at Nassiriya	2199	-	-	61.24	16.19	25.7	41.06	85.47	Al-Awady et.al, 2015
main drainage system	-	-	-	75.46	12	24.6	24	96.25	Atte 2004
Al-Jubayla creek	7863.25	-	-	-	8.88	46.53	27.83	3319.63	Al-Khafaji 2000

Table (4) : Spatiotemporal variations of some heavy metals in dissolved phase of water (µg/l) in the middle part of Shatt Al – Arab River and Shatt Al – Arab estuary.

Location	Fe	V	Co	Ni	Cd	Cu	Pb	Zn	Source
middle part of Shatt Al-Arab	-	-	-	-	0.93	0.52	0.04	0.86	Mustafa 1985
middle part of Shatt Al-Arab	716	0.2	17.7	3.4	0.25	0.93	0.3	1.8	Abaychi&Douabul 1985
middle part of Shatt Al-Arab	-	-	-	-	1.9	0.52	0.4	1.71	Abaychi&Mustafa 1988
middle part of Shatt Al-Arab	-	-	-	1.209	0.239	-	0.095	1.364	Al-Imarah 2001
middle part of Shatt Al-Arab	-	-	-	29.2	0.11	3.3	1.78	32.2	Atte2004
middle part of Shatt Al-Arab	-	7.83	-	10.61	2.48	-	12.4	3.33	Awad et.al, 2004
middle part of Shatt Al-Arab	19.9	-	12.6	-	1.15	0.6	6.16	5.8	AlSaffi 2005
middle part of Shatt Al-Arab	89.45	-	-	9.51	3.01	2.35	43.67	7.58	Al-Hejuje 2014
Shatt Al-Arab estuary	389.2		0.33	2.45	0.15	0.58	0.18	0.93	Al-Saad and Al-Khafaji 1996
Shatt Al-Arab estuary	173	-	-	2.85	0.19	0.47	0.23	0.82	AL-Khafaji 1996
Shatt Al-Arab estuary	223	-	1.1	2.3	0.35	0.45	0.4	1.4	AL-Khafaji et.al, 1997
Shatt Al-Arab	29.11	-	20.9	20.9	-	-	-	-	Al-Hejuje 2000
Shatt Al-Arab	-	0.21	0.57	2.2	0.2	0.32	0.22	0.55	AL-Khafaji 2005
Shatt Al-Arab	479	-	-	-	11	206	143	925	Hassan 2007

Table (5) : Spatiotemporal variations of some heavy metals in dissolved phase of water in Shatt Al – Basrah and Basrah Chanal.

Location	Fe	V	Co	Ni	Cd	Cu	Pb	Zn	Source
upper part of Shatt Al-Basrah	-	26.956	8.31	32.716	13.747	13.493	13.11	-	AL-Saadon2002
upper part of Shatt Al-Basrah	-	-	-	-	-	1.31	8.03	10.25	Aziz et.al, 2006
lower part of Shatt Al-Basrah	-	88.15	13.54	96.61	17.71	70.76	21.87	-	AL-Saadon2002
Basrah chanals	-	-	-	-	2.58	2.13	13.25	28.28	Al-Hejuje 1997
Basrah chanals	-	-	0.054	0.052	-	0.186	-	6.182	AL-Imarah et.al, 2008

Table (6) : Spatiotemporal variations of some heavy metals in dissolved phase of water(µg/l) in southren marshs and different locations south of Iraq

Location	Fe	V	Co	Ni	Cd	Cu	Pb	Zn	
southern iraq	0.07	-	-	0.311	0.095	2.81	0.252	0.03	AL-Imarah et.al, 2000
southern marshes	280	-	1310	660	-	100	-	-	AL-Saad et.al, 2008
Al-Hawiza marsh	-	-	-	-	-	-	-	110	Adam et.al, 2007
Al-Hammar marsh	-	-	-	-	81.36	-	-	-	Mezher et.al, 2008
Al-Hammar marsh	-	-	-	-	0.22	1.52	6.04	4.57	Qazar 2009
Al-Hammar marsh	-	-	-	-	1.77	-	1.94	-	Nazal 2016
Al-Chibayish marsh	-	-	-	6.37	1.05	0.25	1.37	23.37	Mashkhool 2012
Al-Chibayish marsh	-	-	-	6.37	1.05	0.25	1.37	23.37	Al-Kahafaji 2015
Al-Chibayish marsh	-	-	-	-	0.12	1.4	0.24	0.3	AL-khafaji et.al, 2015
Euphrates at Nassiriya city	726	-	-	-	0.15	0.59	0.2	2.5	AL-Khafaji 2011
Nassiriya city	-	23.94	-	23.71	-	-	-	-	Maktoof et.al, 2014
Euphrates at Nassiriya city	160.39	-	-	2.71	0.08	0.12	0.74	20.31	Al-Awady et.al, 2015
Al-Jubayla creek	89.23	-		-	0.17	0.46	0.43	4.2	Al-Khafaji 2000
main drainage system	-	-	-	2.41	0.05	0.2	0.24	14.33	Atte2004

There were no significant spatial differences for the particulate phase of water except for the Zn, while we can find significant differences in the metal concentration of Co, Ni, Zn, and Cd throughout the years.

The degradation of trace metals in water may occur during the natural cycle of water through rocks or soil containing quantities of these elements, or may be derived from sources of human activity, such as sewage and industrial waste, household waste, fuel combustion, metallurgical industries and oil spill (AL-Shahristani and AL-Attiya, 1978; Qazar, 2009).

Among all the studied metals, iron average concentration was higher than the other metals in both dissolved and particulate phases of water, followed by the nickel which represents the fifth most common element in the environment after iron, oxygen, silicon and magnesium (Cempel and Nikel, 2006), wreck ships that found enormously along Shatt Al-Arab river could be a major source for that elements.

The concentration of heavy elements fluctuated through the years, and it values changed from one region to another, this fluctuation could be attributed to the interactions between different factors which affect the concentrations of both dissolved and particulate metals, some of these factors are the unequal amounts of industrial and sewage discharges, the presence and the density of phytoplankton and aquatic plants which accumulate or adsorbed the ionic metals, weather circumstances also could be affecting metal concentrations such as sand storms or rain occurring.

HPI calculations reveals serious pollution at 2002 in Shatt Al-Basrah, that reached 337.46, 447.09 for the upper and the lower part of it respectively. (Table 7)

According to Hassan, 2007 HPI value was very high 576.34 in Shatt Al-Arab that might be due to its being affected by the amrshes water at the time of sampling which occurred in 2004-2005 just after the refloding of the marshlands. This value came back to raise in Al-Hejuje, 2014 study and reached 163.9. (Table7)

Table (7) : Mean HPI for the study area since 1985-2015.

Location	HPI	Source
middle part of Shatt Al-Arab	21.021	Mustafa 1985
middle part of Shatt Al-Arab	64.417	Abaychi&Douabul 1985
middle part of Shatt Al-Arab	43.593	Abaychi&Mustafa 1988
middle part of Shatt Al-Arab	5.624	Al-Imarah 2001
middle part of Shatt Al-Arab	7.292	Atte2004
middle part of Shatt Al-Arab	81.074	Awad et.al, 2004
middle part of Shatt Al-Arab	39.991	AlSaffi 2005
middle part of Shatt Al-Arab	163.919	Al-Hejuje 2014
Shatt Al-Arab	5.040	AL-Khafaji 2005
Shatt Al-Arab	576.342	Hassan 2007
Shatt Al-Arab estuary	18.885	AL-Khafaji 1996
Shatt Al-Arab estuary	26.863	AL-Khafaji et.al, 1997
upper part of Shatt Al-Basrah	337.464	AL-Saadon2002
lower part of Shatt Al-Basrah	447.097	AL-Saadon2002
Euphrates at Nassiriyah city	62.633	AL-Khafaji 2011
Euphrates at Nassiriyah city	16.415	Al-Awady et.al, 2015
main drainage system	1.712	Atte2004
Al-Hammar marsh	17.194	Qazar 2009
Al-Chibayish marsh	39.675	Al-Kahafaji 2015
Al-Chibayish marsh	3.188	AL-khafaji et.al, 2015
Basrah chanals	84.946	Al-Hejuje 1997
southern Iraq	0.529	AL-Imarah et.al, 2000

Urbanization and industrialization development has a clear negative impact on the environment. After 2003, the number of vehicles increased clearly in Iraq, as well as the number of electrical power generators, leading to increased releases of pollutants from fuel combustion including heavy metals to the environment.

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