Plant Archives Vol. 18 No. 2, 2018 pp. 2533-2542 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

MODELING THE DYNAMICS OF MERCURY BIOMAGNIFICATION POND MARTYR MONUMENT, BAGHDAD, IRAQ

Sama Hassan Ali and Reyam Naji Ajmi*

Department of Biology Science, Mustansaryah University, POX 46079, Baghdad, Iraq.

Abstract

Mercury is a heavy metal that occur naturally in the Earth's crust, and are incorporated into biological system as structural compounds or protein, biomagnification refers to the accumulation of pollutants such as toxic metals through a food chain In this study, dynamic model is constructed to study the biomagnification of mercury in aquatic and terrestrial ecosystem. The data is taken from Martyr Monument in Baghdad. The plants show the ability to accumulate mercury and the concentration of mercury in fish *Liza abu* was higher than *Silurus triostegu* due to several factor such as different physical characters, structure, quality of nutrition , size of fishes and the nature of compositional for each one, this refers that the Fish have an accumulative response to mercury metals present and deposited from sources of emissions. The Mollusk important indicator for the water balance andability to adsorption elements and accumulation because There is no significant difference between concentration of Hg in water and mollusk (*Uniotigrids*). The important object of this study was examine biomagnification and determination the ecological risk factor to predict changes in Hg concentration in environmental compartments, results predicted the probability of increasing pollutants in some of samples less than < ten years depending Exposure factors. The primary risk of mercury exposure in terrestrial, vertebrates including humans, agricultural products, industrial and military activities have led to widespread contamination of the environment.

Key words : Biomagnification, mercury, pond Martyr Monument.

Introduction

Basic main pollutants and chemicals components have a tendency to stick to the environment such as cadmium, lead, mercury or copper and others. Minerals in the biotic environment originate from two separate sources of geological processes related to metal fillings geological formations and human resources. Primary contaminants cannot be degraded more so they can undergo different reversible changes in belonging depending on the chemical environment (Campbell *et al*., 2006). Many elements are necessary for life functions (Mertz, 1981) and plants and animals possess different mechanisms for accumulating sufficient amounts of elements from their environment also facilitate the treatment of non-essential minerals (Ballatori, 2002; Zalups and Ahmad, 2003). Treatment and retention of metals (or any other chemical) ,environmental pollution and the effects of chemicals on the environment and natural resources have become one of the major global problems (Burger and Gochfeld, 2009). Research on elements transport through food webs begins from 1960s (Bryan, 1979; Fowler, 1982) and has been developing in recent decade (Wang, 2002). Despite all these research, the mechanism of the transport in food webs is not still well known (Dietz *et al*., 2000; Rainbow, 2002; Wang, 2002; Barwick and Maher, 2003). Biomagnification is defined as an increase in the concentration of metals through a food chain and from an organism to its predator. If metals biomagnified in a food chain, they can cause serious health problems for human-beings consume the top predator of the chain (Agah *et al*., 2009). This process can occur at each step in a food chain, potentially producing very high and toxic concentrations in upper-trophic- level species (Gobas *et al*., 2009). To understand the concept of dynamics biomagnification in ecosystems for Mercury (Hg). The important goals that identify the changes that had happened in the environmental areas from various sites were chosen from pond Martyr Monument site located in the south-eastern part of

***Author for correspondence :** E-mail : reyam80a@yahoo.com

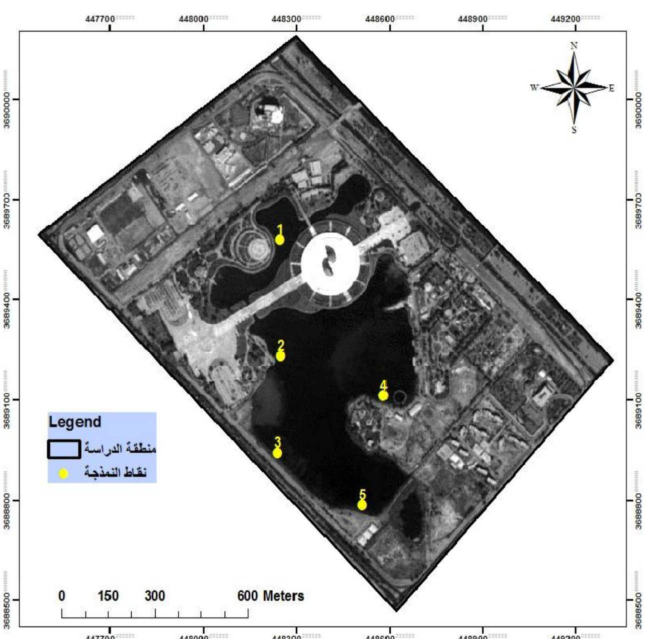
Baghdad with the following :

1. Implementation of ecological model biomagnification of metals occurs within aquatic and terrestrial systems by Mercury in environmental factors (Water, Soil), biological factors: Fish (*Liza abu*, *Silurus triostegu*), Plants (*Myrtus communis*, *Cynodon dactylon*, *Rosa kordesii*, *Phoenix dactylifera*) and aquatic plants (*Ceratophyllum demersum*, *Potamogeton crispus*, *Phragmite saustralis*) and Mollusk (*Unio tigrids*) for 5 locations from Martyr Monument by capacity to absorb and identify the most important sources of elements to identification of health risks according to Potential Ecological Risk Index (RI). Dynamic modeling was used to predict changes in Hg concentration in environmental compartments exposure in response to reductions in pond Martyr Monument. The modeling allowed the assessment reductions in Hg cycle and changes in basin characteristics and allows users to evaluate potential policy options and poses better questions to decision makers seeking to protect susceptible populations' community on this site.

Materials and Methods

Description and samples collection of the study area

In Martyr Monument 5 basic stations were chosen, at Martyr Monument area in Baghdad samples of four pond water and one sample a nearby to the water well (current source of feeding pond) each area was labeled depending on coordinates of these locations, which have been determined by the GPS. Samples were collected during October 2017.



Picture 1 : General map to show the study areas.

Collection samples

A. Environmental samples

- **Soil Samples** were collected by using cleaned polyethylene bags from 30 cm in depth to preparation of soil samples by five replications of each region to get final 25 samples (Yang *et al*., 2008).
- **Water samples** were collected from the surface water (about 30 cm below the surface) by using 20 litter containers. The water samples were immediately filtered through 0.45µ Millipore filters and then frozen till the time of analysis, Standard methods by Pearson and Havill (1988) to get the final 20 sample with replicate from ponds and 5 sample from well (current source of feeding pond) depending (Lenor *et al*., 1998). The pH measurements were carried out with a pH meter (WTW-pHmeter-720). A centrifuge (Hettich Centrifuge, Germany) was used to accelerate the phase separation process. Micro injector (Hamilton, Switzerland). Examined in Ministry of Commerce, General Company for Foodstuff Trading / quality control division).

B. Biological samples

- Fish *Liza abu* (Class : Actinopterygii, Family: Mugilidae)
- *Silurus triostegu* (Class: Actinopterygii, Family: siluridae) collected the samples with help of the security guard in the monument. The length-weight relationships estimated to account for condition factor, which was a good indicator of fish growth. Fish samples were transferred by keeping bags within Ice, and then tested (Muscle). Final sample with five replicate of all station 5 *Liza abu*, 5 *Silurus triostegu.*
- **Mollusks** *Unio tigrids* (Kingdom: Animalia, Phylum: Mollusca, Class: Bivalvia, Order: Unionoida, Family: Unionidae) (Bouchet and von Cosel, 1996) were dried shell by oven in (60^{0}C) on (20 min.) and ground to be ready for analysis.
- **Plant samples :** Plant leaves samples have collected and then rinsed thoroughly with deionized water and dried in the outdoor in room temperature for (3-5) days then ground with a grinder to be ready before analysis, plants was *Myrtus communis* and *Phoenix dactylifera* (permanent), *Rosa kordesii* (seasonal), *Cynodon dactylon* (herbal) and aquatic plants were chosen *Potamogeton crispus*, *Ceratophyllum demersum* and *Phragmites australis*.

Mechanical working of Milestone's Direct Mercury Analyzer (DMA-80)

Directly analysis to any sample solid or liquid at the same time without need to preparation of samplea liquid or solid sample into metal boat or quartz and then transfer sample from DMA-80 to the analytical balance need five minutes for one sample, no need acid digestion. Sample boats loaded on to instrument auto sampler, first dried then thermally decomposed in furnace oxygen. Mercury and combustion products released from the sample and carried to the catalyst section furnace, where sulfur oxides and nitrogen. Mercury (Hg) is flown by the transferor gas into path of the spectrophotometer where it is quantitatively measured. All systems of information are kept on a Windows-based computer and software, providing simple and intuitive, sample parameters including method profile, furnace temperatures, absorbance signals. The results and calibrations are saved information is easily transferred by using a USB memory to Laptop Laboratory (USEPA, 2006).

Method validation was used as certificate reference material CRM as in table 1. Gaithersburg, MD, USA (2013) was utilized to assess the accuracy of the method. Developed spike recoveries were performed on this material as well as samples according to Ataro *et al*. (2008) and Nascimento *et al*. (2008). This principle was used for all sample analysis. This typically contains an automatic sampler, quartz furnace, cobalt-manganese oxide catalyst, gold-coated sand amalgamator and an atomic absorption detection cell with three different path lengths (120,165 and 4mm). The method for solid sample analysis consists of placing a known amount of milled sample in a nickel or quartz boat (Sample holder). The sample is introduced in the quartz furnace, where it is heated up to 200°C (drying temperature) for 600-1000 C, maximum temperature allowed by the software of equipment about 105, which set a limit mercury volatilization and reduction of oxygen O_2 (99.99%) (CEM Corporation, Matthews, USA, 2013).

Determination of the potential environmental risk factor (RI) for samples

This is achieved by determination the CRM (Certificate references materials) of the samples used.

Statistical method

The analysis of variance (ANOVA) using a complete randomized design (CRD) was employed to test the differences between the eight date palm residues and A. tortillas in all the measured properties using the SAS statistical package (Cox, 2006). Least significant difference at 5% level of probability (LSD 0.05) was used to detect the differences among the means of all the measured properties. Correlation analysis was also carried out to find out the relationship between the heating value and each of the chemical constituents and ultimate and proximate analysis of the date palm residues (Cox, 2006).

Results and Discussion

Mercury in types of plants

Results showed the presence of mercury concentration in all plants but differ from one to other depending on the ability to absorb this element and content the terrestrial dominate plants species. Consecutively, *Cynodon dactylon*, *Myrtus communis*, *Phoenix dactylifera*, *Rosa kordesii* that means using it as a positive indicator of pollution in study areas in this area. Through statistical analysis scored a significance between element and plants in a percentage of the corresponding (30%, 19%, 12%, 9%). Respectively, this is consistent with some of the researchers Mercury for plants *Myrtus communis* between (2.01– 8.3 ppm) in Tunis (Ghnaya *et al*, 2013). Concentration elements in aquatic plants in three dominate plants species, consecutively: *Ceratophyllum demersum*, *Phragmites australis*, *Potamogeton crispus*. The results obtained are acceptable with the results of the study conducted by Ajmi (2009). Also in local studies (Ajmi, 2012) found *Ceratophyllum demersum* between (4.3-16.9 ppm) and *Phragmites australis* between (8.6-13.8 ppm). This indicates that aquatic plants are known in accumulating metals from around its environment (Al-Haidary, 2009 and Ajmi, 2010). Table 3 showed the concentration of mercury in plants under study. The concentration of elements varies from station, especially near well and second site because it is the closest to the 'Sindibad land' which is frequented by people on holidays and occasions, in which diesel generators are produced, through which the dust can transfer as it is deposited on the surface of the nearby.

Mercury in water and mollusk

Related to change that occur in the environment from other organisms. Mollusks considered as a monitoring of aquatic ecosystems to determine pollution (Rocque, 2004). Mollusk is evidence bioindicator to assess the environmental characteristics most of its requirement of nutrients and the relationship between environmental factors (Alcamo, 1998; Favero *et al*., 2003; Ajmi and Zeki, 2015; Ammann, 2002; Gaillardet *et al*., 2003; Wang and Liu, 2003; Zhang *et al*., 2008). Results mercury in water and Mollusk (*Uniotigrids*), it observed approximate or similarity to the extent of mercury concentration in water and organism as a monitoring of aquatic ecosystems to determine conformity with pollution

(Rocque, 2004). There are no significant difference P-value (0.03,0.05) in this element this agree with previous studies (Kannan and Falandysz, 1998) suggested a ratio of Mercury concentration in mollusk could be used as an important case describing the pollution in the surfaces water and this agree with the study by Ati (2017) that said, there is no significant difference between water and mollusk P-value (0.637, 0.568). These strongly agreed with same results from Everaarts *et al*. (1993), Ajmi and Zeki (2015). The Mollusk important indicator for the water balance and the ability to adsorption elements and accumulation this result applies with other researchers (Rama Krishnan, 2003). Fig. 1 showed the concentration of mercury in water and Mollusk.

From analyses the significant relationship, it passes biomignification of mercury in the effective transfer bioaccumulation (Favero *et al*., 2003; Ajmi, 2009). Obviously that through results of Mollusk to protect itself from high concentrations and toxicity of mercury and reduce the rate of entry through the permeable surfaces of absorbents and the increase in the output of these metals ions mechanics of the most common (Pederson and Perkins, 1986; Masters and Gilbert, 1991). Depends engender elements in the conch shell on the age and life cycle (Favero *et al*., 2003; Zauke *et al*., 1998). There are many external factors that effect of mollusk and water such as organelle complex molecules and inorganic as well as chemiophysioical factors that control metabolism, such as heat, light, oxygen and nutrients (Scott, 1989; Favero *et al*., 2003). Reflecting their high filter capacity, enhancing exposure to dissolved metals present in the water column (Mouneyrac *et al*., 1999; Ettajani *et al*., 2001; Tran *et al*., 2001).

Mercury in soil and fish

After obtaining the results of mercury concentration in soil in this study area there were no significant correlation P-Value (0.012). It was not of a critical level set by WHO and EUO (UNEP, 2001). Most concentrations were P-value <0.05 and percentage 17% in mercury compared to some researchers reported (Houserova *et al*., 2007; Ullrich *et al*., 2007). These results of mercury concentration were relatively constant that may reflect that mercury input and deposition in sites under study and may be relatively constant during ten recent years, which reflects a fact that Hg concentration is not the only influencing factor these results agree with (Horvat *et al*., 2003). Maybe some environment conditions such as nutrient and redox conditions depending on the specialty of this location, therefore the explanation of mercury vertical distribution in soil were risk complex

Table 1 : Method validation was used as certificate reference material CRM.

Wavelength	Step	Time	CRM and SRM	Type
Gas Flow (L min^{-1})	150	12 min	IAEA-140TM	Plants
Plasma 15	170	16 min	TORT-2	Mollusk
Auxiliary 0.2	100	15 min	DORM-2	Fish
Nebulizer 0.8	100	10 min	0	Blank
Read delay (s) 75	200	25 min	NIST 2709	Soil
Replicates 5	175-200	One time to each	SRM-1974b	Water
Probe in sample (n)	100	10	0	Blank
Rinse (n)	100	10	0	Blank

Table 2 : CRM (Certificate References Materials) Elements CRM. www.crunchbase.com. Retrieved 2017.

Samples	CRM of Hg
Water	1.62 ± 0.06
Soil	2.91 ± 0.01
Plants	0.08 ± 0.01
Mollusk	8.00 ± 1.0
Muscle of Fish	2.1 ± 0.02

@Certified value ± 95% confidence interval of the mean value
c Mean ± standard deviation at 95% confidence limit replicate
Then apply the equation below :
RI = Tin × CRM / Cio.

indirectly the biosphere by bioaccumulation and inclusion in the food chain by human activities nearby this area, table 4 showed concentration of mercury in soil.

The distribution of this mercury in all station area under this study showed a much greater accumulation in soil especially the nearby area on the well and the second near the side of the city Sindibad Land response pollution indices can be used to compare different pollution in sites and essential to understanding the current risks to all organism in aquatic ecosystem in region especially when there spatial database for the distribution of pollutants such as mercury with the rapid development of urbanization and industrialization and soil pollution for the dominant organism dominate in area and agree with the study by Ati (2017) the results showed the level of the Hg concentration was less than expected compared with previous studies was 2.017ppm. This study agrees with researchers (Stewart *et al*., 2008; Ajmi, 2010). About two types fishes from results that have been reached in the muscles in the two types of dominant fishes in the

Table 3 : The concentration of mercury with values standard deviation.

Myrtus Communis	Hg	*Potamogeton crispus*	Hg
Max.- Min	0.06-0.01	Max.- Min	2.81-1.10
Mean	0.03	Mean	1.92
SD	0.798	SD	0.82
LSD	0.126	LSD	0.33
P < 0.05	0.003	P < 0.05	0.04
Rosa kordesii		*Phragmites australis*	
Max.- Min	1.06-0.08	Max.- Min	1.81-1.02
Mean	0.63	Mean	1.04
SD	0.98	SD	0.91
LSD	0.26	LSD	0.01
P < 0.05	0.05	P < 0.05	0.001
Cynodon dactylon		*Ceratophyllum demersum*	
Max.- Min.	0.09-0.2	Max.- Min	3.91-2.91
Mean	0.05	Mean	2.01
SD	0.08	SD	0.71
LSD	0.3	LSD	0.32
P < 0.05	0.07	P < 0.05	0.01
Phoenix dactylifera			
Max.- Min.	0.09-0.1		
Mean	0.05		
SD	0.01		
LSD	0.1		
P < 0.05	0.05		

Table 4 : The concentration of mercury in soil.

Pond location	Mean Soil (Hg)
1	0.91
2	0.99
3	0.63
4	0.67
5 Near well	1.9
LSD	0.92
P *value*	0.03

study area there was significant difference in one group *Liza Abu, Silurus triostegu* of mercury as follows (0.89, 0.65), respectively, this agree with the study by Ati (2017) Hg in one Group *Liza abu* (0.074) ppm and between groups 63%, 27%, respectively.

That's mean depending on different physical characters, structure, quality of nutrition, size of fishes and the nature of compositional for each one, this refers that the fish have an accumulative response to mercury metals present and deposited from sources of emissions.

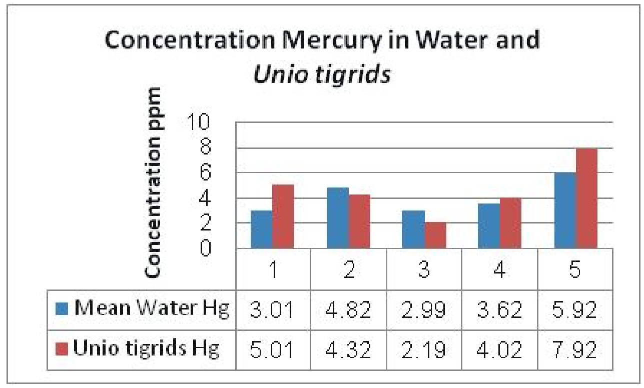


Fig. 1 : The concentration of mercury in water and *Uniotigrids.*

Table 5 : The concentration of mercury in fishes.

	Liza abu	***Silurus triostegu***
	Hg (ppm)	
Max.- Min.	5.06-3.33	4.26-2.86
Mean	4.99	3.86
SD	0.89	0.65
LSD	4.81	3.91
P *value*	0.51	0.13
200 ≤ RI < 400	Considerable risk	
400 ≤ RI	Very high risk	

Table 6 : Factors and measures of potential ecological risk factor (RI) (Katie and Pendias, 2006).

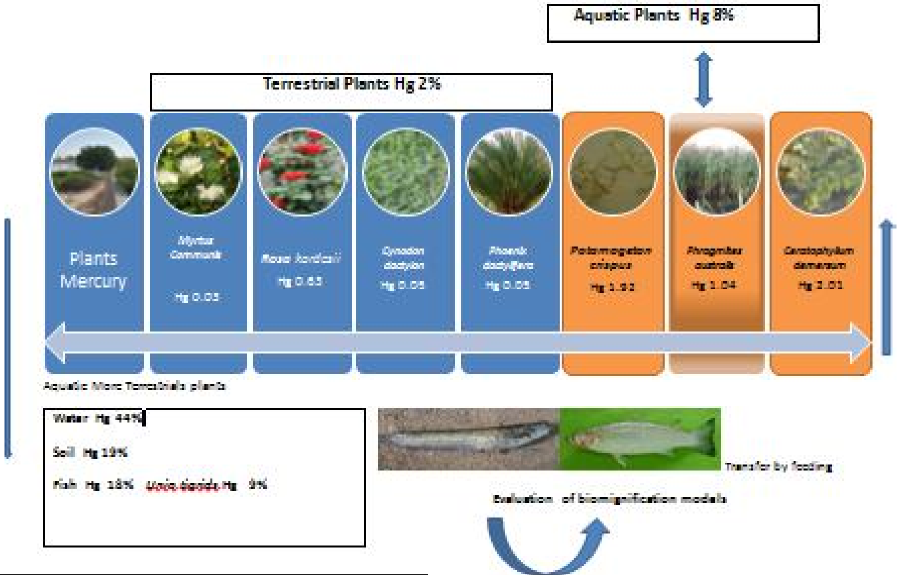
RI value	Grades of the environment
RI < 110	Low risk
110 ≤ RI < 200	Moderate risk
200 ≤ RI < 400	Considerable risk
400 ≤ RI	Very high risk

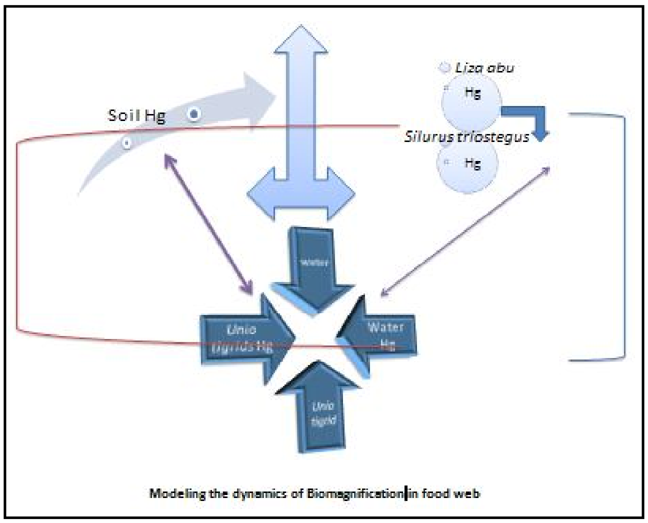
Table 7 : CRM (Certificate References Materials) Elements CRM. www.crunchbase.com. Retrieved 2017.

Samples	CRM of Hg
Water	1.62 ± 0.06
Soil	2.91 ± 0.01
Plants	0.08 ± 0.01
Mollusk	8.00 ± 1.0
Muscle of Fish	2.1 ± 0.02

Relationships between two type fishes were detected with multiple regression. This is a high impact environmental index relative to previous studies; therefore, spatial gradients have been shown for these metals as shown in table 5.

This refers to a good indicator of control mercury in fish essential to understand the current potential environmental risks index to consumers and quality types fish in the region especially when there spatial database





for the distribution of pollutants and biomagnified an increase in the concentration of these metals through a food chain from a muscle fishes occurs at each step in a food chain, potentially producing very high and toxic concentrations in upper-trophic-level species (Gobas *et al*., 2009). This study agrees with researchers (Stewart *et al*., 2008; Ajmi, 2010). Type *Liza abu* was the most absorbing mercury, but low concentration compared with the limits factors (WHO, 2001; UNEP, 2012; EPA, 1997; Stewart *et al*., 2008).

Ecological Model dynamics biomagnification of metals

From our results showed the capacity to absorb and identify the elements in health risks according to Potential Ecological Risk Index (RI) and potential ecological risk factor (Tin) in dynamic modeling to predict changes in Hg concentration in environmental compartments exposure in response to reductions in pond Martyr Monument by calculating the concentration of the metal in the sample and its concentration in the reference value-RI = Tin × CRM / Cio

Tin = Concentration of metals in the sample Cio = reference depending.

CRM value of the metals CRM in table 7, the results as follows in table 7.

Table 8 : Dynamic biomagnified to predict for more than or less than ten years depending on Exposure Factors.

Types	(Tin) Hg	(RI) Hg
Water	0.51	0.62
Water Well	**3.09****	**2.91****
Soil	0.52	0.82
Uniotigrids	0.82	0.71
Liza abu	**8.92****	**7.25****
Silurus triostegu	**3.92****	**6.82****
Myrtus communis	0.69	0.99
Cynodon dactylon	**1.99***	**1.62***
Phoenix dactylifera	0.72	0.81
Rosa kordesii	0.82	0.56
Phragmites australis	**1.92***	**4.92****
Ceratophyllum demersum	**1.92***	**1.00***
Potamogeton crispus	0.81	0.77

•Average values to predicate for more than > ten years depending Exposure Factors.
** Average high values to predicate less than < ten years depending Exposure Factors.

Coclusion

It is the first comprehensive field study of Biomagnification for this region except the study of Abd Ali (2015) seasonal changes of environmental factors and their impact on the fingerlings of carp common in the pool of martyr monument, who studied the accumulation of elements and physical and chemical properties in carp fish fingerlings (*Cyprinus carpio*), statistical analyses were using to evaluate mercury which variables correlated in types plants and estimate with the different area and detect types of plant uptake of these elements as amenability that a biomignificate an important environmental pollution in the region. The balance amount of essential has a key role in the metabolism of a food chain. Demonstrates relationship for most plants to absorb the element and most portability tolerant pollution. Most plants play an important role in circulating nutrients and trace metals in aquatic ecosystems, spread all over the world due to their high capacity in uptake of nutrients and other pollutants from water are proper for wastewater treatment and reduce pollution loadings in the aquatic environment (Brancovic *et al*., 2010). Uptake of in organic complexes by aquatic plants is because of their higher surface area compare to their volume and high membrane sorption and permanent contacts to solutions in media (Brancovic *et al*., 2010). These plants can be applied for monitoring of pollutants and the investigation of ecosystem quality of water bodies (Brankovic *et al*., 2010). The common reed found to be proper for biomonitoring of the environment and can be applied as a bioindicator in ecosystems (Bonanno and Lo Guidice, 2009) and is suitable for wastewater and landfill discharge treatment (Prevely *et al*., 1995). Considering the growth rate and biomass of common reed and other organisms and the growth season for each of them, it is suggested to apply both of these in a constructed wetland for better treatment of pollution. Perhaps the answers to the most of our industrialized world's problems can be found somewhere in nature.

Water as a good indicator of mercury contamination its content in bottom sediments, which can store large amounts of this metal as interactions with mollusk, an important factor for cleaner environment and be a site of its many conversions (Ajmi and Zeki, 2015). Mercury content of the mollusk may differ during the breeding seasons and at the periods of the year particularly during the winter dormancy. According to present experimental results, this concentration was positive regarding in the biogenic metals. This means that their ability as favorable biomonitors for levels mercury. Seasonal variations of the metal concentration at a given site may often be due to seasonal changes of the organisms rather than to any variability of the absolute metal content of the organisms (Phillips and Russo, 1978; Rama Krishnan, 2003). There are many external factors that effect of pollution in it such as organic, inorganic complex as well as chemiophysiological factors, pH, heat, light, oxygen and nutrients and biodegradable of organism (Favero *et al*., 2003). Reflecting their high accumulate capacity, enhancing exposure to dissolved metals (Ettajani *et al*., 2001; Tran *et al*., 2001). Concentrated elements for soil that recent being possible that washed away with large amounts of passage in the raining season especially since it is close to the network of rain channel army (FAO, 2012; UNEP, 2009).

The results showed that the percentage of pollution is few, but compared with the study of Abd Ali (2015) was more and this indicates that the region is vulnerable to pollution in the coming years. Through the results of the mercury concentration that have been obtained from analyzed samples were reached of the bioindication environmental and how to transition in aquatic food chains. Increasing gradually in soil and water well that means the accumulated element through weathering and shelf of the river practical source through the seasons of the year and then followed by the fish, because most of them feed on vegetation, water, small hydro and benthic invertebrates feed on algae and debris. Thus, it accumulated through many trophic levels and transfers of elements and then accumulates in the organism when increase the absorption rate, sometimes reduces the concentrations in types of fish, mainly due to the growth of the fish often which lead biomagnified elements in fish muscles especially mercury this is consistent with Wang *et al*. (2007). Average concentration elements in water of the surrounding environment would enhance the metabolism of the Mollusks would be more rapidly eliminated from balance biota. However, could be transferred to food webs by type emergent in aquatic ecosystems according to Cristol *et al*. (2008). The water well was a potential source of these elements should also be transferred to Fish Muscle tissue and biota samples (plants and mollusks) contained higher contents of elements a because can accumulate through food web depending historical region and growth rates of biota as fish and plants could also affect to mollusks.

Recommendation

Strongly support the more intensive sampling to represent the spatial distribution of the risks of other elements in all Baghdad areas and focus on working spatial information about the idea of the relative risk between variables in environmental and biological factors in the food web by other new technologies such as Telescope and Remote Sensing to get a whole integrated database and allows users to evaluate potential policy options and poses better questions to decision makers seeking to protect susceptible populations community.

Acknowledgment

Extremely grateful to all the people for their cooperation and help to get our data.

References

Abd Ali, H. A. (2015). The seasonal changes of the environmental factors and their effect on the normal carp fish fingerlings in the pool of martyr monument, Baghdad. *M. Sc. Thesis*, boil. Dep. Coll. of Basic Education, Mustansiriyah University.page 5-13.

Agah, H., M. Leermakers, M. Elskens, S. M. R. Fatemi and W. Baeyens (2009). Accumulation of trace metals in the muscle and liver tissues of five fish species from the Persian Gulf. *Environmental monitoring and assessment*, **157(1-4)** : 499.

Ajmi, R. N. (2009). Biogeochemical Assessment to heavy metals in some marsh in south of Iraq by using GIS. *PhD Thesis* Women Science College, University of Baghdad, 190p.

Ajmi, R. N. (2010). Biogeochemical Assessment of some heavy metals in Al-Hammar marsh by using GIS. *PhD Thesis* to college of science/ University of Baghdad.170p.

Ajmi, R. N. and H. F. Zeki (2015). Mercury biomagnifications in Iraqi marshland (AL-Hawizeh (HZ) food chain using stable isotope analyses. *International Journal of Scientific & Engineering Research*, **6(4)** : 2229-5518.

Alcamo, J. M. (1998). Water relationship of food spoilage microorganisms. *Advance Food Research*, **7** : 84-128.

Al-Haidarey, M. J. S. (2009). *Assessment and sources of some heavy metals in Mesopotamian marshes* (Doctoral dissertation, *Ph. D. thesis*, College of Science for Women, University of Baghdad, 275pp).

Ammann, A. A. (2002). Speciation of heavy metals in environmental water by ion chromatography coupled to ICP–MS. *Analytical and Bioanalytical Chemistry*, **372(3)** : 448-452.

Ataro, A., R. I. McCrindle, B. M. Botha, C. M. E. McCrindle and P. P. Ndibewu (2008). Quantification of trace elements in raw cow's milk by inductively coupled plasma mass spectrometry (ICP-MS). *Food Chem*., **111(1)** : 243-248.

Ati, E. M. (2017). Bioindicator of Mercury and Isotope Stable Radioactive Elements in Missan Marshlands by Geographic Information Systems (GIS). *Msc. Thesis*, boil. Dep. Coll. of science, MustansiriyahUniversity.page 47-54.

Ballatori N. (2002). Transport of toxic metals by molecular mimicry. *Environ Health Perspect*, **110** : 689-694.

Barwick, M. and W. Maher (2003). Biotransference and biomagnifications of selenium, copper, cadmium, zinc, arsenic and lead in a temperate sea grass ecosystem from Lake Mac quarie Estuary, NSW, Australia. *Mar. Environ. Res*., **56** : 471 – 502.

Bonanno, G. and R. Lo Giudice (2010). Heavy metal bioaccumulation by the organs of *Phragmeties australis* (common reed) and their potential use as contamination indicators. *Ecological Indicators*, **10** : 639-645.

Brancovic, S., D. PavlovicMuratspahic, M. Topuzovic, R. Glisic and M. Stankovic (2010). Concentration of some heavy metals in aquatic macrophytes in reservoir near city Kragujevac (Serbia). Secend Balkan Conference on Biology, Plodiv :pp21-23.

Bryan, G. W. (1979). Bioaccumulation of marine pollutants. *Phil. Trans R SocLond B*, **286** : 483 – 505.

Burger, J. and M. Gochfeld (2009). Comparison of arsenic, cadmium, chromium, lead, manganese, mercury and selenium in feathers in bald eagle (*Haliaeetus leucocephalus*) and comparison with common Eider (*Somateria mollissima*), glaucous-winged gull (*Larus glaucescens*), pigeon guillemot (*Cepphus columba*) and tufted puffin (*Fratercula cirrhata*) from the Aleutian Chain of Alaska. *Environment MonitorAssessment*, **152** : 357 – 367.

Campbell, P. G. C., P. M. Chapman and B. Hale (2006). Risk assessment of metals in the environment. In: Hest, R. E., R. M. Harrison (eds). Issues in Environmental Sciences, no 22: Chemicals in the Environment: Assessing and Managing the Risk: *The Royal Society of Chemistry*: pp. 102-31.

Cox, D. R. (2006). Principles of statistical inference. Cambridge New York: Cambridge University Press. ISBN 978-0-521-68567-2.

Cristol, D. A., R. L. Brasso, A. M. Condon, R. E. Fovargue, S. L. Friedman and K. K. Hallinger (2008). The movement of aquatic mercury through terrestrial food webs. *Science*, pp. 320-335.

Dietz, R., F. Riget, M. Cleeman, A. Aarkrog, P. Johansen and J. C. Hansen (2000). Comparison of contaminants from different trophic levels and ecosystems. *Sci. Total Environ*., **245** : 221 – 231.

EPA (1997). Exposure Factors Handbook .Office of Research and Development National Center for Environmental Assessment U.S. Environmental Protection Agency Washington, DC 20460.

Ettajani, H., B. Berthet, J. C. Amiard and L. Chevolot (2001). Determination of cadmium partitioning in microalgae and oysters: contribution to the assessment of trophic transfer. *Arch Environ. Contam. Toxicol*., **40** : 209– 215.

Everaarts, J. M., R. Hesster and C. V. Fishcher (1993). Heavy metals (Cu, Zn, Pb, Cd) in sediments, Zooplankton and epibenthic invertebrates from the area of the continental slop of the BanceArgium (Mauritania).

Favero, A., W. Frazer and G. Hesset (2003). *Medical Microbiology*, 11thed., Edinburgh University.

Food and Agriculture Organization of the United Nations Rome. (2012). p 12-16.

Fowler, S. W. (1982). Biological transfer and transport processes In: Kullenberg Pollutant transfer and transportthe Sea, CRC Press, Boca Raton, FL,2, 1 – 65.

Gaillardet, J., J. Viers and B. Dupre (2003). Trace elements in river waters. In: James I. Drever (ed.). Holland, H. D., K. K. Turekian (Executive Editors), Treatise on Geochemistry : Surface and Ground Water, Weathering, and Soils. Elsevier, **5** : 225–272.

Ghnaya, A. B., H. Chograni, C. Messoud and M. Boussaid (2013). Comparative Chemical Composition and Antibacterial Activities of *Myrtus communis* L. Essential Oils Isolated from Tunisian and Algerian Population. *Plant Pathology & Microbiology*, **4** : 7.

Gobas, F. A. P. C., W. de Wolf, E. Verbruggen, K. Plotzke and L. Burkhard (2009). Revisiting Bioaccumulation Criteria for POPs and PBT Assessments. *Integrated Environmental Assessment and Management*, **5(4)** : 624-637.

Horvat, M., N. Nolde, V. Fajon, V. Jereb, M. Logar, S. Lojen and D. Drobne (2003). Total mercury, methylmercury and selenium in mercury polluted areas in the province Guizhou, China. *Science of the Total Environment*, **304(1-3)** : 231-256.

Houserova, P., V. Kubáò, S. Kráèmar and J. Sitko (2007). Total mercury and mercury species in birds and fish in an aquatic ecosystem in the Czech Republic. *Environmental Pollution*, **145(1)** : 185-194.

Kannan, K. and J. Falandysz (1998). Speciation and concentrations of mercury in certain coastal marine sediments. *Water, Air, and Soil Pollution*, **103(1-4)** : 129-136.

Katie, A. and A. Pendias (2006). *Trace Elements in plants and soils*. CRC Press Inc. Boca Raton Forida, 321-337.

Lenore, S. C., E. G. Arnold and D. E. Andrew (1998). Physical and aggregate properties. Standard Methods for The Examination of Water and Waste Water. 20th Edn. Am. Public Health Assoc. Washington DC.

Linnaeus, C. (1758). SystemaNaturae per regna trianaturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis. *Editiodecima, reformata. LaurentiusSalvius: Holmiae.* ii, 824 pp.

Masters, H. I. and M. Gilbert (1991). Introduction to Environmental Engineering and Science. Prentice-Hall International, Inc., p.107.

Mertz, W. (1981). The essential trace elements. *Science*, **213(4514)** : 1332-1338.

Mouneyrac, C., B. Berthet and J. C. Amiard (1999). Cd distribution in the tissues of oysters (*Crassos treagigas*) exposed chronically *in situ*. *Water, Air and Soil Pollution*, **112(1-2)** : 187-196.

Nascimento, E. A., R. Chang, S. A. L. Morais, D. Piló-Veloso and D. C. Reis (2008). Um marcadorquímico de fácildetecçãopara a própolis de alecrim-do-campo (*Baccharisdracun culifolia*). *Rev Bras Farmacogn*, **18** : 379-383.

Pearson, J. and D. C. Havill (1988). The Effect of Hypoxia and Sulphide on Culture-Grown Wetland and non- Wetland Plants. Growth and nutrient uptake. *Journal of Experimental Botany*, **39**:363 374.

Pedersen, E. R. and M. A. Perkins (1986). The use of benthic invertebrate data for evaluating impacts of urban runoff. *Hydrobiologia*, **139(1)** : 13-22.

Peverly, J. H. (1985). Element accumulation and release of macrophytes in a wetland stream. *J. Envir. Qual*., **14** : 130-143.

Phillips, G. R. and R. C. C. Russo (1978). Metal Bioaccumulation in fishes and aquatic invertebrates. A literature review. *U.S.EPA*., **600** : 13-78.

Rainbow, P. S. (2002). Trace metal concentration in aquatic invertebrates: why and so what? *Environmental Pollution*, **120(3)** : 497 – 507.

Rama Krishnan, N. (2003). Bio-Monitoring approaches for water quality assessment in two water bodies at TiruvannaMalai, Tamil Nadu, India, Proceeding of the 3rd Int. Conf. on *Env. And Health, Chennai, India*, 374- 385.

Rocque, A. J. (2004). Water quality standard state of Connecticut. Department of Environment Protection. Harford 0606-5127, ht//www.Dep.state. Ct. us.

Scott, D. A. (1989). *A directory of Asian wetlands*. IUCN, The World Conservation Union.

Stewart, A. R., M. K. Saiki, J. S. Kuwabara, C. N. Alpers, M. Marvin-DiPasquale and D. P. Krabbenhoft (2008). Influence of plankton mercury dynamics and trophic pathways on mercury concentrations of top predator fish of a mining-impacted reservoir. *Canadian Journal of Fisheries and Aquatic Sciences*, **65(11)** : 2351-2366.

Tran, D., A. Boudou and J. C. Massabuau (2001). How water oxygenation level influences cadmium accumulation pattern in the Asiatic clam Corbiculafluminea: a laboratory and field study. *Environmental toxicology and chemistry*, **20(9)** : 2073-2080.

Ullrich, S. M., M. A. Ilyushchenko, G. A. Uskov and T. W. Tanton (2007). Mercury distribution and transport in a contaminated river system in Kazakhstan and associated impacts on aquatic biota. *Applied Geochemistry*, **22(12)** : 2706-2734.

UNEP (2009). Annual report onlinewww.unep.org./annual report.

UNEP (2012).Annual report.www.unep.org/annual report.

USEPA (United States Environment Protection Agency) (2006). Method no.7473.

Wang, W. X. (2002). Interactions of trace metals and different marine food chains. *Marine Ecology Progress Series*, **243**

: 295-309.

Wang, Y., X. Li, A. Li, T. Wang, Q. Zhang, P. Wang and G. Jiang (2007). Effect of municipal sewage treatment plant effluent on bioaccumulation of polychlorinated biphenyls and polybrominated diphenyl ethers in the recipient water. *Environmental Science & Technology*, **41(17)** : 6026-6032.

Wang, Z. L. and C. Q. Liu (2003). Distribution and partition behavior of heavy metals between dissolved and acid-soluble fractions along a salinity gradient in the Changjiang Estuary, eastern China. *Chemical Geology*, **202(3-4)** : 383-396.

World Health Organization (2001). Mental health: new understanding, new hope. annual report.

Yang, J., J. J. Chen and X. Y. Wang (2008). Spatial Distribution of Heavy Metals in Soils around the Coal Waste Rock Pile and Their Environmental Pollution Assessment. *J. Agro-Environ. Sci.*, **27** : 873- 878.

Zalups, R. K. and S. Ahmad (2003). Molecular handling of cadmium in transporting epithelia. *Toxicology and Applied Pharmacology*, **186(3)** : 163-188.

Zauke, G. P., J. Bohlke, R. ytkowicz, P. Napiórkowski and A. Giziñski (1998). Trace Metals in Tripton, Zooplankton, Zoobenthos, Reeds and Sediments of Selected Lakes in North Central Poland. *International review of Hydrobiology*, **83(5 6)** : 501-526.

Zhang, Y. Y., E. R. Zhang and J. Zhang (2008). Modeling on adsorption–desorption of trace metals to suspended particle matter in the Changjiang Estuary. *Environmental Geology*, **53(8)** : 1751-1766.