Study of certain heavy metals with potential human health effects

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Abstract

Heavy metals influence the human body directly or indirectly. Some of these heavy metals including Cu, Co, Mn, and Zn have functional roles that are important for the body's various physiological and biochemical activities. But, several of these heavy metals, at high-dose, could be dangerous to the body. While, others like Cd, Pb, and Cr in minute amounts have harmful effects in the body that cause acute and chronic toxicity in humans. Unmonitored drainage processes in Iraqi rivers have been identified as this river is considered to be the main source of drinking water in Al-Abasia City; hence, the present study aims to detect levels of some heavy metals in the Al-Abasia River. The current study indicates that the highest concentrations of the heavy metals were recorded during winter, while the lowest values were reported during summer, except Pb, Fe, and Co. All heavy metals exceeded Iraqi freshwater content limits, excluding Cu, and Fe.

Keyword: Al-Abasia, Pollution, Heavy metals, Toxicity, Atomic absorption.
Introduction:

Pollution by heavy elements in the aquatic environment is one of the most dangerous types of pollution and is related to different human activities, as these elements have high specific density of 5 g / cm3, high atomic numbers of more than 20, and an atomic weight ranging (62-261). They are often called trace elements due to their presence in low concentrations in the natural biological system (0.01%) [1]. Heavy metals are known for being environmental pollutants due to their toxicity, persistence in the environment, and bioaccumulative nature [2].

Many of these minerals are necessary for human, animal and plant health and have a role in the biological processes with certain concentrations such as copper and its other parts. No vital role has been discovered for some of them like lead and cadmium, and most of these elements are toxic and non-degradable or breakable by microorganisms. Its effect is cumulative and ultimately reaches the human being through the food chain, as it settles in the various tissues of the body, such as blood, liver, kidneys, and other organs in the body [3].

With the progress of science and the development of modern industries, new materials of industrial waste were added to the environment, which are chemicals that cause disturbance to the natural balance of the surrounding environment. These materials are heavy elements [4].

Heavy elements are pollutants that have lethal and sub-lethal effects on the living organisms. They have been recently drawing the attention of researchers because of their harmful effects on the environment as they have harmful effects on human health and living societies in aquatic and terrestrial ecosystems as well as their effects on the ecosystem itself [5]. The most important and harmful pollutants of the aquatic environment are petroleum hydrocarbons and heavy elements that affect water in its dissolved phase, particulates, organisms and sediments [6]. Healthy water surfaces have a balance of plant and animal life characterized by great species diversity. Pollution disturbs this balance, causing a reduction in the variety of individuals and dominance of the surviving organisms [7]. Heavy elements are one of the most important and dangerous types of pollution which threatens the aquatic environment with its living and non-living components, and therefore affects the living organisms [8]. Sources of heavy elements enter the aquatic organisms through water and sediments, or through the food sources of living organisms [9, 2]. Therefore, many studies were conducted on the concentration of heavy elements in water and sediments, among them is the study of Tsai et. al., [10] in Dublin River where the researcher showed that sediment tissue has a role in the content mineral deposits, for those whose sandy texture is the least heavy component. Nowadays, heavy metals have great ecological significance due to their toxicity. In contrary to most pollutants which are not bio-degradable and undergo a global eco-biological cycle in which natural waters are the main pathway. Drainage processes were made in the Iraqi rivers without supervision. Therefore, the present study examines the levels of some heavy metals in Al-Abbassia River.

Material and Methods:
The Euphrates River flows in Al-Kifl city of Babylon Governorate into two branches, Alabbaia River and Kufa River. Alabbaia River continues to Alabbaia city, and Al-Hurriya, Shamiya and Ghamas cities are connected to the Euphrates River in Al-Shanafiyah District in Qadisiyah Governorate. Alabbaia River is divided into 9 streams on both sides to irrigate agricultural and residential lands, as a large part of the population of those areas utilize it directly for drinking and other household uses. Five sites were selected in the present study during two seasons (winter and summer) of 2019 as in Fig. 1.

Water samples were collected in a 1-litre container from five sites by polyethylene containers from 30 - 50 cm depth [11]. Atomic Absorption Spectrometry was used for measuring heavy metals. Standards for elements were used in the specimen analysis. High-purity deionized water purified with a Milli-Q analytical reagent-grade water purification system was used for the preparation of reagents and standards. High-quality concentrated (70% w/v) nitric acid, hydrogen peroxide (35%), hydrofluoric acid (48%), percolic acid (65%), and hydrochloric acid (38%) were also used. Samples, standards, and final volumes were measured by mass in all cases. The standard solutions to make the calibration were prepared from a stock solution of 1000 mg/L (provided from Alfa Aesar a Johnson Matthey Company/ Germany) by successive dilutions with Milli-Q water. The use of glass material was avoided to eliminate possible contamination from this material. Volumetric polyethylene material and micropipets with tips of plastic were used. These samples were filtered as soon as possible through prewashed and pre-weighted (0.45μm pore size) Millipore membrane filters. The filtrate is considered dissolved while the sediments are considered particulates according to the method of [12]. Analysis of Variation (ANOVA), least significant difference test (L.S.D), and standard error were used to analyze the results statistically under the probability level P< 0.05.
Fig. 1. (Study Area): The researcher relies on the General Survey Authority, Iraq administrative map 1/100000, 2010.

Result and discussion:

The lowest cadmium value was 0.0017 mg/l recorded in summer in the first site while the highest value was 0.262 mg/l in winter in the fourth site (Fig. 2). According to statistical analysis, the study revealed significant difference under probability P>0.05 between seasons and sites. Seasonal variations of lead (Pb) metal in the area of study recorded the highest value of 0.05 mg/l in summer in site 4, while the lowest value was 0.019 mg/l, recorded in winter in site 5. The statistical analysis showed significant difference under probability P>0.05 between seasons (Fig. 3). Figure 4 shows the seasonal variations of chromium (Cr) in the study area. The highest value was recorded in winter in site 2, which was 0.294 mg/l while the lowest value of 0.009 mg/l was recorded in summer in site 1. The statistical analysis showed significant difference under probability P>0.05 between seasons and sites. The lowest zinc value was 0.09 mg/l recorded in the summer in the second site and the highest value was 0.91 mg/l in the winter in the first site (Fig. 5). According to statistical analysis (ANOVA), the study indicated significant difference under probability P>0.05 between seasons and sites. Seasonal variations of iron (Fe) in the study area recorded the highest value in summer in site 1 as 0.12 mg/l while the lowest value was 0.03 mg/l, recorded in winter in site 5. The statistical analysis (ANOVA) showed no significant difference under probability P>0.05 between seasons (Fig. 6). Figure 6 shows the seasonal variations of Cu in the study area. The highest value was 0.04 mg/l, recorded in winter in site 2 while lower value was 0.001 in summer in same site. The statistical analysis presented significant difference under probability P>0.05 between seasons and sites. The seasonal variations of Mn in study area recorded 0.06 mg/l as the highest value in winter in site 3, while the lowest value was 0.03 mg/l, recorded in summer in site 1. The statistical analysis revealed significant difference under probability P>0.05 between seasons (Fig. 7). The lowest cobalt value was 0.009 mg/l, recorded in winter in the first site and the highest value was 0.077 mg/l in summer in the fifth site (Fig. 8). According to the statistical analysis, the study displayed no significant difference under probability P>0.05.
between seasons and sites. The results showed that the highest concentrations of the studied heavy metals were recorded in winter, while the lowest values were recorded in summer, except for lead, iron and cobalt which, on the contrary, represented the highest concentrations in summer and the lowest concentrations in winter. All the heavy metals exceeded the Iraqi limitations for freshwater quality, except copper (Cu) and iron (Fe); they were in the range of Iraqi and international limits. Previous studies [13; 14; 15; 16] mentioned that the uptake of dissolved chemicals and nutrients occurs during the growing season leading to increment in concentrations of those metals during spring and winter. However, in the summer, the concentrations of metals increase because of evaporation, degradations of organic matter (after death of many organisms), decrease of productivity (living uptake) processes, and dissolving of most heavy metals in the summer months which is probably attributed to its reduction under anoxic condition [17]. All these processes lead to the increasing of the dissolved metals during the summer months and decreasing them during the spring months. These results are consistent with previous studies [10; 18; 19; 20; 21; 22; 23; 24].

Figure 2: Seasonal variations of Cadmium (Cd) metal in study area

Figure 3: Seasonal variations of Lead (Pb) metal in study area

Figure 4: Seasonal variations of Chromium (Cr) metal in study area
Figure 5: Seasonal variations of Zinc (Zn) metal in study area

Figure 6: Seasonal variations of Iron (Fe) metal in study area

Figure 7: Seasonal variations of Copper (Cu) metal in study area

Figure 8: Seasonal variations of Manganese (Mn) metal in study area
Figure 9: Seasonal variations of Cobalt (Co) metal in study area

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References:

[1] Pouls, M., & Payne, M. (2006). Oral chelation and nutritional replacement therapy for heavy metal toxicity and cardiovascular conditions. Manuscript (written by Extreme Health), Publishing by the University of Michigan. www. extremehealthusa.com.

[2] Ali, H., Khan, E., & Ilahi, I. (2019). Environmental chemistry and ecotoxicology of hazardous heavy metals: environmental persistence, toxicity, and bioaccumulation. Journal of Chemistry, Article ID 6730305, 14 pages.

[3] Åkesson, A., Barregard, L., Bergdahl, I. A., Nordberg, G. F., Nordberg, M., & Skerfving, S. (2014). Non-renal effects and the risk assessment of environmental cadmium exposure. Environmental health perspectives, 122(5), 431-438.

[5] Misra, S. and Mani, D. (2009) Soil Pollution. S. B Nangia APH Publishing Corporation, New Delhi, 29-59.

[6] Tchounwou, P. B., Yedjou, C. G., Patlolla, A. K., & Sutton, D. J. (2012). Heavy metal toxicity and the environment. In Molecular, clinical and environmental toxicology (pp. 133-164). Springer, Basel.

[7] DouAbul, A. A. Z., Al-Hello, M. A. R., Al-Tacdn, S. M., & Al-Saad, H. T. (2009). Hydrocarbons and trace elements in the waters and sediments of the marshland of southern Iraq. Mesopotamian Journal of Marine Science, 24(2), 126-139.

[8] Viessman,W. Jr., and Hammer, M. J. (1985) Water Supply and Pollution Control, 4th ed., Harper Row Publishers, New York.

[9] Al-Ani, R. R., Al Obaidy, A. H. M. J., & Badri, R. M. (2014). Assessment of water quality in the selected sites on the Tigris River, Baghdad-Iraq. International Journal of Advanced Research, 2(5), 1125-1131
[10] Van den Broek, J. L., Gledhill, K. S. and Morgan, D. G. (2002). Heavy metal concentrations in the mosquito fish, Gambusia holbrooki, in the manly Lagoon catchment. In: UTS Freshwater Ecology Report. Pp: 25.

[11] Tsai, Li, Yu, Kc, Chen, Sf, and Kung, Py (2003) Effect of temperature on removal of heavy metals from contaminated river sediments via bioleaching, Water Research Journal 37(10):2449-57.

[12] WASC (the Water watch Australia Steering Committee) (2002) Water watch Australia National Technical Manual. Environment Australia, Commonwealth of Australia.ISBN 0 6425 4856 0.

[13] APHA, AWWA, WEF. Standard Methods for examination of water and wastewater. 22nd ed. Washington: American Public Health Association; 2012, 1360 pp. ISBN 978-087553-013-0

[14] Lacoul, Paresh , and Freedman, Bill (2006) Relationships between aquatic plants and environmental factors along a steep Himalayan altitudinal gradient, Aquatic Botany 84: 3–16.

[15] Hussain, D. A., and Alwan, A. A. (2008) Evaluation of Aquatic macrophytes vegetation after restoration in East Hammar marsh, Iraq, Marsh Bulletin 3(1): 32-44.

[16] Al-Kinzawi, M. A. H. (2007) Ecological Study of Aquatic Macrophytes in the Central Part of the Marshes of Southern Iraq, MSc Thesis, College of Science for Women, Biology Department, University of Baghdad, Iraq.

[17] Al-Kenzawi, M. A. (2009). Seasonal Changes of Nutrient Concentrations in Water of Some Locations in Southern Iraqi Marshes, After Restoration. Baghdad Science Journal, 6(4), 711-718.

[18] Park, N., Kim, J. H., and Cho, J. (2008) Organic matter, anion, and metal wastewater treatment in Damyang surface-flow constructed wetlands in Korea, Ecological Engineering Journal 32(1): 68-71.

[19] Hassan, W. F. (2007) Hydrochemical and geochemical study of the Shatt Al-Arab River Sediments . PhD thesis, Collage of Agriculture, University of Basrah.

[20] Vymazal, Jan (2008) Wastewater Treatment, Plant Dynamics and Management in Constructed and Natural Wetlands, Springer Book: 121-133, available in link: http://books.google.com/books?id=3y-

[21] Al-Haidarey, M. J. 2010. “Using the Site Specific Water Quality Index 1.0 for evaluation of Water Quality Index In Shatt Al-Arab River”, Marina Mesopotamia proceeding of the Marine science conference, 217-228.

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

[23] Al-Haidarey, M. J., Mohammed, Z. A-A. 2012. Responses of phytoplankton communities to water quality in Al-Kufa River/ Euphrats River. 4th Conference of Ecology Sciences, Babylon University, 5-6 Jan. 1-11.

[24] Al-Haidarey, M. J. 2009b. Diurnal Variation of Heavy Metals in Al-Kufa River/Najaf, Iraq. 10th Conference of Biogeochemistry of Trace Element, July, Mexico.