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EVALUATION OF SOME HEAVY METALS IN THREE AQUATIC PLANTS IN SULAIMANI GOVERNORATE/ KURDISTAN REGION- IRAQ

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Abstract
The present study estimated the concentrations of heavy metals iron (Fe), nickel (Ni), cadmium (Cd), chromium (Cr), lead (Pb), copper (Cu) and zinc (Zn) in three plant species (Mentha longifolia, Apium nodiflorum, and Nasturtium officinale) at four sites. In the province of Sulaymaniyah (Darbandikhan, Khormal, Rania, and Bakra Jaw), Iraqi Kurdistan. Samples were collected on a monthly basis from April to September 2016, with three replications for each part of the plants (root, stem, and leaves). Plant samples were prepared and digested with suitable acids to detect the concentrations of these minerals and using a Flame Absorption Spectrophotometer (FAAS). The results of the study showed that all three plant species under study have a high ability to accumulate heavy metals. The results also showed that there are differences in the concentrations of heavy metals accumulated in the tissues of the plant species under study, as the order of the plant species was descending, M. longifolia ← N. officinale → A. nodiflorum, the study also showed that there are differences in the concentrations of heavy metals accumulating in the different plant parts and for all plant species. As the arrangement of the plant parts in terms of the ability of each part to accumulate heavy metals was descending in the roots - the leaves - the stems, the concentrations of heavy metals accumulated in the plant species, clear differences were recorded between the four sites under study, as the highest values were recorded in the species developing in the Joe Reel ← Rania ← Darbandikhan ← Khormal. Through the results of the current study, it was also found that there are differences between the months of the study regarding the ability of plants to accumulate heavy metals within their tissues, as the highest values of heavy metal concentrations in plants were recorded in April and May compared to the months with higher temperatures.

Keywords: heavy metals, aquatic plants, Sulaymaniyah Governorate.

INTRODUCTION

There is an increasing concern regarding the accumulation of heavy metals in the environment because they pose a threat to both human health and the natural environment and this is due to the fact that these minerals are not biodegradable and therefore accumulate in the environment [(1)] The acceleration of agricultural, urban and industrial development has led to pollution that extends to soil, water and air. Population and urban expansion, industrial and sewage water, tourism waste, and the use of fertilizers and pesticides contributed to the acceleration of pollution in the environment [(2)] As some heavy metals have become a source of concern due to their toxicity and tendency to accumulate in food chains and pass them to humans through food, which causes chronic or acute diseases. Some heavy metals enter the aquatic system and are deposited in sediments, aquatic plants and organisms [(3)] Some recent research has found that even low levels of the metallic minerals can cause a variety of health problems. [(4)] Many attempts are made to treat heavy metals using conventional processing techniques, but they are expensive and destructive. Thus, the potential role of biological treatment, especially through phytoremediation, has gained great interest, as plants can accumulate heavy metals at different concentrations, but there are differences in the accumulation of heavy metals between Plant species. The prevalence and diversity of aquatic plants in water bodies and their good tolerance to changing environmental conditions led to their use as life indicators for studying pollution, and plants possess the ability to absorb trace and toxic elements and collect them in tissues [(5)] Heavy metals are usually present in trace levels in water, sediments and vegetation, and organisms feel the need for micro-elements from these minerals. However, these minerals have a toxic effect on living organisms at high levels of content, and their toxicity has an inhibitory effect on plant growth, enzymatic activity, photosynthesis and accumulation of nutrients, as well as damaging the root system [(6)] The previous information shows the extent of the environmental risks of heavy metals on all forms of life, given the lack of information on the levels of heavy metals in the Sulaymaniyah Governorate, especially after the urban, demographic and industrial development in the Kurdistan Region of Iraq. In the reduction of toxic heavy metals such as iron, nickel, cadmium, chromium, lead, copper and zinc. In addition to studying the concentration levels of seven heavy metals (iron, nickel, cadmium, chromium, lead, copper and zinc in the three plants.

MATERIALS AND METHODS

The Study Area

Sulaymaniyah is an Iraqi governorate, in Iraqi Kurdistan, located in the far north-east of Iraq and southeast of the Iraqi Kurdistan region N 35 ° 33'20.74 ”. E 45 ° 26'6.42 The international border with Iran represents the eastern border of the governorate, as it is bordered on the north and northwest by Erbil governorate, on the west by Kirkuk and Salah al-Din governorate, and from the southwest and south by Diyala governorate [7] In view of the significant increase in the number of cars and oil tankers after extracting it from multiple places in Sulaymaniyah Governorate, in addition to the great civilizational and architectural development witnessed by the governorate in recent years, which increases the sources of pollution, this study was actually conducted in four districts in Sulaymaniyah Governorate (Darbandikhan, Khormal, Rania, he hate Joe.

Sample Collection

Plant samples were collected monthly from April to September 2016, with three replications for each part of the plant (root, stem, and leaves) in four different locations. Plant species were collected after washing well with site water to be cleaned well, then placed in paper bags and transported to the laboratory.

Extraction of Heavy Metals

Drying the Samples

The plant species were pressed and dried using wooden presses to remove water from the plant tissues. And put an identification card for each plant type.

Grinding

The plant species were separated into (root, stem and leaves) for each species separately. Samples were grinded using a high-speed stainless-steel mill. After the grinding process was completed, each sample was sifted and then each prepared sample was placed in a clean plastic container bearing the necessary marks and closed safely [8]

Dry Ashing

Dry ash (high temperature combustion) weighing 0.5 g was obtained from the sample dried in clay liners and then heated at 550 ° C in a muffle furnace for 8 hours **Digestion of Plants Samples**

After obtaining the dry ash, we digest the plant samples using a mixture of (2 volumes H2SO4, 3 volumes HCL and 2 volumes of HNO3) at a volume of 20 ml per 0.5 g of complete incineration plant samples, after which the samples were cooled and 25 ml of distilled water was added to them and then filtered using filter paper and the volume was completed To 50 ml with distilled water, the final samples were then used for the purpose of measuring the concentration of heavy metals using a flame atomic absorber [9]

RESULTS & DISCUSSION

Heavy Metals Accumulated in Plants due to Different Polluted Location

The highest value of iron was recorded in the plants of the Rania site, and it was 1875 mg / g, while the lowest value of iron was recorded in the plants of the Khormal site, which was 324 mg / g. The results of the statistical analysis showed statistically significant differences and there is a probability (P <0.05) between the study sites. The highest rate was 1670 mg / g at the Rania site, while the lowest rate was recorded at 379 mg / g in Khormal site. As for nickel, the values recorded in the plants of the different sites ranged between 1.248 - 8.802 mg / g, as the lowest value was recorded at the Darbandikhan site, while the maximum value was recorded at the Bakara Joe site. The results of the statistical analysis showed significant differences between all plants of the study sites and with a probability of P <0.05.

Table (1) ANOVA table of Fe concentration in plant

Tests of Between-Subjects Effects					
Dependent Variable: Fe					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Sites	162197300.338	3	54065766.779	21390.340	.000
Plant type	8805955.361	2	4402977.681	1741.975	.000
Plant part	111487502.620	2	55743751.310	22054.210	.000
Month	6509551.681	5	1301910.336	515.082	.000
Error	1091914.000	432	2527.579		
Total	971241055.000	648			

The sites had a significant effect of P <0.05 on the concentration of cadmium accumulated in plants. The maximum value of cadmium was recorded in plants growing in the early atmosphere and it was 4.360 mg / g, while the lowest value of cadmium was recorded at the Rania site and it was 0.474 mg / g.

As for chromium, its results recorded in the plants of different sites showed great variation, as the maximum value was recorded at the Bakara Joe site and reached 11.745 mg / g, while the lowest value was recorded at the Darbandikhan site, which was 1.494 mg / g. The results of statistical analysis showed that there are statistically significant differences between plants. Contaminated sites, with the exception of Khormal and Rania, did not show any significant differences. Lead also recorded the highest values

Table (2) ANOVA table of Cr concentration in plant

in the plants of the Bakara Joe site, reaching 46,750 mg / g, while the lowest value was recorded at the Khormal site, which was 8,890 mg / g.

The results of the statistical analysis showed the presence of significant statistically significant differences between all study sites and with a probability of P <0.05. Copper values were recorded somewhat similar between most of the plants of the different sites, as the plants recorded values ranging between 5.443 - 22.436 mg / g, as the site in early air recorded the highest value and the lowest value recorded at the Khormal site, the results of the statistical analysis showed the presence of significant differences between all the plants of the different sites. Likelihood P <0.05.

Tests of Between-Subjects Effects					
Dependent Variable: Cr					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Sites	3815.316	3	1271.772	3742.237	.000
Planttype	986.241	2	493.121	1451.026	.000
Plantpart	2580.225	2	1290.113	3796.205	.000
Month	898.321	5	179.664	528.669	.000
Error	146.812	432	.340		
Total	31661.515	648			

Zinc recorded somewhat high values in the plants of the different sites, as the maximum value was recorded at 67.72 mg / g in the Rania site, while the lowest value was recorded, which was 16.784 mg / g in the Khormal site. There were significant differences in terms of zinc concentration between all the plants of the study sites. And with a probability P <0.05. In general, the different sites were arranged in terms of the amount of heavy metals accumulated in the plants in a descending order as follows: Bakra Joe → Rania → Darbandikhan → Khormal, the different plant species are affected by the different sites in terms of their accumulation of heavy metals, and the reason for the high values of heavy metals in virgin plants is In addition to what contradicts that area in terms of mineral pollution and various sources, it is an industrial area with a high population density and high traffic movement in addition to pollution due to waste and factory waste. This coincides with the study of [10] when studying heavy metals accumulating in two plant species in several locations in the city of Sulaymaniyah, as the highest values were recorded in Bakara Joe and other industrial areas. Another reason for the high values of heavy metals in plants growing in early atmosphere may also be due to the high pH values and salinity, as they increase the sedimentation of suspended materials and thus increase the organic matter in the sediments to become more available for absorption by plants, and this is consistent with the study of each From [11] Plants are the medium through which elements from soil, sediments, water and air are transferred to the human body through consumption. The reason for the high values of heavy metals in early atmosphere can also be explained by the high values of heavy metals in the sediments compared to other sites, as it recorded the highest values of heavy metals in the sediments of the aforementioned region and thus gives a greater chance for the accumulation of heavy metals within the plants growing at the site, and this is consistent with the study of [12] as he explained the reason for the rise in heavy metals in plants to the existence of a relationship between the concentration of minerals in sediments and their concentration in plants, while it was not in agreement with several other studies that they stated that minerals in plants may be lower than the concentrations of minerals in sediments despite the high of these values. In sediments [13].

Table (3) ANOVA table of Zn concentration in plant

Tests of Between-Subjects Effects					
Dependent Variable: Zn					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Sites	129829.491	3	43276.497	4016.640	0.001
Plant type	11447.450	2	5723.725	531.238	0.001
Plant part	66968.662	2	33484.331	3107.795	0.001
Month	22762.669	5	4552.534	422.536	0.001
Error	4654.500	432	10.774		
Total	1661647.677	648			

Heavy Metals Accumulated in Plants due to Different Plant Species

The results of the current study showed differences in the amount of heavy metals accumulated in the three plant species under study. Iron concentration in plant species showed high values, as the highest value of iron was recorded in all parts of N. officinale plant, reaching 1237 mg / g, while the lowest value for iron content was recorded in parts of M. longifolia plant, reaching 693 mg / g. The results of the statistical analysis showed differences. Significant statistically significant and with a probability P <0.05 among all plant species, as the following rates were recorded: 1091, 923 and 807 mg / g for N. officinale, M. longifolia, and A. nodiflorum and respectively The recorded values of nickel concentration also differed between the three plant species, as the highest value was recorded at 5.323 mg / g in M. longifolia plant, while the lowest value of nickel concentration was recorded in N.officinale plant, which was 2.340 mg / g. The results of the statistical analysis showed significant differences between all three plant species, and with a probability of P <0.05, the highest rate of nickel was recorded at 4.244 mg / g in M.longifolia plant, while the lowest rate was recorded at 3.123 mg / g for N.officinale. As for cadmium, slightly similar values were recorded in the parts of A. nodiflorum and M.longifolia plants. The highest values were recorded at 2.388 and 2.363 mg / g, respectively, while the lowest value was recorded in Officinale which was 0.749 mg /. The results of the statistical analysis showed differences between all species and with a probability of P <0.05, with rates of 1.780, 1.716 and 1.326 mg / gm recorded for A. nodiflorum, M.longifolia and N.officinale, respectively. As for the concentration of chromium, the maximum value was recorded in N.officinale, which was 8.717 mg / g, and the lowest value was recorded in A. nodiflorum, which was 2.781 mg / g. The results of the statistical analysis showed significant differences with a probability of P <0.05 between all plant species. The highest concentration of lead was recorded in all parts of M.longifolia plant, at 36.904 mg / g, and the lowest concentration was recorded in all parts of A. nodiflorum plant. Statistically, the results showed significant differences between all plant species, with a probability of P <0.05. The copper concentration results showed close values in the two species A. nodiflorum and N.officinale under study, as they recorded values of 9.127 and 8.543 mg / g, respectively, while the highest value was recorded in M.longifolia plant and reached 20.1 mg / g. As for the results of statistical analysis It showed significant differences for M.longifolia type, while the other two types did not show any significant differences between A.nodiflorum and N.officinale with a probability of P <0.05. Zinc also showed similar values between the three species, as the highest concentration was recorded in N.officinale, which was 56.1 mg / g, and the lowest concentration was recorded in A. nodiflorum, which was 30.696 mg / g. The results of the statistical analysis did not show any significant differences in the accumulated zinc concentration in the two species M. Consecutively. The concentrations of minerals accumulated in the aquatic plants under study were higher than those found in water and sediments, and this may be explained by the fact that plants are not able to regulate mineral absorption. The accumulated heavy metals differ between plant species, as the current study recorded some varying values in the amount of minerals accumulated in their tissues, scientifically, the order of the plant species in terms of the amount of heavy metals accumulated from the most accumulating minerals to the least as follows: M.longifolia ← N.officinale ← A. nodiflorum, and the reason for the superiority of M.longifolia species can be explained to the size of the somewhat larger biomass, as [14] stated that the higher the plant biomass, the higher and better the potential for removal and treatment. Plants are characterized by the phenomenon in which the concentration of the element inside the plant is higher than its concentration in the medium in which it grows, which is called the phenomenon of accumulation. Plants are used as a good indicator of heavy metal pollution, as they have the ability to absorb minerals from sediments and water and accumulate them in their tissues [15], as the absorption of heavy metals varies with different types of plants and is affected by the bioavailability of minerals and the extent of their survival in the environment [3] and this coincides with the study of [4] when he studied the heavy metals accumulated in the Boriganga river plants, as he stated that the absorption of minerals by the plants depends on the quantity or availability of those minerals in the study area. As for the study of [7], it showed the highest values of minerals in sediments compared to plants, and the reason for this was attributed to the density of plants in the study area, which leads to an increase in mineral precipitation and thus an increase in sediments. While [3] stated that plant species show significant differences in the accumulation of heavy metals within their tissues, as the results of his study showed the existence of differences between plant species belonging to the same sex and in the same location and under the same environmental conditions.

Table (4) ANOVA table of Ni concentration in plant

Tests of Between-Subjects Effects					
Dependent Variable: Ni					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Sites	2683.968	3	894.656	8995.656	.000
Plant type	139.265	2	69.632	700.144	.000
Plant part	6.950	2	3.475	34.939	.000
Month	350.122	5	70.024	704.086	.000
Error	42.964	432	.099		
Total	14010.555	648			

Heavy Metals Accumulated in Plants due to Different Study Months

The results of the current study showed differences in the amount of heavy metals accumulated in plants according to the different study periods.

Iron recorded the highest concentration in April and reached 1052 mg / g, while the lowest value of the accumulated iron concentration was recorded in plant species in September, which was 820 mg / g. The results of the statistical analysis showed significant differences with a probability of P <0.05 between the months of the study except for the month of April. Ayar and also did not record any significant differences between August and September. As for nickel, the highest accumulation value was recorded in plants in May, reaching 4,637 mg / g, while the lowest value was recorded in September, which was 2.787 mg / g. The results of the statistical analysis showed that there were some significant differences between the months of the study and with a probability of P <0.05. Cadmium recorded the highest value in April, which was 2.203 mg / g, and the lowest value was recorded in August, which was 1.059 mg / g.The results of the statistical analysis did not show any significant differences between April and May, as well as between August and September, while significant differences were recorded between the rest of the months and at Likelihood P <0.05. As for chromium, the highest accumulation value was 6.815 mg / g in May, and the lowest accumulation value was recorded in August, which was 4.003 mg / g. The results of the statistical analysis recorded the presence of significant differences with a probability of P <0.05 between the majority of the study months. The results of the statistical analysis showed that there were no significant differences between April and May, as well as between August and September in

terms of the amount of accumulated lead, as very close values were recorded in those months, while significant differences were recorded between the other months of the study. The highest recorded rate of lead was 28,897 mg / g in April, while the lowest recorded rate was 19,142 mg / g in September. As for copper, the results of the statistical analysis recorded significant differences, and with a probability of P <0.05, between all the months of the study except for April and May, no significant difference was recorded. The highest rate was recorded at 16.673 mg / gm in May, while the lowest rate was recorded in August, which was 9.814 mg / g. As for zinc, the results of the statistical analysis showed that there were significant differences between the months of the study, and with a probability of P <0.05, the highest rate was recorded at 52.51 mg / g in May, and the lowest rate was 37.116 mg / g recorded in September.

Table (5) ANOVA table of Cd concentration in plant

Tests of Between-Subjects Effects					
Dependent Variable: Cd					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Sites	551.515	3	183.838	9440.162	.000

Plant type	26.136	2	13.068	671.056	.000
Plant part	76.336	2	38.168	1959.946	.000
Month	150.954	5	30.191	1550.309	.000
Error	8.413	432	.019	8.413	432
Total	2803.195	648	2803.195	648	2803.195

The results of the study showed that there are differences in the ability of plant species to accumulate heavy metals from water and sediments according to different sampling periods, as the order of the study months was descending as follows: May, April, June, July, August, September. The reason for the high values of heavy metal accumulation in plants during May and April compared to the months with higher temperatures can be attributed to several reasons, including the high growth rates and plant activity in the spring months, which leads to an increase in the process of mineral absorption from water and sediments, as well as the high pH values with the beginning Higher temperatures lead to less mineral bonding strength in sediments and thus easier to transfer to plants. As for the lowest value, it was recorded in September, in addition to the months of high temperature, this may be due to a slight decrease in the activity of plant species, especially in the month of September (autumn) and the beginning of leaf fall, and this is confirmed by the results of the current study of the high values of heavy metals in the water and sediments in the months Warm compared to the hottest months. The results of the study coincide with many studies. (8) recorded the highest values in the warm months and explained the reason for this to the high salinity values, which leads to an increase in the sedimentation of suspended materials and an increase in organic carbon in the sediments, which provides a greater opportunity for their absorption by plants. This is in agreement with A study (5) stated that the reason for the increase in minerals accumulation in plants in the warm months is due to the increase in the alkalinity of the water and thus leads to an increase in the precipitationof soluble minerals and thus increase their concentration in plants. . While (3) stated in their study that an increase in organic matter increases the ability of sediments to retain minerals and thus reduces their availability of minerals. As for (9), they recorded the absence of any value for nickel in water in sites containing aquatic plants during the spring season, while they recorded the highest value of nickel in the spring in sites without aquatic plants.

Table (5) ANOVA table of Cu concentration in plant

Tests of Between-Subjects Effects					
Dependent Variable: Cu					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Sites	7254.489	3	2418.163	783.031	.000
Planttype	2394.282	2	1197.141	387.649	.000
Plantpart	3341.565	2	1670.783	541.020	.000
Month	4988.378	5	997.676	323.060	.000
Error	1334.105	432	3.088		
Total	142903.130	648			

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