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ASSESSMENT OF THE HEAVY METALS POLLUTION IN WATER, SEDIMENTS AND WATER HYACINTH PLANT IN THE RIVER NILE

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ABSTRACT

The purpose of this study is to gather the information on the aquatic ecosystem of the River Nile at El -Qanater El Khayreyya region,El-Qalyubia governorate and El-Mariotya canal, El-Giza governorate and to investigate the effectiveness of water hyacinth as adsorbent to remove some heavy metals from water. Also, the heavy metals (Cd, Cu, Fe, Pb and Zn) in water, sediment and water hyacinth plant samples was determined using atomic absorption spectrophotometry.

The heavy metal levels in water samples ranged between (0.945±0.214 to 3.025±0.210 µg/L) for cadmium, while, copper levels were from (8.296±1.692 to 20.529±2.135 µg/L). Also, concentration of iron ranged (150.94±1.682 to 412.84±2.376 µg/L), while the concentrations of lead were (0.922±0.185 to 4.365±0.458 µg/L) and zinc concentrations ranged between (3.979±0.264 to 7.057±0.500 µg/L) in El-Marutia canal and El-Qanater El-Khayreya region during all seasons.

Also, the heavy metal levels in sediment samples ranged between (11.18±0.98 to 18.19±1.57 µg/g) for Cd and varied between (10.58±2.18 to 52.2±3.64 µg/g) for Cu. While, iron concentration varied from (207.11±3.99 to 700.4±4.32 µg/g). On the other hand, Pb concentrations ranged between (7.08±1.95 to 24.28±2.31 μg/g) and Zn levels was ranged between (23.54±3.85 a to 74.52±2.09 μg/g) during all seasons in El-Marutia canal and El-Qanater region.

The range of cadmium in water hyacinth plant was between (12.94±2.34 to 29.83±0.69 μg/g), (8.82±1.25 to 16.73±2.05 μg/g) and (1.78±2.82 to 10.28±2.01 μg/g) for root, and leaves samples, respectively during all seasons in El-Marutia canal and El-Qanater El-Khayreya region. While Cu concentrations were (22.22±2.61 to 71.93±1.59 μg/g), (15.97±3.54 to 50.45±4.19 μg/g) and (13.73±3.47 to 45.40±1.4 μg/g) for root, and leaves samples, respectively during all seasons in El-Marutia canal and El-Qanater El-Khayreya region. Concentrations of Fe in roots, shoots and leaves samples were ranged from (96.7±4.06 to 185.31±1.5 μg/g), (85.26±3.5 to 115.13±1.4 μg/g) and (74.88±5.0 to 108.7±3.4 μg/g), respectively. Also, lead concentrations in roots, shoots and leaves samples were ranged from (6.22±6.24 to 13.51±0.96 μg/g), (4.22±2.57 to 11.49±5.08 μg/g) and (2.1±2.06 to 7.17±2.39 μg/g), respectively, while Zn concentrations were (6.98±3.25 to 18.30±3.31 μg/g), (3.95±4.69 to 13.03±2.17 μg/g) and (2.49±6.21 to 6.65±3.58 μg/g) for roots, shoots and leaves samples, respectively

Key words: Atomic absorption spectrophotometry, Heavy metals, River Nile, Water hyacinth plant.

INTRODUCTION

Egypt is an arid country which depends almost entirely on the River Nile for its water supply. It is estimated that the Nile River provides about 97% of the country's fresh renewable water supply. Agriculture is almost totally dependent on this source. It is estimated that 85 percent of the water released from the High Aswan Dam is using for irrigation with the remaining 15 percent for other purpose. In Egypt, drinking water comes from surface or ground water. On large-scale, water supply occurs from surface water resources, and smaller water systems tend to use ground water. Surface water includes rivers, lakes and reservoirs.

Water Pollution is considered to be one of the most dangerous hazards affecting Egypt. Pollution in the Nile River System (main stream Nile, drains and canals) has increased in the past few decades because of increases in population; several new irrigated agriculture projects, industrial development and other activities along the Nile, the present free style way of disposal of agricultural, industrial and domestic effluents into natural water-bodies results in serious surface and ground water contamination.

Metal contamination raises environmental concerns, such as influences on the food chain, which can be potentially harmful to humans (**Kishe & Machiwa, 2003** and **Ramchander *et al.*, 2015**).

Heavy metal ions do not degrade into harmless end products (**Gupta *et al*., 2001**). The presence of heavy metal ions is of major concern due to their toxicity to many life forms.

Cadmium and Lead are two of the most toxic food chain contaminants. Cadmium damages the lungs and causes the painful Itai-Itai disease. Lead affects the blood, numerous organs, and the nervous system. Increasing pollution of aquatic environments with heavy metal has currently become a serious concern the continual leading of metals into our environment creates water pollution problems due to their direct toxic effects on aquatic biota. In addition, metals ions can be incorporated into food chains and concentrated in aquatic organisms to level that affect their physiological status. Copper is an essential element for all living organisms. Excess of copper in human body is toxic, causes hypertension and produces pathological changes in brain tissues.

Although there is growing public interest and commercial attraction and success in phytoremediation as a cost effective and technically viable method of removal of metal ions from wastewater and contaminated soils, more basic research is still needed to better understand the complex interactions between the metal ions, plant roots and micro- organisms in the rhizosphere.

Water hyacinth (*Eichhornia crassipes*) an aquatic plant which could successfully be used for removing various pollutants from water, thus it has great importance in wastewater treatment. It has a huge potential for removal of vast range of pollutants from wastewater (**Ayaz and Acka, 2001**).

This study was designed to evaluate the levels of heavy metals in aquatic environments (water hyacinth plant, water and sediment samples) collected from (El Qanater El khayreyya region, El-Qalyubia and El-Marutia canal, El-Giza, Egypt).

MATERIALS AND METHODS

1. Stock solutions the heavy metals.

Stock standard solution of cadmium (Cd), copper (Cu), iron (Fe), lead (Pb) and zinc (Zn), were obtained from Merck in concentration of 1000 mg/l (Merck, Darmstadt, Germany).

2. Sampling location.

The water, sediment and water hyacinth plant samples were collected seasonally from May 2016 to March 2017 during four successive seasons from two sites (El Qanater El khayreyya region, El-Qalyubia governorate and El-Marutia canal, El-Giza governorate, Egypt).

3. Water, sediment and hyacinth plant sampling.

3.1. Water.

Water samples (4L) were collected in glass bottles from the water course with 50 cm below water surface level from the selected sites. The bottles were covered with screw caps and immediately transferred to the laboratory for analysis. Water samples were filtered to remove sand and debris.

3.2. Sediment.

Sediment samples (about 2 kg each) were taken from the same locations and the same time of water sampling sites at a depth 5 cm of sediment surface. The water was discarded from the sediments by decantation and then transferred to the laboratory. Samples were air dried in dark for 48 hours before analysis.

3.3. Water hyacinth plant (*Eichhornia crassipes*).

Water hyacinth plant samples were collected by hand from the Nile River from two sites (El Qanater El khayreyya region, El-Qalyubia governorate and El-Marutia canal, El-Giza governorate, Egypt). Then, the samples were kept in polyethylene plastic bags and transferred to the lab., The plants were thoroughly washed with deionized water before being left to air dry for 10 days. The samples were divided into 3 parts (roots, shoots and leaves), and grinded by wooden mortar to obtain a fine powder (**Al Rmalli *et al.*, 2005**). Samples were sieved through plastic sieve which have equally small pores (2 mm in size).

4.Digestion of heavy metal in water, sediment and water hyacinth.

4.1. Water samples.

A 250 ml of well-mixed water samples were transferred to beakers. Five milliliters of HNO_3 were added in each sample. Then, samples were allowed to reach 80-85 ºC using hotplates to a final volume of about 10-20 ml before metal precipitation. The digestion procedure was repeated twice. The beaker walls were washed with metal free water and then the total water was filtered. The filtrate was then transferred to 25 ml volumetric flask (completed with addition of water) for determination (**Radulescu *et al.*, 2014**).

4.2. Sediment samples.

One gram of well mixed sediment samples was transferred to the digestion tubes. Ten milliliters of aqua regia reagent (HNO_3- HCl) (1:3 v/v) were added in each sample. Then, samples were heated to reach 90-95 ºC using heating mantle for one hour. The sample was cooled to room temperature. The content of each digestion tube was filtered through separated acid prewashed filter paper. The digestion tube walls were washed with metal free water and then the rinse water was filtered. The filtrate was then transferred to 25 ml volumetric flask (completed with addition of water) for determination, **(Ogoyi *et al.*, 2011**).

4.3. water hyacinth (*Eichhornia crassipes)* samples.

One gram of well mixed plant samples was transferred to the digestion tubes. Ten milliliters of aqua regia reagent (HNO_3- HCl) (1:3 v/v) were added in each sample. Then, samples were heated to reach 90-95 ºC using heating mantle for one hour. The sample was cooled to room temperature. The content of each digestion tube was filtered through separated acid prewashed filter paper. The digestion tube walls were washed with metal free water and then the rinse water was filtered. The filtrate was then transferred to 25 ml volumetric flask (completed with addition of water) for determination, **Brahma and Misra (2014)**.

RESULTS AND DISCUSSION

1. Determination of heavy metals in water and sediment samples.

The obtained results indicated the existence of variable concentrations of heavy metals in water and sediment samples collected from two sites around the River Nile (EL-Marutia canal and El-Qanater El -Khayreya region).

1.1. Heavy metals in water.

The results of heavy metals concentration in water samples in the selected areas at different seasons are given in **Table (1)**.

The Cd levels in water samples were ranged between (0.945 ± 0.214) to (2.641 ± 0.199) µg/L in El-Marutia canal while the it's levels in El-Qanater El-Khayreya region were ranged between (1.057 ± 0.187) to (3.025 ± 0.210) µg/L. The results showed the value of Cd was higher in spring season of both selected areas, while it was lower in winter. According to **WHO (2011)** the permissible levels of cadmium were 0.003 mg/L, so only the samples of water which were collected from El-Qanater in spring season were exceeded the permissible level. These results agreed with **Mansour and Sidky,** (**2003**) who found that concentration of cadmium in water at Wadi El-Rayan Lake was 3.5 µg/L.

Otherwise **Abouhend and El-Moselhy (2015)** who studied the spatial and seasonal variations of heavy metals in water and sediments at the northern red sea coast found the different seasons had a little influence on Cd variation in water at different sites.

The copper concentrations in the water samples were varied from 8.296± 1.692 to 17.654±1.953 µg/L in El-Marutia canal. While it was 10.577± 2.278 to 20.529±2.135 µg/L for water samples that taken from El-Qanater El-Khayreya region. The maximum permissible level of copper in surface water is 11 µg/L according to **US-EPA (2001**), so all water samples were exceeded the permissible levels except the samples were collect from el Marutia canal during autumn seasons and the samples were collected from El-Qanater El-Khayreya region during spring seasons. But, according to **WHO (2011)** the permissible levels of copper were 2000 µg/L, so all samples were below the permissible levels of copper. According to **Mansour and Messeha, (2001)** the level of copper in water sample of Qarun Lake was 147 µg/L. Also, **Malhat and Nasr(2012)** found the Cu mean concentration ranged from 0.500 to 4.908 µg/L in water samples collected from Bher Shebin canal and El-Embaby drain, respectively. On the other hand, **Abd Elsalam (2013)** studied the copper concentration in water samples collected from Zawyet El-Nagger canal, it was varied from 0.28 to 218.1 µg/L.

Also, **Table (1)**. showed that, the concentration of iron in water samples which collected from EL-Marutia canal were 302.67± 2.453 µg/L in spring season followed by 271.39±0.133 µg/L in autumn, 215.18± 4.732 µg/L in summer and 150.94± 1.682 µg/L in winter season, while the iron concentrations in water samples which collected from El-Qanater El-Khayreya region were 412.84± 2.376 µg/L in spring season, 406.82± 0.918 µg/L in summer, 200.43±5.245 µg/L in winter and 187.29± 0.211 µg/L in autumn season. The maximum permissible level of iron in surface water revealed that, US-EPA is 1000 µg/L **US-EPA (1996)**, so all water samples had iron concentrations below the permissible level. **Abd Elsalam, (2013)** found the minimum concentration of iron in Zawyet El-Nagger canal was 35.05 µg/L in winter, while its maximum concentration in Zawyet El- Naggar drain was 51.72 µg/L in summer. Our results agreed with **Mansour and Sidky, (2003)** who found the concentration of iron in water at Wadi El-Rayan lake was 115 µg/L.

The contaminations of lead in water were 7.185±0.546 in winter season followed by 2.895±0.311 µg/L in summer, 2.586± 0.112 µg/L in spring then become 1.582± 0.234 µg/L in autumn for water samples from El-Marutia canal. While the contamination of lead in water samples which taken from El-Qanater El-Khayreya region were 4.365±0.458 µg/L, 3.428± 0.427 µg/L, 2.005±0.125 µg/L and 0.922± 0.185 µg/L in autumn, winter, summer and spring seasons, respectively. According to **US-EPA (1996)**, the maximum permissible level of lead in surface water is 2.5 µg/L. So, lead concentration in winter, summer and spring in El-Marutia canal and in autumn and winter in El-Qanater El-Khayreya region were higher than the permisiable level in surface water. Also, **Mansour and Messeha, (2001)** found the level of lead in water's Qarun Lake (53 µg/L) which, was higher than the permissible levels.

The concentrations of zinc in water samples ranged between 4.157 ± 0.147 µg/L to 6.162 ± 0.339 µg/L in El- Marutia canal, the results showed the higher concentration of Zn in autumn followed by spring season then winter and summer and the Zn concentration ranged between 3.979 ± 0.264 µg/L in summer to 7.057 ± 0.500 µg/L in spring at El-Qanater El-Khayreya region.

The maximum permissible level of zinc in surface water recommended by **US-EPA (2001)** is 5000 µg/L. While, according to, **Environment Canada (1998)** the Canadian maximum permissible level of zinc in surface water is 30 µg/L, so all investigated samples were below the permissible level.

Also, **Abd Elsalam (2013)** found the concentrations of zinc in water samples ranged between 0.130 - 9.58 µg/L and 0.130 - 8.97 in Ezbet Abou Ayash canal and Ezbet Arab Abes canal while it was 0.650 - 283.6µg/L in samples collected from Zawyet El-Naggar drain.

Our results indicated that the metal concentration values increased statistically significant different related to season.

The higher metal concentrations in summer could be attributed to an increase in the rate of metal accumulation due to the higher temperature, also high evaporation rate may be affected. In addition, summer could increase the amount of toxicant flushed into the water, desalinations plants and high fishing activities. But the lower salinity in autumn could reduce the rate of metal accumulation due to sedimentation, **Coulibaly *et al.*, (2012)**.

The highly levels of Cu caused by the use of CuSo4 to kill bilharzia snails in the River Nile. addition of $CuSo_4$ may increase acidity (decrease pH) of water and solubility of Cu metal.

Table 1. The heavy metals concentrations in water samples collected from EL-Marutia canal and El-Qanater El -Khayreya region at different seasons.

Sites	Elements	Spring µg/L±s.d.*	Summer µg/L±s.d. *	Autumn µg/L±s.d. *	Winter µg/L±s.d. *
El-Marutia Canal	Cd	2.641±0.199	1.125±0.132	1.585±0.212	0.945±0.214
	Cu	17.654±1.953	15.849±1.201	8.296±1.692	11.536±1.148
	Fe	302.67±2.453	215.18±4.732	271.39±0.133	150.94±1.682
	Pb	2.586±0.112	2.895±0.311	1.582±0.234	7.185±0.546
	Zn	6.067±0.225	4.157±0.147	6.162±0.339	5.253±0.132
El-Qanater El -Khayreya region	Cd	3.025±0.210	1.548±0.387	1.396±0.228	1.057±0.187
	Cu	10.577±2.278	12.591±1.709	14.39±1.850	20.529±2.135
	Fe	412.84±2.376	406.82±0.918	187.29±0.211	200.43±5.245
	Pb	0.922±0.185	2.005±0.125	4.365±0.458	3.428±0.427
	Zn	7.057±0.500	3.979±0.264	4.855±0.495	5.477±0.240

*sd: standard division

1.2. Heavy metals in sediment.

The range of cadmium concentrations and standard deviation in sediment samples obtained in **Table (2)** were ranged between 11.18±0.98 to 13.14±1.02 µg/g in El-Marutia canal samples while the cadmium concentrations ranged between (13.44±2.04 to 18.19±1.57 µg/g) in El-Qanater El-Khayreya region samples. The value of Cd was higher in the spring season in El-Marutia canal samples (13.14±1.02 µg/g) compared to other seasons. Followed by winter, autumn and summer (12.75±1.52, 12.54±2.17 and 11.18±0.98 µg/g, respectively). While, the values of Cd were higher in the winter season in El-Qanater region samples (18.19±1.57 µg/g), the autumn season was 17.96±2.12 µg/g, the spring season was 15.95±1.68 µg/g while in summer it was 13.44±2.04 µg/g.

The maximum allowed limit of cadmium in sediments is 5 µg/g **(Macdonald *et al.*, 2000)**. But, according to **WHO (2011)** the permissible levels of cadmium are 0.003 µg/g, so all the samples showed higher concentrations of cadmium in sediments than the allowed limit. Otherwise, **Al-Wesabi *et al.* (2015)** found the highest concentration of Cd was recorded in Al-Kumrah (1.099 ± 0.010 mg/kg dry weight) and the lowest in Al-Shoaibah (0.017 ± 0.006 mg/kg dry weight).

From **Table (2)** the copper levels in sediments varied between 10.58±2.18 to 43.59±3.98 µg/g in El-Marutia sediment samples, while the levels varied between 18.21±3.08 to 52.2±3.64 µg/g in El-Qanater sediment samples. According to **Mansour and Messeha (2001)** the level of copper in sediment of Qarun Lake was 3.69 µg/g. So, all the sampling sites recorded more than this value. Copper maximum allowed limit in sediments is 111 µg/g, **(Macdonald *et al.*, 2000)**. All the sediment samples had lower levels of copper than the acceptable limits. While according to, **WHO (2011)** the permissible limits of copper in sediment samples is 2.00 µg/g, so all samples ewer higher than the permissible levels.

From **Table (2)** iron concentration in sediment samples varied from 307.46±5.02 to 500.58±6.84 µg/g in El-Marutia sediment samples. While the levels varied between 207.11±3.99 to 700.4±4.32 µg/g in El-Qanater sediment samples. The concentration of Fe was higher in spring season of El-Marutia and in summer season of El-Qanater El-Khayreya sediment samples because the release of iron from anoxic sediments that becomes oxidized, precipitates and carries metals with it. Also, with pH increasing, the adsorption abilities of metals increase. According to, **WHO (2011)** the permissible levels of Fe is 0.3 µg/g, all the samples collected during different seasons in the two sites showed higher concentrations of iron in sediments than the allowed limit. The concentration of Fe was lower in winter season of El-Marutia and in autumn season of El-Qanater El-Khayreya sediment samples because and solubility of heavy metals were lower at low temperature than high temperature. So, the adsorption abilities of Fe increase. Also, with pH increasing, the adsorption abilities of metals increase and the concentration of Fe increases in sediment.

According to **Mansour and Messeha (2001)** the level of iron in sediments of Qarun Lake was 969.8µg/g. All the sampling sites recorded less than this value.

The concentration of Fe was higher in spring season of El-Marutia and in summer season of El-Qanater El-Khayreya sediment samples because the release of iron from anoxic sediments that becomes oxidized, precipitates and carries metals with it. Also, with pH increasing, the adsorption abilities of metals increase. Lead concentrations in sediments are seen in **Table (2)** with a range of data between 7.08±1.95 and 14.55±3.21 µg/g in El-Marutia sediment samples. While the levels varied between 12.03±2.05 to 24.28±2.31 µg/g in El-Qanater samples. The maximum limit of lead in sediments is 158 µg/g **(Macdonald *et al.*, 2000)**. While the maximum limit of lead in sediments is 0.01 µg/g according to **WHO (2011)**, the results showed that all samples were exceeded the limits of WHO. Also, **Malhat, (2010)** found that the average concentration of lead ranged from 17.12 to 46.42 µg/g in sediment samples collected from El-Bagoria canal and Miet-Rabiha drain, respectively. The concentration of Pb was higher in winter season of El-Marutia sediment samples because the release rates and solubility of heavy metals were lower at low temperature than high temperature. So, the adsorption abilities of Pb increase and its concentration in sediment increases.

From **Table (2)** The concentration of zinc in sediments was ranged between 23.54±3.85 and 62.55±3.29 µg/g. in El-Marutia sediment samples. While the levels varied between 33.13±1.87 to 74.52±2.09 µg/g in El-Qanater sediment samples. On the other hand, **Abd Elsalam, (2013)** found that the concentration of zinc in sediments was ranged between 27.65µg/g and 58.30 µg/g. it could be observed that the Zn values of the soils were lower than the permissible level. The sediment maximum allowed limit is 459 µg/g for zinc, **(Macdonald *et al.*, 2000)**, but **WHO (2011)** recorded that the permissible limits of zinc is 5.00 µg/g, the results showed that all samples were exceeded the limits of WHO. The solubility and temperature degrees affected on the concentration of heavy metals and dissolutions of carbonates and hydroxides increased and the metal release rate of water-soluble fraction, carbonate fraction from sediment into the overlying water increased. also, with pH decreasing, the replacement between (H^+) or ($H3O^+$) in water and metals bounded with ligands and organic compounds in sediments increases. The sediment could be exposing to the aerobic environment more easily and the organic phase and sulfide fraction metals released more rapidly. Additionally, the flow rate also contributed to the physical disturbance may change the physical environment, such as pH and dissolved oxygen (DO).

Table 2. Heavy metals concentration in different seasons in El-Marutia and El-Qanater sediment samples.

The sediment sources	Element	Spring µg/g ± s.d.*	Summer µg/g ± s.d.*	Autumn µg/g ± s.d.*	Winter µg/g ± s.d.*
El-Marutia Canal	Cd	13.14±1.02	11.18±0.98	12.54±2.17	12.75±1.52
	Cu	43.59±3.98	10.58±2.18	30.12±2.04	25.01±4.59
	Fe	500.58±6.84	385.74±4.62	317.05±4.28	307.46±5.02
	Pb	11.75±2.69	7.08±1.95	10.30±2.06	14.55±3.21
	Zn	62.55±3.29	26.21±3.07	23.54±3.85	34.02±3.27
El-Qanater El -Khayreya region	Cd	15.95±1.68	13.44±2.04	17.96±2.12	18.19±1.57
	Cu	52.2±3.64	18.21±3.08	22.51±2.13	35.10±3.52
	Fe	689.25±4.96	700.4±4.32	207.11±3.99	394.28±2.65
	Pb	16.26±1.25	24.28±2.31	12.03±2.05	16.37±2.38
	Zn	74.52±2.09	43.75±1.52	58.25±2.30	33.13±1.87

*sd: standard division

2. Heavy metals in water hyacinth plant. :

The aquatic plants Water hyacinth (*E. crassipes*) that belongs to the family pontederiaceae stands as a challenging, most productive invasive aquatic plant on earth showing extreme risk to the ecosystem. Water hyacinth originated in the tropics and spread to all tropical climate countries. In Egypt, they can be found in large water areas in the River Nile. Due to vegetative reproduction and vigorous growth rate of this plant. A typical biomass from land plants is composed of 30-50% cellulose, 20-40% hemicellulose and 15-30% lignin. It is also found to have high nitrogen content and in combination with cow dung it can be used for biogas production, **Bhattacharya and Pawan, (2010)**. Its enormous biomass production rate, its high tolerance to pollution, and its heavy metal and nutrient absorption capacities (**Chanakya *et al.*, 1993; Singhal & Rai, 2003; Ingole & Bhole, 2003; and Liao & Chang, 2004)** qualify it for use in wastewater treatment ponds.

Water hyacinth Its minimum growth temperature is 12 °C; its optimum growth temperature is 25-30 °C and its maximum growth temperature is 33-35 °C. so, the results showed that all metals uptake by plant is maximum in summer and spring seasons except for lead its maximum uptake by plant in autumn followed by summer season in El-Marutia. So, this plant has the ability to accumulate these heavy metals due to absorption during the life time of the plant which is longest in summer and spring season.

Heavy metals concentrations and standard deviation in hyacinth plant (roots, shoots and leaves) sample **Table (3)** showed that the range of cadmium was between (5.36±2.14 to 27.31±1.35 μg/g) in El-Marutia samples while the cadmium concentrations ranged between (1.78±2.82 to 29.83±0.69 μg/g) in El-Qanater El-Khayreya samples. The value of Cd was higher in the summer season in root samples which collected from El-Marutia (27.31±1.35 μg/g) compared to other seasons. Followed by spring, autumn and winter, (24.83±2.04, 22.82±0.45 and 13.78±1.09 μg/g), respectively). While The values of Cd were higher in summer season in root samples which collected from El-Qanater El-Khayreya (29.83±0.69 μg/g) followed by the spring season 26.78±2.35 μg/g, the autumn season 21.90±1.3 μg/g while in winter it was 12.94±2.34 μg/g. The level of Cd was higher in summer in both El-Marutia and El-Qanater El-Khayreya plant samples due to the effect of temperature on adsorption process which increase with an increase in temperature. The concentration of Cd in shoot samples ranged between (14.73±1.34 to 9.53±1.12 μg/g) in the samples which collected from El-Marutia during different seasons, while the Cd levels of shoot samples which collected from El-Qanater El-Khayreya ranged between (16.73±2.05 μg/g to 8.82±1.25μg/g), also data showed that the shoot samples which collected during the summer season have higher levels of Cd compared to the samples collected during the winter season in El-Marutia, while samples which collected during the autumn season have higher levels of Cd compared to the samples collected during the winter season in El-Qanater El-Khayreya. The results showed that the levels of Cd in the leaves were the lowest concentrations compared to the roots and the shoots. The Cd levels in spring were 10.28±2.01μg/g followed by summer 9.10±1.03μg/g, autumn 8.06±1.35μg/g and winter were 5.36±2.14μg/g in the samples which collected from El-Marutia and the samples which collected from El-Qanater the Cd levels were 9.90±2.64μg/g during the autumn season followed by spring season 9.30±1.52μg/g, winter 5.72±0.85μg/g and summer 1.78±2.82μg/g.

The copper levels in hyacinth plant (roots, shoots and leaves) samples between (71.93±1.59 to 13.59±3.64 μg/g) in El-Marutia plant samples, while the levels varied between (63.96±1.01 to 13.73±3.47 μg/g) in El-Qanater El-Khayreya samples. The value of Cu was higher in the summer season in El-Marutia root samples 71.93±1.59 µg/g compared to other seasons. Followed by spring, autumn and winter, (63.55±4.56, 54.72±2.38 and 28.83±0.21 µg/g, respectively). While The values of Cu were higher in summer season in El-Qanater El-Khayreya samples 63.96±1.01 µg/g, the Spring season was 56.26±1.36 µg/g, the Autumn season was 43.76±0.58µg/g while in winter it was 22.22±2.61 µg/g. The results showed that the Cu levels in roots more than shoots and leaves during all seasons. Also, the root samples which collected from El-Marutia had Cu levels more than the samples which collected from El-Qanater El-Khayreya. The root samples which collected during summer season had Cu more than spring, autumn and winter in both sites (71.93±1.59, 63.55±4.56, 54.72±2.38 and 28.83±0.21 µg/g) in El-Marutia root samples and (63.96±1.01, 56.26±1.36, 43.76±0.58 and 22.22±2.61 µg/g) in El-Qanater El-Khayreya root samples. Results also showed that the Cu levels in the leaves samples were the lowest levels compared by roots and shoots and the results showed the leaves samples which collected during summer season were higher than other seasons (45.40±1.4 and 33.02±1.1 µg/g) while the Cu levels in samples collected during spring (32.68±3.06 and 25.90±2.36 µg/g), autumn (22.39±1.68 and 19.76±2.72 µg/g) and winter (13.59±3.64 and 13.73±3.47 µg/g) in El-Marutia and El-Qanater, respectively. The Iron levels in hyacinth plant (roots, shoots and leaves) samples between 130.54±1.0 to 74.88±5.0µg/g in El-Marutia plant samples, while the levels varied between 185.31±1.5 to 76.17±1.65µg/g in El-Qanater samples. The value of Fe was higher in the summer season in El-Marutia root and shoots samples (130.54±1.0, 105.18±3.4µg/g) compared to other seasons. Followed by spring, autumn and winter, (118.55±4.7, 97.70±4.2), (113.13±1.41, 89.25±2.2), (96.7±4.06, 85.52±4.7) µg/g, respectively. While The values of Fe were higher in the Spring season in El-Qanater root and shoot samples (185.31±1.5, 115.13±1.4) µg/g, the summer season was (125.78±3.5, 109.23±1.3) µg/g, the Autumn season was (118.21±0.85, 99.56±2.6) µg/g, while in winter it was (110.13±0.2, 85.26±3.5) µg/g. The results showed that the Fe levels in roots more than shoots and leaves during all seasons in both sites. The results showed that the Fe levels in shoots samples were higher than leaves samples in all seasons in both sites except in the summer season in El-Marutia samples while the leaves samples (108.7±3.4 µg/g) were higher than shoots samples (105.18±3.4 µg/g), and the results showed Fe levels in the leaves samples in El-Marutia which collected during summer season were higher (108.7±3.4 µg/g) compared to other seasons. Followed by spring, autumn and winter (96.95±3.2, 84.13±5.9, 74.88±5.0 µg/g) in El-Marutia samples. While the Fe levels in leaves samples collected during spring season were higher (102.34±1.1 µg/g) compared to other seasons. Followed by summer, winter and autumn (92.05±0.9, 77.24±4.7, 76.17±1.65 µg/g) in El-Qanater El-Khayreya. The lead levels in hyacinth plant (roots, shoots and leaves) samples between 13.51±0.96 to 2.1±2.06 µg/g in El-Marutia plant samples, while the levels varied between 8.68±5.17 to 2.19±4.55 µg/g in El-Qanater El-Khayreya samples. Significantly positive relationships were observed among the concentrations of Pb in the shoot of hyacinth plant in autumn and those in El-Qanater El-Khayreya water samples. The value of Pb was higher in the autumn season in El-Marutia root and shoots samples (13.51±0.96, 11.49±5.08µg/g) compared to other seasons. The root samples were Followed by summer, winter and spring (9.85±4.69, 9.19±2.45, 7.80±3.89) µg/g, respectively. The shoots samples were followed by winter, summer, spring (7.43±3.57, 5.3±3.64, 5.10±6.14) µg/g, respectively. While The values of Pb were higher in the Spring season in El-Qanater El-Khayreya root samples (8.68±5.17 µg/g), the summer season was (7.78±4.39µg/g), the Autumn season was (6.99±1.42µg/g) while in winter it was (6.22±6.24 µg/g) and The values of Pb in the shoots samples were higher in the autumn season (5.87±4.98 µg/g) followed by spring, summer, winter (4.78±2.31, 4.39±2.30, 4.22±2.57) µg/g, respectively.

The results showed that the Pb levels in roots more than shoots and leaves during all seasons in both sites. The results showed that the Pb levels in shoots samples were higher than leaves samples in all seasons in both sites, and the results showed Pb levels in the leaves samples which collected during autumn season were higher (7.17±2.39µg/g) compared to other seasons. Followed by winter, spring, summer (5.48±2.68, 3.55±2.59, 2.1±2.06µg/g) in El-Marutia samples. while the Pb levels in leaves samples collected during spring season were higher (3.95±3.19µg/g) compared to other seasons. Followed by summer, autumn and winter (3.53±2.32, 3.4±0.87, 2.19±4.55 µg/g) in El-Qanater El-Khayreya. The Zn levels in hyacinth plant (roots, shoots and leaves) samples between 14.35±4.30 to 2.49±6.21 µg/g in El-Marutia plant samples, while the levels varied between 18.30±3.31 to 2.70±6.18 µg/g in El-Qanater El-Khayreya samples. Significantly positive relationships were observed among the concentrations of Zn in the shoot and leaves of the plant in the autumn season and those in water in El-Marutia samples and in the spring season and those in El-Qanater El-Khayreya water samples. The value of Zn was higher in the summer season in El-Marutia root samples (14.35±4.30 µg/g) compared to other seasons. The root samples were followed by autumn, spring, winter (11.86±4.20, 10.45±1.39, 10.14±4.78 µg/g), respectively and the value of Zn was higher in the autumn season in the shoot's samples (10.89±3.64 µg/g) were Followed by spring, winter, summer (5.63±3.89, 5.54±5.08, 5.43±2.34µg/g), respectively. While The values of Zn were higher in the summer season in El-Qanater El-Khayreya root samples (18.30±3.31µg/g), the spring season was (15.85±2.49µg/g), the Autumn season was (8.64±2.34µg/g) while in winter it was (6.98±3.25µg/g) and The values of Zn in the shoots samples were higher in the spring season (13.03±2.17µg/g) followed by summer, autumn, winter (9.45±2.55, 7.19±3.24, 3.95±4.69 µg/g), respectively. The results showed that the Zn levels in roots more than shoots and leaves during all seasons in both sites. The results showed that the Zn levels in shoots samples were higher than leaves samples in all seasons in both sites. **Matindi (2016)** found the concentration ranges were: < 0.065 to 9.1 mg kg^{-1} in the roots, < 0.065 to 5.5 mg kg^{-1} in the stem and < 0.065 to 6.4mg kg^{-1} in the leaves during January sampling period. During May, the Cu concentrations ranged between < 0.065 to 31 mg kg^{-1}, < 0.065 to 52 mg kg^{-1} and < 0.065 to 12 mg kg^{-1} for roots stem and leaves respectively. While, the iron was highly accumulated in the roots of the water hyacinth in comparison to other plant parts. In January iron concentrations in the plant parts ranged as follows; 1857 to 5103 mg kg^{-1}, 316 to 2761 mg kg^{-1} and 282 to 3715 mg kg^{-1} in the roots, stems and leaves respectively. In May, the concentrations ranged between 2464 to 27812 mg kg^{-1} in the roots, 667 to 4322 mg kg^{-1}in the stem and 506 to 2925 mg kg^{-1} in the leaves. Also, in January, the concentration of Zn ranges was; < 0.055 to 79 mg kg^{-1} < 0.055 to 64 mg kg^{-1} < 0.055 to 46 mg kg^{-1} for the roots, stem and leaves respectively. In May concentration ranges for Zn were; < 0.055 to 280 ± 13 mg kg^{-1}, < 0.055 to 774 mg kg^{-1} and < 0.055 to 59 mg kg^{-1} for the roots, stem and leaves respectively. Also, **Ratan and Verma, (2014)**, found that Fe was the highest and easily accumulated heavy metal by water hyacinth in a river polluted by industrial and municipal waste. Comparing with results from their average Fe concentrations from the plants were found to be 311.17, 4.89 and 2.49 mg kg $^{-1}$ in the roots, stem and leaves. **Buta *et al.*, (2011)** also reported that harvested water hyacinth growing in contaminated water had high levels of Zn in roots at 84 mg kg^{-1} while the shoots of the plants had concentrations of 51 mg kg $^{-1}$.

Table 3: Heavy metals concentration in different seasons in El- Marutia and El-Qanater in water hyacinth plant samples.

Cites	Element	Spring µg/g±s.d.			Summer µg/g±s.d.			Autumn µg/g±s.d.			Winter µg/g±s.d.		
		Roots	Shoots	Leaves	Roots	Shoots	Leaves	Roots	Shoots	Leaves	Roots	Shoots	Leaves
El-Marutia	Cd	24.83±2.04	12.28±2.06	10.28±2.01	27.31±1.35	14.73±1.34	9.10±1.03	22.82±0.45	12.66±1.65	8.06±1.35	13.78±1.09	9.53±1.12	5.36±2.14
	Cu	63.55±4.56	48.83±2.19	32.68±3.06	71.93±1.59	50.45±4.19	45.40±1.4	54.72±2.38	30.57±4.21	22.39±1.68	28.83±0.21	15.97±3.54	13.59±3.64
	Fe	118.55±4.7	97.70±4.2	96.95±3.2	130.54±1.0	105.18±3.4	108.7±3.4	113.13±1.41	89.25±2.2	84.13±5.9	96.7±4.06	85.52±4.7	74.88±5.0
	Pb	7.80±3.89	5.10±6.14	3.55±2.59	9.85±4.69	5.3±3.64	2.1±2.06	13.51±0.96	11.49±5.08	7.17±2.39	9.19±2.45	7.43±3.57	5.48±2.68
	Zn	10.45±1.39	5.63±3.89	3.43±2.36	14.35±4.30	5.43±2.34	3.62±1.64	11.86±4.20	10.89±3.64	6.31±3.41	10.14±4.78	5.54±5.08	2.49±6.21
El-Qanater	Cd	26.78±2.35	15.19±1.39	9.30±1.52	29.83±0.69	12.68±1.61	1.78±2.82	21.90±1.31	16.73±2.05	9.90±2.64	12.94±2.34	8.82±1.25	5.72±0.85
	Cu	56.26±1.36	33.55±1.64	25.90±2.36	63.96±1.01	42.35±3.22	33.02±1.1	43.76±0.58	21.09±0.23	19.76±2.72	22.22±2.61	19.47±4.02	13.73±3.47
	Fe	185.31±1.5	115.13±1.4	102.34±1.1	125.78±3.5	109.23±1.3	92.05±0.9	118.21±0.85	99.56±2.6	76.17±1.65	110.13±0.2	85.26±3.5	77.24±4.7
	Pb	8.68±5.17	4.78±2.31	3.95±3.19	7.78±4.39	4.39±2.30	3.53±2.32	6.99±1.42	5.87±4.98	3.4±0.87	6.22±6.24	4.22±2.57	2.19±4.55
	Zn	15.85±2.49	13.03±2.17	6.65±3.58	18.30±3.31	9.45±2.55	4.78±4.17	8.64±2.34	7.19±3.24	5.11±1.95	6.98±3.25	3.95±4.69	2.70±6.18

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تقييم تلوث المعادن الثقيلة في الماء والرواسب ونبات ورد النيل في نهر النيل

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تهدف الدراسة الي التعرف علي النظام البيئي لمياه نهر النيل في منطقة القناطر الخيرية بمحافظة القليوبية وترعة المريوطية بمحافظة الجيزة، والتحقق من فعالية نبات ورد النيل

كمادة ادمصاصية للتخلص من بعض المعادن الثقيلة من مياه نهر النيل. تم تقدير المعادن الثقيلة (الكادميوم، النحاس، الحديد، الرصاص و الزنك) في عينات المياة و الرواسب و نبات ورد النيل باستخدام طيف الامتصاص الذري.

أوضحت الدراسة أن مستويات المعادن الثقيلة في عينات المياه تراوحت ما بين (0.214±0.945 إلى 0.210±3.025 ميكروجرام / لتر) للكادميوم و بينما كانت مستويات النحاس من (1.692±8.296 إلى 2.135 ±20.529 ميكروجرام / لتر). أيضا و تراوحت تركيزات الحديد (1.682±150.94 إلى2.376 ±412.84 ميكروجرام / لتر). بينما كانت تركيزات الرصاص (0.185±0.922 إلى 0.458 ± 4.365 ميكروجرام / لتر) وتراوحت تركيزات الزنك بين (0.264±3.979 إلى0.5±7.057 ميكروجرام / لتر) في ترعة المريوطية ومنطقة القناطر الخيرية خلال المواسم المختلفة.

لقد تراوحت مستويات المعادن الثقيل في عينات الرواسب بين (0.98 ±11.18 إلى1.57 ± 18.19ميكروجرام / جرام) للكادميوم وتراوحت بين (2.18±10.58 إلى3.64 ±52.2 ميكروجرام / جرام) بالنسبة للنحاس. بينما تفاوت تركيزات الحديد من (3.99±207.11 إلى 4.32 ±700.4 ميكروجرام / جرام). من ناحية أخرى و تراوحت تركيزات الرصاص بين (1.95±7.08 إلى2.31 ±24.28 ميكروجرام / جرام) وكانت مستويات الزنك بين (3.85±23.54 إلى2.09 ±74.52 ميكروجرام / جرام) في ترعة المريوطية ومنطقة القناطر الخيرية خلال المواسم المختلفة.

وتراوحت تركيزات عنصر الكادميوم في نبات ورد الماء من2.34 ±12.94 إلى0.69±29.83 ميكروجرام / جرام و من1.25±8.82 إلى2.05 ±16.73 ميكروجرام / جرام و من 2.82±1.78 إلى2.01 ±10.28 ميكروجرام / جرام لكل من الجذور والسيقان والاوراق على التوالي خلال جميع فصول السنة في ترعة المريوطية ومنطقة القناطر الخيرية. بينما كانت تركيزات عنصر النحاس من2.61 ±22.22 إلى1.59 ±71.93 ميكروجرام / جرام ، من3.54±15.97 إلى4.19±50.45 ميكروجرام / جرام و من3.47 ±13.73 إلى1.4 ± 45.40 ميكروجرام / جرام لكل من الجذور والسيقان والاوراق على التوالي خلال جميع الفصول في ترعة المريوطية ومنطقة القناطر الخيرية.

تراوحت تركيزات عنصر الحديد لكل من الجذور والسيقان والاوراق من4.06±96.7 إلى1.5 ± 185.31ميكروجرام / جرام ،3.5±85.26 إلى1.4±115.13 ميكروجرام / جرام و5.0±74.88 إلى3.4 ±108.7ميكروجرام / جرام على التوالي. و أيضا تراوحت تركيزات عنصر الرصاص في الجذور والسيقان والاوراق من6.24 ±6.22 إلى0.96 ±13.51 ميكروجرام / جرام ،2.57 ±4.22 إلى5.08±11.49ميكروجرام / جرام و 2.1±2.06إلى2.39 ±7.17 ميكروجرام / جرام على التوالي ، بينما تراوحت تركيزات عنصر الزنك من3.25 ± 6.98 إلى3.31±18.30 ، من 4.69 ±3.95 إلى2.17±13.03 ميكروجرام / جرام و من6.21 ± 2.49إلى3.58 ±6.65 ميكروجرام / جرام للجذور و السيقان والاوراق على التوالي

الكلمات المفتاحية: طيف الامتصاص الذري، المعادن الثقيلة ، نهر النيل ، نبات ورد النيل.