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Soil Pollution Enhances the Accumulation of Heavy Metals in Plants

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Authors' contributions

This work was carried out in collaboration between both authors. Author HMI managed the analyses and literature searches of the study. Author NMMS designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Both authors read and approved the final manuscript

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ABSTRACT

The determine heavy metals levels (Cu, Pb, Cd and As), in different samples (Tomato, Cucumber, Hot Green Peppers, Spinach, Green Beans, Eggplant, Beans of Harati, Zucchini and its soil). The samples collected from different Egyptian fields (Bani Salamah, Barkata, and Ministry of Agriculture). The obtained results show that in many of the samples increase the heavy elements in the plant more than the soil Perhaps due to the absorption of quantitative heavy elements from soil to plant as well as keep in mind the other causes of them an increase in the amount of spraying pesticides on them and there are other reasons, absorb part of the pollution of the surrounding environment.

Keywords: Heavy metals; atomic absorption spectrometry; vegetables and soils contamination.

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1. INTRODUCTION

Heavy metals are essential environmental pollutants, and their presence in the atmosphere, soil, water and in the food chain can cause severe problems to living things. Heavy metal contamination of vegetables cannot ignore because vegetables are essential components of human diet as they are rich sources of vitamins, minerals, fibers, and antioxidants. However, intake of heavy metal-contaminated vegetables may pose a risk to the human health; In humans, heavy metals enter the body mainly through the dietary consumption [1,2]. Absorption of heavy metals and contaminants through a rice-based diet may have severe consequences for human health [3].

Copper is essential elements which are required by living organizes. It participates in photosynthesis and respiration of plants [4]. Copper deficiency in humans causes anemia is disorders of nervous and circulation systems.

Lead is toxic heavy metal to the humans and animals. Its extensive use and widespread disposal in the environment have resulted in numerous Pb-contaminated soils [5]. The health concern with Pb-contaminated soils arises mostly from the plant contamination by humans, by soil particles and dust ingestion especially children and grazing animals [6]. However, The highest total Pb concentration in the berm soils can be attributed to an accumulation of lead bullets, projectiles and shots into the berm [7].

Cadmium poisoning has been reported from many parts of the world. It is one of the global health problems that affect many organs and in some cases, it can cause deaths annually. Long-term exposure to cadmium through air, water, soil, and food leads to cancer and organ system toxicity such as skeletal, urinary, reproductive, cardiovascular, central and peripheral nervous, and respiratory systems. Cadmium levels can be measured in the blood, urine, hair, nail and saliva samples. Furthermore, it has been likewise recommended to determine the level of food contamination and suspicious areas, consider public education and awareness programs for the exposed people to prevent cadmium poisoning [8].

Arsenic is one of the most toxic elements. It is absorbed from the gastrointestinal tract, distributed to the body and especially the nails, hair, and skin. As forms ligands with the sulfhydryl group of enzymes and block their activity. Some evidence exists about the essential role of As in mammals as an activator of certain enzymes and substitute of phosphate in metabolizing [9]. Symptoms of As poisoning are vomiting, diarrhea, bleeding, hematuria, kidney failure, lack of appetite, weight loss, abdominal pain, facial deem, difficulty breathing and obstructive jaundice [10]. It most of the arsenic exists as sulfide because of its strong affinity for sulfur fungicides [11]. Heavy metals, which have widespread environmental distribution and originate from natural and anthropogenic sources, are common environmental pollutants [12].

2. MATERIALS AND METHODS

2.1 Heavy Metals

Monitoring of heavy metals such as Cu, Pb, Cd and As in plants and soil collected from Bani Salamah, Barkata, and Ministry of Agriculture during the period of (1/2017 to 6/2017).

2.2 Sampling

The samples studied represent items most commonly consumed in an Egyptian diet according to the data obtained from the Nutrition Institute, Ministry of Health.

2.3 Determination of Heavy Metals in Tested Samples

Plant and soil samples dried at 60ºC overnight to constant weight. After homogenization, 1 g of samples (plant and soil) digested with a mixture 10 ml (HCl: HNO_3), the ratio (1:3). The solution kept at room temperature overnight before of water condenser was attached and at the solution heated to boiling for 2 hours to 10 ml of water was added down the condenser before filtration of the mixture through using a Whatman No. 42 filter. The filtered residue was rinsed twice with 5 ml of water, and the solution was made up to 50 ml. All solution prepared with 18.3MΩ deionized water. Thermal elemental atomic absorption spectrometer model (M-series) with flame atomization used for the determination of the concentration of heavy metals [13].

2.4 Atomic Absorption Measurement

Measurements of parameters by atomic absorption spectrometry were as follow: optical parameter for Cu, Cd, As and Pb (Table 1)

Table 1. Spectrometry and flame parameters for metal

S- Spectrometry and flame parameters	Cu	Pb	Cd	As
Wave length (nm)	324.75	405.7	228.8	193.7
Lamp current(MA)	75	75	75	75
Measurement time (sec)	3	3	3	3
Band width (nm)	0.5	0.5	0.5	0.5
Flame type	Air-C_2H_2	Air-C_2H_2	Air-C_2H_2	Air-C_2H_2
Burner height (mm)	7.0	7.0	7.0	7.0

3. RESULTS AND DISCUSSION

Persistence of heavy metals in plants and soil: The heavy metals are absorbed into the body by way of mouse and skin. Heavy metals in the environment are readily absorbed and accumulated by plant and animals, which in turn are consumed by humans. Lead and cadmium are important target pollutants in environmental protection [14]. The sampled were taken from (Bani Salamah) Giza is Sandy soil, (Barkata) Qalyubiyah is clay soil and Ministry of Agriculture (greenhouse) Giza is Sandy soil in Table (2), Table (3) and Table (4), respectively. The heavy metal mean concentrations determined based on vegetables dry weight.

In the present study represented in table 2, 3 and 4 showed that, the concentrations of heavy metal such as Cu, Pb, Cd and As.

3.1 Copper Content

These results in a table (2) and Fig. 1 indicated that the concentrations of Copper were (0.43, 0.97, 0.43, 0.32, 1.24, 0.17, 1.7 and 0.25 ppm) in (Tomato, Cucumber, Hot Green Peppers, Spinach, Green Beans, Eggplant, Beans of Harati and Zucchini) respectively in plants. While the concentrations of Copper in soils were (0.56, 0.32, 0.35, 0.48, 0.09, 0.45, 0.29 and 0.7 ppm) respectively, for the samples collected from (Bani Salamah) Giza (field 1).

On the other hand, the concentrations of Copper collected from **(**Barkata) Qalyubiyah (field 2) were 0.16, 0.33, 0.37 and 0.34 ppm respectively, for Tomato, Green Beans, Eggplant, and Zucchini in plant. However, the concentrations of Cu in soil were 1.11, 0.85, 1.03 and 1.10 ppm respectively, in the table (3) and Fig. (2). Finally, that the concentrations of Copper collected from of greenhouse (field 3) were 1.11, 1.03 and 1.39 in Cucumber, Hot Green Peppers and Eggplant in plant but in soil is 1.26, 0.71 and 1.34 ppm respectively, in table (4) Fig. 3.

The contents of Copper in this study are about the permissible levels by the finish MRL'S for Cu (5.0 ppm).

3.2 Lead Content

From the data reported in table (2) and Fig. (1) indicated that the concentrations of Pb is found to be (0.12, 0.09, 0.26, 0.24, 0.11, 0.26, 0.32 and 0.12 ppm) in (Tomato, Cucumber, Hot Green Peppers, Spinach, Green Beans, Eggplant, Beans of Harati and Zucchini) respectively in plant. While the concentrations of Pb in soil were (0.11, 0.12, 0.10, 0.11, 0.04, 0.14, 0.05 and 0.12 ppm) respectively, for (field 1).

On the other hand concentrations of pb for plant collected from (field 2) were (0.54, 0.19, 0.11 and 0.14 ppm) in (Tomato, Green Beans, Eggplant, and Zucchini) respectively. While in soil was 0.33, 0.05, 1.43 and 0.08 ppm respectively, in the table (3) and Fig. (2) for (field 2). However, the concentrations of Pb in Hot Green Peppers and Eggplant collected from (field 3) is (0.11 and 2.47 ppm) in plant respectively, while non detected for Cucumber. However, in soil is (1.29, 0.34 and 0.4 ppm) in Cucumber, Hot Green Peppers and Eggplant, respectively as shown in the table (4) and Fig. 3.

Pb was detectable in (Tomato, Hot Green Peppers, Spinach, Eggplant, Beans of Harati and Zucchini) in a plant in (field 1) It was found to have levels higher than MRL'S of (0.1 mg /kg) according to Zurera-Cosan et al. [15].

In most of these results, the lead ratio in the plant is higher than the soil may be due to its absorption from the soil of the plant.

3.3 Cadmium Content

Results in a table (2) and Fig. (1) indicated that the concentrations of Cd non detected for Tomato, Cucumber, Hot Green Peppers, Spinach, Green Beans, Eggplant, Beans of

Harati and Zucchini in the plant. However, the concentrations of Cd in soil was 0.10 ppm for the Beans of Harati in soil from (field 1). On the other hand, the samples from (field 2) the concentrations in plant non detected for Tomato, Green Beans, Eggplant, and Zucchini, but in the soil of Tomato is 0.02 ppm. However, non detected for Green Beans, Eggplant and Zucchini table (3) and Fig. (2). While in was observed from table (4) and Fig. (3) Cucumber, Hot Green Peppers and Eggplant in (field 3) are 0.15, 0.01 and 1.24 ppm at the plant, but none detected in the soil for Hot Green Peppers and Eggplant, while 1.23 ppm in Cucumber shown in the table (4) and Fig. (3).

Cd in plant and soil for Cucumber and plant of Eggplant were higher than the respective allowed MRL'S (0.1 mg /kg). These results were by the previously reported data Feng, et al. [16].

3.4 Arsenic Content

Results in table (2) and Fig. (1), indicated that the residue of As detected plants in (Tomato, Cucumber, Hot Green Peppers, Spinach, Green Beans, Eggplant, Beans of Harati and Zucchini) were (0.66, 0.57, 0.46, 0.74, 0.83, 0.76, 0.61 and 0.57 ppm) respectively. While it observed for the soil were (0.16, 0.34, 0.49, 0.33, 0.30, 0.31, 0.56 and 0.29 ppm) respectively. for (field 1).

It observed from the table (3) and Fig. (2) that the As of concentrations for Tomato and Green Beans was 0.09, 0.27 ppm respectively, but Eggplant and Zucchini was none detected in the plant. It the concentrations of As in soil was 0.7 and 0.02 ppm for Tomato and Eggplant, but that none detected in Green Beans and Zucchini from the field (2). On the other hand, the samples that collected from the field (3) is none detected for Cucumber, Hot Green Peppers and Eggplant in vegetable but the soil are 0.37, 0.34 and 0.4 ppm respectively.

As in all plant of field (1) were higher but in soil is higher in Beans of Harati while in a field (2) is higher of soil for Tomato were higher than the respective allowed MRL'S (0.5 mg /kg).

Found from this results data for arsenic is higher than another heavy metal in many of samples for the field (1,2) due to This limit of arsenic was exceeded by all the soil samples which were

Table 2. The standard deviation and relative standard deviation value of heavy metals concentration (ppm) in plants and soils from Bani Salamah (field 1)

Metals \ Samples			Tomatoes	Cucumber	Hot Green peppers	Spinach	Green beans	Eggplant	Beans of harati	Zucchini
Cu	**Plant**	mean*	0.43	0.97	0.43	0.32	1.24	0.17	1.70	0.25
		SD	0.02	0.03	0.01	0.01	0.04	0.01	0.02	0.01
		RSD%	3.63	3.09	2.33	3.13	2.84	3.78	1.18	4.00
	Soil	mean*	0.56	0.32	0.35	0.48	0.09	0.44	0.29	0.70
		SD	0.02	0.01	0.01	0.02	0.01	0.02	0.01	0.02
		RSD%	2.87	3.13	2.29	3.45	5.88	3.57	2.33	2.66
Pb	**Plant**	mean*	0.12	0.09	0.26	0.24	0.11	0.26	0.34	0.12
		SD	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01
		RSD%	4.22	6.89	4.06	5.00	5.09	4.22	4.54	5.71
	Soil	mean*	0.11	0.12	0.11	0.11	0.04	0.14	0.05	0.12
		SD	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
		RSD%	6.24	4.95	5.23	5.97	6.40	4.06	5.80	6.45
Cd	**Plant**	mean*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Soil	mean*	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
As	**Plant**	mean*	0.66	0.57	0.46	0.74	0.83	0.76	0.61	0.57
		SD	0.02	0.03	0.01	0.04	0.02	0.04	0.02	0.03
		RSD%	3.03	5.26	1.25	5.41	2.41	5.26	2.49	5.26
	Soil	mean*	0.16	0.34	0.49	0.33	0.30	0.31	0.56	0.28
		SD	0.01	0.01	0.02	0.01	0.01	0.02	0.01	0.01
		RSD%	6.25	2.42	3.08	1.75	3.66	4.85	1.02	3.57

** number of replicated = 3; ppm= mg/ kg*

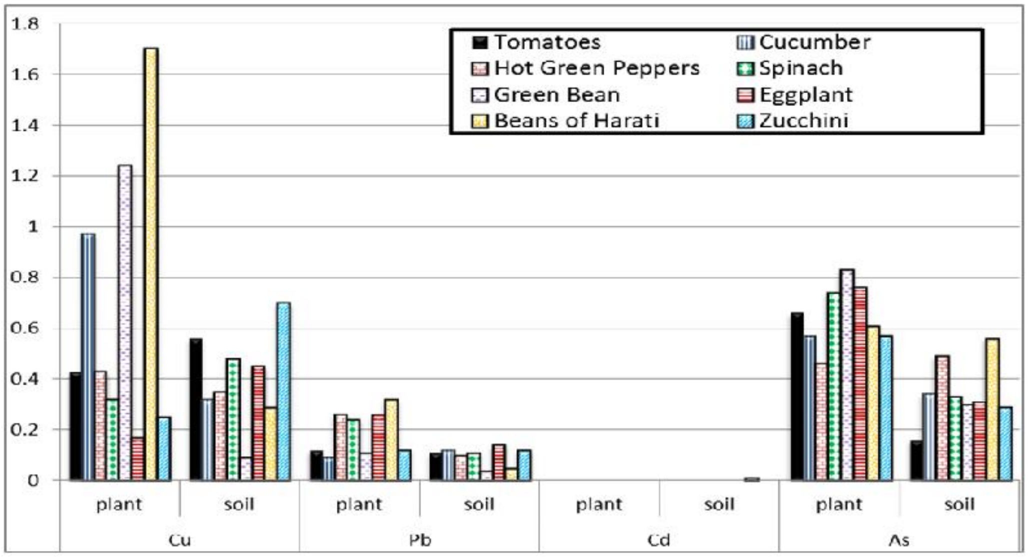

Fig. 1. Levels of heavy metal in plants and soil from Bani Salamah (field 1)

Table 3. The standard deviation and relative standard deviation value of heavy metals concentration (ppm) in plants and soils from Barkata (Field2)

Metals	Samples		Tomatoes	Zucchini	Green beans	Eggplant
Cu	**Plant**	Means*	0.16	0.34	0.33	0.37
		SD	0.01	0.02	0.01	0.01
		RSD%	3.46	4.41	2.10	2.70
	Soil	Means*	1.10	1.13	0.85	1.03
		SD	0.03	0.01	0.03	0.01
		RSD%	2.41	0.88	3.53	0.97
Pb	**Plant**	Means*	0.55	0.14	0.19	0.11
		SD	0.02	0.00	0.01	0.00
		RSD%	3.81	1.01	3.74	0.53
	Soil	Means*	0.33	0.08	0.05	1.43
		SD	0.01	0.00	0.00	0.04
		RSD%	1.55	1.96	1.29	2.80
Cd	**Plant**	Means*	0.00	0.00	0.00	0.00
	Soil	Means	0.02	0.00	0.00	0.00
		SD	0.02	0.00	0.00	0.00
		RSD%	0.58	0.00	0.00	0.00
As	**Plant**	Means*	0.09	0.00	0.27	0.00
		SD	0.01	0.00	0.02	0.00
		RSD%	5.59	0.00	5.76	0.00
	Soil	Means*	0.70	0.00	0.00	0.02
		SD	0.02	0.00	0.00	0.00
		RSD%	2.47	0.00	0.00	2.70

** number of replicated = 3*

analyzed. The soils of the study areas contain a large amount of arsenic, which indicates that soils are polluted by arsenic. Therefore it is assumed that the plants that are grown in these soils will absorb more arsenic from the soil and thereby polluted by arsenic. Plant arsenic concentrations tend to increase due to absorbed from the soil. On the other hand, the As uptake by plants is higher in the loamy sand than silty clay loam this is agreement with O'Neil [17].

Finally, Plants are the known to take up and accumulate trace metals from contaminated soil. Hence detection in plant leaves and crops sample, however, continuation consumption could lead to accumulation and adverse health implication particularly for Pb, Cd, and As. Also, continuous usage of these farmlands for growing crops lead to bioaccumulation of these metals and their eventual entry into the food chain with the associated health risk manifested this finding is similar to that by Opaluwa [18]. The variations of the metal contents observed in these vegetables depend on the physical and chemical nature of the soil and absorption capacity of each metal by the plant, which is altered by many environmental and human factors and nature of the plant this is harmony with Zurera-Cosan et al. [15].

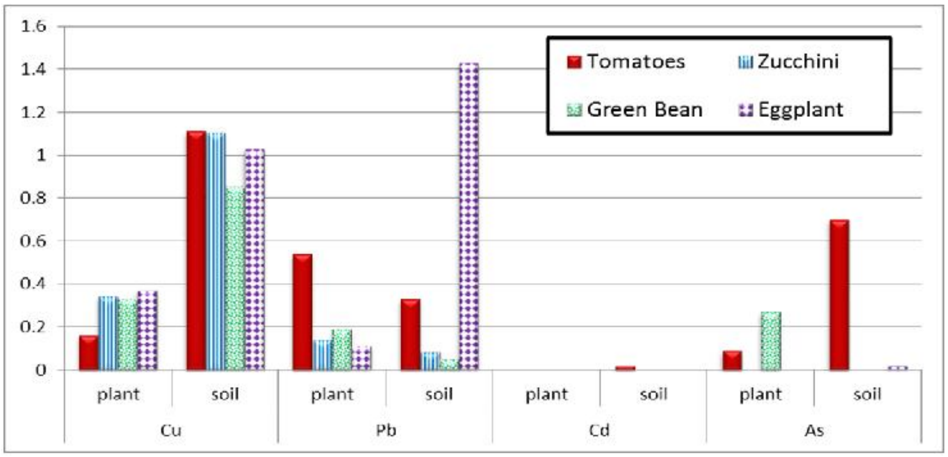

Fig. 2. Levels of heavy metal in plants and soil from Barkata (field 2)

Table 4. The standard deviation and relative standard deviation value of heavy metals concentration (ppm) in plants and soils from greenhouse (field3)

Metals \ Samples			Cucumber	Hot green peppers	Eggplant
Cu	**Plant**	mean*	1.11	1.03	1.39
		SD	0.02	0.01	0.01
		RSD%	1.80	0.97	3.30
	Soil	mean*	1.26	0.71	1.34
		SD	0.01	0.01	0.01
		RSD%	0.79	1.55	0.27
Pb	**Plant**	mean*	0.00	0.11	2.47
		SD	0.00	0.004	0.04
		RSD%	0.00	2.99	0.73
	Soil	mean*	1.29	0.35	0.40
		SD	0.02	0.01	0.01
		RSD%	1.18	2.91	2.50
Cd	**Plant**	mean*	0.15	0.01	1.24
		SD	0.01	0.005	0.01
		RSD%	3.63	4.90	0.14
	Soil	mean*	1.23	0.00	0.00
		SD	0.01	0.00	0.00
		RSD%	0.87	0.00	0.00
As	**Plant**	mean*	0.00	0.00	0.00
	Soil	mean*	0.37	0.34	0.40
		SD	0.01	0.01	0.01
		RSD%	2.20	1.71	1.60

** number of replicated = 3*

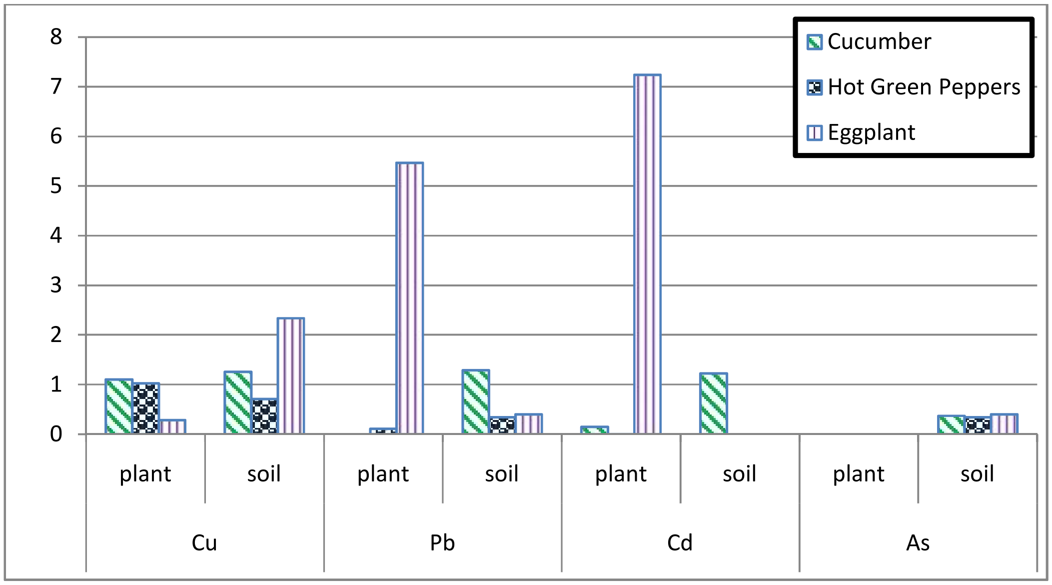

Fig. 3. Levels of heavy metal in plants and soil from greenhouse (field3)

The data reported in the table (2), table (3), table (4) give the value of SD and RSD obtained for three replicates. It found that the SD (0.004 to 0.04) and RDS (%) values are less than 7% which indicates the reproducibility of the proposed methods.

4. CONCLUSIONS

The aim of this work is to evaluate some heavy metals in different soil and natural food products collected from different agricultural regions in Egypt. The results indicate that some heavy metals such as Pb, Cd, and As have been accumulated in plants. This may be due to the absorption of the plant part of the heavy elements found in the soil and the influence of effect external factors, so find that the heavy metals increase in most of the plant from the soil. Attention must be paid to this because the plant is the source of life and at the same time if it is contaminated is the source of the disease.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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