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Concentrations of Cd, Co, and Pb in Soil and Taro Plant (*Colocasia esculenta*) at Various Distances from a Phosphate Fertilizer Factory

M. F. El-Mamoon[1], A. A. Abdel-Salam[1], A. H. Abdel-Hmied[1], A. A. Moursy[2] and M. A. Hekal[2]
[1]Soil and water Dept., Faculty of Agriculture, Mostohor Benha University
[2] Soils and Water Research Dept., Nuclear Research Center, Egyptian Atomic Energy Authority, Egypt
E-Mail: mostafafadel8585@gmail.com

Abstract

A survey study was conducted with the aim of monitoring the pollutants of cadmium, cobalt and lead around the phosphate fertilizer factory. At distances of C_0, C_1 , C_2, C_3 and C_4 of 0, 200, 400, 800, and 1600-m from the Abu-Zaabal phosphate fertilizer factory, samples of soil at D_1, D_2 and D_3, i.e. depths 0-15 cm , 15-30 cm and 30-45cm as well as samples of taro plants (*Colocasia esculenta*) were collected for analysis of Co, Cd, and Pb. Highest Co in soil was at D_2 compared with D_1 or D_3 samples of taro fruit collected from the research zone had heavy metal contents that followed a trend of $C_0>C_4> C_1>C_3>C_2$. The highest Co of 0.208 g kg^{-1} in taro shoots, was found at C_2. A pattern of C2>C0>C3>C1>C4 was given by Co. The greatest Pb content in Taro soil was 258 mg kg^{-1}, with an increase of approximately 71% across a 400 m distance and a depth of 0-15 cm.

Keywords: Taro; heavy metals; soil and water pollution; Co, Cd, and Pb.

Introduction

Heavy metals (HMs) are the naturally occurring metal elements having atomic number > 20 with characteristically high atomic density (4 g/cm^3 or five times than that of H_2O), and may be toxic at very low concentrations **[1,2]**. Their accumulation in soil is regarded as one of the major culprits for degradation of pedosphere. In nature, HMs are present deeply hidden in the earth as a non-degradable constituent of the earth's crust **[3]**. But overexploitation of natural resources has given an easy way to these HMs to rise up to the surface of earth. These are present in soil either innately (volcanic activities, weathering of rocks) or added to it by various anthropogenic activities like metal smelting, overuse of fertilizers and industrial waste etc. **[4]**.

Toxic heavy metals can enter the human food chain in significant amounts of needing great attention. Several anthropogenic sources of heavy metals pollution in sediments, water, and shells have been the focus of extensive researches **[5,6,7]**. According to estimations, the area around the phosphate fertiliser plant in the Abu Zaabal area, which is located 30 kilometres northeast of Cairo, is the biggest source of pollution. This company, which was established in 1957, manufactures calcium diphosphate, sulfuric acid, and phosphate acid **[8]**. Depending on the raw materials had been using, the manufacturing process, and the state of the pollution control equipment, the production of fertiliser has an impact on the environment. **[9].** Since these phosphates are mostly used to make phosphoric acid and fertilizers, the phosphate fertilizer industry is thought to be a possible source of radioactive contamination from natural sources. At the level of the industrial operations, which entail the mining and transportation of phosphate ores and the manufacturing of fertilizers, their radioactivity causes health issues from radiation. Fertilizers have the capacity to transfer to living things at the use level when they are spread into the geo and biospheres. Another possible source of radiation dispersal that might increase the exposure of employees, the general public, and the environment to these radionuclides is leaching of the minerals and wastes **[10].** Due to anthropogenic activities including mining and industrial processing, heavy metals such as lead (Pb), cadmium (Cd), nickel (Ni), cobalt (Co), iron (Fe), zinc (Zn), chromium (Cr), iron (Fe), arsenic (As), and silver (Ag) may be present in the environment .By analyzing the pollution levels and distribution patterns of three heavy metals.

The current study aims to assess the environmental effects of a phosphate fertilizer factory in the Abu Zaabal region (Pb, Cd and Co).

Materials And Methiods

The purpose of the research is to determine the level of pollution in the area around the fertiliser factory owned by the Abu-Zabal Company for Fertilizers and Chemical Industries in Qalyubia Governorate, Egypt's Nile water and arable land (30°16'46"N, 31°23'18"E). Using an auger, soil samples were taken at depths of 0-15, 15-30, and 30-45 cm at locations 0, 200, 400, 800, and 1600 m from the phosphate fertilizer factory. The samples were air dried, crushed, and sieved through a 2-mm sieve before being oven dried at 105°C for 24 hours before being stored for analysis.

According to the techniques given by Carter and Gregorich **[11]**, soil analyses were performed according to **Estefan et al. [12]**, plant samples were collected, oven-dried at 70°C, and then digested with sulphuric acid (H_2SO_4) and hydrogen peroxide solution for examination. Atomic absorption Model Buck 210 was used to measure the heavy metals

Rasults And Discussion

Total Co, Cd and Pb, content in taro soil:

Data (Table 1) indicate that the soil contained Co, Cd, and Pb. Co.

Co: Cobalt ranged from 235 in C_3D_3 to 542 mgkg^{-1} in in C_0D_3 with the latter surpassing the former by

307%. The main effect of distance shows a decrease with distance, particularly within the two upper layers of D_1 and D_2. The effect of depth shows a decrease with depth at each of C_2 and C_3; and an increase with depth at C_4 distance. There was a little change with depth at C_1 distance, and an increase with depth at C_0 distance. The change with distance followed a pattern of decrease.

Cd: Cadmium ranged from 24 $mgkg^{-1}$ in D_1C_3, D_2C_1, or D_3C_4 to 29 in D_3C_3; with the latter surpassing the former by 20.8%. The main effect of distance shows a slight difference with distance. The main effect of depth shows in increase with depth at C_0 as well as at C_4. At $_{C2}$ and C_3 there was a decrease with depth, and at other distances, there was no pattern of change.

Pb: Lead ranged from 151 $mgkg^{-1}$ in D_3C_0 to 270 in D_3C_1; with the latter surpassing the former by 57.9%. The main effect of distance shows an increase with distance up to C_2 then a decrease from then on. The main effect of depth shows in a slight decrease with depth in general.

When evaluating heavy metal contamination, the bioavailable forms are more important than total ones **[13]**. **Nour et al. [14]** found that soil near the Abu-Zabal superphosphate fertilizer factory had the highest contents of Zn (168 mg kg^{-1}), Pb, Mn, and Cu (209 mg kg^{-1}). According to **Lahmesh et al. [15],** workers at the factory had significantly higher blood levels of zinc. Potentially dangerous contaminants may infiltrate the food chain through using the phosphate fertilizers, posing a risk to human health **[16]**. According to **Nour et al. [14]** Abu-Zabal phosphate fertiliser factories, vehicles using lead gasoline, and wastes from drinking water purification facilities have all been blamed for environmental pollution.

Total heavy metals content in taro corms

The taro fruit's Cd content ranged from 0.018g kg^{-1} at C_0 while the highest of 0.0350 was in plants at C_2 space (200 m). The lowest was at $C_{3.}$ Contents at C4 were 0.031 g kg^{-1} (Figure 1). The results show a trend of 400>1600>800>C0>200 with no statistically significant differences between any of the distances. By extending the distance between the sample and the production, Cd rose. The taro fruit had a 0.074 g kg^{-1} Pb concentration, which was measured at a distance of 0 m. The taro fruit's lowest Pb concentration, measured across a 400 m distance, was 0.053 g kg^{-1}. With the exception of 0,200 m, all lengths had non-significant variances in the pattern of 0>1600>800>200>400 m. The taro fruit's highest Co concentration was 0.339g kg^{-1}, measured at a distance of 0 m. The taro fruit's lowest Co concentration, measured across a distance of 800 m, was 0.033g kg^{-1}. The heavy metals concentration (gkg^{-1}) in taro fruit samples that were obtained from the research zone showed a trend of 0>1600>200>400>800 m.

Table (1) Co, Cd and Pb, content (mg kg^{-1}) in the taro soil adjacent to the phosphate fertilizer factory at Abo-Zabal , Egypt. as affected by the distance from factory and soil depth

Depth (cm) (D)	Distance 'm' (C)											
	C_0	C_1	C_2	C_3	C_4	mean	C_0	C_1	C_2	C_3	C_4	mean
	Co						Cd					
D_1	511	536	504	353	343	450	28	25	25	24	27	26
D_2	519	538	500	277	393	445	25	24	25	26	25	25
D_3	542	536	467	235	395	435	25	26	26	29	24	26
Mean	524	537	490	288	377	443	26	25	25	26	25	26
LSD 0.05= S: 0.020 ; D:ns ; SD: 0.034							LSD 0.05= S: ns ; D: ns ; SD:0.002					

Depth (cm) (D)D	Distance 'm' (D)					
	C_0	C_1	C_2	C_3	C_4	mean
	Pb					
D_1	244	163	258	223	207	219
D_2	248	250	224	163	201	217
D_3	151	270	226	267	207	224
Mean	215	228	236	218	205	220
LSD 0.05= S: 0.0144 ; D: ns ; SD: 0.011						

C_0, C_1, C_2, C_3 and C_4 are distances of 0, 200, 400, 800, and 1600-m from the Abu-Zaabal phosphate fertilizer factory. D_1, D_2 and D_3 are depths of 0.30, 30-45 and 45-60cm from soil surface. Critical limits in soil according to Pendias and Pendias **[17]**

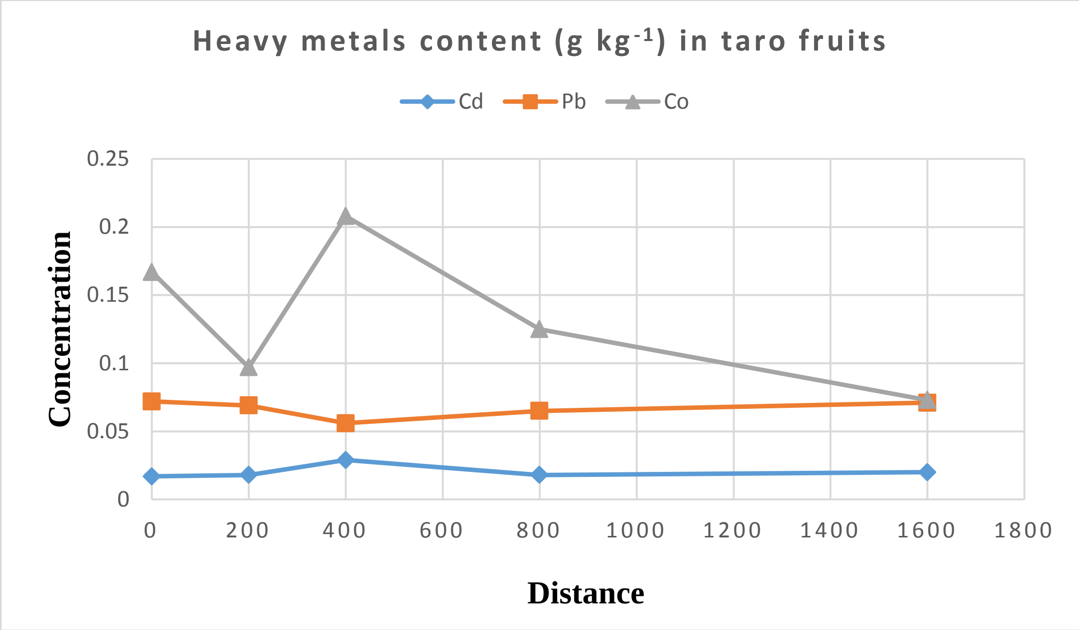

Fig. (2) Heavy metal contents (mg kg^{-1}) in taro shoots as affected by the distance from factory and soil depth C_0, C_1, C_2, C_3 and C_4 are distances of 0, 200, 400, 800, and 1600. Critical limits in soil according to Pendias and Pendias [17]

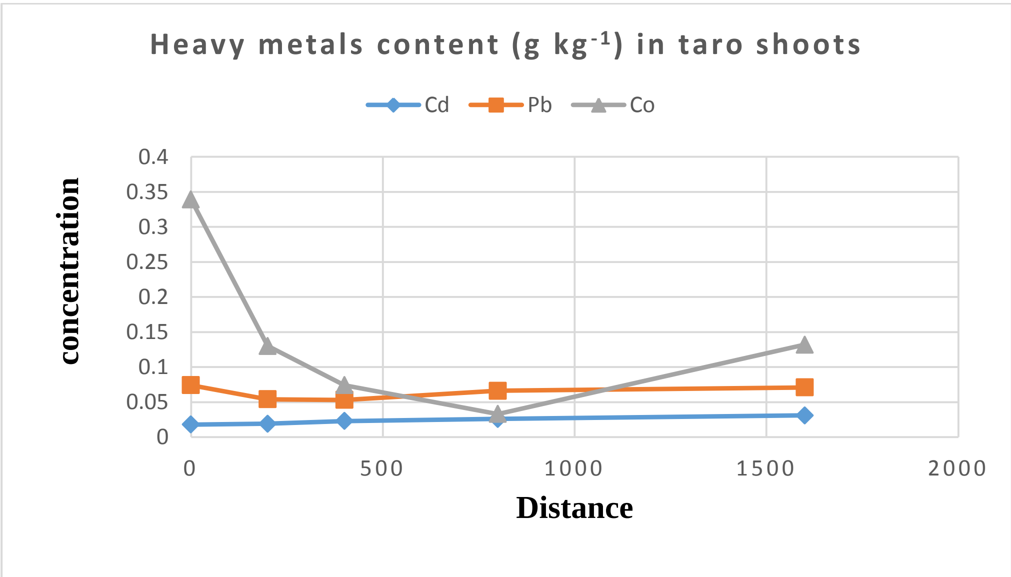

Fig. (3) Heavy metal contents (mg kg^{-1}) in taro shoots as affected by the distance from factory and soil depth. See Fig. 2 footnotes

Total heavy metals content in taro shoots

The lowest Cd content in taro shoots was 0.017g kg^{-1} obtained C_0. The highest was 0.029g kg^{-1} (Figure 2) obtained by distance C_2. The pattern was $C_2>C_1>C_4>C_3>C_0$. The lowest Pb content in taro shoots was 0.056 gkg^{-1} o

btained at C_2. The highest was 0.072g kg^{-1} obtained at C_0.. The pattern was $C_0>C_4>C_1>C_3>C_2$ with little significant differences between them except for C_2 which was highest. The highest Co level the pattern for Co was C2>C_0> $C_3>C_1>C_4$ .With the exception of C_2, all lengths showed significant variances.

According to Gara Luis et al. [18], Cd and Pb are lower than the acceptable European Commission guidelines of (0.1 mg/kg weight for each element. Taro consumption (10.41 g/person/day) helps people get enough of the important metals and trace elements as follows: Mg (1.265% in adult women and 1.084% in adult men) and Cu (1.182% for adult men and women) in their diets. The acceptable weekly intakes for Cd (0.031 g/day) and Pb (0.062 g/day) from taro were not met on average Because of the samples' metal contents and legal permitted intakes, it was determined that they were safe to ingest. Comparing the obtained results mentioned data with those reported by **Pendias and Pendias [17]**, we can conclude that all total heavy metal contents, except for Co, Cd and Pb in the studied sites of phosphate factory location exceeded, the permissible limits and can be considered highly contaminated with Co, Cd and Pb elements. These results force the farmers not to grow economical grain crops e.g. cereals and legumes or edible leafy vegetables or freshly consumed vegetables in such like contaminated soils.

Conclusion

Away from the fertilizer factory, the concentration of heavy metals (cobalt, cadmium, and lead) declined. On the other hand, with soil depth there was some increases. Away from the phosphate fertilizer factory, the taro plant absorb less of these heavy elements, and this drop in absorption is caused by the element's concentration in the soil being lower.

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