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Heavy metals accumulation in soil and uptake by plant species: focusing phytoremediation

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Abstract

An experiment was carried out in the experimental field and laboratory of the Department of Environmental Science, Bangladesh Agricultural University, Mymensingh during the period of November 2016 to May 2017 to assess the quantity and extent of pollution of soils with heavy metals from industrial and municipal waste and to determine the heavy metals accumulating performance of plant species (Helianthus annuus and Amaranthusdubius) from soil. The experiment was laid out in a randomized completed block design (RCBD) for field trials. Three treatments (T_o= Control soil; T_1= Industrial waste incorporated soil; T_2= Municipal waste incorporated soil) were used for this study with three replications. In field experiment, two types of wastes (industrial and municipal) were collected from waste discharging point of Kaderia Textile Mills in Tongi and waste dumping site near to Konabari, Gazipur. Plants were grown according to the experimental design. For analytical experiment, soils of each treatment were analyzed to measure the metal contents. Plant samples were collected from fields and prepared for analysis. The initial contents of heavy metals (Cu, Zn, Pb, Cr) in soils and the heavy metals accumulating performance of sunflower and data were evaluated in this experiment. The results revealed that heavy metals (Cu, Zn, Pb, Cr) contents were 31.64, 76.25, 22.14 and 30.83mg/kg in control soils respectively while municipal waste samples showed of 76.83, 165.43 53.68 and 64.09mg/kg of Cu, Zn, Pb and Cr, respectively. The initial contents of Cu, Zn, Pb and Cr in industrial waste samples were 108.38, 205.53, 101.09 and 79.28mg/kg. This experiment showed that the roots of sunflower accumulated more copper (Cu), zinc (Zn), lead (Pb), and chromium (Cr) than shoots of sunflower from all treatment combinations and the shoots of data accumulated more copper (Cu), zinc (Zn), lead (Pb), and chromium (Cr) than roots of data from all treatment combinations except control soil. Both plants (Helianthus annuus and Amaranthus dubius) showed different strategies of removing heavy metals from soils and sunflower having the greatest ability for removing the most common and toxic heavy metals from soils. It would be an important impact for management of soil pollution, especially for heavy metal pollution.

Keywords: Accumulation of metals, plant uptake, *Helianthus annuus*, *Amaranthus dubius*.

Introduction

Metal pollution is increasing day-by-day as one of the major severe environmental problems. Soil, plants and animal tissues contain metals naturally[1]. The major sources of such metals are agricultural activities like- fertilization, maturing, pesticide application; industrial activities, fossil fuels, municipal wastes, mining wastes, animal wastes etc.[2,3]. Those metals have a great problem as pollutants of soil and water due to their persistency and finally affect plant growth and human health. The Excess toxic metals in the environment are responsible for the significant hazards on plants, animal and human health. The properties of such metals are cytotoxic, mutagenic, and cancer genic effects that are directly cause of negative impacts[4]. Different physiological process like-photosynthesis, respiration, mineral nutrition, membrane structure and function etc. are affected due to presence of heavy metals[5].

The wastes originated from industries and municipalities has influence the metal levels in soil and plants grown in dumping sites which responsible for the threat to the human health[6]. Wastes of industrial areas contain larger amount of metals like- Cr, Cu, Zn and Pb[2,7]. The polluted metals of fields exposed by human being after consumption of such food crops[2,7,8]. Another reports focused on the abilities of crops varied on variety to variety and soil conditions. The accumulation of metals in their different parts of plants and there is a wide variation in metal uptake and translocation between species of plants[2,9]. The transfer of metals like-cadmium, lead, copper, zinc and nickel from soils to vegetables (e.g. spinach, brinjal, tomato and cauliflower etc.) grown in industrially polluted soils[2,10]. The soil and plants on these dumpsites will constitute a serious threat to the health of people living around such areas[6].

Metal pollution of agricultural soil and vegetables is one of the ecological problems worldwide and also in Bangladesh. Some trace elements are essential in plant nutrition, but plants growing in the nearby zone of industrial areas display increased concentration of heavy metals serving in many cases as bio monitors of pollution loads[11].Crops have different abilities to absorb and accumulate metals in their different parts and that there is a wide variation in metal uptake and translocation between plant species although conditions of all things are identical[2,9]. Plants grown on a polluted soil with municipal domestic or industrial wastes can absorb toxic metals in form of mobile ions present in the soil using their roots. The bioaccumulation of metals in the root and shoot is established in different plant species[12].

About 400 plants have been identified as potential species of plants for soil and water remediation from the toxicity of metals. Phytoremediation is one of the ways to manage the excessive metal in soil and our environment become safe. In this study, author aimed to explore the role of *Helianthus* and *Amaranthus* species as removal/accumulation of the toxic metals from soils. This experiment was conducted to investigate also the phytoremediating performance of *Helianthus* and *Amaranthus* species; and to compare the heavy metal accumulating performance between shoots and roots of both studied species from soils.

Materials and methods

The experiment was carried out in the field laboratory and analytical laboratory of the Department of Environmental Science, Bangladesh Agricultural University, Mymensingh during the period of November 2016 to May 2017 to assess heavy metal accumulation in *Helianthus* and *Amaranthus* species.

Experiment site: The experimental trial was located at 24.75^0N latitude and 90.5^0E longitude based on geographical information. The study site is under the old Brahmaputra floodplain of Agro–ecological Zone-9 (AEZ–9) based on Bangladesh soil zones. The soil type of the study area is non-calcareous dark gray plain soil[13].

Experimental design and layout: The randomized completed block design (RCBD) was followed for the field experiment where the length and width of each plot was 2m and 2m respectively. The inter-plot distance was 0.50m. Two plant species were used as test plants for this study. Three replications were maintained for each treatment.

Collection of wastes sample: Municipal waste was collected from the unplanned dumping site near to *Konabari, Gazipur*. Industrial waste was collected from waste discharging point of *Kaderia* Textile Mills in *Tongi, Gazipur*.

Treatments: Two varieties such as- V_1(BARI-Sunflower) and V_2(BARI-Data) were planted in the study plots. Different waste materials were collected and incorporated with soil where plants grown. Undesired materials were removed from the collected wastes before mixing. There were 3 treatments, like- T_o= control soil, T_1= soil mixed with industrial waste, T_2= soil mixed with municipal waste.

Cultivation procedure: Land preparation, manuring and wastes sample mixing: Initially the experimental field was ploughed 5 times and laddering properly to prepare well pulverized field. Decomposed cow dung was mixed into the ploughed field. Recommended dose of fertilizers was applied in the experimental field. In case of sunflower, full dose of FYM, TSP, MOP and Gypsum along with 50% Urea were applied during final land preparation and the rest 25% Urea was applied at button stage and 25% Urea at flowering stage. In case of data, full dose of FYM, TSP and 50% each of Urea and MOP were applied as basal dose during final land preparation. Rest 50% of Urea and MOP were top dressed 15 days after sowing. The control and mixed waste soils were followed based on design of the experiment. Soils of six plots were incorporated with municipal waste and the soils of another six plots were incorporated with industrial waste. Total 15kg wastes (prepared and cleaned) were incorporated in soils of each plot properly. Rest of the six plots were marked as control where nomixing of waste materials.

Seed collection and sowing: Seeds of BARI-Sunflower 2 and BARI-Data 2 were collected from the Horticulture division of Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur, Bangladesh. Seeds of BARI-Sunflower 2 and BARI -Data 2 were sown in the experimental plots in 8th November 2016 at the spacing of 60cm x 30cm for BARI-Sunflower 2 and 50cm x 30cm for BARI -Data 2.

Intercultural operation: After sowing of seeds, the following intercultural operations (irrigation, weeding & thinning, plant protection technique) were accomplished for better growth and development of the plants.

Harvesting of tested plant parts: After getting maturity, different plant parts (healthy and fresh) were harvested accordingly. Collected parts (Shoot and Root) were kept separately for further analytical activities.

Sample preparation for analysis: Samples (soils and plant parts) were kept in polybags with proper tags and then transferred to the laboratory. Collected samples were dried in air in room temperature for three days. Oven drying was followed after air drying where temperature was maintained at 80°C for 7 days. Then grinding of dried samples was done by mortar and pestles. Then obtained powder samples were preserved in paper-packet for metal assessment in analytical laboratory through AAS (Atomic Absorption Spectrophotometer).

Sample analysis: Heavy metal content in shoots and roots of sunflower and data plants were analyzed followed by proper digestion method. Analyses were conducted at the analytical laboratory under the Soil Science Division, Bangladesh Institute of Nuclear Agricultural (BINA), Mymensingh.

Preparation of waste sample for analysis: Undesired materials in collected waste samples were removed properly. Grinding and sieving were done just after air drying of the waste samples. Final sieved samples were kept in bag for metal assessment.

Identification and quantification of heavy metal in wastes and soils: Metals (Cu, Zn, Pb, Cr) were identified and quantified from the collected waste mixed soil samples in the laboratory. About 1gm of grinded and sieved sample was digested with HNO_3: HCl (1:3). Evaporation and drying were followed by addition of 5mL acid solution. Repeatedly extraction was done 2–3 times. Then filtration of the digest was done and the final digested volume was made 25mL with HNO_3. Atomic Absorption Spectrophotometer (AAS) (PG990, England) was used to analyze the metals. Each metal was identified and quantified using Mono element Hollow Cathode lamp. A standard calibration curve was prepared by plotting the absorbance reading on Y–axis versus the concentration of each standard solution of metal on X–axis. Finally the quantity of metals was calculated by plotting the AAS reading on the standard curve.

Data collection and analysis: The data were statistically analyzed according to the objectives of the study. Variations among the treatments were observed. The mean of all data were compared by using Tukey's Test at 1% level of probability.

Results and discussion

Initial heavy metal contents of different soil samples: Copper (Cu): The contents of Cu in control soil samples illustrated in Table-1. The acquired data show that waste originated from industry has the highest amount of copper (108.38mg/kg) and the control soil have the lowest amount (31.64mg/kg) (Table-1). The Cu content in industrial waste mixed soil showed significantly larger than other soil samples. The Cu content in soil samples after harvesting sunflower where the lowest and highest concentration of Cu were found in control soil (19.26mg/kg) and industrial waste mixed soil (40.25 mg/kg) respectively (Table-2). In soil after harvesting of *Amaranthus* plant and the lowest and highest concentration of Cu were obtained in control soil (16.53mg/kg) and industrial waste mixed soil (56.75mg/kg) respectively (Table-3). From the Table-2 and 3 it shows that the concentration of Cu was reduced in all types of soil due to the accumulation of such metal by both tested plant species. The industrial waste has elevated amount of Cu (67.65mg/kg) than municipal waste[2]. The mean concentration of Cu was 195.2mg/kg in the textile sludge[14]. Another report focused *t*hat the textile sludge contained 14.983 ppm Cu[15].

Zinc (Zn): Analytical results illustrated that the industrial waste mixed soil contained the higher amount of Zn (205.53mg/kg) than the control soil (76.25mg/kg) (Table-1). After harvesting of sunflower plants the lowest and highest concentration of Zn were obtained in control soil (18.19mg/kg) and industrial waste mixed soil (107.24mg/kg) respectively (Table-2). In Table-3 showed the contents of zinc in soil after harvesting of *Amaranthus* where the lowest and highest concentration of Zn were obtained in control soil (29.06mg/kg) and industrial waste mixed soil (123.13mg/kg) respectively. From the results of Table-2 and 3, it shows that the Zn was reduced in all types of soil due to the accumulation of heavy metal by *Helianthus* and *Amaranthus* species. The significant variation of Zn content in soil samples were noted after harvesting of cultivated plant species. Similar significant accumulation of Zn from soil samples were noted[2]. Another research group detected the ranges of Zn in soil of different distance was 127–177ppm[16]. The soils of former incineration sites had the highest concentrations of zinc with mean values of 3690mg/kg[17].

Lead (Pb): Pb contents in different soil samples showed significant variations where industrial waste mixed soil has more metal than municipal waste mixed soil and control soil (Table-1). The obtained result shows that industrial waste mixed soil contained the highest amount of Pb (101.09mg/kg) but the control soil has the lowest amount of Pb 22.14mg/kg. The similar significant results showed inanother research report[2]. Previous research reports on the Pb in soil was 28mg/kg where another group noted that the detected Pb ranges in soil of different distance was 19-24ppm[14,16]. Another report also detected Pb from soils of various land use practice from BAU farms, Bhaluka (forest land), Boira farmer's field of Mymensingh district, Board *Bazar* industrial site of *Gazipur* was 21.48–34.00mg/kg[18]. Table-2 and 3 indicate the contents of Pb in soil after harvesting of studied plants. There are significant variations of Pb content in soil samples observed after cultivation of both plant species.

Chromium (Cr): The initial content of chromium in control soil and waste mixed soils illustrated in Table-1. Similarly significant variation was found between waste mixed soil and control soil. Such results also found by previous research group[2]. The mean concentration of Cr in soil samples was 29.21 µg/g[19]. But in the study soil samples of waste mixed showed three times higher than previous report, due to variation of metal contained in different wastes. Table-2 and 3 indicates the Cr content in soil decreases after harvesting of plants; this means the cultivated plants may uptake the rest amount of metals from soil. From the results it shows that the concentration of Cr was reduced in all types of soil due to the accumulation of heavy metal (Cr) by both plants.

Table-1: Initial heavy metals contents in different soil samples.

Sample items	Metal contents (mg/kg)*			
	Cu	Zn	Pb	Cr
Control soil	31.64c	76.25c	22.14c	30.83c
Municipal waste mixed soil	76.83b	165.43b	53.68b	64.09b
Industrial waste mixed soil	108.38a	205.53a	101.09a	79.28a

Table-2: Heavy metals (Cu, Zn, Pb, Cr) contents in different soils after harvesting of plants (sunflower) grown.

Types of soil	Cu (mg/kg)	Zn (mg/kg)	Pb (mg/kg)	Cr (mg/kg)
Control soil	19.26c	18.19c	10.27c	13.25c
Municipal waste mixed soil	42.23b	83.22b	18.28b	22.43b
Industrial waste mixed soil	40.25a	107.24a	55.28a	31.27a

Table-3: Heavy metals (Cu, Zn, Pb, Cr) contents in different soils after harvesting of plants (data) grown.

Types of soil	Cu (mg/kg)	Zn (mg/kg)	Pb (mg/kg)	Cr (mg/kg)
Control soil	16.53c	29.06c	9.43c	8.47c
Municipal waste mixed soil	15.23b	105.03b	21.24b	25.14b
Industrial waste mixed soil	56.75a	123.13a	62.52a	37.56a

*Letters indicate levels of significant at 1% probability.

Metal accumulation by *Helianthus annuus:* Copper (Cu): Accumulation of Cu was significantly influenced by both shoots and roots of sunflower in various types of soil. The highest amount of Cu was accumulated from industrial waste mixed soil by sunflower roots (45.32mg/kg) and the lowest amount of Cu accumulation was found in control soil by shoots of sunflower (5.34mg/kg) (Figure-1). Comparing both waste mixed soils, the pattern of Cu accumulation by roots is higher than shoots which is significantly different. The uptake of Cu in roots and shoots of sunflower plant was 24.21mg/kg and 12.05mg/kg respectively[20]. In brinajl fruits, Cu accumulation was 11.74 mg/kg[2]. Comparatively Cu accumulation in root was higher than accumulation of other plant parts based on previous reports. From the result, it shows that the roots of sunflower accumulated more Cu than shoots of sunflower from all treatment combinations because roots of sunflower has the highest heavy metal accumulating performance from soil than shoots of sunflower.

Zinc (Zn): The highest amount of Zn was accumulated from industrial waste mixed soil by sunflower roots (58.58mg/kg) and the lowest zinc (Zn) accumulation was found in control soil by shoot of sunflower (24.59). Accumulation of Zn was significantly influenced by the interaction of sunflower parts (shoots and roots) with various types of soil (Figure-2). The uptake of Zn from soils in the shoots of sunflower was found 1889µg/gm at lower doses (5ppm); whereas uptake increased upto 15,940µg/gm at higher level exposures of heavy metal (50 ppm)[21]. The concentration of Zn was found 2.1 times more in roots than shoots at the higher exposure concentration, i.e. 50ppm[21]. But in this study Zn accumulation was not twice by roots than shoots due to availability of metals and environmental conditions. From the results it shows that the roots of sunflower accumulated more zinc (Zn) than shoots of sunflower from all treatment combinations because roots of sunflower has the highest heavy metal accumulating performance in soil than shoots of sunflower. On the other hand the quantity of accumulation of the *H. annus* differed from the previous results, especially for Zn accumulation due to less availability of such metal or cause of other factors during growing the tested plant species.

Lead (Pb): The roots of sunflower accumulated more Pb than shoots of sunflower from all treatments because roots of sunflower have the highest heavy metal accumulating performance. Accumulation of Pb was significantly influenced by the interaction of shoots and roots in various types of soil. The lowest lead (Pb) accumulation was observed in control soil by shoots of sunflower (6.81) where as the highest amount of lead (Pb) was accumulated from municipal waste mixed soil by roots (32.03mg/kg) and (Figure-3). Cu and Zn accumulation reported higher from industrial waste mixed soil but in case of Pb the accumulation was higher in municipal waste mixed soils. The variation occurred between waste samples due to Pb contents or availability of Pb. The accumulation of Pb was recorded highest in roots of sunflower plant followed by shoots[22].He also reported that the bioaccumulation of Pb in roots of sunflower was increased upto 32,473µg/gm whereas uptake in shoots of sunflower was found 16,22µg/gm at higher metal concentration (50ppm).It was also noted that the accumulation of Pb was found more in roots followed by shoots of *H. annuus*[22].

Chromium (Cr): Accumulation of Cr was significantly influenced by the interaction of sunflower parts (shoots and roots) in various soil types. The highest amount of Cr was accumulated from municipal waste mixed soil by sunflower roots (29.31mg/kg) and the lowest Cr accumulation was observed in control soil by shoots of sunflower (10.27) (Figure-4). A similar finding with the present study was also reported bya research group where the accumulation of Cr was highest in roots of sunflower plant followed by shoots in sunflower plants[22]. The accumulation of Cr in roots of sunflower was increased up to 35,600µg/gm whereas the uptake in shoots of sunflower was found 8,194µg/gm at higher metal concentration (50ppm). He also reported that the accumulations of Cr were found more in roots followed by shoots of *H. annuus.* But the amount of accumulation was far differed from the previous reports. It may cause of availability of such metal in soil and waste samples or any other unknown causes.

Metal accumulation by *Amaranthus dubius:* Copper (Cu): The highest amount of Cu was accumulated from industrial waste mixed soil by shoots of *A. dubius* (30.20mg/kg) and the lowest accumulation reported in control soil by roots (9.34) (Figur-5). For contrasting among roots and shoots of *A. dubius*, the trend of accumulation is always higher in shoot than root (Figure-5). More Cu accumulation occurred from industrial waste mixed soil than municipal waste due to the availability of such metal. The uptake of Cu from soils by *A. dubius* was 41.07 mg/kg and the high concentrations of Cu accumulated by *A. dubius* (150mg/l)[10,23]. This variation of Cu accumulation depends on the status of soil grown. Cadmium, mercury, zinc and copper from soil uptake by *Amaranthus tricolor* and *Amaranthus retroflexus*[24,25]. *Helianthus annuus* (sunflower) and *Amaranthus hybridus* (data) have the ability to bioaccumulate heavy metals (Pb, Cu, Cd, Zn) to a great extent[26].

Zinc (Zn): Accumulation of zinc influenced by plant parts and sources of soil where grown of plant (*A. dubius*). Due to the availability of Zn content in soils the accumulation was also varied which significantly different. The highest amount of Zn was accumulated from industrial waste mixed soil by *A. dubius* shoots was 45.23mg/kg and the lowest Zn accumulation was in control soil by shoots of *A. dubius* (24.32) (Figure-6). The highest uptake of Zn in Brijal was 20.59mg/kg reported [2]. The highest Zn accumulation was found in *Lalsak* (400mg/kg) at Demra-2 near Jahir Steel Mills Ltd., and (390mg/kg) at Keranigonj[27]. The amount of accumulation of Zn was higher than the present study due to variation of soil. Zn concentrations in Lalsak ranged from 120 to 1684mg/kg[10]. The accumulation ability of *A. tricolor* of Zn was 10-15g/kg DW[28]. Ca and Zn were found in both roots and shoots of data plant although the shoots had higher concentrations of Zn[29]. *A. tricolor* and *A.retroflexus* were used for the uptake of cadmium, mercury, zinc and copper from soil[25]. The shoots of *A. dubius* accumulated more Zn than roots from all treatments and waste mixed soils due to their higher accumulating performance.

Lead (Pb): Accumulation of lead was significantly influenced by the interaction of plant parts (shoot and root) of *A. dubius*. In different waste mixed soils Pb accumulation always showed higher in shoot than root. The highest amount of Pb was accumulated from industrial waste mixed soil by *A. dubius* shoots was 22.52mg/kg and the lowest was observed in control soil by shoots was 9.21mg/kg (Figure-7). The highest Pb content in fruits of Brinjal was 0.363 mg/kg when grown in soil mixed with industrial waste[2]. The concentration of Pb in the roots and shoots of data were 53 ± 10 and 27 ± 1mg/kg and the concentration of Pb in the leaves of *A. dubius* was 9 ± 1mg/kg in the concentration (100ppm) in soil[30]. Such variation occurred due to species variation and capability differences of accumulation as well as growth conditions. Results showed that the shoots of *A. dubius* accumulated more Pb than roots from all treatments except control soil where roots accumulated more Pb than shoots.

Chromium (Cr): Chromium accumulation found in shoot of *A. dubius* than roots. The significant variation observed among different waste mixed soils, but in one case root and shoot accumulation of *A. dubius* noted statically similar for Cr accumulation (Figure-8). The heavy metals such as Cr concentration in *Amaranthus* ranged from 20.4 to 31.0mg/kg which was almost identical with present study[31]. The concentration of Cr in the roots and shoots of *Amaranthus* was 308 ± 117mg/kg and the concentration of Cr in the leaves of data was 63 ± 2mg/kg in the concentration (100ppm) in soil[30]. This variation was found due to availability of metal contents in soil and other conditions**.** The Cr content in *Amaranthus* ranged from 26.4 to 37.90mg/kg which is almost similar result of present study[32]. From the Figure-8 it indicated that the shoots of *A. dubius* accumulated more Cr than roots from all treatment combinations.

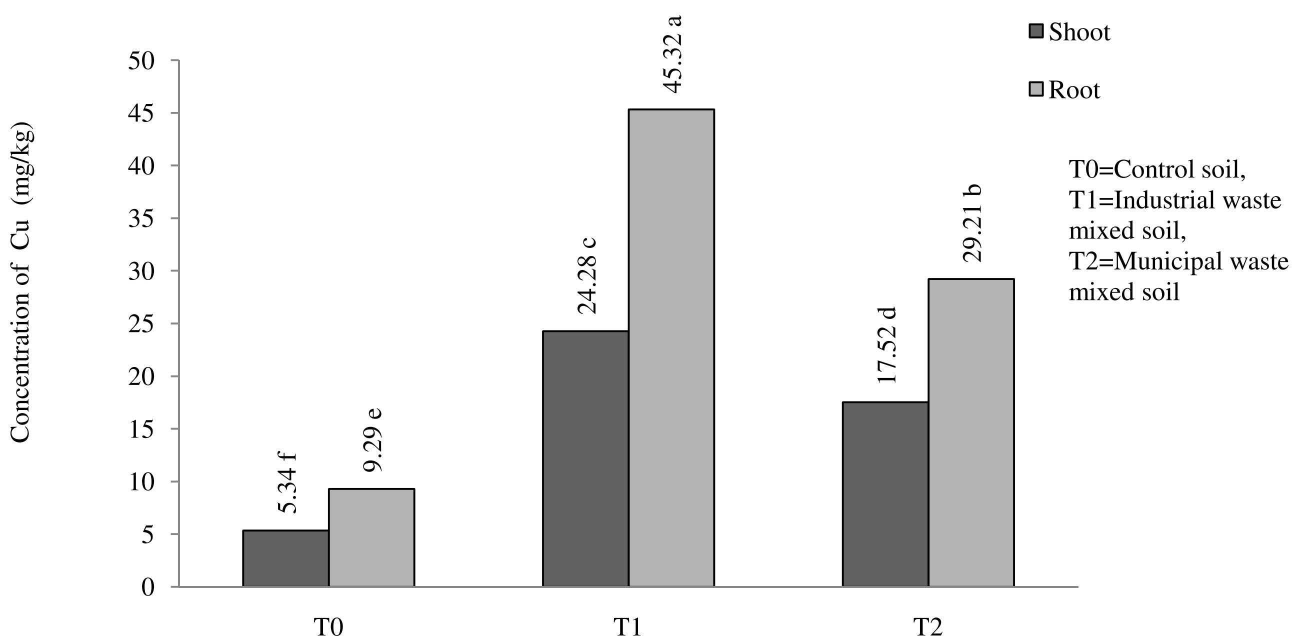

Figure-1: The concentration of Cu in plant parts of Sunflower grown in different soils.

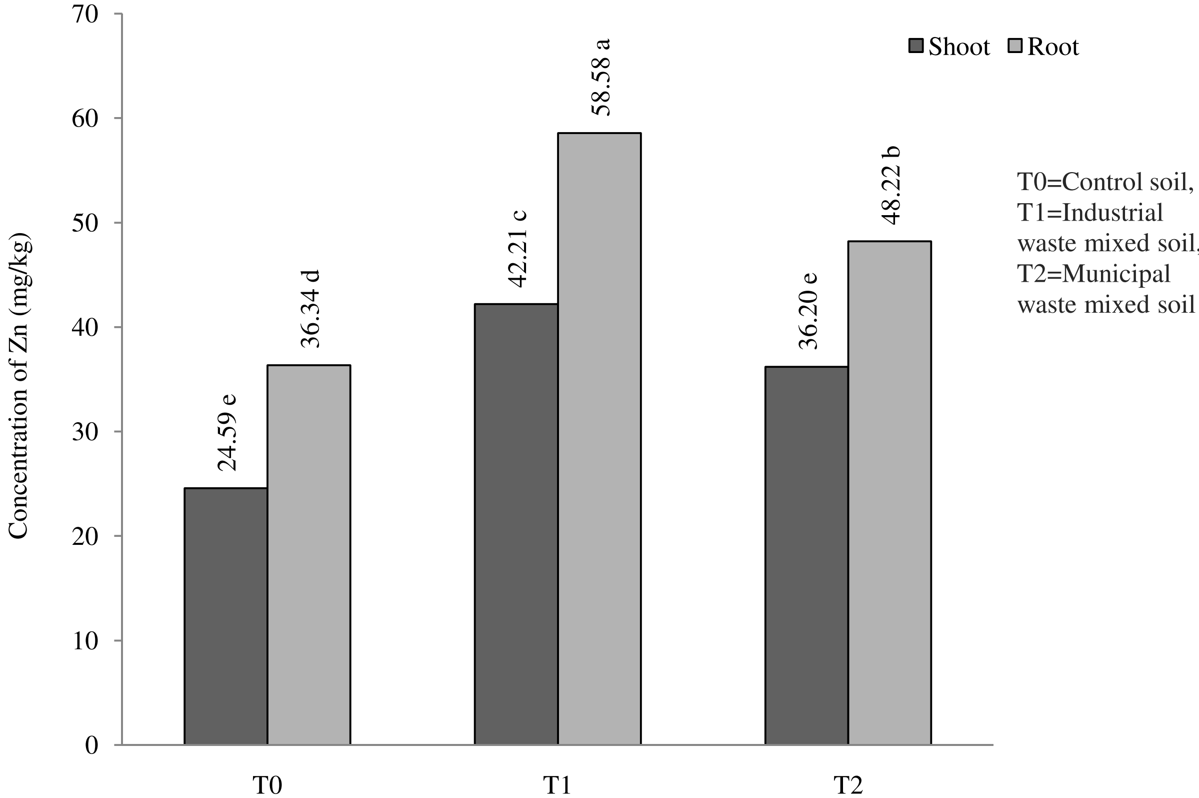

Figure-2: The Zn contents in plant parts of Sunflower grown in different soils.

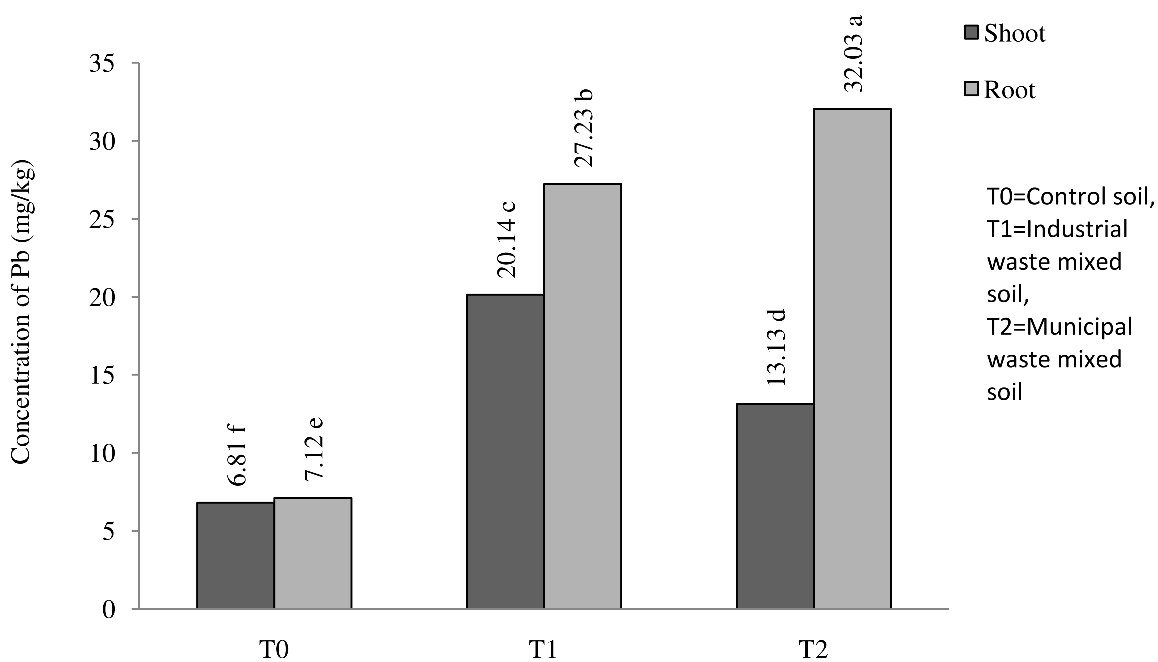

Figure-3: The concentration of Pb in shoots and roots of Sunflower grown in different soils.

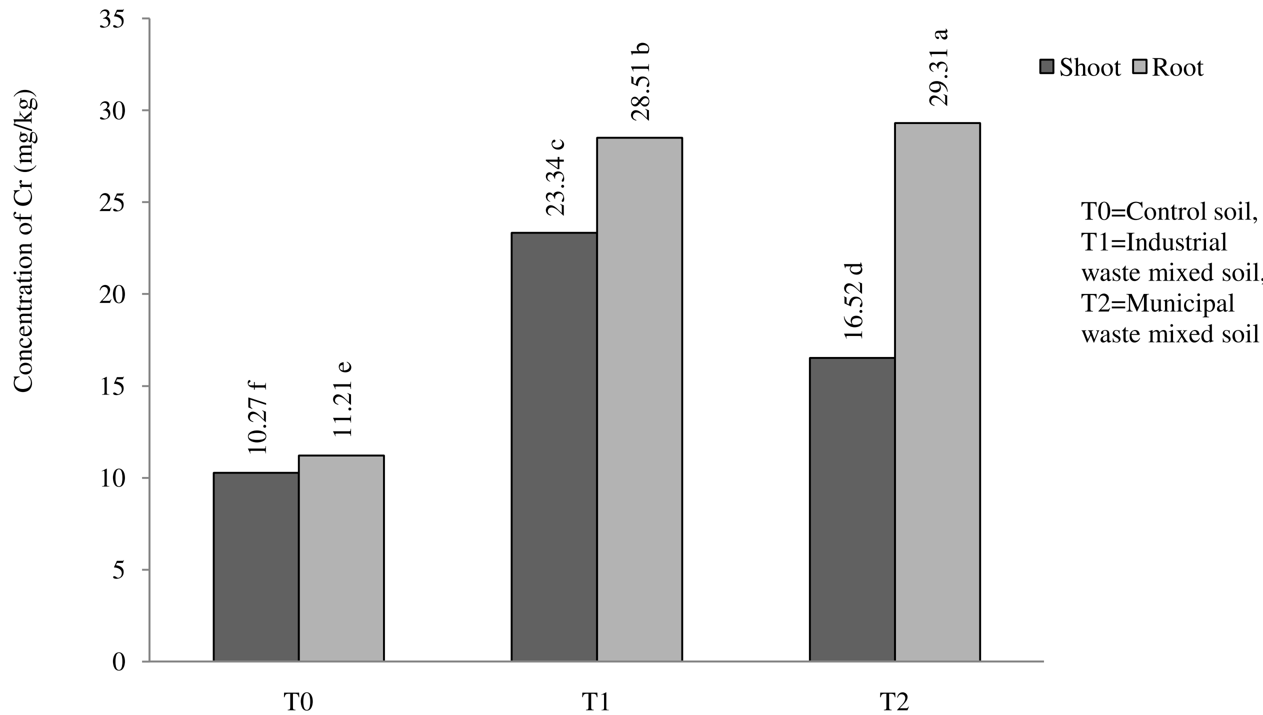

Figure-4: The concentration of Cr in different plant parts of Sunflower grown in different soils.

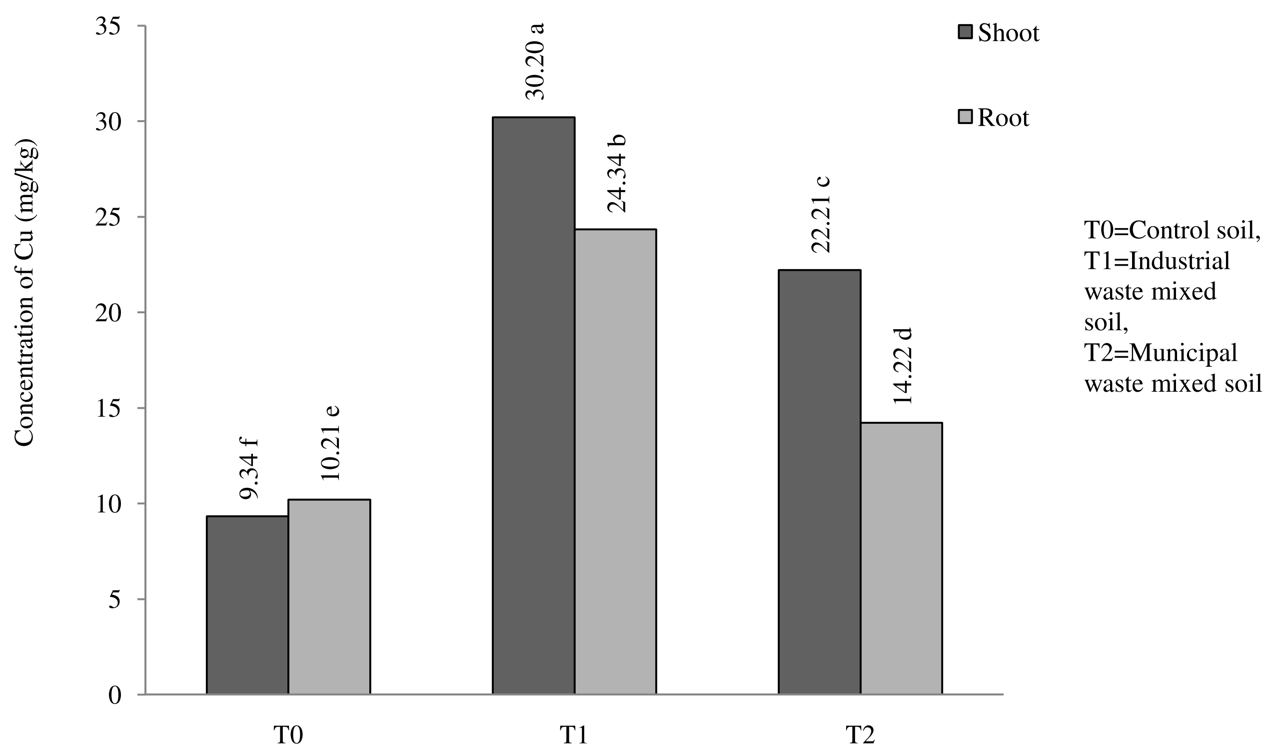

Figure-5: The Cu contents in different plant parts of *Amaranthus annus* grown in different soils.

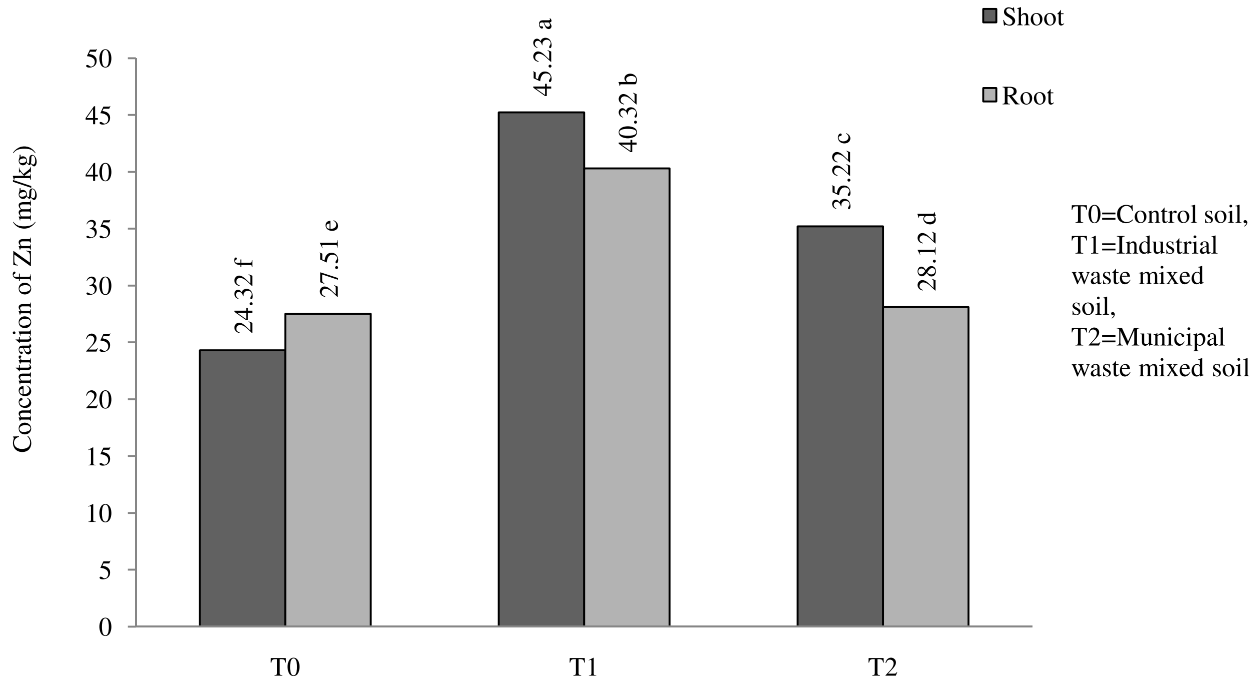

Figure-6: The Zn contents in plant parts of *Amaranthus annus* grown in different soils.

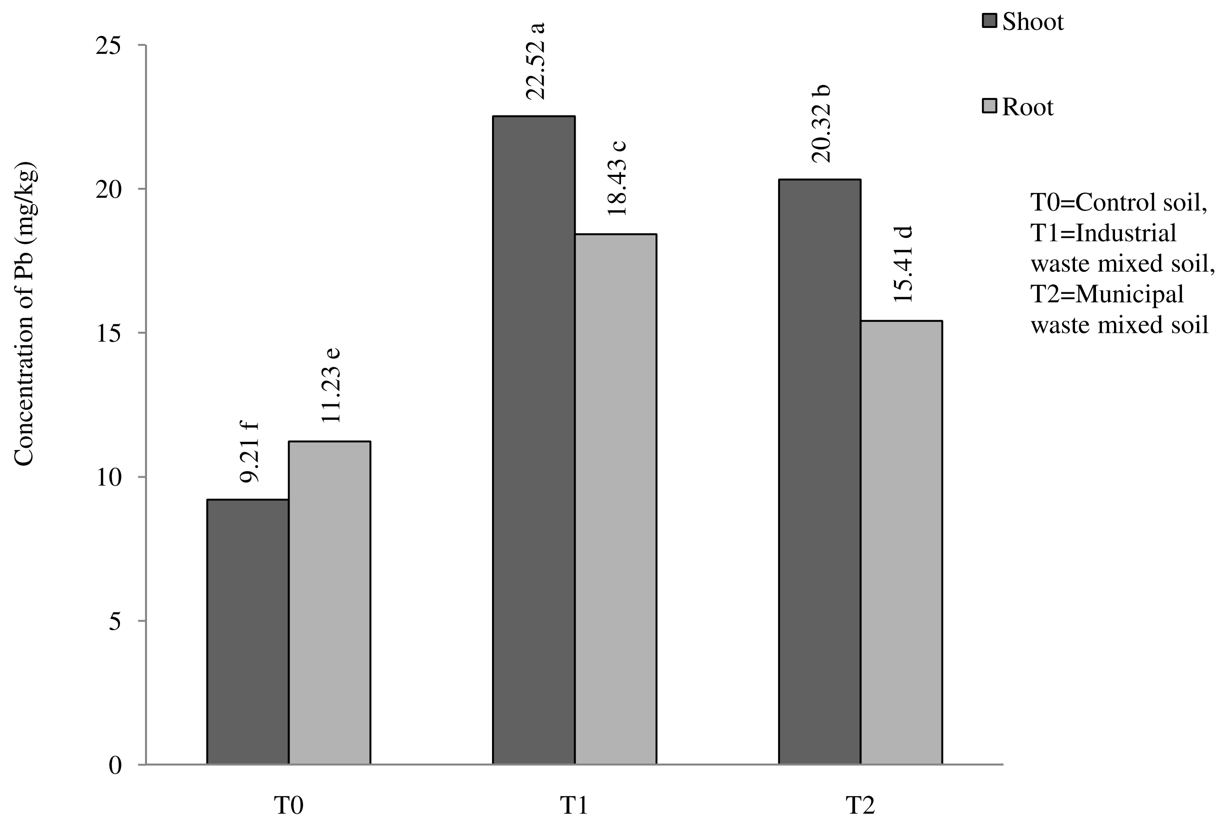

Figure-7: The Pb contents in plant parts of *Amaranthus annus* grown in different soils.

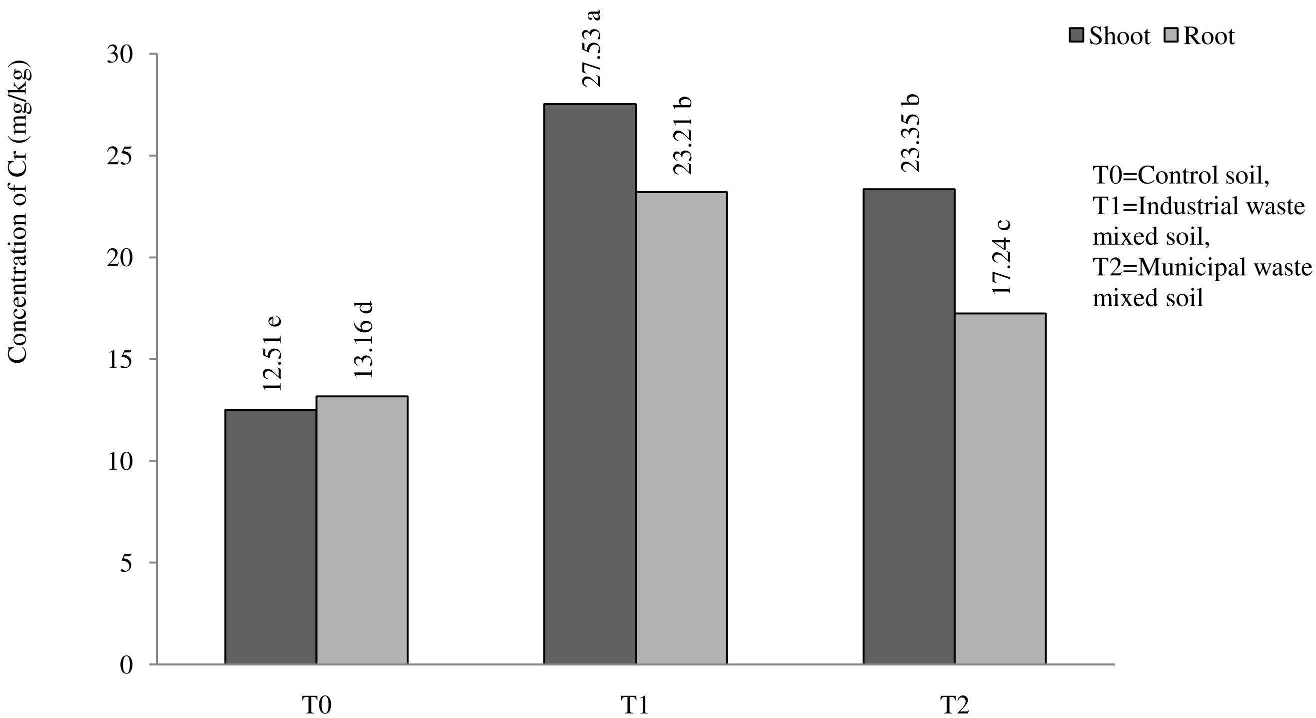

Figure-8: The concentration of Cr in plant parts of *Amaranthus dubius* grown in different soils.

Interaction of metal accumulation between plant species and treatments: Copper (Cu): Accumulation of Cu was significantly influenced by the interaction of plant species grown with various types of soil. The highest amount of Cu was accumulated from industrial waste mixed soil by sunflower (69.60mg/kg) and the lowest Cu accumulation was found in control soil by sunflower (14.63) whereas the highest amount of Cu was accumulated from industrial waste mixed soil by data (54.54mg/kg) and the lowest Cu accumulation was found in control soil by data (19.55) (Figure-9). Results indicate the both plant species can effectively removed Cu contents from soils. Sunflower (*H. annuus*) effectively removed the toxic metals like Cu, Pb, Cr, Ni, Pb and Zn from soils[33]. The uptake of Cu from soils by sunflower plant was 48 to 72mg/kg whereas the uptake of Cu from soils by *A. dubius* ranged from 32 to 61mg/kg[10,20]. From the results, it might be say that phytoremediation of *H. annus* has more capability than *A. dubius.*

Zinc (Zn): The highest amount of Zn was accumulated from industrial waste mixed soil by *H. annus* than *A. dubius.* A similar situation was observed in case of Zn accumulation from industrial waste mixed soil than other soils. Sunflower plant showed significantly higher accumulating performance than other studied plant species (Figure-9). The uptake of heavy metals Zn from soils by data plant was 90mg/kg at Keranigonj[27]. Whereas the uptake of heavy metals zinc (Zn) from soils by sunflower ranged from 96 to 120mg/kg[20]. Accumulation of Zinc (Zn) was significantly influenced by the interaction of plants with various types of soil.

Lead (Pb): Mean Pb contents in Sunflower plant species was little bit higher than *A. dubius* based on accumulation performance. Although the statistically significant variation was observed between two test plant species. Accumulation of Pb for both plant species were shown similar but grown in different wastes mixed soils because of their availability of such metals in samples. It was significantly influenced by the interaction of plants with various types of soil.

The highest amount of Pb was accumulated from industrial waste mixed soil by sunflower (47.37mg/kg) and the lowest Pb accumulation was observed in control soil by sunflower (13.93) whereas the highest amount of Pb was accumulated from industrial waste mixed soil by *A. dubius* (40.95mg/kg) and the lowest Pb accumulation was observed in control soil by *A. Dubius* (20.44mg/kg) (Figure-9). The uptake of heavy metals from soils by *A. dubius* was 2.2 to 12mg/kg[10]. Whereas the average lead uptake was similar in both sunflower and Indian mustard with a value of 1000mg/kg in the sunflower and 856 mg/kg (dry weight)[34]. The average lead uptake was often similar in both sunflower and *A. dubius* with a value of 1000mg/kg in the sunflower and 856mg/kg (dry weight) in *A. dubius*[34]. Sunflower, Indian mustard, tobacco, rye, spinach, data and corn have the ability to remove Pb from effluent and sunflower having the greatest ability[34]. But the present study showed significant different among the tested plant species due to variability of soils grown and environmental conditions.

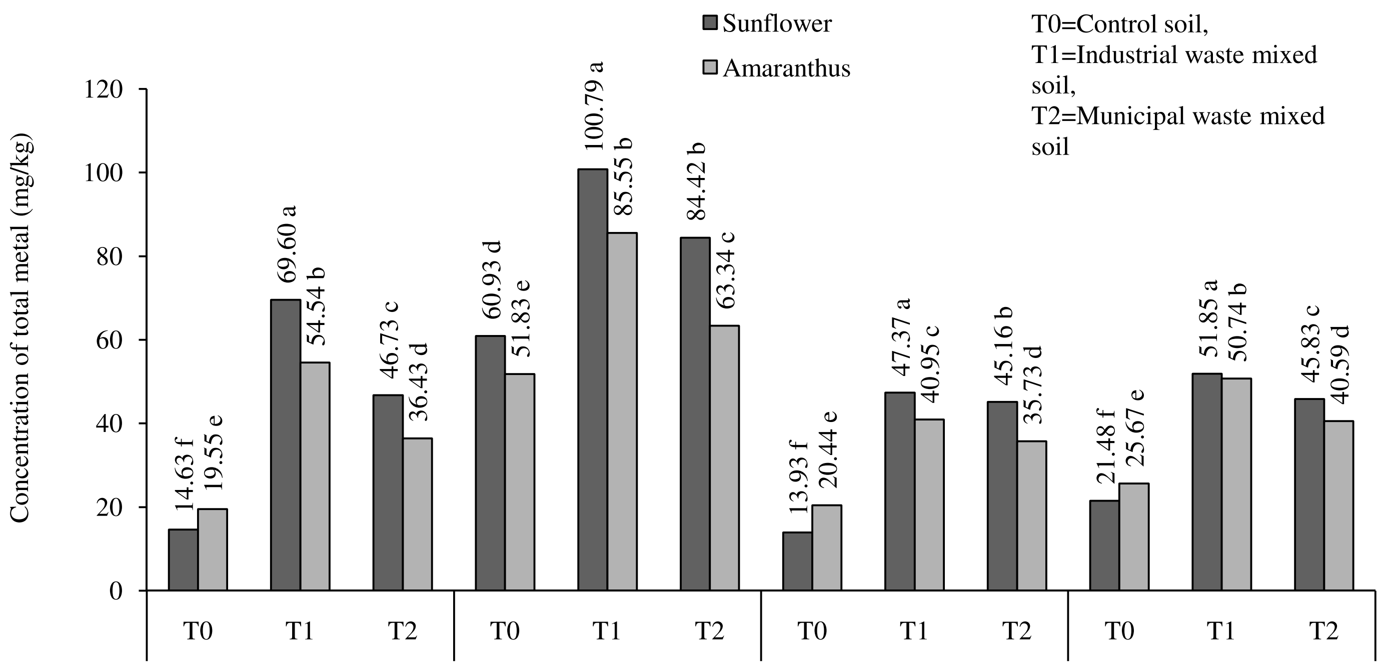

Figure-9: Comparison of metals (Cu, Zn, Pb, Cr) accumulation through *Helianthus annus* and *Amaranthus dubius* grown in different soils.

Chromium (Cr): Accumulation of Cr was significantly influenced by the interaction of plants with various types of soil and waste mixed soils. The highest amount of Cr was recorded from industrial waste mixed soil by sunflower (51.85mg/kg) and the lowest Cr accumulation was found in control soil by sunflower (21.48) where as the highest amount of chromium (Cr) was accumulated from industrial waste mixed soil by data (50.74mg/kg) and the lowest Cr accumulation was found in control soil by data (25.31mg/kg) (Figure-9). The both tested plant species showed higher accumulative performance in industrial waste mixed soils, since the Cr availability was higher in such waste. The uptake of Cr from soils by data plant was 20.4 to 31.0mg/kg[31]. Whereas the average uptake of chromium from soils by sunflower plant was 46 to 84mg/kg[34]. Present study showed that the sunflower accumulated more chromium than data from all treatment combinations except control soil where data accumulated more chromium than sunflower.

Conclusion

This study was designed to determine the accumulation efficiency of heavy metals from soil using *Helianthus annus* and *Amaranthus dubius* from different wastes mixed soil. The assessments on accumulation of Cu, Zn, Pb and Cr in both plant species were studied. The initial contents of heavy metals (Cu, Zn, Pb, Cr) and final contents of such metals were measured in different soil conditions. The initial Cu, Zn, Pb and Cr contents of industrial waste mixed soil samples were recorded as 108.38, 205.53, 101.09 and 79.28mg/kg respectively. In case of the plant parts, the roots of sunflower accumulated more Cu, Zn, Pb and Cr than shoots of sunflower from all treatment combinations and the shoots of *Amaranthus* species accumulated more Cu, Zn, Pb and Cr than roots from all treatment combinations except control soil. In case of the effect of treatments in respect of soil types, roots of sunflower accumulated the highest content of Cu, Zn, Pb and Cr from industrial waste mixed soil (45.32, 58.58, 27.23 and 28.51mg/kg, respectively) compared with other treatments of the study while the shoots of sunflower accumulated.

Food chain contamination by heavy metals has become a critical issue in recent years because of their potential accumulation in biosystems through contaminated water, soil and irrigation water. To clean up the heavy metals contaminated soil using plant species (*Helianthus* and *Amaranthus*) and to investigate and compare the phytoremediating performance the present study was conducted. From the above summary of the obtained results it may be concluded that the both plant species showed significant strategies of removing heavy metals from soil. It is hopeful that the studied plant species cleaned up the soils contaminated with various heavy metals to save our environment. The remediation of polluted agricultural lands is just one, but an absolutely necessary prerequisite for the sustainable development of agricultural production. Phytoremediation is considered to be an innovative technology. Thus the use of *Helianthus* and *Amaranthus* are recommended for phytoremediation of soil polluted with heavy metals and research related to this technology needs to be promoted, emphasized and expanded in developing countries like Bangladesh.

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