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The Effects of compost and Effective Microorganism on taking up tending of heaving metals by Vegetables

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Abstract

The impacts of compost and Effective Microorganism in heavy metal availability in different vegetables grown in Addis Ababa small scale irrigation farm with polluted Akaki River has been studied by AAEPA during the previous years. In this study two different types of vegetables (one leaf and one root vegetable) which are Swiss chard and beet root samples were brought from three sites (great Akaki ,little Akaki and control site).In the field, the whole parts were taken and brought to the laboratory. In the Addis Ababa Environmental protection Authority (AAEPA) laboratory, all parts of plant leaf and root were analyzed to know the concentration of heavy metals (As, Cr, Hg, Fe, Pb, Zn, Cd,) Soil samples 34 subsamples (based on the acreage of the farm) from 0-30cm depth were taken for the analysis of texture, PH, CEC, OM, exchange base, EC_{H2O} and heavy metal concentration As, Cd, Hg, pb, Cu, Zn, Fe , two replication of soil sample were taken & six sample of irrigation water at each site were taken to analyzed waste water parameters PH, Temperature, DO, EC, BOD_5, TDS, T-N, T-P, fecal and total coliform and heavy metals. Parts of plant analysis showed that the concentration of heavy metal accumulation capacities of root and leaf are vary due to the existence of compost, effective microorganism, river water and using clean water .Even The types of plant species can affect the availability of heavy metals in the soil taken by plants.

Keywords: Beet root, Swiss chards, soil physicochemical parameter, remediation, heavy metals

Introduction

Industry, mining and agricultural activities have lead to large scale contamination of the environment with toxic heavy metals. Several treatments are available for metal remediation, but most are expensive to apply and lack specificity. The toxic heavy metals entering the ecosystem may lead to geoaccumulation, bioaccumulation and biomagnifications. Heavy metals like Fe, Cu, Zn, Ni, Pb, As, Hg and other trace elements are important for proper functioning of biological systems and their deficiency or excess could lead to a number of disorders(Evanko, 1997). The release of these metals results in the increase a heavy metal availability, which will additionally increase the risk of heavy metals leeching into the water system. Organic soil amendments can ameliorate metal toxicity to plants by redistributing metals to less available fractions. Phosphates such as apatite amendments have been successfully used to lower the bio availability and increase the geochemical stability of metal contaminated soil (Sneddon, 2002). Compost amendments are also used as viable soil amendment within these processes. Compost and other amendments can be used as a vital tool to restrict the availability of heavy metals in soil. Organic amendments aid in a binding process that occurs if high pH levels are maintained. Heavy metals bind to the surface of soil particles, resulting in a reduction of availability (Evanko, 1997) Heavy metal pollution is a wide spread problem within all industrially developed countries of the world. Past waste disposal practices associated with mining and manufacturing activities have been such that air, soil, and water contamination was common, and as a result there are many metal contaminated sites that pose serious health risks (Wei, 2015). Traditional approaches to remediation of toxic heavy metal contaminated soils are typically expensive, labor intensive, and environmentally inefficient. Available space at hazardous waste disposal sites and growing regulations are rapidly depleting incineration and land filling processes as remediation options. The use of plants to remove hazardous heavy metal contamination from soil is a promising alternative of method soil remedy (J.C., 2010). Soil amendments can aid in the increase or decrease of the accumulation efficiency of toxic heavy metals within plants (Jadia, 2008). Several studies have indicated that vegetables, particularly leafy crops, grown in heavy metals contaminated soils have higher concentrations of heavy metals than those grown in uncontaminated soil (Wei, 2015). Additionally, foliar uptake of atmospheric heavy metals emissions has also been identified as an important pathway of heavy metal contamination in vegetable crops (European Commission, 2013). Vegetable growing areas are often situated in, or near sources of atmospheric deposits, and thus have an elevated risk of potential contamination(Adam, 2005). The main problems of Ethiopian industries were constructed nearby large and small Akaki Rivers. These Industries has to be discharge their liquid wastes to the river(Yohannes, 2017). This problem is affecting the all environmental issue like water, soil, and human health’s. Because, About 90% of these industries do not have waste water treatment and discharge their waste in to the environment. The goal of this study is to investigate the effects of Compost and effective Microorganisms on the decreasing of up taking abilities of heavy metals by vegetables in the case of Beet Root & Swiss chards.

Materials and Methods

Description of the study area

It is the capital city of Ethiopia and of the Africa Union and its predecessor. The OAU, and also the largest city in Ethiopia .As a character city (ras gez astedader), Addis Ababa has the status of both a city and a state. It is often called the capital of Africa or the “Africa Capital” due to its historical, diplomatic and political significance for the continent. The City is populated by people from different regions of Ethiopia –the country has as many as 80 nationalities speaking 80 languages and belonging to different religious communities including Christians, Muslims, and jews .Addis Ababa is a grassland biome and is located at9^{0}02’N38^{0}44’E9.03^{0}N38.74^{0}E. From its lowest point, around Bole international Airport, at 2,326 meter (7,630 ft) above sea level in the southern periphery, the city rise to over 3,000meter (9,800 ft) in the Entoto Mountains to the north. Based on the preliminary 2007 census results (CSA, 2012), Addis Ababa has a total population of 2,738,248,consisting of 1,304,518,men and 1,433,730 women. The city is fully urban, with no rural dwellers within the city administrative boundaries .Addis Ababa contains 22.9% of all urban dwellers in Ethiopia .With an estimated area of 530.14square kilometers (204.69 sq.mi),this chartered city has an estimated density of 5,165.1 inhabitants per square kilometer(13,378/sq mi)

Sample collection & preparations

In the field, soil samples were collected from 34 plots. In each plot, soil samples were collected at three depths (0-5 cm, 5-10 cm and 10-15 cm), by using spiral auger of 2.5cm diameter. Soil samples from the Agricultural site were randomly sampled and bulked together to form a composite sample. In all cases, soil samples were put in clean plastic bags and transported to the AAEPA laboratory. Soil samples were then air-dried, crushed and passed through 2mm mesh sieve. The samples were then put in clean plastic bags and sealed. Soil samples were analysed for the following parameters: pH, electrical conductivity, organic matter, organic carbon, cation exchange capacity and heavy metals. Vegetables (Beet Root & Swiss Chards) from the Akaki agricultural site were freshly harvested from twelve farms and packaged into labelled paper bags, and transported to the laboratory awaiting analysis. The vegetable samples were collected and divided into root and leaf. Soil and vegetable samples were collected four times a month from the period of September to July, 2009.

Soil sample analysis

The pH was measured using a 1:2 soil: water ratio (8); electrical conductivity was determined using the aqueous extraction (1/5) method (Van Herk, 2012). Organic matter and organic carbon (OC) were determined using Anne method (modified Walkey-Black method) (Van Herk, 2012). Cation exchange capacity (CEC) was determined using standard method taken from Rowell (1994). The cation used in this method to saturate the soil solution is Na. Five gramme (5g) of soil were weighed into a 50 ml plastic centrifuge tube and 30 ml of 1 M NaOAc pH 8.2 were added. The sample was shaken at an end-to-end shaker at 21OC for 5 minutes and was then centrifuged for 10 minutes at 4000 rpm. The supernatant was discarded and 30 mL of 1 M NaOAc pH 8.2 was added the sample was resuspended and the procedure was repeated for 2 more times. After the supernatant was discarded for the third time 30 ml of 95 % ethanol solution were added, the sample was resuspended and another 3 cycles were conducted. At the end of the third cycle, 30 ml of NH4OAc pH 7 were added, the sample was resuspended and a new phase of 3 cycles was commenced. This time the supernatants were filtered through a filter paper, Whatman No 42, and collected into a 100 mL volumetric flask. At the end of this, the flask was made to the volume with NH4OAc pH 7 solution. The samples were kept at 4 OC until Na was measured on the FAAS according to standard procedure. CEC value was then determined by the formula

CEC, $cmol_c$ kg-1

soil=10*Na concentration in mg L^{-1}

Mass of sample (g)

Sample preparation and digestion of vegetables for heavy metal

The vegetables samples were weighed to determine the fresh weight and dried in an oven at 80OC for 72 hours to determine their dry weight. The dry samples were crushed in a mortar and the resulting powder digested by weighing 0.5g of oven-dried ground and sieved (<1mm) into an acid-washed porclain crucible and placed in a muffle furnance for four hours at 500OC. The crucibles were removed from the furnance and cooled. 10ml of 6M HCl were added covered and heated on a steam bath for 15minute. Another 1ml of HNO3 was added and evaporated to dryness by continuous heating for one hour to dehydrate silica and completely digest organic compounds. Finally, 5ml of 6 M HCl and 10ml of water were added and the mixture was heated on a steam bath to complete dissolution. The mixture was cooled and filtered through a Whatman no. 541 filter paper into a 50ml volumetric flask and made up to the mark.

Elemental analysis of samples

Determination of Cu, Zn, Co, Mn, Mg, Fe, Cr, Cd As, Ni and Pb in soil and vegetable samples were made directly on each of the final solution using Perkin-Elmer AAnalyst 400 Atomic Absorption Spectroscopy (AAS).distilled water.

Results and Discussion

Heavy metals in plant leaf

The heavy metals on plant leaf had a wide range of values for measured plant leaf (Table 1). The Zn values on the plant leaf were ranged from 54.95ppm to 138.28ppm and varied with the size of plant leaf. Pb values ranged from 6.608pmm to 96.33ppm due to the size of plant leaf. Fe were ranged from 505.84pp to 2060.14ppm and increased with the size and high absorbability of Iron (Fe) by plant leaf.

Table 1: Summary statistics of heavy metals in plant leaf

No	Lab code	Mn .ppm	Fe.ppm	Ni.ppm	Pb.ppm	Cr, ppm	Cd.ppm	Zn.ppm	Hg.ppb	As.ppb
MEAN	SCECRW	127.12	1517.5	5.79	6.61	4.89	3.434	138.3	116.44	65.14
MEAN	SCERW	147.91	2060.1	18.92	29.15	12.15	9.26	86.69	ND	121
MEAN	SCCRW	90.37	1042.8	11.04	18.89	6.395	5.73	112	112.83	69.57
MEAN	SCCW	77.22	397.7	27.29	96.33	29.79	7705.19	68.07	112.83	77.36
MEAN	SCRW	96.31	1218.8	14.31	21.16	10.04	9.09	88.61	17.054	431.08
MEAN	SCECW	88.98	1768.7	15.82	29.42	9.44	9.225	83.67	ND	99
MEAN	SCECCW	102.62	995.24	8.29	14.19	5.97	8.184	77.87	ND	44.94
MEAN	SCCCW	124.99	1688.64	19.58	17.68	8.265	8.56	75.69	54.75	137.8
MEAN	BRRW	105.09	1117.7	8.503	18.81	ND	6.49	78.19		69.57
MEAN	BRCW	59.41	765.72	12.02	17.90	6.865	7.28	74.82	116.31	92.68
MEAN	BRCRW	74.28	859.73	13.74	19.54	5.11	7.81	82.11	8.59	32.95
MEAN	BRECRW	98.67	656.47	13.22	28.76	1.455	7.78	233.01	115.26	755.63
MEAN	BRCCW	81.96	778.14	19.71	15.69	3.13	8.28	94.50	ND	30.26
MEAN	BRECCW	89.35	1342.02	7.12	7.18	ND	3.79	54.95	73.62	56.8
MEAN	BRECW	60.26	1120.64	14.67	22.36	14	8.06	77.37	ND	43.65
MEAN	BRECRW	116.38	505.84	12.49	13.52	4.78	8.06	86.17	ND	138.6
MEAN	BRX	84.85	559.62	7.32	10.92	ND	4.39	81.11	80.59	1689.3

Heavy metals on plant root

The heavy metals on plant leaf had a wide range of values for measured plant leaf (Table 2). The Cd values on the plant leaf were ranged from 0.81ppm to 9.16ppm and varied with elongation of plant root. Mn values were ranged from 96.26pmm to 293.63ppm due to the elongation of plant root. Fe was ranged from 5301.84ppm to 12554.3ppm and this value was increased with the length and high absorbability of Iron (Fe) by plant root.

Table 2: Summary statistics of heavy metals on plant root.

Lad code	Na (cmol /kg soil)	K (cmol/ kg soil)	Ca (cmol/kg soil)	Mg (cmol/kg soil)	CEC (meq/kg soil)	P (PPM)	% Moisture	PH (H2O)	EC (ms)	O.C %	T.N %
BRCW	0.29	1.134	46.97	9.46	56.76	52	7.50	8.23	0.12	1.24	0.17
BRCRW	0.6	2.04	49.39	9.69	61.73	64	6.61	8.37	0.15	1.59	0.17
BRERW	0.31	1.725	52.23	9.99	62.75	49	6.76	8.44	0.12	1.3	0.17
BRECCW	0.29	2.095	53.07	8.41	61.66	58	6.68	8.48	0.15	1.49	0.18
BRRW	0.5	2.15	59.46	25.27	70.38	49	7.23	8.39	0.55	1.15	0.16
BRECRW	0.29	1.269	57.55	9.27	69.05	54	8.05	8.42	0.18	1.65	0.19
BRCCW	0.36	2.715	55.54	9.52	65.11	64	7.23	8.35	0.16	1.51	0.18
BRECCW	4.84	1.81	48.35	8.58	66.52	55	7.5	8.55	0.15	1.56	0.16
SCRW	0.38	2.285	56.06	10.17	65.89	52	7.43	8.27	0.13	1.25	0.14
SCERW	0.32	2.4	51.92	9.27	60.91	46	6.61	8.52	0.11	1.225	0.16
SCCCW	0.34	1.78	54.67	9.89	64.33	54	7.26	8.29	0.13	1.25	0.19
SCCW	0.23	1.89	37.59	10.79	48.49	49	7.15	8.39	0.13	1.205	0.15
SCECRW	0.56	1.97	61.9	9.69	71.61	58	7.61	8.28	0.15	1.38	0.18
SCCRW	0.50	1.906667	60.84	9.79	70.04	58	7.09	7.92	0.14	1.23	0.16

Physicochemical properties of soil with heavy metals

The soil properties had a wide range of values for measured soil properties (Table 3). The soil pH values range from slightly (7.916) to moderately alkaline (8.55) and varied with depth. Conductivity values ranged from 0.1095ms to 0.1746ms Organic carbon ranged from 1.15% to 1.64% and decreased with depth. Cation exchange capacity values were 48.48 to 70.043(meq/kgsoil),

Table 3: Physicochemical Properties of soil with heavy metals

Lab code	Cr.ppm (2.5ppm)	Cd.ppm (0.2ppm)	Pb.ppm (0.3ppm)	Mn. ppm	Ni. ppm	Fe.ppm (425.5ppm)	Zn.ppm (99.4ppm)	As.ppb (0.43ppm)	Hg.ppb (0.025ppm)
SCCCW	106.52	0.694	50.55	1335.44	79.333	65029.66	46.78	1000.96	98.23
SCCW	123.88	0.55	75.19	1168	86.59	56130		1229	123.6
SCECRW	107.51	ND	24.08	1092.66	65.35	68579.5	163.24	1213	
SCERW	103.4	ND	33.29	991.11	62.69	58294.5	102.07	836.1	27
SCCRW	116.54	0.58	67.77	1211.21	76.23	60663	98	1298.33	85.42
SCRW	115.11	ND	54.55	1053.51	72.93	64509.5	83	1056	45.3
ERCW	116.54	0.75	67.77	1211.21	66.92	68232.67	118.16	1111.1	59.26
ERERW	92.99	0.99	41.89	1099.81	73.16	60389.5	54.17	1083.35	45.01
ERCRW	91.43	0.91	51.7	1191.66	66.69	62209.5	88.92	1099.35	34.43
ERECCW	132.64	0.45	13.03	907.89	62.86	70131.5	158.365	455.03	0.35
ERCCW	103.71	ND	23.55	670.81	65.5	71789	170.09	743.9	0.44
ERECRW3	121.16	1.1	42.2	1588.88	81.58	64383.09		1561.88	
ERRW	123.66	ND	70.71	1165.5	98.98	61700		1162.5	77.67
XCECW3	129.46	ND	ND	900.71	64.53	72039	196.84	913	ND
ERECW2	132.26	ND	62.79	1021	86.8	61960		1308	111.1

Concentration of Heavy Metals on growing vegetables

Their presence in the atmosphere, soil and water, even in traces can cause serious problems to all organisms, and heavy metal bioaccumulation in the food chain especially can be highly dangerous to human health. Heavy metals enter the human body mainly through two routes namely: inhalation and ingestion, ingestion being the main route of exposure to these elements in human population. Heavy metals intake by human populations through food chain has been reported in many countries. These organic compound (compost and EM) form complex (chelaets) with heavy metals ,but the existence of high electrochemical series metals might be increased the availability and up taking of less electrochemical series heavy metals. The solubility of oxides hydrates or phosphate of compounds of different heavy metals is dependent on PH value of the soil. Even the concentration of these heavy metals is different in different condition. Example the concentration of iron in SCCw leaf (swiss chard planted without compost and effective microorganism and with clean water) 397.37ppm and the concentration of Cd is 7705.35ppm. The Concentration of iron is below the recommended maximum limit (425.5ppm) and the concentration of cadmium is above the recommended maximum limit(0.2ppm) .This result indicate as the concentration of these heavy metals are affect each other and some other factors. Such as Hg, Cd, Fe, Pb, Cr, Cd, Zn, are important environmental assessing potential dietary toxicity, in Heavy metals, such as cadmium, copper, lead, chromium and mercury pollutants, particularly in areas with high anthropogenic pressure.

Heavy metals in Plant Leaf

From the Graph, the accumulation each heavy metal varied in various plants grown in different locations. Accumulation of the metals in the chronological ordersSCECRW<SCERW<SCCRW<SCCW<SCRW< SCECW<S CECCW<SCCCW shows in Table 4.

Table 4: Indicates that the full name of abbreviation Swiss chard with effective microorganism, clean water and row water.

SCCW	Swiss Chard Clean water
SCERW	Swiss Chard effective microorganism row water
SCCCW	Swiss Chards compost clean water
SCECCW	Swiss Chards effective microorganism clean water
SCECRW	Swiss Chards effective microorganism compost row water
SCRW	Swiss Chards row water
SCCRW	Swiss Chards compost row water
SCCW	Swiss Chards compost row water
SCCRW	Swiss Chards compost row water

The minimum heavy metal uptake is for every site is obtained in the Swiss Chards grown with Effective microbe, compost grown with river water. This is a good indication to recommend Swiss chard grown on Effective microbe and compost for consumption purpose and on the other hand Swiss chard with mere compost and clean water for the remedial technology of removing high amount of the heavy metals from the soil(fig 1).

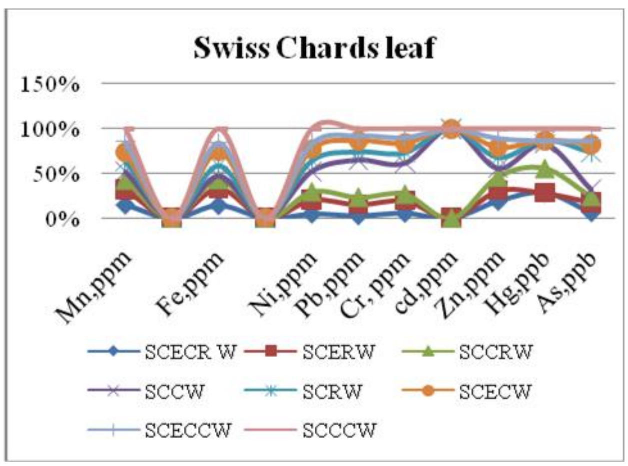

Fig 1: Swiss card leaf and accumulation of heavy metals in plant leaf

Beet Root Leaf

The minimum concentration heavy metals for all the analyzed metals except for Arsenic is achieved in the Beet Root plant Enriched with Effective micro Organism and compost grown with river water (BRECRW) shows in Table 5.

Table 5: Indicates that the full name of abbreviation of beet root with effective microorganism, row water and clean water

BRECW	Beet Root effect microorganism clean water
XCECW	Control or compost effective microorganism with clean water
BRRW	Beet root row water
BRCCW	Beet root compost clean water
BRERW	Beet root effective microorganism with row water
BRCRW	Beet root compost row water
BRECCW	Beet root effective microorganism compost clean water
BRCW	Beet root clean water
BRECW	Beet root effective microorganism clean water

At the same time as reached its maximum concentration at the indicated sample site. And the maximum concentration of the heavy metal accumulation was in the Beet Root grown with Effective microbe and compost irrigated with clean water (Fig2).

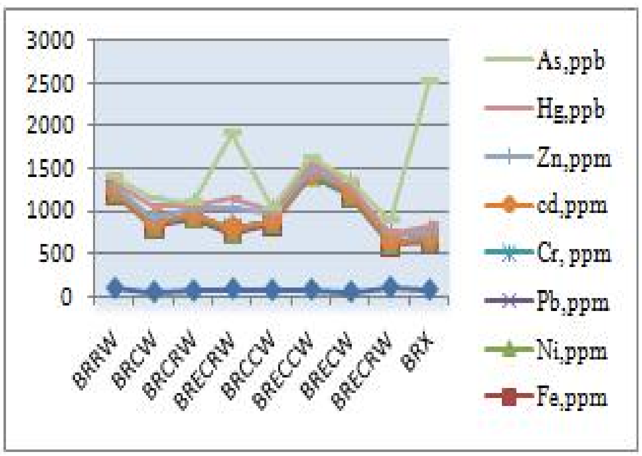

Fig 2: Concentration of Heavy metal in Beet root leaf grown in various

Concentration of heavy metals in growing of Swiss Chards leaves

The heavy metal accumulation of every species is close to zero except for iron which indicates the effective Chelation of the metals due to the presence Effective micro organism and compost. On the other hand the maximum uptake of the heavy metal was achieved in the Swiss Chards grown without Effective Microbe compost and clean water. This clearly indicates that the effect of using the either of the Effective microbe or the compost will affect the heavy metal uptake of the vegetable.

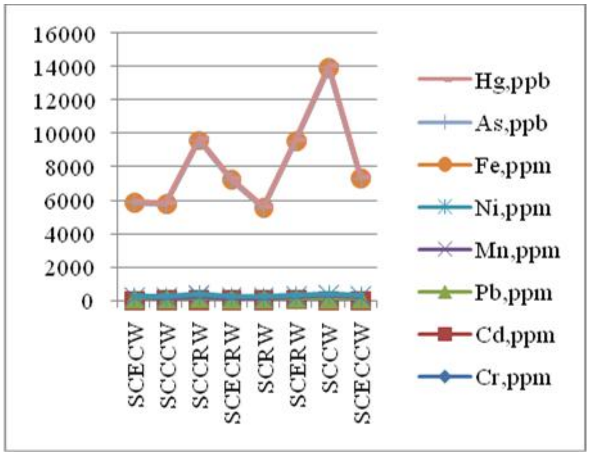

Fig.3 Concentration of heavy metals in Swiss Chards leaves grown at various places

Comparison of heavy metal uptake by Beet Root & Swiss Chards

Fig. 4 compares the degree of heavy metal up take by the two species of vegetable Beet Root & Swiss Chards. It is indicated that the figure that the relatively higher concentrations Heavy metals is taken up by Swiss Chards plant than Beet root at every point. From this one can easily conclude that the degree of the up take depends on species diversity. On the other hand from fig. 5 Heavy metal concentration is relatively higher Beet root than that of the Swiss chard root and this due to the probably due to the place of accumulation of nutrients in the leaf and the root.

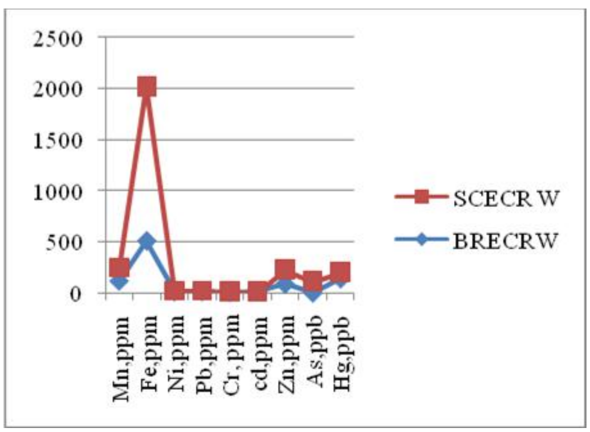

Fig 4: Comparison of heavy metal uptake by Beet Root & Swiss Chards grown on Effective Microbe & Compost plant leaf.

Conclusion and Recommendation

Soil threshold for heavy metal toxicity is an important factor affecting environmental capacity of heavy metal and determines heavy metal cumulative loading limits. For soil-plant system, heavy metal toxicity threshold is the highest permissible content in the soil (total or bio-available concentration) that does not pose any phototoxic effects or heavy metals in the edible parts of the crops does not exceed food hygiene standards. Factors affecting the thresholds of dietary toxicity of heavy metal in soil-crop system include: soil type which includes soil pH, organic matter content, clay mineral and other soil chemical and biochemical properties; and crop species or cultivars regulated by genetic basis for heavy metal transport and accumulation in plants. In addition, the interactions of soil-plant root-microbes play important roles in regulating heavy metal movement from soil to the edible parts of crops. Agronomic practices such as fertilizer and water managements as well as crop rotation.

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