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Effect of Organic Amendments on Selected Heavy Metals (Cd, Cr and Pb) Uptake by Tomato (*Lycopersicon Esculentum Miller*) Plant

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Abstract: The accumulation of heavy metals in agricultural products and soil is a serious issue since it affects crop development and productivity as well as food safety and marketability. Global interest in the cleanup of heavy metal-contaminated soils has grown. The amendment of contaminated soil with organic materials is considered an environmentally friendly technique to immobilize heavy metals and minimize their subsequent bioaccumulation in plants. The aim of this experiment was to remediate waste Akaki River-irrigated Akaka irrigation farm soil with organic materials (animal manure, compost, and vermicompost) in a pot experiment with 3%, 6%, and 9% rates of organic material and contaminated soil in a greenhouse with ten treatments. Soil Comparative research on the impact of organic soil additives on heavy metal remediation from contaminated soil with heavy metals (Cd, Pb, and Cr) and the uptake of these elements by tomato (Lycopersicon esculentum Miller) plants was carried out. Also, the heavy metal removal efficiency of organic additives from contaminated soil was examined, and vermicompost showed good removal efficiency compared to compost and animal manure. Organic amendments led to decreased heavy metal content in tomatoes and this decrease was best expressed with 9% vermicompost. It shows with increasing amount of organic materials the heavy metal removal efficiency also increases. Organic amendments were especially effective in reducing the lead content of tomatoes.

Keywords: Heavy Metal, Organic Amendment, Tomato

1. Introduction

In the periodic table, heavy metals are any elements with atomic numbers higher than 20 and densities larger than 6 g/cm^3, with the exception of alkali metals and alkaline earth metals [1]. The most damaging inorganic pollutants in the environment are heavy metal ions, which can be either naturally occurring or caused by human activity [2]. They are the outcome of various industries, including mining, plating, dyeing, electrochemistry, metal processing, battery storage, and more [3]. Due to their difficulty in being eradicated and the fact that the majority of them are harmful to plants and animals even at low concentrations, heavy metals pose environmental issues [1]. The problem of heavy metal pollution is a major concern because of its toxicity for humans, plants, and animals due to its lack of biodegradability. Excess levels of heavy metals have an adverse effect on plant metabolic activities, affecting food production. Toxic heavy metals, when reaching human tissues through different absorption pathways such as direct ingestion, dermal contact, diet through the soil-food chains, inhalation, and oral intake, may seriously affect their health. Some of the traditional methods are either extremely costly or are simply applied to isolate contaminated sites [4]. In many regions of the world, soils are heavily contaminated with heavy metals, and cleaning up these soils is a challenging undertaking. Numerous in-situ and ex-situ remediation methods, including soil cleaning, stabilization, solidification, and phytoremediation, have been developed [5]. Among heavy metal remediation techniques, chelating and complexion agents, phosphate compounds, liming materials, and organic composts are some of them [6].

According to Walker *et al*. [7], organic soil amendments are frequently employed to immobilize soil heavy metals (HMs) by altering their speciation from the originally highly bioavailable forms (i e., free metals) to the significantly less bioavailable fractions associated with organic matter (OM), metal oxides, or carbonates. Due to their presence of humic acids, which can bind with a wide range of metal (loid) s, including Cd, Cr, Cu, and Pb, these amendments are known to have considerable immobilizing effects on heavy metals [8, 7].

Animal manures, vermicompost, and compost have all been extensively studied in relation to the background heavy metal contamination of agricultural soil. These organic materials can be used as fertilizer to improve soil fertility, boost crop productivity, raise microorganisms, and modify agricultural soil to reduce HM pollution [9]. They are also rich in nutrients, humic matter, and microbes.

According to Salt *et al*. [10], phytoremediation is the process of removing contaminants from the environment or reducing their toxicity while also using plants, soil amendments, and agronomic practices. In comparison to other remediation techniques, this method offers numerous benefits, including low economic costs and the potential to be applied to soils with minimal environmental impact. For the immobilization of heavy metals and soil improvement of contaminated soils, it is usual practice to add organic matter amendments, such as compost, fertilizers, and wastes [11]. The effect of organic matter amendments on heavy metal bioavailability depends on the nature of the organic matter, their microbial degradability, salt content and effects on soil pH and redox potential, as well as on the particular soil type and metals concerned [7].

The end result of the microbial breakdown of organic materials (organic waste), compost, and vermicompost is rich in humus, microorganisms, and inorganic components. The mobility and bioavailability of heavy metals in soil environments, as well as their harmful effects on plants and animals, can all be altered by the addition of compost, vermicompost, and animal manure to polluted soil. According to Huang et al. [9], these effects are related to a number of mechanisms, including adsorption, complexation, precipitation, and redox reactions. For instance, cow and pig manure reduced the quantity of DTPA-extractable Ni in soil due to the formation of strong complexes with organic components [12]. Therefore, the study focuses on the comparative impacts of various organic materials on the removal of heavy metals from soils irrigated by the Akaki River water.

2. Materials and Method

2.1. Study Area

The Akaki River is found in the central sideway of the western border of the main Ethiopian rift valley. The Akaki River catchment is found at 8°46′–9°14′N and 38°34′–39°04′E. Addis Ababa, which lies within the Akaki River catchment, has a fast-growing population, abandoned development and industrialization, poor sanitation, and untreated waste dumping, which results in serious deterioration of surface and groundwater quality. Different reports showed that a huge amount of untreated solid, liquid, and gaseous waste was generated and released into the environment around the city [13]. Different industrial and urban wastes join the Akaki River, and farmers around the river use the contaminated Akaki River water for irrigation and the production of different horticultural crops. Studies showed that crops produced in the area and originated soil different heavy metal levels are above the recommended limit set by different organization. Therefore, this study has been as conducted in order to remediate the heavy metal contaminated Akaki soil with different organic materials.

2.2. Soil Sample Collection and Preparation

For a pot experiment and laboratory examination, 45 soil samples were obtained from an irrigation farm in the Akaki area at a depth of 0 to 20 cm. The soil was contaminated with several heavy metals. The gathered samples were combined into one and sent to the soil, plant, and water laboratory at the Debre Zeit Agricultural Research Centre for laboratory analysis and pot tests [14]. Large soil particles, trash, and other contaminants were removed from the composite sample and dried for seven days at room temperature. The sample is then divided into pots for laboratory analysis. The material was homogenized and put in a polyethylene bag until lab analysis using a mortar and pestle to grind it through a 2 mm sieve [14].

2.3. Pot Experiment

With organic amendments added at rates of 3%, 6%, and 9% (calculated on a dry weight basis for the soil) to contaminated Akaki soil, a pot experiment was undertaken. Changes were made by adding organic components, which were then thoroughly blended by hand. The containers each contained 4 kg of amended soil. each treatment is completed in triplicate. Three additional control pots were positioned in the same location without any changes. The pots were watered and allowed to settle in a greenhouse for at least two weeks at room temperature before the tomatoes were planted. Tomato seeds will first be immersed in 3% (v/v) formaldehyde for 5 minutes to prevent fungus contamination, and then they will be repeatedly rinsed with distilled water. The tomato plants grown with regular watering and random rotation of the position of the pots. After maturity, plants harvested. Then plants, cleaned, and washed under running water in order to remove stuck soil and other materials. Following drying, milling, sieving and store in polyethylene bags for laboratory analysis.

2.4. Tomato Sample Digestion

The tomato sample, which weighed 0.5g, was placed in a borosilicate digestion flask together with 10 HNO3-HCl-H_2O_2 (8: 1: 1, v/v/v). In a borosilicate digestion flask, 120g of heated mixture were added. For three hours, the mixture was cooked on the block digester at 120°C. The digested samples were then preserved for heavy metal analysis using a clear, colourless solution that had been filtered into a 50-mL volumetric flask and filled to the line with distilled water. Additionally, the black sample was digested in a manner comparable to that of the tomato samples [15, 16].

2.5. Soil and Organic Materials Sample Digestion

A 0.5g prepared soil samples before pot experiment, after tomato harvesting and similar prepared organic materials (vermicompost, compost, and animal manure) samples were transferred into block digestion tube. In each tube 5 mL deionized water and 30 mL mixture HNO_3 (69%) and 37% HCl with volume ratio of 5: 1 added. The sample dissolved in the acid mixture digested in digestion hood (at 200°C) for 1 h and kept to cool. After adding 2 mL of H_2O_2 to the cold digestion mixture. Then final the digested samples filtered in to 100 mL volumetric flask and filed up to mark with distilled water [17]. In addition, the black sample digested similar to the soil and organic material samples, Heavy metals content were determination by FAAS at Holeta agricultural research Center soil lab.

2.6. Soil and Organic Materials Physicochemical Property Analysis

Soil physicochemical properties of contaminated Akaki soil and after pot experiment were determined according to standard producers. Soil and organic materials pH were determined potentiometrically in 1: 2.5 soil to distilled water ratio (pH-H_2O) [18]. Electrical conductivity (EC) measured from PH supernatant by using conductivity meter [19]. Organic matter was determined by using Walkley-black wet oxidation method [20]. Total nitrogen was analysed by using Kjeldahl method using sulfuric acid and mixed catalyst to convert organic nitrogenous to ammonium sulfate. The distillation process was conducted in the presence of 10% sodium hydroxide to evolve ammonium in the form of ammonia gas [21]. Phosphorus in Soil and organic matter were determined by using Olsen method [22]. Cation exchange capacity (CEC) was determined in both soil and organic materials, from extracts which were obtained from residue of exchangeable cations, after removal of unbounded ammonium salt with 97% alcohol and then extracted with 10% NaCl. The distillation was conducted using Kjeldahl distillation apparatus and the quantification made by titration method [23].

2.7. Bio-Concentration Factor (BCF)

Bio-concentration factor was calculated using the formula metal concentration in This was calculated using the metal concentration ratio in plant roots to that in soil [24] and is given as follows: BCF = metal concentration in root/metal concentration in soil.

2.8. Heavy Metal Removal Efficiency

The efficiency of organic materials remove the heavy metals from contaminated soil were determined by using (equation 1.) as used by Emenike et al. [25]

$$\%\ \text{Heavy metal removal} = \frac{C0(x) - CF(x)}{C0(x)} * 1 \qquad (1)$$

Where:

C0(x) = initial concentration of heavy metals contaminated Akaki soil before pot experiment

CF(x) = final concentration of heavy metals after pot experiment

2.9. Statistical Analyses

The statistical analyses performed using SAS for evaluating experiment data. Pearson’s linear correlations used to assess the relationships among different physicochemical properties and available Pb, Cu, Zn and Cd in soil. Significant difference among treatment means was assessed using the least significant difference (LSD) test at 0.05 probability level [26].

3. Result and Discussion

3.1. The Effect of Organic Material Additive on Tomato Growing Soil After Pot Experiment

Some of the physicochemical soil properties were determined before and after the pot experiment. Before the pot experiment, the Akaki River irrigated soil had PH (8.81 and 8.8.62), EC (0.20 and 0.21), TN (0.09 and 0.10), OM (0.16 and 0.14), P (15 and 16), and CEC (38 and 37). Also for organic materials (animal manure, compost, and vermicompost), physicochemical analyses were determined and presented in Table 1. for two experimental years. Application of various treatments with animal manure, vermicompost, and compost revealed significantly good impacts on the chemical properties of soil samples taken after harvest. The effect of organic material application (animal manure, compost, and vermicompost) on heavy metal-contaminated tomato growing soil in terms of physicochemical properties (pH, electrical conductivity (EC), total nitrogen (TN), phosphorus (P), organic matter (OM), and cation exchange capacity (CEC)) was determined and presented in Table 2. The amounts of PH, and CE in the organic material treated tomato growing soil decreased with increasing amounts of organic matter, while the amounts of P, TN, and OM increased with increasing amounts of organic materials in the order of vermicompost>compost>animal manure in both experimental years. The addition of compost materials to soil has substantial effects on soil physiochemical properties [27, 28].

Table 1. *Organic materials (animal manure, compost and vermicompost) used for pot experiment physicochemical properties.*

Parameter	Year 2019					Year 2020				
	%TN	%OM	P mg/kg	pH (1: 5)	EC ds/m	%TN	%OM	P mg/kg	pH (1: 5)	EC ds/m
Vermicompost	0.70	11.03	85.95	7.22	2.05	0.81	12.01	70.89	7.08	2.01
Animal manure	1.04	26.25	74.10	7.56	3.6	1.07	25.45	71.12	7.34	3.45
Compost	0.56	9.38	91.10	7.02	3.15	0.61	10.01	95.34	7.12	3.33

Table 2. *Soil physicochemical properties after pot experiment.*

Parameters	Year 2019						Year 2020					
	PH	EC dm/S	%TN	P ppm	CEC	%OM	PH	EC dm/S	%TN	P ppm	CEC	%OM
T1SC	8.74a	0.17ab	0.11e	19.62f	30.79ab	2.0e	7.81b	0.19a	0.10e	11.62f	31.34a	1.79h
T2SM	8.71a	0.18a	0.15cd	25.87e	35.65a	2.18f	7.13d	0.16bc	0.12d	15.16e	27.78b	2.20f
T3SM	8.60b	0.18a	0.20b	28.80cde	30.56ab	2.36ef	7.51c	0.14de	0.12d	17.75cd	24.64c	2.53de
T4SM	8.67ab	0.16ab	0.25a	30.93c	29.07b	2.34ef	7.03d	0.12e	0.13d	20.85b	21.69d	2.76c
T5SCO	8.67ab	0.15ab	0.12e	30.01c	31.26ab	2.50e	8.07a	0.17b	0.15c	17.17cd	28.24b	1.93gh
T6SCO	8.65ab	0.18a	0.16c	26.47de	33.56ab	2.84d	7.56c	0.15cd	0.15c	20.54b	25.58c	2.41e
T7SCO	8.60b	0.12b	0.21b	30.83c	31.36ab	3.36c	7.11d	0.12c	0.17bc	24.24a	21.23de	2.92b
T8SVC	8.45c	0.18a	0.14d	37.34b	27.29b	4.63b	8.15a	0.19a	0.17bc	16.39de	28.24b	2.00g
T9SVC	8.33d	0.17ab	0.20b	44.49a	33.47ab	4.65b	7.44c	0.16bc	0.19b	18.34e	25.83c	2.64cd
T10SVC	8.14e	0.12b	0.24a	47.89a	27.33b	5.23a	7.04d	0.12e	0.22a	21.43	20.25e	3.08a
CV	0.75	18.18	7.73	7.26	11.89	4.37	1.59	6.55	5.48	4.97	2.86	3.48
LSD (0.05)	0.11	0.08	0.02	4.01	6.35	0.24	0.2	0.02	0.02	1.56	1.25	0.15

Where T1SC = Control (100% contaminated soil), T2SM = Contaminated soil+3% cattle manure, T3SM = Contaminated soil +6% cattle manure, T4SM = Contaminated soil+9% cattle manure, T5SCO = Contaminated soil+ 3% compost, T6SCO = Contaminated soil +6% compost, T7SCO = Contaminated soil + 9% compost, T8SVC = Contaminated soil +3% vermicompost, T9SVC = Contaminated soil+ 6% vermicompost and T10SVC = Contaminated soil+ 9% vermicompost. Values were given as means of triplicate analysis. The mean in the same column having different superscript letters are significantly differ from each other at 5% confident interval.

3.2. Heavy Metal Content in Akaka Soil and Organic Additive

The results of heavy metals concentration in Akaki river irrigated soil showed that the soil was substantially polluted with heavy metals. The order of contamination was Pb > Cr > Cd. Among the selected heavy metals Cd and Cr concentration were above the permissible limits of FAO/WHO [29] and USEPA [30] as we shown in Table 3. Also the concentration of those selected heavy metals in vermicompost, compost and manure were below the recommended limit set by those organizations. The possible source of contamination of cultivatable land may either be through irrigation Akaki river water or agricultural activities which not only affect plant growth and yield but also entered to the food chain. Higher concentration of these heavy metals in soil has adverse effects on plant growth and human health as these metals have no known function in human body and can cause severe toxicity [27, 28].

Table 3. *Organic materials (animal manure, compost and vermicompost) and soil used for pot experiment heavy metal content in mg/kg.*

Parameter	Year 2019			Year 2020		
	Cd	Pb	Cr	Cd	Pb	Cr
Vermicompost	0.19	23.00	5.12	0.25	22.47	4.87
Animal manure	0.17	18.25	4.89	0.32	21.87	3.89
Compost	0.45	35.01	6.12	0.37	27.12	5.12
CASBPE	5.01	65.07	49.57	6.12	70.12	40.18

Where: CASBPE=contaminated Akaki soil sample before pot experiment

3.3. Accumulation of Heavy Metals in Soil Samples After Pot Experiment

The results of a heavy metal remediation experiment using animal manure, compost, and vermicompost in amounts of 3%, 6%, and 9% organic materials to soil watered by the Akaki River. After conducting pot experiments, the amount of heavy metals (Cd, Pb, Co, Fe, Zn, Cr, and Cu) in the soil sample treated with organic materials for tomato growth was evaluated and presented in Table 4. The result showed that when the amount of organic materials in the soil prepared for tomato growth increased, so did the concentration of these discovered heavy metals. Among organic materials, vermicompost-treated Akaki soil demonstrated a substantial reduction in the content of heavy metals. The organic materials like vermicompost, animal manure, compost and other are immobilized heavy metals from available form to organic-metallic complexes (unavailable form) [31].

Table 4. Heavy metals (Cd, Cr and Pb) concentration in mg/kg in Akaki irrigation soil after organic materials amendment and tomato production.

Parameters	Year 2019			Year 2020		
	Cd	Pb	Cr	Cd	Pb	Cr
T1SC	4.74a	60.00a	43.93a	4.81a	64.42a	36.33a
T2SM	3.37b	49.28bc	39.16b	4.00b	49.06bc	29.40b
T3SM	3.28cd	48.02bcd	32.81cd	3.51d	47.12de	24.50c
T4SM	3.27d	45.22e	32.31cd	3.44de	45.54f	21.46d
T5SCO	3.68b	50.63b	39.47b	3.96b	50.27b	30.52b
T6SCO	3.25d	46.53cde	33.33c	3.50d	48.09cd	25.63c
T7SCO	2.93e	49.23bc	31.28d	3.22fg	45.90ef	21.36d
T8SVC	3.51bc	47.84cde	39.27b	3.74c	48.63c	30.26b
T9SVC	3.07de	45.33de	31.81cd	3.32ef	45.23f	22.18d
T10SVC	287e	37.81f	29.47e	3.07g	37.78g	18.06e
FAO/WHO [29]	3.00	100.00	50.00			
USEPA, [30]	3.00	300.00	150.00			
EU, [32]	3	300.00	-			
CV	3.98	3.37	2.96	2.83	1.77	2.81
LSD (0.05)	0.23	2.78	1.79	0.18	1.45	1.25

3.3.1. Chromium

Chromium is one of toxic heavy metals found in rocks, soil, plant, animal, and in volcanic dust and gases. It presents in the soil as (Cr III) or (Cr VI) ions. Chromium (III) is an essential nutrient in the in the diet, but it is required in a very small amount [33]. It have a role in the metabolism of cholesterol, fat and glucose, while at higher concentration it is toxic and carcinogenic [34]. As shown in Table 4 the concentration of chromium in akaki irrigated soil were 49.57 and 40.18 mg/kg, in 2019 and 2020 cropping season those are nearer to the recommended levels set by different organization WHO/FAO [29] permissible limit of chromium in soil is 50 mg/kg. After pot experiment the vermicompost treated soil shows significant decrement in chromium concentration followed by, compost and animal manure treated soils, which were much lower from permissible limit set by different organization as we shown in Table 4.

3.3.2. Cadmium

Cadmium is a very toxic heavy metals, its long term exposure to lower levels leads to a buildup in the kidneys, lungs, reproductive organs, etc. and caused for cancer, anaemia, cardiovascular disease, reduced fertility, lung damage, kidney disease, and strokes are its some add long term [35]. Cadmium added to agricultural soils with phosphate fertilizers [36]. Other sources include metal working industry, waste incinerators, urban traffic and atmospheric deposition; cement factories etc [37]. The permissible limit of cadmium in soil is 3 mg/kg, as shown in Table 3, and the concentration of cadmium in the contaminated Akaka soil before organic amendment was 5.01 and 6.12 mg/kg in 2019 and 2020, respectively. These values were above the levels set by various organisations, including the WHO/FAO [29], USEPA [30], and EU [32]. Vermicompost treated soil exhibits a large reduction in chromium concentration after the pot experiment, followed by compost and animal manure treated soils, but both are still beyond the permissible limit established by those organisations, as seen in Table 4.

3.3.3. Lead

Lead is also one toxic heavy metals in the environment, the major source of lead in the environment are automobile exhaust, industrial wastewater and pesticides [38]. Lead enters in to the human body system through air, water and food and they cannot be, removed by washing fruits and vegetables [39]. It is a serious cumulative body poison, which can affect every organs and system in the human body. As shown in Table 3 the concentration of Pb in contaminated Akaka soil before organic amendment were 65.07 and 70.12 mg/kg, in 2019 and 2020, respectively, those were still below the recommended levels set by different organization (WHO/FAO [29], USEPA [30] and EU [32] permissible limit of Pb in soil are 100,300 and 300 mg/kg, respectively After pot experiment the organic material treated soil shows significant decrement in Pb concentration, in the order of animal manure, compost and vermicompost treated soils, respectively as shown in Table 4.

Heavy metal removal efficiency of vermicompost, compost and animal manure from contaminated Akaki irrigated soil.

Heavy metal removal efficiency of compost, vermicompost, and animal manure application at different rates in wastewater (Akaki river water) irrigated Akaki soil vermicompost shows higher removal efficiency compared to compost and animal manure, but in the case of chromium 9%, compost, and animal manure show the highest removal efficiency. Removal efficiency increases with an increasing rate of organic additives as we shown in Figures 1 and 2.

3.4. Accumulation of Heavy Metals in Tomatoes Grown on Contaminated Akaki Soil After Being Treated with Organic Materials

The application of animal manure, compost and vermicompost in contaminated Akaki soil in 3%, 6% and 9% of each organic materials type give significant amount of heavy metal decreasement in tomato and originated soil after pot experiment. The concentration of heavy metals (Cd, Pb and Cr) in tomato were determined that grown in organic materials treated contaminated Akaki soil result revealed that the concentration of these detected heavy metals in tomato were close to recommended limit set by different organization like FAO and WHO [29]. In organic materials (animal manure compost and vermicompost), treated soil grown tomato showed that significant amount of heavy metal, concentration reduction. The mean concentration of these heavy metals Cd, Pb and Cr ere determined in tomato fruits grown in pot trials at 2019 and 2020 in organic materials (animal manure, compost and vermicompost) treated contaminated soil from Akaki area were presented in Table 5.

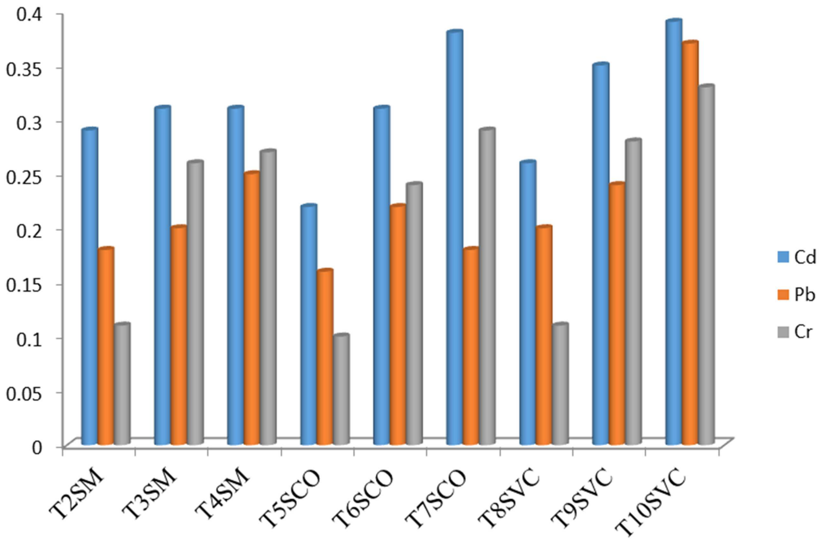

Figure 1. *Heavy metal removal efficiency of vermicompost, compost and animal manure (n=3), 2019.*

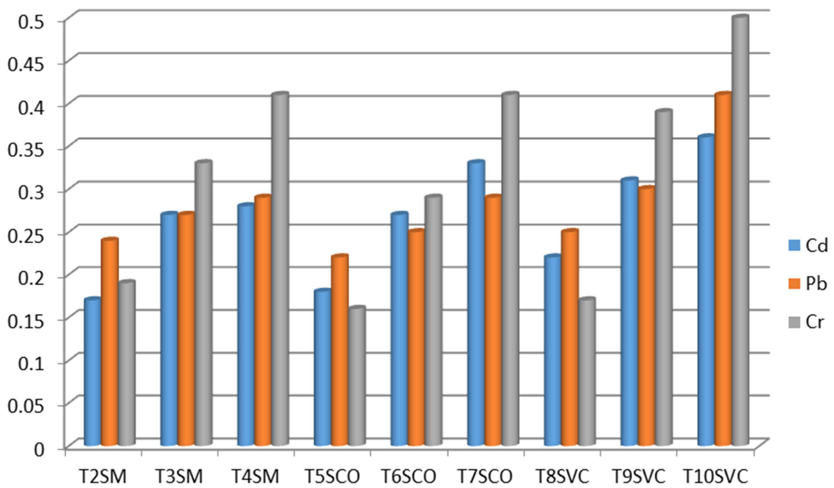

Figure 2. *Heavy metal removal efficiency of vermicompost, compost and animal manure (n=3), 2020.*

Table 5. *Mean concentration of Cr, Cd and Pb of tomato samples after pot experiment in mg/kg n=3.*

Parameters	Year 2019			Year 2020		
	Cd	**Pb**	**Cr**	**Cd**	**Pb**	**Cr**
T1CT	0.28a	5.70a	2.33a	0.27a	6.16a	4.81a
T2MT	0.22b	4.86bc	2.03bc	0.16c	4.77c	3.22bc
T3MT	0.19de	4.80bcd	1.64def	0.14def	4.73c	2.64de
T4MT	0.18de	4.39d	1.66def	0.15cde	4.56d	2.57e
T5COT	0.21bc	5.10b	1.83cd	0.19b	5.13b	2.94cd
T6COT	0.18de	4.65cd	1.78de	0.14def	4.72c	2.78de
T7COT	0.18de	5.03bc	1.54ef	0.13f	5.01b	2.54e
T8VCT	0.20cd	4.78bcd	2.07b	0.15cd	4.76c	3.55b
T9VCT	0.18de	4.92bc	1.59def	0.14def	5.10b	2.59de
T10VCT	0.17e	3.78e	1.44f	0.13ef	3.65e	2.44e
CV	6.38	5.09	7.97	5.31	5.09	7..28
LSD (0.05)	0.01	0.42	0.24	0.02	0.42	0.38
WHO [40]	0.20	0.50	1.20			
FAO [41]	0.1	5.00	-			

3.4.1. Lead

Lead is one of toxic heavy metals in the environment, plant, animals and humans, the major target of lead toxicity are hematopoietic and nervous systems, especially in infants and young children where the nervous system is still developing. Another body system affected by lead toxicity is reproductive system. Low levels of Pb toxicity could cause some adverse effects on health and reproduction [42]. Results show that the levels of lead in the tomato a range of 6.16 to 3.65 mg/kg as shown in Table 5. Data showed that in non-treated soil growing tomato lead concentration above the permissible limit set by FAO [41] and HWO [40].

3.4.2. Chromium

Cr is essential nutrient metals, necessary for metabolism of carbohydrates [43]. Cr inter in to the environment, animal, plants and human through effluents discharged from leather tanneries, textiles, electroplating, metal finishing, mining, dyeing and printing industries, ceramic, photographic and pharmaceutical industries etc [44]. Poor treatment of different industries effluents are lead to the presence of Cr (VI) in the environment and living organisms and humans bodies, where it is cause for different [45, 46]. The chromium levels in tomato samples used in this investigation varied from 4.81 to 1.44 mg/kg, and these results were greater than the WHO permissibility standard of 1.2 mg/kg (Table 4). Chromium concentration in tomatoes that have been cultivated in soil that has been treated with organic material, particularly vermicompost, has significantly decreased. Cr mobility depends on sorption characteristics of the soil and the amount of organic matter present. VC soil amendment is effective in improving soil fertility and physical properties as well as remediates soil heavy metals from contamination [47]. Park et al. [48] also showed the same results and stated that VC is useful in immobilization of heavy metals which is then unavailable to plants. Organic composts are low in metals and are used to lessen heavy metals availability in contaminated soils [48].

3.4.3. Cadmium

Cd is one of naturally occurring nonessential heavy metal element and their tendencies to bio accumulate in living organisms often in hazardous levels [49]. Cd production, consumption and emission to the environment have increased dramatically during the 20th century, due to its industrial use (batteries, electroplating, plastic stabilizers, pigment), and consequently leads to contamination the environment. The use of cadmium containing fertilizes, agricultural chemicals, pesticides and sewage in farmland, might contribute to the contamination of environment [50]. Cd levels in tomatoes grown in organically treated soil have fallen dramatically as compared to tomatoes grown in untreated soil, particularly in vermicompost-treated soil, which has results that fall below the permissible limit established by WHO [40] and FAO [41].

4. Conclusion

Soil contamination due to wastewater irrigation is growing concern regarding soil quality, plant growth and public health. Several agricultural farms have been contaminated with heavy metals like iron, zinc, copper, chromium, cadmium, and lead, which have become a serious problem in developing countries. Among several remediation techniques, we use environmentally friendly and advantageous organic materials (vermicompost, compost, and animal manures). This study provides effective and inexpensive materials (vermicompost, compost, and animal manures) for the in situ amendment of multi-metal-contaminated agricultural soils. The addition of different ratios of the amendments has the potential to reduce Cd, Cr, and Pb accumulation in tomatoes, especially in vermicompost-treated soil.

Conflicts of Interest

The authors declare that they have no conflicts of interests.

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