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Evaluation of Heavy Metal Concentrations in Soil and Edible Vegetables Grown in Compost from Unknown Sources in Al-Jiftlik, Palestine

Mohammed Bawwab[1], Ahmad Qutob[2], Mahmoud Al Khatib[3], Husam Malassa[3], Ayman Shawahna[4], Mutaz Qutob[3*]

[1]Department of Materials Engineering, Faculty of Engineering, Al-Quds University, Jerusalem, Palestine
[2]Department of Electrical Engineering, Faculty of Engineering, Al-Quds University, Jerusalem, Palestine
[3]Department of Chemistry and Chemical Technology, Al-Quds University, Jerusalem, Palestine,
[4]Environment Quality Authority, Al-Bireh, Palestine
Email: *kutob@staff.alquds.edu

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Abstract

The use of compost as a fertilizer has been widely used in many countries. However, compost that contains heavy metals can transfer these **metals** to soils and plants (**vegetables**). This study investigates the concentrations of metals in soil and edible vegetables that were fertilized by polluted unknown compost in Al-Jiftlik region (**Palestine**). The source of the compost is the **autocratic** dumping sites of the Israeli settlements. The compost is distributed free of charge to the Palestinian farmers. The concentrations of Ba, Cu, Pb, Th, Se, Mn, Co and As in the contaminated farms were measured. Vegetables include: Eggplant, Corn, Bell Pepper, Cucumber and Marrow. Metals availability as well as the pH, was also examined in the soil samples. Normal farms that did not use this unknown compost were used as a reference. The concentrations of Ba, Cu, Pb, Th, Se, Mn, Co and As in soil and vegetables in the polluted farms were above the WHO limits. Barium concentrations in the vegetables were ranged from 1.00 mg/kg to 0.453 mg/kg. It is high when compared to WHO limit of 0.3 mg/kg. Copper concentrations in the vegetables were ranged from 63.84 mg/kg to 50.53 mg/kg. It is high when compared to WHO limit of 40 mg/kg. Lead concentrations in the vegetables were ranged from 1.00 mg/kg to 0.453 mg/kg. Lead concentration is high when compared to WHO limit of 0.3 mg/kg. Thallium concentrations in the vegetables were ranged from 2.99 mg/kg to 1.22 mg/kg. Thallium concentration is high when compared to WHO limit of 0.3 mg/kg. Selenium concentrations in the vegetables were ranged from 0.550 mg/kg to 0.348 mg/kg. It is high when compared to WHO limit of 0.3 mg/kg. Manganese concentrations in the vegetables were ranged from 825.3 mg/kg to 446.2 mg/kg. It is almost high when compared to WHO limit of 500 mg/kg. Cobalt concentrations in the vegetables were ranged from 1.119 mg/kg to 0.522 mg/kg. Cobalt concentration is high when compared to WHO limit of 0.1 mg/kg. Arsenic concentrations in the vegetables were ranged from 4.306 mg/kg to 0.662 mg/kg. It is high when compared to WHO limit of 0.2 mg/kg. On the other hand, all metals concentrations in the clean farms were below the WHO limits. The study had recommended preventing farmers from using this unknown compost.

Keywords

Compost, Heavy Metals, Vegetables, Autocratic Dumping

1. Introduction

Food quality and safety are global issues [1]. Agricultural products free of chemical contaminants especially heavy metals are important for food safety [1] [2]. Consumption of food products contaminated with metals **(repeated)** may **cause** health risks to people. They are often considered to be toxic-and toxicity depends on the dose of the **toxic** metal, route of exposure, and the nutritional status of the exposed human being [3] [4]. The dangerous **effects** of heavy metals lie in the fact that it tends to be bio-accumulated in **different organs or tissues**. The bioaccumulation of these compounds in living things is due to their speed of taking [5].

Compost is a decomposed organic fertilizer resulting from the fermentation and decomposition of chopped plant residues, animal waste or aerobic garbage [6]. The use of compost as a fertilizer is significant enthusiasm for the soil and for keeping up an appropriate soil structure as well as adding organic matter that is lost due to the practice of intensive agriculture [6] [7]. Among the **possible** negative impacts of applying compost to cropland, are the potential arrival of dangerous metals into the soil, and the exchange of these components from the soil to the food cycle [8]. In order to use compost as a fertilizer it should be free from any Plastic materials, metals and metal objects, Grease, petroleum materials and contaminated materials [8] [9].

Recently, some regions in the West Bank agricultural land have been used as random dumps and landfills for Israeli solid wastes, especially the toxic wastes [10] [11]. Most of these lands are located close to Israeli settlements and beyond the separation wall. This operation is often carried out in coordination with local contractors. The unknown waste, which is transported from the Israeli settlements, is buried in nearby agricultural lands. The dumping waste is not subjected to any waste treatment process or any supervision practice according to international standards [12] The process of environmental pollution that begins with the soil, water, unpleasant smells and bad appearance continue by distributing freely without any charge the compost to the Palestinian farmer in order to empty the landfill for future dumping.

This study investigates the concentrations of metals in soil that was fertilized by polluted unknown compost in Al-Jiftlik region. The study also investigate the concentrations of metals in vegetable crops that were grown on this compost and evaluate their contamination level with respect to food standard guidelines. Vegetables include: Eggplant, Corn, Bell Pepper, Cucumber and Marrow.

Barium, Copper, lead, Thallium, Selenium, Manganese, Cobalt and Arsenic, metals were measured in soil and vegetables. The results were compared to International standards (FAO/WHO) [13]. In addition, pH of the polluted soil was measured and analyzed. The pH value has a direct effect on the soil. It is related to soil properties as cation exchange Capacity, particle size distribution, organic matter content and oxide content. These characteristics have a direct effect on heavy metal accumulation and affect their transfer to crops, vegetables, leaves or other components of the environment [14].

This study has significant importance to locals who consume these vegetables, farmers who plant these vegetables, legislators and relevant fields.

2. Experimental

2.1. Study Area

Al Jiftlik is a Palestinian village in Jericho governorate in the west bank. The village is located (horizontally) 33 km north of Jericho city, its land area is 1242 dunams. The village crosses the main street in the middle and divides it in two halves east and west, latitude of 32˚08'39''N longitude of 35˚29'36''E [15] (**Figure 1**). It is located on the border of the Jordan Valley in the occupied Palestinian territories. The village is bordered by the Jordan River to the East, Marj Al Ghazal village and Tubas Governorate lands to the north. The surrounding villages of Nablus Governorate to the east include Duma, Majdal Bani Fadil, Aqraba to the west and Al Fasayil village to the south. Few kilometers away from Jiftlik are Israeli settlements [15].

2.2. Climate

The area has an arid Mediterranean climate. The mean annual rainfall is 232 mm. The average annual temperature is 22˚C, and the average annual humidity is approximately 49.2% [15].

2.3. Soil Types

Desert alluvial soil was formed as a result of erosion of calcareous silty and clayey materials. This soil type supports herbaceous vegetation of desert annual halophytes and glycophytes and responds well to irrigation, producing various crops, mainly subtropical and tropical fruits, such as citrus, bananas, and dates, as well as winter vegetables. The American great group classifications that represent this soil association are Haplargids and Camborthids [10] [11].

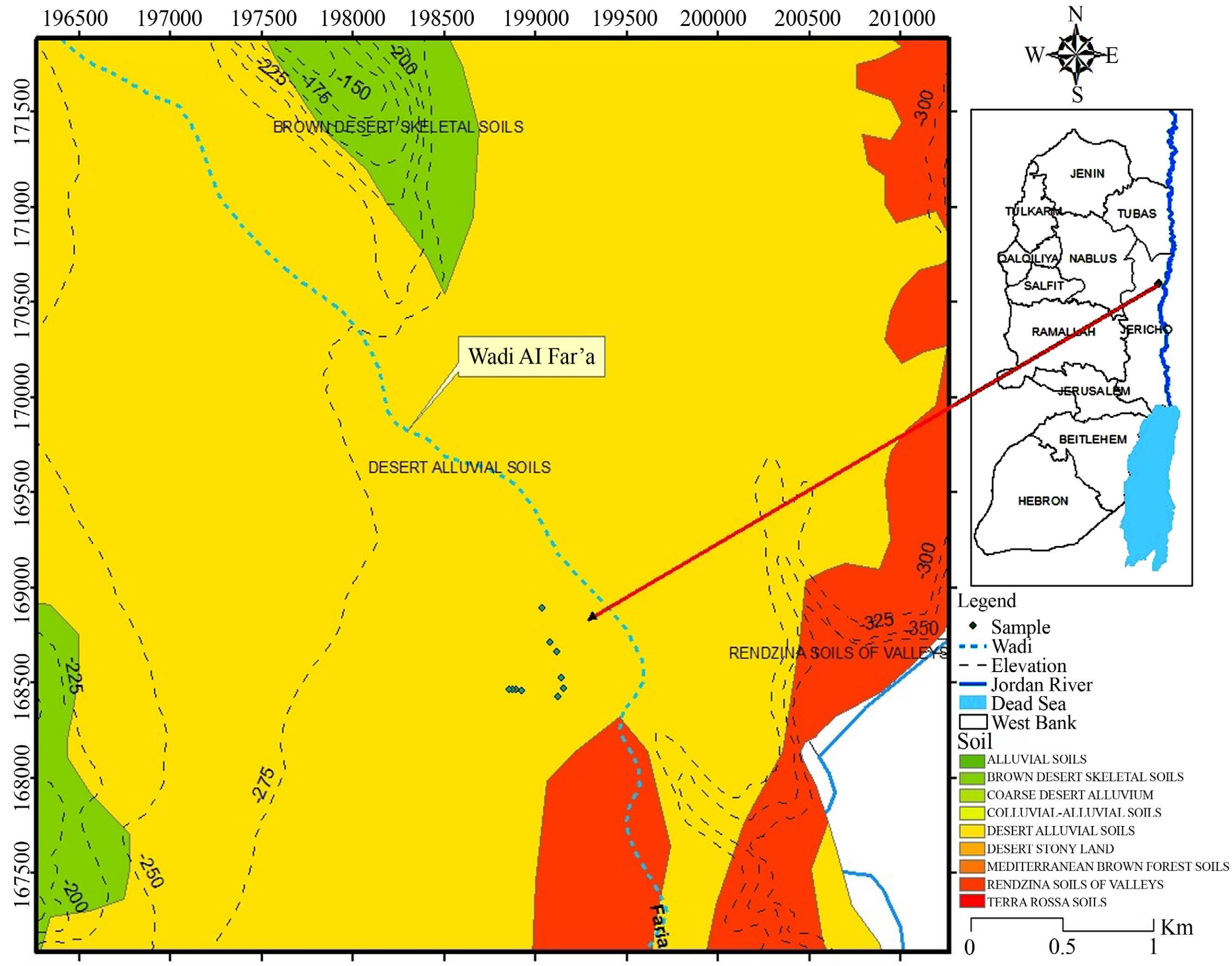

Figure 1. Map of West Bank and topography of the study area Al Jiftlik. Source: GIS laboratory at Al-Quds University. Locations of the sampling sites are indicated.

2.4. Population

According to the Palestinian Central Bureau of Statistics (PCBS), the total population of Al Jiftlik in 2007 was 3714; of whom 1857 were male and 1857, female. There were additionally registered to be 578 households living in 692 housing units [16].

2.5. Economy

The economy in Al Jiftlik depends on several economic sectors, mainly: the agriculture sector, which absorbs 90% of the human workforce. The results of a field survey conducted by ARIJ for the distribution of labor by economic activity Al Jiftlik are as follows [15]:

1) Agriculture Sector (90%);
2) Trade Sector (5%);
3) Israeli Labor Market (3%);
4) Government or Private Employees Sector (2%).

3. Sampling and Analysis

3.1. Soil Sampling

20 soil samples were sampled from both polluted and reference clean locations. Samples were taken from the surface and from the depth of 0 - 30 cm according to the type of vegetables. The coordination and the vegetable type are shown in Table 1. Sampling was done according to the random method [17] for each location as shown in Figure 2. The sampling method includes:

1) A sample from each location (polluted, Reference) was taken from soil, water and vegetables. Vegetables include: Eggplant, Corn, Bell Pepper, Cucumber and Marrow.

2) The representative sample was taken by the identification of circle with a radius of 6 meter (Figure 2).

3) Five cores were sampled inside the 6-meter circle at the surface and at a depth of 0 - 30 cm from all the sites (Figure 2).

4) The five cores were mixed with each other to form a homogeneous represented sample according to each depth, site (polluted, Reference) and the type of vegetables.

5) The representative samples were analyzed in the laboratory.

3.2. Vegetables Sampling

10 representative vegetable samples were taken during November-December 2019, from contaminated and reference vegetables. In addition, in April 2018, three more vegetable samples (Marrow, Eggplant, Bell pepper) were sampled from the same sites.

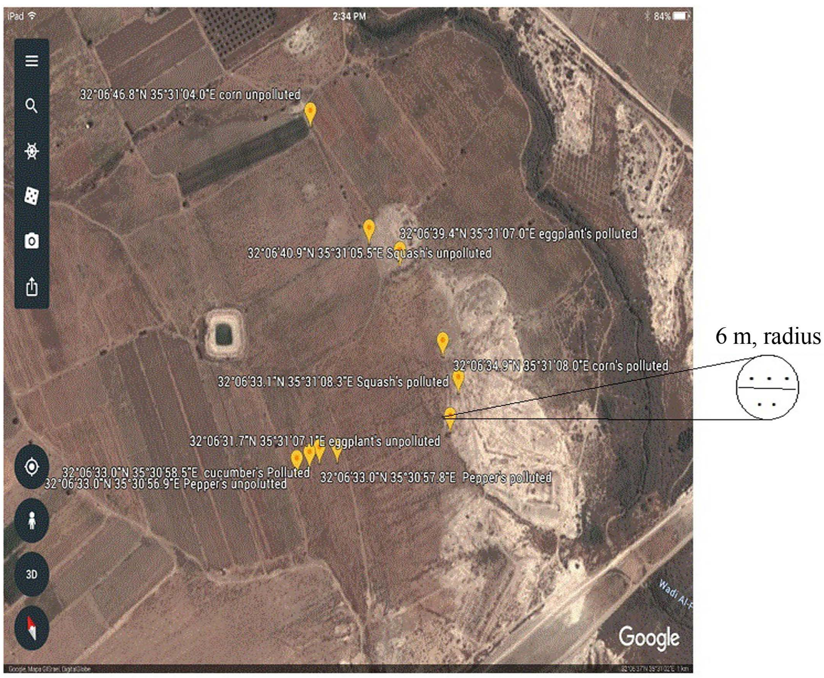

Figure 2. Sampling of polluted and reference soil samples (Google earth, 2019).

Table 1. Heavy metals concentration in soil samples.

Soil samples and depth	Metals Concentration (mg/kg)							
	Ba	Tl	Mn	Co	Cu	As	Se	Pb
Polluted soil from Corn farms, 0 cm	175.962 ± 0.003	11.926 ± 0.182	741.838 ± 0.003	17.934 ± 0.006	17.656 ± 0.026	2.384 ± 0.014	5.860 ± 0.133	12.211 ± 0.041
Polluted soil from Corn farms, 0 - 30 cm	230.295 ± 0.004	12.910 ± 0.019	1075.468 ± 0.004	27.315 ± 0.005	34.870 ± 0.019	3.360 ± 0.016	10.497 ± 0.101	24.106 ± 0.010
Clean soil from Corn farms, 0 cm	15.043 ± 0.001	2.320 ± 0.614	128.587 ± 0.004	4.514 ± 0.015	0.141 ± 0.013	0.017 ± 0.044	0.051 ± 0.170	4.020 ± 0.001
Clean soil from Corn farms, 0 - 30 cm	12.067 ± 0.006	2.144 ± 0.022	94.324 ± 0.011	2.254 ± 0.020	0.133 ± 0.009	0.012 ± 0.047	0.064 ± 0.095	2.955 ± 0.041
Polluted soil from Bell pepper farms, 0 cm	151.793 ± 0.002	22.042 ± 0.786	951.016 ± 0.004	19.056 ± 0.011	12.342 ± 0.077	5.172 ± 0.026	12.871 ± 0.045	34.144 ± 0.065
Polluted soil from Bell pepper farms, 0 - 30 cm	136.639 ± 0.004	11.600 ± 0.003	744.514 ± 0.002	12.197 ± 0.004	10.112 ± 0.050	5.237 ± 0.017	10.536 ± 0.092	22.915 ± 0.019
Clean soil from Bell pepper farms, 0 cm	14.060 ± 0.004	1.234 ± 0.098	109.044 ± 0.004	3.670 ± 0.013	0.082 ± 0.011	0.007 ± 0.024	0.311 ± 0.027	5.344 ± 0.002
Clean soil from Bell pepper farms, 0 - 30 cm	7.848 ± 0.003	0.168 ± 0.057	109.044 ± 0.001	0.369 ± 0.046	0.021 ± 0.004	0.007 ± 0.030	0.066 ± 0.036	5.360 ± 0.002
Polluted soil from Eggplant farms, 0 cm	125.384 ± 0.003	23.200 ± 0.156	478.976 ± 0.003	26.062 ± 0.009	13.709 ± 0.006	6.362 ± 0.024	3.621 ± 0.218	12.651 ± 0.013
Polluted soil from Eggplant farms, 0 - 30 cm	62.641 ± 0.006	16.020 ± 0.056	273.810 ± 0.005	14.655 ± 0.005	7.110 ± 0.019	3.264 ± 0.027	2.781 ± 0.772	10.216 ± 0.051
Clean soil from Eggplant farms, 0 cm	18.050 ± 0.002	1.624 ± 0.020	73.053 ± 0.009	3.931 ± 0.005	0.111 ± 0.014	0.018 ± 0.016	0.406 ± 0.038	2.680 ± 0.020
Clean soil from Eggplant farms, 0 - 30 cm	34.028 ± 0.006	2.320 ± 0.001	145.392 ± 0.002	0.100 ± 0.003	0.031 ± 0.012	0.006 ± 0.055	0.031 ± 0.121	3.350 ± 0.024
Polluted soil from Cucumber farms, 0 cm	103.193 ± 0.005	24.932 ± 0.032	572.315 ± 0.002	11.019 ± 0.008	10.766 ± 0.173	3.423 ± 0.026	7.600 ± 0.067	21.310 ± 0.022
Polluted soil from Cucumber farms, 0 - 30 cm	70.178 ± 0.005	14.243 ± 0.028	545.220 ± 0.002	2.383 ± 0.017	9.000 ± 0.016	1.573 ± 0.019	5.056 ± 0.150	14.402 ± 0.038

Continued

Clean soil from Cucumber farms, 0 cm	7.673 ± 0.003	1.624 ± 0.960	117.524 ± 0.081	4.627 ± 0.009	0.149 ± 0.009	0.010 ± 0.022	0.082 ± 0.028	4.262 ± 0.022
Clean soil from Cucumber farms, 0 - 30 cm	9.124 ± 0.010	2.320 ± 0.920	36.348 ± 0.003	0.433 ± 0.014	0.057 ± 0.013	0.008 ± 0.043	0.084 ± 0.052	2.010 ± 0.080
Polluted soil from Marrow farms, 0 cm	122.875 ± 0.003	13.287 ± 0.124	579.683 ± 0.001	18.219 ± 0.004	33.246 ± 0.035	12.585 ± 0.015	3.894 ± 0.437	17.703 ± 0.026
Polluted soil from Marrow farms, 0 - 30 cm	264.692 ± 0.004	12.959 ± 0.164	1099.454 ± 0.005	24.917 ± 0.009	27.243 ± 0.002	8.427 ± 0.043	8.748 ± 0.148	13.219 ± 0.083
Clean soil from Marrow farms, 0 cm	21.703 ± 0.002	1.777 ± 0.010	105.889 ± 0.002	10.794 ± 0.004	0.182 ± 0.009	0.026 ± 0.029	0.068 ± 0.101	4.212 ± 0.010
Clean soil from Marrow farms, 0 - 30 cm	12.839 ± 0.001	2.320 ± 0.011	81.853 ± 0.190	4.606 ± 0.012	0.096 ± 0.008	0.016 ± 0.071	0.135 ± 0.119	2.680 ± 0.120
FAO/WHO limit (mg/kg)	100	5	437	10	6	0.2	2	10

3.3. Water Sampling

Samples were collected and stored in clean plastic bottles and brought to the laboratory for analysis. Water samples were collected from the wells and the pools that were used for irrigating these vegetables in this region following the reported procedure [18].

3.4. ICP-MS Analysis

3.4.1. Soil Analysis

80 ml of milli-Q water were added to 20 grams of the soil sample. The soil samples were leaved for fourteen days. Then 2 ml of the leachate were taken for analysis [18]. The samples were then analysed for the following metals Ba, Cu, Pb, Th, Se, Mn, Co and As by ICP/MS (Agilent technologies 7500 series). For accurate quantitative determination of heavy metals in water samples, an internal standard method was used using Nd as internal standard and a multi-standard calibration method: 22 metals standard (Ag 10 mg/L, Al 50 mg/L, B 50 mg/L, Ba 10 mg/L, Bi 100 mg/L, Ca 10 mg/L, Cd 10 mg/L, Co 10 mg/L, Cr 50 mg/L, Cu 10 mg/L, Fe 10 mg/L, K 100 mg/L, Li 50 mg/L, Mg 10 mg/L, Mn 10 mg/L, Mo 50 mg/L, Na 50 mg/L, Ni 50 mg/L, Pb 100 mg/L, Sr 10 mg/L, Tl 50 mg/L, Zn 10 mg/L, matrix 5% HNO_3). Samples were prepared by dilution of 1.0 mL of the water samples to 10.0 mL with 0.3% ultrapure nitric acid and analysed by ICP/MS. Each sample was analysed three times and the results are expressed as mean ± SD (SD: standard deviation). Relative standard deviation (RSD) of the three results are calculated and found to be less than 5% for all samples for all

metals analyzed in this study, reflecting the precision the method for the analysis of these heavy metals. Calibration curves for all metals analysed were constructed by plotting the ratio of the intensity of the analyse metal to that of the internal standard (Nd) vs. concentration of the trace metal (in μg/L), and results showed that the calibration curves are linear with correlation coefficient (r^2) greater than 0.999 for the trace metals analysed [18].

3.4.2. Vegetables Analysis

The collected vegetable samples were washed with distilled water to remove dust particles. The samples were cut into small pieces. The vegetables' part was take, and dried in an oven at 50˚C. After drying, the samples were ready for acid digestion. 0.5 grams of the dried vegetable was digested with 5 ml of 65% pure nitric acid using Mars 6 digestive apparatus, until the solution has transparent color. The digested samples were filtered using CA sterile syringe filters that has a diameter of 30 mm and the pore size 0.22 μm [19]. Determination of heavy metals in the filtrate of vegetables was achieved using ICP-MS, as described above.

3.4.3. Water Analysis

Water samples were tested for their content by the addition of 65% pure nitric acid. 2 ml of the sample were taken for analysis. They were analyzed by the use of ICP-MS [18].

3.4.4. pH Soil Analysis

The pH of soil samples was measured after the soil was soaked in water for more than 24 h. pH of the filtrate was measured using a pH meter.

4. Result and Discussion

4.1. Field Soil Samples

The concentrations of heavy metals in soil samples are shown in **Table 1**. Lead concentrations for soils from 0 cm were ranged from 4.020 mg/kg to 5.344 mg/kg. Lead concentrations for samples taken from 0 - 30 cm mixture were ranged from 2.010 mg/kg to 5.360 mg/kg. Lead concentrations in Corn soil, Bell pepper soil, Eggplant soil, Cucumber soil and Marrow soil at 0 cm were 12.211 mg/kg, 34.144 mg/kg, 12.651, 21.310 mg/kg and 17.703 mg/kg respectively. Lead concentrations for the 0 - 30 cm soil samples were 24.106 mg/kg, 22.915 mg/kg, 10.216 mg/kg, 14.402 mg/kg, and 13.219 mg/kg respectively. Lead concentrations in all samples were very high and exceed the limit given by WHO which is 10 mg/kg [13]. Lead is widely used in batteries and many industries. It is clear that the compost does not come from household sources, but it comes from sources that contain high concentration of lead [20]. Lead concentrations for all soil samples from clean soil farms did not exceed the limits given by FAO/WHO [13] (**Table 1**).

Barium concentrations in soil samples (**Table 1**) for the 0 cm soils for Corn soil, Bell pepper soil, Eggplant soil, Cucumber soil and Marrow soil were 175.962

mg/kg, 151.793 mg/kg, 125.384 mg/kg , 103.193 mg/kg and 122.875 mg/kg respectively. Barium concentration for 0 - 30 cm mixture soil samples were 230.295 mg/kg, 136.639 mg/kg, 62.641 mg/kg, 70.178; 264.692 mg/kg respectively. Barium concentration in soil samples was very high and exceeds the limit given by WHO/FAO of 100 mg/kg [13]. It is important to say UDC main source does not come from Animal or Agricultural sources, but it comes from other sources that contain high concentration of Barium. Barium compounds are important pigment industry and paints [21]. Barium is also used in optical glass, ceramics, glazed pottery, glassware and Motor oil detergents [22]. Barium concentrations for all soil reference field samples at 0 cm and 0 - 30 cm did not exceed the limits given by [13] (**Table 1**).

Thallium concentrations in soil samples for Corn soil, Bell pepper soil, Eggplant soil, Cucumber soil and Marrow soil for 0 cm soil samples were 1.926 mg/kg, 22.042 mg/kg, 23.200 mg/kg, 24.932 mg/kg and 13.287 mg/kg respectively. Thallium concentrations in soil samples at 0 - 30 cm soil mixture were 12.910 mg/kg, 11.600 mg/kg, 16.020 mg/kg, 14.243 mg/kg and12.959 mg/kg respectively. These concentrations exceed the limit given by WHO/FAO of 5 mg/kg [13]. Thallium is used in optics, high-density glasses electronics industry and radiation devices [23]. The concentration of Thallium in the clean farms at 0 cm and 0 - 30 cm soil mixtures does not exceed the FAO/WHO limit of 5 mg/kg [13].

Copper concentrations in soil samples for the soil farms at 0 cm was 17.656 mg/kg; 12.342 mg/kg, 13.709 mg/kg, 10.766 mg/kg, 33.246 mg/kg, respectively. Copper concentrations for the 0 - 30 cm soil mixture were 34.870 mg/kg, 10.112 mg/kg, 7.110 mg/kg, 9.000 mg/kg and 27.243 mg/kg respectively (higher than WHO limit of 6 mg/kg [13] [23] (**Table 1**). Copper is used in wires, roofing and plumbing and pipe products (Callister, 2013). The value of copper in clean soil at 0 cm and 0 - 30 cm were very lower than WHO limits for all samples [24].

Manganese concentrations in soil samples (**Table 1**) at 0 cm were 741.838 mg/kg, 951.016 mg/kg, 572.315 mg/kg and 579.683 mg/kg respectively. Manganese concentrations in soil samples at 0 - 30 cm soil mixtures were 1075.468 mg/kg, 744.514 mg/kg, 545.220 mg/kg and 1099.454 mg/kg respectively. The concentration of Manganese exceeds the permissible limit set by WHO/FAO of 437 mg/kg [13]. Manganese is used in alloying, dry cells and paints industry [13] [25]. It is used in quantitative analysis techniques and Medicine. The concentrations of Manganese in the clean soil farm were below the standard limits for all samples [26].

Selenium concentration in soil samples (**Table 1**) were 5.860 mg/kg; 12.871 mg/kg; 3.621 mg/kg; 7.600 mg/kg and 3.894 mg/kg respectively. For the 0 - 30 cm mixture soils were 10.497 mg/kg; 10.536 mg/kg; 2.781 mg/kg; 5.056 mg/kg and 8.748 mg/kg), respectively. These concentrations are higher than FAO/WHO of 2 mg/kg [13]. Selenium is used in photovoltaic photocells, light meters and solar, photoconductive industry and glass industry [27]. The concentrations of Selenium in the clean soil farm were below the standard limits for all samples.

Cobalt concentrations in soil samples at 0 cm were 17.934 mg/kg, 19.56 mg/kg, 26.062 mg/kg; 11.019 mg/kg, 18.219 mg/kg respectively. For the 0 - 30 cm soil samples the concentrations were 27.315 mg/kg, 12.197 mg/kg, 14.655 mg/kg, 7.943 mg/kg and 24.917 mg/kg, respectively. The concentrations are higher than WHO/FAO limits of 5 mg//kg [13]. Cobalt has many applications in industry [28]. The concentrations of Cobalt in the clean soil farm were below the standard limits for all samples.

Arsenic concentrations in soil samples at 0 cm were 2.384 mg/kg, 5.172 mg/kg, 6.362 mg/kg, 3.423 mg/kg and 12.58 mg/kg respectively. Arsenic concentrations in soil from 0 - 30 cm wer 3.360 mg/kg, 5.237 mg/kg, 3.264 mg/kg, 1.573 mg/kg and 8.427 mg/kg, respectively. Arsenic concentrations are higher than WHO/FAO limit of 0.2 mg/kg [13]. Arsenic is used in semiconductor and microchip industry. The concentrations of Arsenic in the clean soil farm were below the standard limits for all samples.

4.2. Heavy Metals Concentration in Vegetable Samples

The concentrations of heavy metals in vegetable samples are shown in **Table 2**. Lead concentrations in Corn soil, Bell pepper, Eggplant, Cucumber and Marrow that were fertilized by the compost were 0.900 mg/kg, 0.530 mg/kg; 1 mg/kg, 0.453 mg/kg and 0.549 mg/kg, respectively. Lead concentrations in vegetables exceeded the WHO limit of 0.3 mg/kg [13] [29]. Lead concentrations in Corn soil, Bell pepper, Eggplant, Cucumber and Marrow in clean farms were 0.070 mg/kg, 0.091 mg/kg, 0.035 mg/kg, 0.089 mg/kg and 0.084 mg/kg. These concentrations are below the permissible limits. The concentrations of Barium in the vegetables were 1.398 mg/kg, 1.855 mg/kg, 3.021 mg/kg, 0.850 mg/kg and 2.641 mg/kg respectively. Barium concentrations in these vegetables exceeded the WHO limit of 0.850 mg/kg [13]. Barium concentrations in the vegetables that were grown in the clean farms were below the permissible limits (**Table 2**). The concentrations of Thallium in the vegetables that were fertilized by the compost were 2.350 mg/kg, 1.215 mg/kg, 2.608 mg/kg, 1.608 mg/kg and 2.986 mg/kg respectively. Thallium concentrations in vegetables exceeded the WHO limit of 0.3 mg/kg [13]. Thallium concentrations in the vegetables that were grown in the clean farms were below the permissible limits. The concentrations of Copper in the Corn, Bell pepper, Cucumber and Marrow vegetables that were fertilized by the compost were 59.586 mg/kg, 56.772 mg/kg, 50.527 mg/kg, 63.842 mg/kg respectively. Copper concentrations in these four vegetables exceeded the WHO limit of 40 mg/kg [13]. Copper concentration in the Eggplant sample was 23.049 mg/kg below the permissible limits. Copper concentrations in the vegetables that were grown in the clean farms were below the permissible limits (**Table 2**). Manganese concentrations in Corn soil, Bell pepper, Eggplant, Cucumber and Marrow that were fertilized by the compost were 825.301 mg/kg, 463.743 mg/kg, 795.835 mg/kg, 499.792 mg/kg, and 446.196 mg/kg. Manganese concentrations in these vegetables are very close or even exceeded the WHO limit of 500 mg/kg [13] [30]. Manganese concentrations in the vegetables that were grown in the

Table 2. Heavy metals concentration in vegetables samples.

Vegetables type	Metals Concentration (mg/kg)							
	Ba	Tl	Mn	Co	Cu	As	Se	Pb
Corn from polluted farm	1.398 ± 0.001	2.350 ± 0.009	825.301 ± 0.001	0.204 ± 0.012	59.586 ± 0.001	0.662 ± 0.006	0.550 ± 0.064	0.900 ± 0.001
Corn from clean farm	0.133 ± 0.001	0.154 ± 0.022	21.114 ± 0.012	0.082 ± 0.001	2.493 ± 0.003	0.162 ± 0.017	0.061 ± 0.015	0.070 ± 0.001
Bell pepper from polluted farm	1.855 ± 0.002	1.215 ± 0.009	463.743 ± 0.001	0.537 ± 0.012	56.772 ± 0.001	2.677 ± 0.018	0.408 ± 0.050	0.530 ± 0.002
Bell pepper from clean farm	0.321 ± 0.001	0.081 ± 0.017	30.276 ± 0.001	0.027 ± 0.013	1.540 ± 0.002	0.103 ± 0.017	0.014 ± 0.126	0.091 ± 0.001
Eggplant from polluted farm	3.021 ± 0.003	2.608 ± 0.012	795.835 ± 0.025	0.917 ± 0.009	23.049 ± 0.002	4.306 ± 0.003	0.348 ± 0.114	1.000 ±0.003
Eggplant from clean farm	0.226 ± 0.004	0.139 ± 0.032	46.808 ± 0.017	0.068 ± 0.007	6.245 ± 0.001	0.049 ± 0.024	0.076 ± 0.015	0.035 ±0.004
Cucumber from polluted farm	0.850 ± 0.006	1.608 ± 0.033	499.792 ± 0.005	0.522 ± 0.003	50.527 ± 0.001	1.591 ± 0.023	0.417 ± 0.041	0.453 ±0.006
Cucumber from clean farm	0.253 ± 0.001	0.250 ± 0.031	88.271 ± 0.001	0.083 ± 0.007	7.366 ± 0.001	0.113 ± 0.008	0.056 ± 0.038	0.089 ± 0.001
Marrow from polluted farm	2.641 ± 0.003	2.986 ± 0.006	446.196 ± 0.001	1.119 ± 0.004	63.842 ± 0.002	3.798 ± 0.015	0.348 ± 0.108	0.549 ± 0.003
Marrow from clean farm	0.073 ± 0.002	0.160 ± 0.021	3.154 ± 0.001	0.057 ± 0.001	5.487 ± 0.035	0.088 ± 0.012	0.028 ± 0.032	0.084 ± 0.002
FAO/WHO limit (mg/kg)	0.85	0.3	500	0.1	40	0.2	0.3	0.3

clean farms were below the permissible limits (Table 2). The concentrations of Selenium in the vegetables that were fertilized by the compost were 0.550 mg/kg, 0.408 mg/kg, 0.348 mg/kg, 0.417 mg/kg and 0.348 mg/kg respectively. Selenium concentrations in vegetables exceeded the WHO limit of 0.3 mg/kg [13]. Selenium concentrations in the vegetables that were grown in the clean farms were below the permissible limits. The concentrations of Cobalt in Eggplant, Bell pepper, Cucumber and Marrow vegetables that were fertilized by the compost were 0.537 mg/kg, 0.917 mg/kg, 0.522 mg/kg, 1.119 mg/kg respectively. Cobalt concentrations in these four vegetables exceeded the WHO limit of 0.1 mg/kg [31] [32]. Cobalt concentrations in the Corn samples were below the permissible limits. Cobalt concentrations in the vegetables that were grown in the clean farms were also below the permissible limits (**Table 2**). Arsenic concentrations in Corn soil, Bell pepper, Eggplant, Cucumber and Marrow vegetables that were fertilized by the compost were 0.662 mg/kg, 2.677 mg/kg, 4.306 mg/kg, 1.591 mg/kg, 3.798 mg/kg, respectively. Arsenic concentrations in these vegetables exceeded the WHO limit of 0.2 mg/kg [13] [31] [32]. Arsenic concentrations in the vegetables that were grown in the clean farms were below the permissible limits (**Table 2**).

4.3. Heavy Metals Concentration in Water Used for Irrigation

The concentration of lead, cobalt, copper, Arsenic, Selenium, Barium in Agricultural water Pools were 0.042 mg/kg, 0.118 mg/kg, 0.163 mg/kg, 0.051 mg/kg, mg/kg, 0.052 mg/kg and 0.317 mg/kg respectively. The concentration of these metals in the Wells were 0.064 mg/kg; 0.034 mg/kg, 0.062 mg/kg, 0.042, 0.047 mg/kg and 0.307 mg/kg respectively). All of these values are below the WHO limit of 2.236 mg/kg, 0.224 mg/kg, 0.447 mg/kg, 0.316 mg/kg, 0.141 mg/kg, 1 mg/kg for lead, cobalt, copper, Arsenic, Selenium and Barium respectively [18]. Thalium metal was not detected in this water. Manganese was approximately equal to WHO limit of 0.447.

4.4. pH of Soil Samples

The pH of soil samples ranges between 7.15 and 8.05. There is no clear relation between compost farms and pH values. Soil pH was basic for all clean and compost soil farms.

5. Conclusion

From the present study, it can be concluded that heavy metals concentrations in soil and vegetables are very high when compost is applied as a fertilizer. Heavy metals concentrations are above the recommended levels of the WHO/FAO limit. Clearly, the compost is largely composed of industrial wastes. This kind of compost should not be used as fertilizer because of its high content of heavy metals.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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