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Characteristics of mineralogical composition and heavy metals in vegetable cultivation land in the Van Noi - Tien Duong (Dong Anh) and Dai Thinh (Me Linh) areas, Ha Noi city

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ABSTRACT

The green vegetable belt for Hanoi city extended in Thanh Tri, Gia Lam, Dong Anh and Me Linh districts, is providing daily thousands of tons of green vegetables for the city. Previously there were some studies on the distribution of heavy metals in the suburbs of Hanoi, including in the Dong Anh area, but the results were limited. Thus the study of material composition and heavy metal distribution in vegetable lands in the Van Noi - Tien Duong area (Dong Anh) (one of the critical vegetable growing areas in the suburbs of Hanoi) and Dai Thinh area (Me Linh) has been selected to contribute to the scientific basis for the production of safe vegetables for the study area. The authors used traditional research methods (Field trip investigation) and modern methods (X-Ray, ICP-EOS and AAS) to show that the soil developed in these areas is rich in quartz. The soil, therefore, has relatively good ventilation and drainage but still ensures the necessary moisture for plants, suitable for the cultivation of short-term vegetables. At the time of the study, vegetable cultivation land in Tien Duong - Dong Anh and Dai Thinh - Me Linh has generally not been polluted by most the heavy metals, excepting the signs of Pb, Cu pollution at a deficient level in some sites. In addition, vegetable cultivation land in Van Noi - Dong Anh has been polluted with typical heavy metals, such as arsenic (As) and lead (Pb). Measures are needed to minimize and progressively eliminate pollution to ensure safe vegetable production.

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1. Introduction

Heavy metals are generally defined as metals and metalloids with relatively high densities (A density of more than 5 g/cm3 is often mentioned as a typical heavy metal representing factor). Some heavy metals are either essential nutrients (for example, iron, cobalt and zinc) or relatively harmless (such as ruthenium, silver and indium) but can be toxic in larger amounts or specific forms. Other heavy metals, such as cadmium, mercury and lead, are highly poisonous to biota in general and human beings in particular (Fergusson, 1990).

For cultivated land in general and vegetable land in particular, in addition to the threat of pesticide pollution, the soil quality also dramatically affects the quality of vegetables and fruits. Heavy metals and other toxic components can be accumulated in leaves and fruits by plants; when the concentrations exceed the allowable levels, they will be harmful to humans and animals (Tchounwou et al., 2012). Therefore, special attention must be paid to their content in the soil and concerning the quality and safety of the food chain.

The green vegetable belt in the North of Hanoi is located in Gia Lam, Dong Anh and Me Linh districts, playing an important role in providing food for the inner city. Every day, thousands of tons of green vegetables from vegetable-growing regions are supplied to the city, including famous localities such as Le Chi (Gia Lam), Van Noi - Tien Duong (Dong Anh) and Dai Thinh (Me Linh).

Research on soil and water environment related to agricultural production has also begun to be attended over the past decades such as (Pham and Nguyen, 2004; Nguyen and Duong, 2007; Nguyen and Le, 2009; Nguyen et al., 2009; Dang and Nguyen, 2011). Many other types of research carried out on the pollution status affected the food chain in Vietnam, including safe vegetable food sources in Hanoi. Still, most of the projects focused on surface water and soil chemical only. Starting from the 2000s, (Vu and Pham, 2004; Nguyen, 2005) researched the distribution of heavy metals in soil, water and vegetables in some localities in the suburbs of Hanoi. Results of Pham et al. (2006) indicate that the soil and surface water and groundwater in some areas also have signs of pollution. However, the results are only used in studying the current state of pollution regarding environmental management. No more profound research on mineralogical composition or soil environments has been conducted.

Stemming from that facts, studying the soil mineralogical and chemical composition and pollution status of some key vegetable production areas around Hanoi is one of the most crucial tasks. The study proposes solutions to reduce soil pollution and rational planning of agricultural land for the development safe vegetable belt in Hanoi to serve environmental protection and public health. With the sponsorship of the Hanoi University of Mining and Geology for the project T20 - 30 and the project "Study on soil environmental geochemical characteristics of the safe vegetable cultivation areas in Dong Anh and Gia lam districts, Hanoi City" of the Institute of Natural Resources and Environment (Vietnam Union of Sciences and Technologies Associations - VUSTA), the authors conducted a field survey, collected and analyzed samples to determine the mineralogical and chemical composition of the soil, to assess soil quality in vegetable planting areas in Van Noi - Tien Duong (Dong Anh) and Dai Thinh (Me Linh) to serve the planning of safe vegetable production regions in Hanoi. We will present the initial research results in this paper.

2. Research methods

2.1. Field trip investigation

We selected study areas located in the Van Noi and Tien Duong (Dong Anh) and Dai Thinh (Me Linh) communes, belonging to the green vegetable belt north of the Hanoi inner city (Figure 1). These are famous vegetable and fruit growing areas, providing hundreds of tons of vegetables and fruits for the inner city every day.

The research team conducted field surveys, focusing on the Van Noi - Tien Duong communes (Dong Anh) and Dai Thinh commune (Me Linh) and collected soil, water and vegetable samples according to the survey transects. Tens of holes were dug along these transects. Samples were taken at the wall of the digging holes (Figure 2)

with various depths from 0.6÷1.2 m, depending on the structure of the soil layers.

The chemical composition of the studied samples was determined by the Inductively Coupled plasma - optical emission spectrometry Method (ICP - EOS) and atomic adsorption method (AAS) to determine the content of heavy metals in soil. Collected data processed, synthesizing analysis results, compared with Vietnamese environmental standards (Vietnam National Standard, 2015; Industry Standard, 2008). There is also a reference to foreign standards (Canadian Environmental Guideline, 2003) to assess soil, water and vegetable pollution in the study area.

2.2. Lab works

The collected samples are processed as follows: soil is dissolved by distilled water, using a 0.1 mm sieve to separate soil grains into two batches: (1) the coarse-grained batch (>0.1 mm) collected to determine mineralogical composition under the stereo-optical microscope and (2) the fine batch (<0.1 mm) was dried before sending to analyze the mineral and chemical composition.

Figure 1. Location of studied areas.

Figure 2. Typical soil profiles in Van Noi and Dai Thinh areas.
(a) Imperial gray soil developed on the sediments of the Vinh Phuc Formation in the Dam Village, Van Noi (Dong Anh); (b) Imperial gray soil developed on the sediments of the Vinh Phuc Formation in the Noi Dong Village, Dai Thinh (Me Linh).

The soil environment geochemical parameters of pH, Eh, Ec are measured using the HANA Hi 98120 meter for pH and the SDL100 meter to determine the Eh, Ec indices.

The mineral composition of soil samples was determined in two ways: The mineral composition of the raw part (>0.1 mm) was studied under stereo-microscope while those of fine-grained batch by X-Ray analysis and Scanning Electronic Microscopy.

A total of 21 soil samples were selected to determine the mineralogical composition of the fine-grained batch. These samples include different soil types (color, particle size) and the fine particles send for analysis at the analytical Center of the General Department of Geology and Minerals. The results will be presented below.

3. Results and Discussion

The characteristics of vegetable cultivation land in the studied areas.

3.1. Distribution characteristics of soil

The field survey results show that vegetable land in the two study areas is often distributed in high field spills with good drainage capacity. Most of the land for vegetable cultivation in the two study areas is of unfertile grayish soil developed on the sediments of the Vinh Phuc Formation. The soil profiles have distinct zoning layers: the uppermost part of a gray silty clay layer, poor organic matter (unfertile discolored soil), overlying and clayish products with patchy spots. In some sites, the soil profile includes washed layers mainly composed of light gray sand-powder (Figure 2). These layers are different in color and grain and mineral composition.

The analysis of the grain size component indicates that in the upper part of the soil profile, the coarse grain composition (>0.1 mm) often accounts for a large proportion, sometimes up to 70÷80%. The fine-grain batch (<0.1 mm) accounts for a higher proportion in the lower part, but rarely over 50%.

3.2. Soil mineral composition

The analysis of the grain size of the soil samples, as mentioned above, shows that the coarse grain composition often plays a major role (accounting for more than 80% of the soil mass). Especially in the infertile soils originating from the sediments of Vinh Phuc Formation, the proportion of coarse grain batch in some samples accounts for up to 80%.

Analysis results under the stereomicroscope showed that the main mineral components of the coarse batch are quartz (accounting for more than 80%) and iron hydroxide/oxide (goethite, hydro - goethite).

The X-ray analysis results of the fine-grain batch (particle size <0.1 mm) are shown in Table 1.

Table 1 indicates that the main mineral composition of this fine-grained batch is also quartz (accounting for 47÷87%), followed by hydromica (illite - accounting for 4÷23%) and kaolinite (5÷13%). The minor minerals include goethite, lepidocrocite, montmorillonite/chlorite, hematite, feldspar, etc. The common presence of quartz in the soil will reduce the soil's ability to store nutrients. Meanwhile, it also reduces the risk of soil pollution. Because quartz is an inert mineral, it is doubtful to adsorb heavy metals and other pollutants, so the soil is less likely to be contaminated.

On the other hand, soil with many quartzes will have relatively good air permeability and drainage. Thus, it is convenient to wash out polluting components, promoting to clean the soil, but still likely ensure to keep the necessary soil moisture for crops and vegetables. In addition, clay minerals such as illite and chlorite/ montmorillonite can absorb and retain the toxins to contribute a small proportion. Therefore, the initial works on the mineral composition in the soil show that the soil in the study area is quite suitable for the production of safe vegetables.

3.3. Heavy metal concentration in the soil

Seventy-six soil samples were collected and determined the composition of heavy metals in vegetable cultivation soil in study areas. Its process is carried out according to the related standard (Collected after TCVN 7538 - 2: 2005) (ISO 10381 - 2: 2002) (Processed according to TCVN 6647: 2007 (11464: 2006)). The samples were sent for analysis at the experimental analysis center of the General Department of Geology and Minerals. Analysis results are presented in Tables 2, 3 and 4.

Table 1. X-ray Analytical results of soil samples collected from Van Noi - Tien Duong (Dong Anh) and Dai Thinh (Me Linh) areas.

Sample Number	Mineralogical composition (~%)						
	Illite	Kaolinite	Chlorite/Mont	Quartz	Feldspar	Goethite	Other Minerals
VN01/1	4÷6	4÷6	4÷6	78÷80	3÷5	3÷5	Talc
VN01/2	5÷7	5÷7	4÷6	70÷72	4÷6	3÷5	Am, Bo
VN05/1	5÷7	4÷6	4÷6	74÷76	3÷5	6÷8	Lep
VN05/2	9÷11	9÷11	4÷6	58÷60	3÷5	8÷10	-
VN10/1	4÷6	4÷6	4÷6	78÷80	3÷5	3÷5	-
VN10/2	7÷9	7÷9	4÷6	66÷68	3÷5	4÷6	-
VN16/1	4÷6	4÷6	4÷6	77÷79	3÷5	4÷6	-
VN16/2	9÷11	9÷11	4÷6	61÷63	3÷5	5÷7	-
VN18/1	5÷7	4÷6	4÷6	80÷82	4÷6	-	-
VN18/2	4÷6	5÷7	4÷6	73÷75	3÷5	2÷4	Lep, He
VN19/1	4÷6	4÷6	4÷6	79÷81	2÷4	3÷5	-
VN19/2	6÷8	5÷7	4÷6	71÷73	3÷5	2÷4	Talc
TD01/2	-	5÷7	-	87÷89	-	2÷4	Gyp, Lep
TD09/2	-	4÷6	-	82÷84	1÷3	6÷8	Am
TD12/2	-	4÷6	2÷3	85÷87	ít	4÷6	Am
ĐT 01/2	16÷18	5÷7	6÷8	48÷50	5÷7	4÷6	Am, Gyp
ĐT 02/2	4÷6	4÷6	4÷6	72÷74	1÷3	6÷8	Am, Lep
ĐT 04/3	4÷6	4÷6	4÷6	72÷74	3÷5	4÷6	-
ĐT 06/2	4÷6	5÷7	4÷6	72÷74	3÷5	3÷5	Am
ĐT 07/2	6÷8	9÷11	4÷6	61÷63	3÷5	5÷7	Am, Lep
ĐT 08/2	14÷16	11÷13	4÷6	48÷50	3÷5	7÷9	-
ĐT 10/2	6÷8	7÷9	4÷6	70÷72	-	5÷7	-
ĐT 12/2	-	5÷7	-	85÷87	-	4÷6	Am
ĐT 19/1	21÷23	3÷5	7÷9	47÷49	4÷6	4÷5	Am, Gyp, Do

Note:VN: Van Noi; TD: Tien Duong; DT: Dai Thinh; Am: Amphibol; Mont: Montmorillonit; Bo: Boemite; Gyp - Gypsum; Lep: Lepidocrocite; He: Hematite.

Table 2. The concentration of heavy metals in soil samples from the Van Noi area.

TT	Sample Number	The concentration of heavy metals (mg/kg)																
		Ag	As	Ba	Be	Cd	Co	Cr	Cu	Mo	Ni	Pb	Sb	Sn	Zn	Se	Tl	Hg
Analytical Method				(ICP - EOS) TCNB: 01 - ICP/04										(AAS) QT ĐQ.06 - HTNT/05				
1	VN01/1	0.4	11.2	62.3	0.6	0.8	4.9	38.8	7.0	< 1	5.5	59.9	6.7	9.6	19.6	0.03	0.01	< 0.02
2	VN01/2	0.5	29.3	166.8	0.7	0.9	12.2	82.3	8.2	< 1	15.3	75.7	3.6	14.0	42.8	0.02	0.02	< 0.02
3	VN02/1	0.5	19.5	103.0	0.7	0.7	7.4	45.6	13.7	< 1	8.2	64.0	6.5	16.0	31.5	0.07	0.03	< 0.02
4	VN02/2	0.6	12.7	151.7	0.9	0.7	13.4	70.9	5.7	< 1	15.4	76.6	12.3	10.6	32.6	0.02	0.01	< 0.02
5	VN03/1	0.4	12.1	59.0	0.5	0.8	4.2	36.2	10.0	< 1	4.5	64.7	6.0	7.7	30.6	0.13	0.02	< 0.02
6	VN03/2	0.9	24.4	143.6	0.7	0.5	11.9	69.9	8.5	< 1	13.1	71.8	18.8	11.1	29.4	0.02	0.01	<0.02
7	VN04/1	0.6	13.2	98.6	0.7	0.8	8.0	44.6	25.6	< 1	7.5	73.2	< 5	17.0	74.1	0.19	0.03	<0.02
8	VN04/2	0.1	22.0	125.5	0.6	0.8	9.5	67.2	3.9	< 1	10.7	58.9	< 5	10.6	24.2	0.02	0.01	<0.02
9	VN05/1	0.5	12.9	120.4	0.6	0.6	5.9	49.6	10.6	< 1	5.4	75.7	10.0	10.6	38.6	0.24	0.03	<0.02
10	VN05/2	0.8	27.8	388.8	0.8	0.8	20.9	81.3	22.9	< 1	13.4	79.2	10.8	33.2	39.9	0.11	0.12	0.02
11	VN06/1	0.5	19.8	82.0	0.7	0.7	5.7	44.2	21.0	< 1	7.1	74.7	11.2	12.1	37.6	0.10	0.01	< 0.02
12	VN06/2	0.5	23.7	258.6	1.4	0.8	23.3	92.5	15.5	< 1	34.8	77.4	7.5	8.6	64.4	0.03	0.01	<0.02
13	VN07/1	0.9	23.4	130.7	0.8	0.9	9.5	60.8	29.9	< 1	11.8	84.2	3.1	19.0	90.6	0.23	0.03	0.02
14	VN07/2	0.9	12.9	198.0	0.8	1.0	12.0	82.1	2.4	< 1	15.6	67.9	9.8	13.5	44.6	0.02	0.01	0.02
15	VN08/1	0.6	18.9	85.0	0.8	0.7	7.8	42.8	14.3	< 1	6.7	68.6	9.9	8.6	47.2	0.11	0.02	< 0.02
16	VN08/2	0.3	26.8	175.9	0.9	0.7	14.9	82.0	8.8	< 1	24.0	75.4	12.2	13.5	52.0	0.03	0.01	0.02
17	VN09/1	0.5	15.3	87.8	0.7	0.7	7.3	42.4	16.8	< 1	5.3	64.6	5.8	13.1	36.1	0.06	0.03	0.02
18	VN09/2	0.4	28.8	245.0	1.1	0.9	15.9	84.0	6.7	< 1	25.1	74.3	8.2	13.0	51.9	0.03	0.01	< 0.02
19	VN10/1	0.6	16.8	89.4	0.7	0.8	7.1	42.2	24.7	< 1	6.9	65.1	8.2	14.5	50.6	0.12	0.03	0.02
20	VN10/2	0.5	27.8	182.2	1.0	0.7	12.1	79.1	6.1	< 1	18.2	73.8	5.2	13.0	44.7	0.03	0.01	0.02
21	VN11/1	0.9	19.3	123.7	0.8	0.8	8.9	51.8	18.6	< 1	9.9	64.7	10.4	9.1	68.9	0.15	0.03	< 0.02

22	VN11/2	0.8	22.8	176.5	0.8	0.7	13.5	72.9	17.1	< 1	18.9	69.0	6.8	15.0	76.9	0.03	0.02	0.02
23	VN12/1	0.7	19.8	111.1	0.8	0.8	9.0	47.2	19.5	< 1	7.9	73.4	5.8	20.0	62.8	0.20	0.04	<0.02
24	VN12/2	0.9	25.5	172.6	0.9	0.8	15.0	66.5	12.5	< 1	14.4	82.5	5.4	5.7	37.8	0.05	0.03	<0.02
25	VN13/1	0.7	12.8	93.1	0.7	1.1	9.0	49.6	14.6	< 1	8.1	66.2	8.7	18.0	36.1	0.07	0.01	<0.02
26	VN13/2	0.6	25.0	199.5	0.8	0.7	15.4	86.7	12.8	< 1	19.3	75.5	13.1	8.1	52.1	0.03	0.02	0.02
27	VN14/1	0.6	18.7	103.0	0.7	0.6	8.0	46.1	18.9	< 1	8.0	72.5	5.5	19.0	58.4	0.22	0.03	<0.02
28	VN14/2	0.9	12.2	97.2	0.8	0.6	9.6	52.5	2.4	< 1	9.2	67.0	9.0	16.0	22.3	0.02	0.01	0.02
29	VN15/1	0.6	14.4	81.9	0.6	0.7	6.7	44.3	12.2	< 1	4.7	80.5	3.8	16.0	42.8	0.13	0.04	< 0.02
QCVN03:2015		-	15.0	-	-	1..5	-	150.0	100.0	-	-	70.0	-	-	200.0	-	-	-
CCME		-	12.0	700	-	1.4	40.0	64.0	63.0	-	-	70.0	20,0	5,0	200.0	-	1,0	6,6
Note: Sample with sign/1: Sample from upper layer; sign /2: sample from lower layer; QCVN: National Standard 03 - MT: 2015/BTNMT; CCME: Canadian Environmental Guideline.																		

Table 3. The concentration of heavy metals in soil samples from the Tien Duong area.

TT	Sample Number	The concentration of heavy metals (mg/kg)															
		Ag	As	Ba	Be	Cd	Co	Cr	Cu	Mo	Ni	Pb	Sb	Se	Sn	Tl	Zn
1	TD 01/1	0.1	6.8	73.6	3.5	0.2	14.6	31.9	21.5	0.4	6.9	19.7	5.2	4.6	4.3	5.0	56.8
2	TD 01/2	0.3	9.1	61.7	3.7	0.1	32.6	36.1	13.9	0.6	6.1	9.6	5.2	4.5	4.1	4.7	21.6
3	TD 02	0.2	15.0	454.0	4.5	0.4	20.4	89.4	40.9	0.6	43.4	27.5	4.3	3.7	4.0	3.9	119.4
4	TD 03	0.3	11.7	124.3	4.3	0.5	16.0	45.7	25.4	0.6	12.8	29.2	4.4	3.5	3.7	3.7	40.0
5	TD 04/1	0.5	9.4	83.0	4.7	0.5	21.1	34.9	26.9	0.8	10.3	20.3	3.6	4.2	3.9	9.7	46.0
6	TD 04/2	0.7	8.5	106.3	3.9	0.6	13.9	57.5	16.6	0.7	16.9	13.9	4.2	4.1	4.5	4.6	35.6
7	TD 05/1	0.5	9.8	66.2	4.2	0.4	24.8	24.7	19.1	1.3	5.1	10.0	4.1	4.5	4.7	8.7	42.7
8	TD 05/2	0.6	9.2	114.1	4.4	0.5	12.4	44.0	14.1	1.4	8.6	8.4	4.4	4.7	4.5	4.9	26.8
9	TD 06/2	0.6	8.1	99.2	4.0	0.5	11.9	44.3	16.8	0.9	9.1	10.1	4.6	4.3	4.2	4.7	21.3
10	TD 09/1	0.5	5.5	93.3	3.9	0.6	32.1	33.2	28.1	1.5	12.0	24.3	4.5	4.4	4.3	3.8	57.3
11	TD 09/2	1.0	7.5	68.9	4.7	0.8	10.4	38.4	255.5	1.4	8.7	19.7	3.8	4.2	3.9	3.6	20.3
12	TD 10/1	0.4	11.3	87.0	4.5	0.3	12.7	32.6	29.0	0.7	7.4	17.6	3.9	3.5	4.4	4.4	56.4
13	TD 10/2	0.5	6.0	108.4	4.2	0.6	11.4	42.3	25.9	0.8	8.3	14.6	4.5	4.4	3.7	4.5	22.2
14	TD 12/1	0.3	10.2	112.8	4.1	0.2	13.1	41.8	45.2	0.6	11.1	19.2	4.5	4.6	3.6	3.5	71.4
15	TD 12/2	0.4	6.4	100.1	3.8	0.3	11.4	42.3	28.4	0.7	10.0	19.9	4.0	3.8	3.6	3.7	27.9
16	TD 14/1	0.2	4.5	59.7	4.2	0.1	11.8	24.6	19.9	0.4	4.4	12.6	4.2	4.7	3.9	4.5	31.0
17	TD 14/2	0.3	10.0	123.7	4.3	0.3	12.7	49.3	11.9	0.6	10.3	8.4	4.3	4.5	3.6	3.2	27.3
18	TD 16/1	0.7	8.8	95.4	4.6	0.7	13.4	30.7	30.7	1.4	8.6	25.7	3.5	4.6	3.9	3.1	55.3
19	TD 16/2	0.8	5.7	62.5	4.7	0.9	12.0	30.6	15.1	1.5	5.7	9.8	3.7	3.6	4.3	4.5	18.6
20	TD 18/1	0.1	6.0	73.6	3.1	0.3	13.6	27.1	22.7	0.7	6.0	13.2	4.5	3.9	4.4	8.8	46.0
21	TD 18/2	0.3	6.9	117.6	3.2	0.4	16.5	45.9	14.4	0.9	9.0	7.2	4.6	4.3	4.5	3.7	27.2
22	TD 20/1	0.4	7.1	83.6	4.4	0.2	13.2	34.6	27.0	1.1	7.3	16.7	4.1	4.2	4.9	4.1	43.6
23	TD 20/2	0.5	6.0	130.0	4.5	0.4	12.7	58.8	14.8	1.2	12.8	14.3	4.3	4.6	4.6	4.2	30.5
QCVN 03: 2015		-	15	-	-	1.5	-	-	100	-	-	70	-	-	-	-	200
CCME		20	12	750	4	1,4	40	64	63	5	-	70	20	1	5	1	200
Note: Sample with sign/1: Sample from upper layer; sign /2: sample from lower layer; QCVN: National Standard 03 - MT: 2015/BTNMT; CCME: Canadian Environmental Guideline																	

Table 4. The concentration of heavy metals in soil samples from the Dai Thinh area.

Order	Sample Number	The concentration of heavy metals (mg/kg)															
		Ag	As	Ba	Be	Cd	Co	Cr	Cu	Mo	Ni	Pb	Sb	Se	Sn	Tl	Zn
Analytical Method				ICP - TCNB: 01 - ICP/04										AAS - QT ĐQ.06 - HTNT/05			
1	ĐT1/1	0.7	9.3	87.1	3.7	0.2	13.2	25.7	25.4	1.2	7.2	22.5	5.0	3.7	4.2	4.5	50.3
2	ĐT1/2	0.9	13.9	204.7	4.2	0.1	16.5	71.1	30.3	1.3	23.6	14.3	4.1	4.4	4.0	4.7	35.1
3	ĐT2/1	-	14.7	-	-	1.1	16.8	117.3	46.2	6.2	66.3	20.5	8.7	3.5	4.3	-	71.7
4	ĐT2/2	0.5	15.1	296.5	4.1	0.0	24.3	64.1	29.1	1.7	14.8	65.8	4.4	4.5	4.4	3.7	43.6
5	ĐT3/2	1.2	9.7	171.7	4.0	0.1	14.2	38.3	18.9	1.5	14.0	12.0	4.5	4.2	3.9	4.2	22.9
6	ĐT07/2	0.6	11.3	210.7	4.5	0.0	35.0	56.7	27.9	0.9	29.1	33.9	4.7	4.9	4.7	4.4	59.3
7	ĐT08/1	0.5	10.5	107.8	3.9	0.2	10.7	24.4	17.5	0.7	6.2	16.0	4.2	3.9	4.2	4.1	33.8
8	ĐT08/2	0.4	12.1	226.3	4.6	0.1	22.3	49.3	23.8	1.4	14.3	25.9	3.9	3.6	4.5	3.9	26.4

9	ĐT09/1	0.6	14.9	160.4	4.4	0.2	15.1	32.4	53.3	1.2	9.1	74.9	18.9	4.4	3.7	4.7	68.4
10	ĐT09/2	0.7	9.7	168.0	4.7	0.2	14.8	37.2	20.3	1.6	9.8	17.9	4.5	4.2	3.5	4.5	42.5
11	ĐT10/2	0.5	7.6	145.2	4.3	0.2	15.3	48.4	15.7	0.8	11.9	22.9	4.7	4.5	4.4	4.4	23.7
12	ĐT11/2	0.4	12.5	152.7	3.5	0.1	12.3	54.4	21.4	1.7	11.1	12.0	4.4	4.6	4.5	4.2	28.5
13	ĐT12/1	0.4	5.7	80.5	3.7	0.1	10.4	17.4	13.2	1.5	3.4	10.2	4.5	4.1	4.7	3.8	20.1
14	ĐT12/2	0.6	7.1	90.6	4.6	0.1	10.1	34.9	15.4	1.4	8.1	8.6	4.0	4.0	4.2	4.1	16.7
15	ĐT14/1	0.7	9.2	128.8	4.5	0.2	10.0	25.4	26.7	1.2	6.6	22.4	4.6	4.7	4.1	4.2	49.8
16	ĐT14/2	0.5	8.3	101.1	4.7	0.1	9.9	38.7	17.1	1.1	10.6	8.8	4.5	3.9	4.6	4.0	17.8
17	ĐT16/1	0.9	5.8	86.2	4.1	0.1	10.1	26.9	23.2	1.0	7.3	15.5	4.7	3.7	4.4	4.5	69.2
18	ĐT16/2	0.5	7.3	133.5	4.0	0.0	16.5	50.7	17.8	1.8	16.9	14.6	4.2	4.4	4.5	4.6	24.9
19	ĐT18/1	0.5	8.5	117.8	4.2	0.2	28.5	30.4	31.4	1.5	10.1	18.0	3.7	4.5	3.7	4.5	64.8
20	ĐT18/2	0.6	6.4	73.9	3.9	0.0	10.9	27.9	13.7	1.4	7.1	12.2	4.2	4.7	4.2	4.9	16.3
21	ĐT19/1	-	12.2	-	-	0.15	23.7	130.1	94.4	6.2	66.3	62.3	20.8	-	27.7	-	184.1
22	ĐT19/2	0.4	9.7	107.1	4.4	0.0	23.6	45.4	16.3	0.7	14.0	12.8	4.4	4.2	4.4	4.7	24.3
23	ĐT20/1	0.5	8.3	88.0	4.5	0.1	19.3	27.2	26.4	1.2	8.3	14.4	4.5	4.3	4.5	4.2	64.2
24	ĐT20/2	0.7	7.5	102.8	4.1	0.0	15.9	42.8	15.8	1.6	12.9	12.9	4.7	4.6	4.2	3.9	21.5
QCVN 03:2015			15.0			1.5		150.0	100.0			70.0					200.0
CCME			12.0	700		1.4	40.0	64.0	63.0			70.0	20.0	5.0	5.0	1	200.0
Note: Sample with sign/1: Sample from upper layer; sign /2: sample from lower layer; QCVN: National Standard 03 - MT: 2015/BTNMT; CCME: Canadian Environmental Guideline.																	

The results of soil composition analysis in the study area are compared with national standards on soil environment (Vietnam National Standard, 2015) to assess pollution levels of heavy metals (As, Cd, Cu, Pb and Zn) in the study area. Some indicators not included in QCVN 03-MT: 2015/BTNMT (Sb, Co, Mo, Hg, Se, Tl and Sn) are compared according to Canadian Standards (Canadian Environmental Guideline, 2003): concentration of heavy metals in soil. The comparison (Normalized) results of vegetable soil samples in the Van Noi - Tien Duong area (Dong Anh) are in Figure 2; those of the Dai Thinh (Me Linh) area are in Figure 3.

It can be seen that in vegetable cultivation land in the Van Noi - Tien Duong area, the concentrations of analyzed heavy metals in the soil are generally lower than those of permitted thresholds (Vietnam National Standard, 2015). However, the content of Pb and Cu in some samples became higher than the standard. In Tien Duong, only one of the analyzed samples has a heavy metal that exceeded the threshold (Cu content of the sample TD-09/2 is 2.5 times higher than the reference standard). The As concentration in the soil samples in Van Noi and Tien Duong shows a clear differentiation. For example, the samples in Tien Duong have lower As concentrations than the comparing standard from several to dozens of times. On the contrary, the soil samples in Van Noi have higher As content than the referred standard from one to several times, which means the vegetable soil in Van Noi is As polluted. More details are studied for the causes of the apparent differences in As levels of vegetable cultivated land in two adjacent areas. One of the reasons may be the high As content in groundwater (water wells used to water vegetables). The abuse of high arsenic content pesticides for vegetables may be another reason.

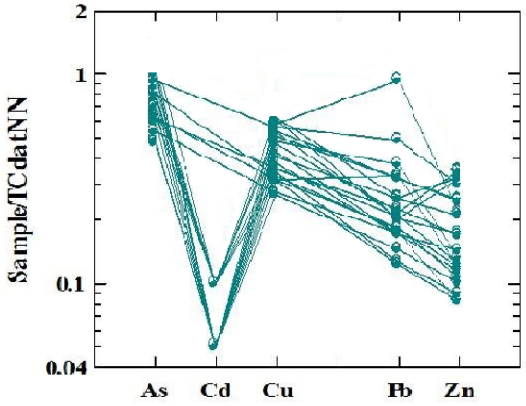

Figure 3. Diagram normalized heavy metal contents of vegetable cultivate land in the Dai Thinh area to those of QCVN 03 - MT 2015/BTNMT (As, Cd, Cu, Pb, Zn).

Unlike the Van Noi - Tien Duong area, in the Dai Thinh area, the results of heavy metals in vegetable cultivate land showed that when comparing heavy metals in soil samples with those of Vietnamese standards (Vietnam National Standard, 2015) (Figure 3), in general, the concentration of elements As, Cd, Cu, Pb, Zn in the soil is lower than the permitted threshold (for Pb,

one sample exceeds the standard at a low level (> 1 time)).

Hence, the above-mentioned heavy metals had not contaminated the cultivated land in Dai Thinh (Me Linh).

We have referred to the Canadian Environmental Guideline for a more comprehensive view of the heavy metal distribution profile in soil samples in the study area (Canadian Environmental Guideline, 2003).

The results show that the content of some heavy metals had exceeded the permitted threshold, such as As, Pb and Sn. The tin content exceeded the comparison standard in all analyzed samples. Some soil samples had Sn content ten times higher than the comparison standard (Figure 4).

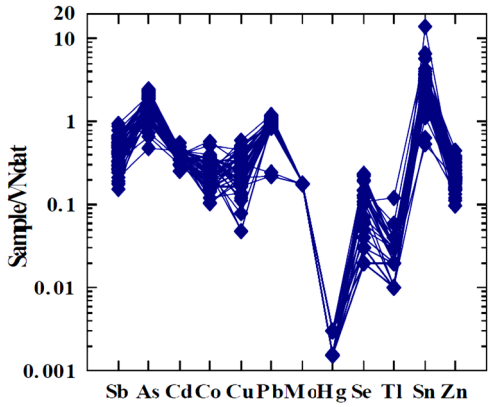

Figure 4. Normalised Diagram of heavy metal content in vegetable soils in the study area against Canadian Soil Environmental Standards (Canadian Environmental Guideline, 2003).

4. Conclusion and Recommendation

From the analysis of soil samples for vegetable cultivation land in Van Noi - Tien Duong (Dong Anh) and Dai Thinh (Me Linh) areas, the authors have some initial conclusions as follows:

- The soil for vegetable cultivation land in the two above areas has the mineral composition of the coarse-grained batch, mainly quartz. In addition to quartz, there are illite, kaolinite, chlorite and some other minerals in fine-grained batches. The presence of a large amount of quartz in the soil will reduce the risk of soil pollution. The soil has relatively good air ventilation and water drainage but still keeps the necessary moisture. This soil is quite suitable for short-term fruit and vegetable cultivation.

- Vegetable land in Tien Duong and Dai Thinh has not been polluted by As, Cd and Zn. However, in the Tien Duong area, there is an expression of Cu pollution (one out of 23 samples); in the Dai Thinh area, there is a sign of Pb pollution (one out of 24 samples), both of which are polluted at very low levels. Therefore, the land for vegetable cultivation in these two areas can still produce safe vegetables.

- Cultivation land in Van Noi (Dong Anh) has not been polluted by Cd, Cu and Zn. However, the soil here shows As and Pb pollution. Besides, it is worth noting the spike in the concentration of some metals such as Sn.

Overcoming the current pollution situation and eliminating the pollution in the future, it is necessary to take the following measures:

- Properly managing the use and storage of pesticides, expanding propagation and mobilizing people to build a clean vegetable project by strictly observing the regulations on the appropriate and safe use of pesticides.

- Conducting a regular inspection of the discharge into the water environment in the areas of factories, enterprises and entertainment areas in the study area; strictly managing and punishing objects that do not comply with the regulations on environmental protection.

- Minimizing and terminating the use of groundwater (drilled wells) to irrigate vegetables, causing wastefulness and loss of precious water resources for the daily life of local people and surrounding areas.

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Author contributions

Manuscript is prepared by Vinh Thi Dang; Manuscript is commented and edited by Giang Khac Nguyen; Analytical results of soil samples were tested by Minh Hong Thi Tran; Typical soil profiles were described by Nhan Thi Tran; Diagrams were made by Quyen Xuan Pham.

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