

Accumulation of lead and cadmium in vegetables and farmland near Hoa Khanh industrial zone, Da Nang city

Vo Van Minh^{1,*}, Nguyen Van Khanh¹, Dam Minh Anh¹, Tran Duy Vinh²

¹Danang University, 459 Ton Duc Thang, Da Nang, Vietnam

²Okayama University, Japan

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Abstract. Farmland around industrial zones is generally polluted by the emission of heavy metal from factories. Thus the farmland can potentially cause negative accumulation of heavy metal in soil and in vegetables. Hoa Khanh industrial zone where many factories are now located, has led to adverse impacts on environment and habitats. The result from the scientific research has presented that concentration of lead in soil in Hoa Khanh Bac and Hoa Hiep Nam ward has been not yet polluted, but cadmium content is from 1.92 to 2.37 times higher than Vietnamese standard. Alternatively, heavy metal (Pb, Cd) content in spinach (*Impomea aquatic* Forrsika) shows that it is approximately the allowed limit; concentration of heavy metal in cabbage (*Brassica juncea* L. Czern. et Coss) is over, somewhere up to 18.7 times within Pb, up to 3.4 times within Cd, compared to the standard. The results of analytical correlation between heavy metal concentration in soil and vegetables are in a range from “weak correlation” to “strong correlation”. The results of this research are expected to provide significant data for both environment and vegetable management aspects.

Keywords: Accumulation, heavy metal, *Impomea aquatic*, *Brassica juncea*.

1. Introduction

Heavy metal pollution in soil and vegetable is the significant issue which has received much attention of society for its danger to human health. Some recent studies have indicated that the heavy metal concentration of the areas near industrial zones were high [1-3].

Hoa Khanh industrial zone is one of the biggest industrial zones of Danang City where many factories of electronic manufacturing,

metallurgy, engineering, textiles, packaging products are now located. These factories are hence threatening to influence negatively on soil environment of nearby regions. In this paper, we present the result of the study on the extent of heavy metal (Cd, Pb) pollution in soil and the residue accumulation in spinach and cabbage, alternatively on the correlation between heavy metal concentration in soil and in botanical species. These data are extremely necessary for environmental management and food safety in the locality.

* Corresponding author. Tel: 84-905234706.

E-mail: vominhdn@gmail.com

2. Research objects and methods

Research objects in this research are lead (Pb) and cadmium (Cd), heavy metals with high toxicity in farmland and in 2 species, including spinach (*Impomea aquatica* Forrsika) and cabbage (*Brassica juncea* L. Czern. et Coss).

In this study, we conducted to collect soil and vegetable samples at 6 points which are representative of research sides in Hoa Hiep Nam and Hoa Khanh Bac ward, Lien Chieu district, Danang City. It should be noticed that these areas have been negatively affected by discharging activities of Hoa Khanh industrial zone [2,4].

Vegetable samples are collected randomly from beds of vegetables at the same time - one day before harvesting. The soil samples are simultaneously taken at 10 – 15 cm depth of the topsoil. The mixture of $H_2SO_4 + H_2O_2 + HNO_3$ was used to transfer all of vegetable and soil samples into inorganic solution in which concentration of Pb and Cd analyzed by the

method of atomic absorption spectroscopy (AAS) in the laboratory of Meteorological and Hydrological stations of the Central Region of Vietnam.

Data is processed by statistical methods and comparison of the average value by Anova (Analysis of variance) with significant level $\alpha = 0.05$. Values of determining correlation coefficient are transformed with the formula $x' = \log(x+10)$.

3. Results and discussion

3.1. Concentration of Pb and Cd in vegetable-planting soil

To evaluate the pollution levels of Pb and Cd in soil, we conducted collection of soil samples within 6 points in topsoils in Hoa Khanh Bac and Hoa Hiep Nam in the wet season (MM) and the dry season (MK). The analytical results are revealed in table 1.

Table 1. Concentration of Pb and Cd in vegetable-planting soil

	Location	Concentration	
		Pb (mg/kg) (n = 3)	Cd (mg/kg) (n = 3)
Hoa	Wet season	8.36 ± 3.44	4.23 ± 0.92
Khanh	Dry season	33.97 ± 5.43	3.99 ± 0.96
Bac	Average (n = 6)	21.12 ± 8.17	4.13 ± 0.20
Hoa	Wet season	30.88 ± 5.52	4.62 ± 2.18
Hiep	Dry season	35.76 ± 6.23	4.73 ± 1.54
Nam	Average (n = 6)	33.32 ± 3.45	4.67 ± 0.08

The result of Anova analysis shows that there is significant difference between 2 sample-collecting stages in Hoa Khanh Bac area, specifically, concentration of Pb is 8.36 ± 3.44 mg/kg in the wet season, is $33,97 \pm 5,43$ mg/kg in the dry season. In Hoa Hiep Nam area, the fluctuation of concentration of Pb in

soil between 2 stages is insignificant, within Pb content 30.88 ± 5.52 mg/kg at the wet season, 35.76 ± 6.23 mg/kg at the dry season.

Comparing to Vietnamese standard QCVN 03:2008/BTNMT about concentration level of Pb allowed in agricultural soil (≤ 70 mg/kg)

indicated that Pb concentration in Hoa Khanh Bac and Hoa Hiep Nam are in the allowed limitation. Collating to the result of Phan Thi Thuy Hang's research within concentration of heavy metals at some areas at Thai Nguyen city where the Pb content ranged from 2.52 to 3.16 mg/kg, the result of Pb concentration in this study is from 6.67 to 13.18 times as high as Pb content in soil at some areas at Thai Nguyen city [2].

Yet Cd content in soil in the wet season significantly differs from the analytical results at the dry season ($\alpha = 0,05$). Specifically, in comparison to the standard QCVN 03: 2008/BTNMT about concentration allowed in agricultural land (≤ 2 mg/kg) illustrates that, Cd content in vegetable-farming land greater than the limited level from 1.92 to 2.00 times in Hoa Khanh Bac, from 2.31 to 2.37 times in Hoa

Hiep Nam. Comparing to the result of Vo Van Minh's research in Hoa Hiep which showed that Cd content in soil was in a range from 0.11 – 0.12 mg/kg. Therefore, there is an increase of Cd content in soil at some areas near Hoa Khanh industrial zone. Cd content in this study in comparison with as the research of Vo Van Minh done in 2006 [4] is from 35.78 to 40.47 times higher.

3.2. Concentration of Cd and Pb in spinach

Contaminating heavy metals in vegetable is a problem that producers and consumers particularly pay attention. In order to evaluate the level of heavy metal accumulation (Pb, Cd) in spinach in Hoa Khanh Nam and Hoa Hiep Bac, we analyzed concentration of Pb and Cd in spinach species, the specific results are showed in table 2.

Table 2. Concentration of Pb and Cd in spinach

Location	Concentration	
	Pb (mg/kg) (n = 3)	Cd (mg/kg) (n = 3)
Hoa Khanh Bac		
Wet season	0.82 ± 0.27	0.012 ± 0.005
Dry season	1.69 ± 0.48	0.027 ± 0.014
Average (n = 6)	1.26 ± 0.59	0.019 ± 0.010
Hoa Hiep Nam		
Wet season	0.75 ± 0.13	0.008 ± 0.002
Dry season	1.13 ± 0.35	0.033 ± 0.017
Average (n = 6)	0.94 ± 0.28	0.021 ± 0.017

The result from table 2 show that there is a significant difference between 2 seasons ($\alpha = 0.05$). Specifically, Pb content in spinach in Hoa Khanh Bac, is 0.82 ± 0.27 mg/kg in the wet season, is 1.69 ± 0.48 mg/kg in the dry season; in Hoa Hiep Nam, Pb content results 0.75 ± 0.13 mg/kg at the wet season, 1.13 ± 0.35 mg/kg at the dry season. In comparison to the allowed standard (≤ 0.1 mg/kg), Pb content in spinach planted at some farmland areas is over, up to 1.26 times in Hoa Khanh Bac and

up to 1.14 times in Hoa Hiep Nam. Compare with the research study of Phan Thi Thu Hang (2006), the Pb content in spinach samples in Hoa Khanh Bac and Hoa Hiep Nam is from 2.55 to 3.40 times higher than Pb content in spinach at some areas at Thai Nguyen city [2].

Regarding Cd, the results from Anova analysis show that Cd content in spinach in Hoa Khanh Bac differ from the analytical result in Hoa Hiep Nam ($\alpha = 0,05$). Specifically, Cd content at Hoa Khanh Bac, is $0,012 \pm 0,005$

mg/kg at the wet season, is 0.027 ± 0.014 mg/kg at the dry season; concentration of Cd in Hoa Hiep Nam is 0.008 ± 0.002 mg/kg at the wet season, is 0.033 ± 0.017 mg/kg at the dry season. As comparison to allowed limitation ($\leq 0,02$ mg/kg), concentration average of 2 stages is approximate. Comparing to Vo Van Minh's research result (2006) indicated that there is a considerable increase of Cd content in

vegetables at some areas near Hoa Khanh industrial zone [4].

3.3. Concentration of Pb and Cd in cabbage

The result of Pb and Cd content in cabbage in Hoa Khanh Bac and Hoa Hiep Nam is illustrated in table 3.

Table 3. Concentration of Pb and Cd in cabbage

Location		Concentration	
		Pb (mg/kg) (n = 3)	Cd (mg/kg) (n = 3)
Hoa	Wet season	0.96 ± 0.51	0.034 ± 0.014
Khanh	Dry season	1.78 ± 0.14	0.068 ± 0.013
Bac	Average (n = 6)	1.37 ± 0.58	0.051 ± 0.024
Hoa	Wet season	1.24 ± 0.16	0.013 ± 0.002
Hiep	Dry season	1.87 ± 0.63	0.080 ± 0.008
Nam	Average (n = 6)	1.55 ± 0.44	0.046 ± 0.017

As the result in table 3 showed, the difference between Pb content in cabbage at the wet season and the dry season is relatively clear ($\alpha = 0,05$) at two research sites. Specifically, Pb content in cabbage collected at the wet season is greater than cabbage samples collected at the dry season within 1.85 times in Hoa Khanh Bac and 1.50 times in Hoa Hiep Nam. It can be observed that Pb content in cabbage samples is over the standard ($\leq 0,1$ mg/kg) within from 9.65 to 17.88 times in Hoa Khanh Bac and from 12.47 to 18.70 times in Hoa Hiep Nam.

In cases of Cd, its concentration in cabbage has showed a significant difference between two seasons at both of two research sites, particularly, Cd in cabbage at the dry season is greater than cabbage planted at the wet season, up to 2 times at Hoa Khanh Bac, up to 6.15 times in Hoa Hiep Nam. Comparing to the allowed limit (≤ 0.02 mg/kg) shows that Cd

content in cabbage is over, from 1.70 to 3.40 times at Hoa Khanh Bac, up to 6.15 times at some research points in Hoa Hiep Nam. Collating to the result of Vo Van Minh (2006) which presented 0.008 ± 0.004 mg/kg Cd in cabbage at Hoa Hiep (previously), the result of this study indicates that Cd in cabbage planted in the farmland in Hoa Khanh Bac approximately 6.46 times greater than, in Hoa Hiep Nam 5.82 times greater than. Therefore, there is an appreciable increase of Cd content in vegetable in the regions near Hoa Khanh industrial zone.

Both of two research species, spinach and cabbage, at two research sites indicated signs of unsafe vegetable. Thus, utilizing the above vegetables as food demand is able to influence negatively on the health of the local people and the people living near this region.

3.4. Correlation between concentration of Pb, Cd in soil and in spinach, cabbage

From research results of previous studies as of Phan Thi Thuy Hang (2006), Vo Van Minh (2006), Pham Ngoc Thuy et al. (2006) which showed that concentration of heavy metals in soil correlates linearly with plants grown on the

topsoil which contaminated by heavy metals [2,3]. So as to determine the relationship between Pb and Cd content in soil with in botanical species at research sites, correlation between heavy metals (Pb, Cd) in soil with spinach and cabbage was calculated and the analytical result is described in figure 1 and 2.

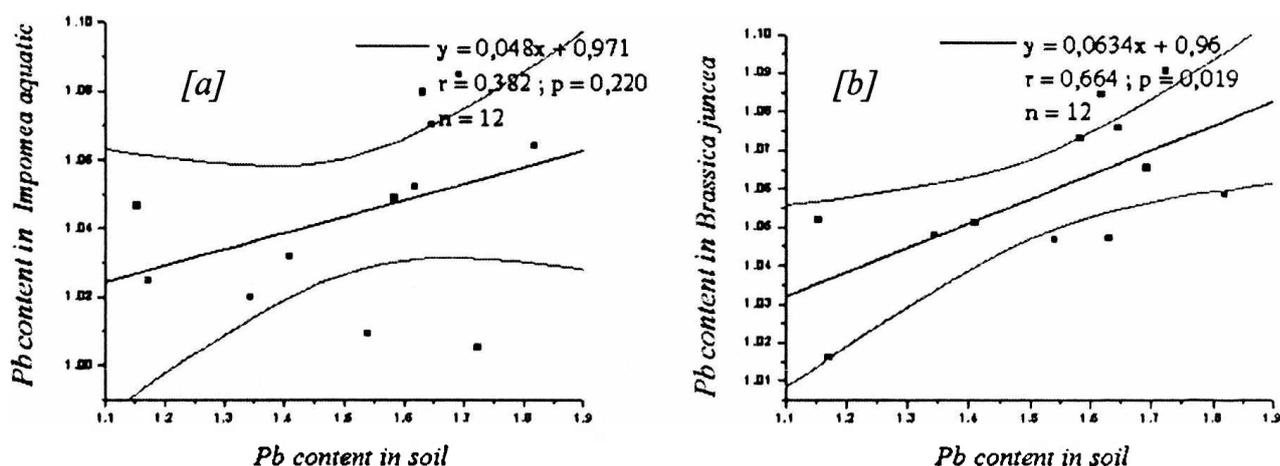


Figure 1. The correlation between Pb content in spinach and cabbage with Pb content in soil. [a]: spinach (*Impomea aquatic* Forrsika), [b]: cabbage (*Brassica juncea* L. Czern. et Coss).

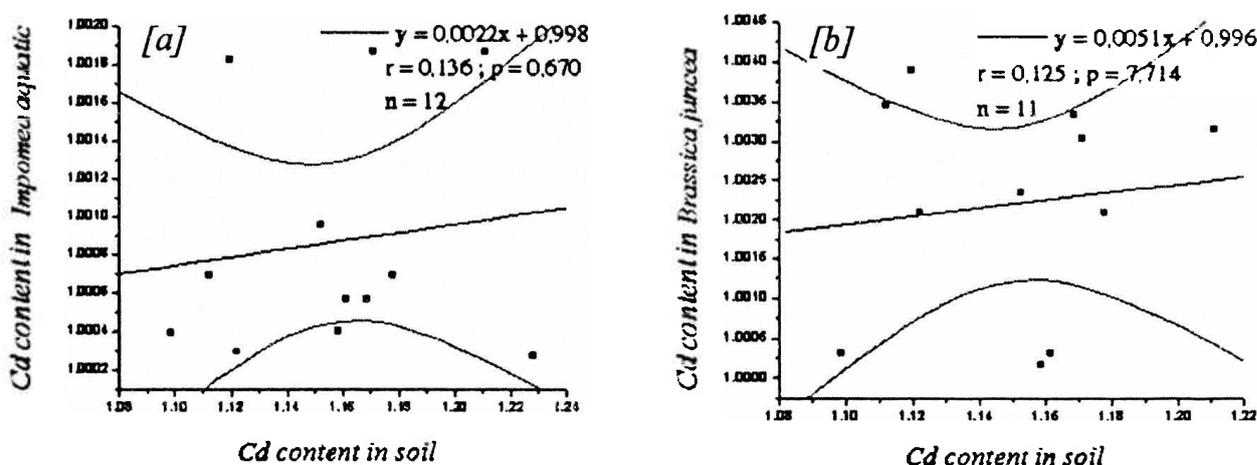


Figure 2. The correlation between Cd content in spinach and cabbage with Pb content in soil. [a]: spinach (*Impomea aquatic* Forrsika), [b]: cabbage (*Brassica juncea* L. Czern. et Coss).

The analytical result shows that Pb content in soil is positively correlative with Pb content in spinach and cabbage, specifically, the correlation between Pb content in soil correlates in medium level with coefficient $r = 0.38$ ($p_{\text{value}} = 0.22$) within Pb content in spinach, in strong level with coefficient $r = 0.66$ ($p_{\text{value}} = 0.02$) within Pb content in cabbage. Alternatively, Cd content in soil also indicates linear relationships with Cd content in spinach and cabbage, however, the level is weaker than the correlation of Pb metal in soil and in species. Specifically, Cd in soil is in positive correlation with Cd content in spinach with coefficient $r = 0.14$ ($p_{\text{value}} = 0.67$), Cd in boroccoli with coefficient $r = 0.13$ ($p_{\text{value}} = 7.71$).

A study of Bui Cach Tuyen et al (1995) on accumulation of heavy metals in agricultural product and indicated that correlation coefficient of heavy metals in soil and in broccoli (*Brassica oleracea*) is 0.12 within Pb and 0.99 within Cd [5]. On the other hand, the study of Vo Van Minh (2006) illustrated the correlative level between Cd content in soil and in mustard species are in difference levels; strong correlation ($r = 0.999$) within cabbage, medium correlation ($r = 0.50$) within sweet mustard (*Brassica integrifolia* (West.) O.E. Schulz). The differences of correlation coefficient among studies are able to explain by capacity of heavy-metal accumulation which depends on many factors, such as mechanism of heavy-metal anabolism in plant, pH of environment, quantity of heavy metals in soil and irrigated water, age of plants, and type of heavy metals, ion exchanging capacity, soil texture and etc [3, 4].

4. Conclusion

1. The analytical results have indicated that concentration of Pb is not polluted in Hoa Khanh Bac and Hoa Hiep Nam. However, both of two research sites have signs of pollution, comparing the allowed limitation showed that Cd content in soil is from 1.92 to 2.37 times higher than the standard.

2. Both of two species, spinach and cabbage at research sites, have signs of pollution within concentration of heavy metals (Pb, Cd). In spinach, heavy metals are approximately with the allowed limit, but in cabbage, concentration of heavy metals is over, from 9.65 times to 18.7 times within Pb, from 1.7 to 3.4 times within Cd.

3. Concentration of heavy metals in soil correlates linearly with concentration of heavy metals in two botanical species, spinach and cabbage. Specifically, Pb content in soil correlates in medium level ($r=0.38$) within Pb content in spinach, in strong level ($r = 0.66$) within Pb content in cabbage. On the other hand, correlative level between Cd content in soil and Cd content in spinach, cabbage are low. Thus cultivating and managing suitably use of spinach and cabbage is extremely necessary in order to control safety of vegetables.

References

- [1] Nguyen Thi Ngoc An, Duong Thi Bich Hue (2006), Current situation of heavy metal pollution in vegetables in suburb areas of Ho Chi Minh City, *Science – Technology magazine*, Vol.10, No.01(2007).
- [2] Phan Thi Thu Hang, *Study on Nitrate and heavy metal concentration in soil, water, vegetables and methods to mitigate their accumulation in*

- vegetables in Thai Nguyen*, Doctoral thesis, Thainguyn University, 2006.
- [3] Pham Ngoc Thuy et al, Existing situation of heavy metals (As, Hg, Pb, Cd) in soil, water, and some vegetables in Dong Anh district, Ha Noi City, *Magazine of Agricultural Science and Technology*, Vol. 4(2006) 162-168.
- [4] Vo Van Minh, Concentration of Cadmium in some Brassicaceae species and farmland in Hoa Hiep ward, Lien Chieu district, Danang City, *Journal of Science-Vietnam National University*, Vol. 26 (2006) 98-100.
- [5] Bui Cach Tuyen, Research results on residues of agricultural chemicals and heavy metal concentrations in agricultural and land in some areas in the region of Ho Chi Minh city, Lam Dong province, Tien Giang province, Ninh Thuan province, *Scientific Journal of agricultural and forestry* (1995) 26-29.
- [6] Shashank Sharma and F.M. Prasad, Accumulation of lead and cadmium in soil and vegetable crops along Major Highways in Agra (India), *E-Journal of Chemistry* 7(4) (2010) 1174-1183.