CHAPTER VI

CONCLUSION, DISCUSSION AND RECOMENDATIONS

6.1 Conclusion

Results of field survey and interview farmers in 2010 showed that there were three water sources were used for irrigating vegetables which are water from ponds (taken water from canals, ditches source from Cau river), well water (groundwater) and tap-water. Water resource is mainly provided by Cau river through the system of ponds and canals. Specifically, 100 percent of the respondents used irrigation water from Cau river. 9.33 percent of the households used well water while 10.67 percent used tap-water for vegetable irrigation.

Farmers in the study area have used a large amount of water to irrigate vegetables during cultivation process with an average of 1.91 liters per square meter per day. This farming operation is related to the addition of substances into the environment of cultivated soil.

Farmers have tradition and experiences of vegetable production. They have been participated in many training courses about vegetable cultivation, methods of using pesticides and fertilizers, and participated in training classes about IPM (Integrated Pest Management) and GAP (Good Agriculture Practices). Farmers used only pesticides and fertilizers that were allowed by the government or ones which government officials recommended for using.

Generally, the amount of fertilizers which farmers applied low rate of fertilizer for vegetables in Tuc Duyen ward, depending on production condition and economic condition of each household. Most farmers fertilized based on their experiences even though many farmers have been through training. In three important types of chemical fertilizers (nitrogen, phosphorus, potassium), growers only noticed nitrogen fertilizer, followed by phosphorus fertilizer, majority households did not use potassium.

Animal manure was used very little in vegetable production in the study area. Some households used fresh animal manure water or compost to fertilize their vegetables. The animal manures are mainly chicken and pig manures.

In addition, to prevent pest damage on the vegetables, the vegetable growers applied plant protection chemical especially for bitter melon. The vegetable growers used various types of pesticides at a high rate.

Lead (Pb) content in irrigation water samples for selected vegetables in the research area is still in the permissible limit of FAO/WHO (0.1 mg/l). However, there were 5 irrigation water samples of 5 bitter melon fields in the southern region of Tuc Duyen ward (Chua hamnet) have lead (Pb) content increased suddendly and exceeded the permitted standard. As results of the irrigation water source there was polluted by waste water source discharged from commercial and residential area in Thai Nguyen city's market area.

Lead (Pb) content in vegetables samples is about 3.1 times compared to allowed standard. Lead (Pb) content in vegetable samples of three research vegetables was polluted at a high level. Comparing the content of Pb in vegetables found that jute had the highest lead (Pb) content, followed by bitter melon and basella alba. In addition, there was a favorable/corresponding correlation between Pb accumulation in cultivated soils for plating three selected vegetables and Pb accumulation in selected vegetables.

The lead (Pb) content in soil was still in the permitted standard. However, lead (Pb) content in cultivated soil was close to the threshold content (average content of Pb is 65.49 mg/kg). Lead (Pb) content in soil for jute production is the highest, followed by bitter melon and basella alba.

Cd content in irrigation water samples for selected vegetables in the study area is still in the permissible limit. Bitter melon fields which planted in southern region of Tuc Duyen ward (Chua hamlet) were still in permitted standard (average of 0.005 mg/litre). Waste water source from the Thai Nguyen market area at the time of analysis is not infected with Cd accumulation. One main reason for low Cd content in water samples is the time of analysis of research was observed in rainy season.

Research results also showed Cd content in vegetables samples in research area was higher than the permissible limit and polluted at a high level. Average Cd content in samples of vegetables is 0.131 mg/kg, equivalent to 4.37 times compared to allowed standard (0.03 mg/kg). Cd content in vegetable jute is the highest, followed by basella alba, and bitter melon.

Cd contents in cultivated soil samples of three research vegetables in the research area are in the permitted standard with an average of 1.073 mg/kg. However, cultivated soil in this area had signs of Cd contamination. Specifically, Cd concentrations in soil of most of the cultivated soil samples are below the permitted standard. Cd content in soil planting 3 kinds of vegetables has variation, in which Cd content in soil planting basella alba tended to contain higher than average content of Cd in two other vegetables. Cd content in cultivated soil in the research area is still ensure for cultivate activity. However, the issue of Cd accumulation in vegetables in the city of Thai Nguyen province in general and in particular Tuc Duyen ward had been warned due to solubility of Cd in acidic soil environment. Therefore, the Cd accumulation in soil in the research area needs to be studied. In addition, more investigations are needed to gain full understand of the situation.

About 71% of the total variation of Pb accumulation in vegetables explained by the independent variables and the remaining 29% may be due to error and other factors omitted in the model such as fertilizer factors etc. The significance of the model reflects the factors affecting Pb accumulation in three vegetables. Particularly, Pb accumulation in vegetables is strongly positive influenced by four variables in component No.1 which includes Pb in cultivated soil (X13), average amount irrigation water (X9), time watering (X10), Pb in irrigation water (X14). They are variable relate to practices in farming using irrigation water and characteristic content of Pb in cultivated soil and Pb in irrigation water. The main cause leading to the Pb accumulation in vegetable highly due to vegetables absorbed Pb from farming environment, especially from cultivated soil environment.

About 32% of the total variation of Pb accumulation in cultivated soil explained by the independent variables and the remaining 68% may be due to error and other factors omitted in the model such as fertilizer factors etc.. The model has low significance, therefore the significance of the model could not reflect almost factors that affecting to Pb accumulation in cultivated soil. Particularly, that Pb accumulation in cultivated soil is strongly positive influenced by three variables in component No.2 which includes average amount irrigation water (X9), time watering (X10), Pb in irrigation water (X13). They are variables relate to practices in farming using irrigation water and characteristic content of Pb in irrigation water. In particular, an increase of average amount irrigation water (X9), time watering (X10), Pb in irrigation water (X13) (component No.2) would lead to increase the Pb accumulation in cultivated soil.

The cultivated soil in this area had signs of contaminated Pb with high level of lead (Pb) content. Specifically, lead (Pb) content in cultivated soil was close to the threshold content (average content of Pb is 65.49 mg/kg), therefore it seem that Pb accumulation in cultivated had tended to increase rapidly. Pb accumulation in cultivated soils has increased after many years of cultivation.

The main cause leading to the Pb accumulation in cultivated soil is due to cultivated soil absorbed and accumulated Pb from substances added into cultivated soil environment, especially substances from irrigation water sources. Specifically, cultivated soil environment in the study area affected by the supplement of substances containing Pb into cultivated soil environment, including irrigation water contaminated by wastewater sources from sewage sludge, residential waste water, industrial waste water, etc with frequency and large amounts of irrigation water etc. In addition is the mobility of heavy metals (such as Pb) in the acidic cultivated soil environment.

About 42% of the total variation of Cd accumulation in vegetables explained by the independent variables and the remaining 58% may be due to error and other factors omitted in the model such as pH factor etc.. The significance of the model could not reflect factors that affecting to Cd accumulation in vegetables. Particularly, Cd accumulation in vegetables is strongly positive influenced by four variables in component No.3 which includes average amount irrigation water (X9), time watering (X10), Cd in cultivated soil (X13), Cd in irrigation water (X14). They are variable relate to practices in farming using irrigation water and characteristic content of Cd in cultivated soil and Cd in irrigation water.

Results indicate a strong relationship between Cd accumulation in vegetables and four variables in component No.3. Therefore, an increase of four variables in component No.3 included average amount irrigation water (X9), time of watering (X10), Cd in cultivated soil (X13), Cd in irrigation water (X14) (component No.3) would lead to increase the Cd accumulation in vegetables.

The main cause which leading to the Cd pollution in vegetables in the study area due to the selected vegetables absorbed Cd from farming environment, especially from soil environment. Specifically, cultivated soil environment in the study area affected by the supplement of substances containing Cd into cultivated soil environment, including irrigation water contaminated by wastewater sources from sewage sludge, residential waste water, industrial waste water, etc with frequency and large amounts of irrigation water. In addition, the mobility of heavy metals (especially Cd) in the acidic cultivated soil environment may enhanced uptake into the vegetables.

The results of Cd accumulation in cultivated can be explained by five components about 12%. The model has very low significance, therefore the significance of the model could not reflect almost factors that affecting to Cd accumulation in cultivated soil.

About 12% of the total variation of Cd accumulation in cultivated soil explained by the independent variables and the remaining 88% may be due to error and other factors omitted in the model such as fertilizer factors etc. The model has very low significance, therefore the significance of the model could not reflect almost factors that affecting to Cd accumulation in cultivated soil.

6.2 Discussion

Normally, metals in fertilizers have been given to increase the growth and yield of plants. However, Cd is a non-essential metal and is the main contaminant in fertilizers concerned. According to the survey results, majority of households growing research vegetables (about 60% of research households) frequently used types of phosphate fertilizer. Farmers used phosphate and fertilizer (containing phosphorus) with the risk Cd contamination and fresh manure (chicken manure and pig manure) with the risk of containing high Pb and Cd level have been also warned (Hang, 2007; HMMVA, 2010).

According to the warning from research results of HMMVA (2010), Cd was found in sediments containing zinc and phosphorus, so it often is in the type of phosphates. Cd level which exists in fertilizers containing phosphate depends on the origin of phosphate rocks that used to produce phosphate fertilizer. In addition, calcium phosphate also contains a high concentration of Cd as well as some other unnecessary metals. Therefore, the use of fertilizers such as phosphate fertilizers containing Cd is one of the causes of Cd accumulation in soil at the research area.

In fact, at the research area, people tend to use lime to fertilize soil after cultivation. Liming for acidic soil such as soil at Tuc Duyen ward significantly reduce the release of Cd and other heavy metals including Pb from soil. Thus, metals such as Pb and Cd in soil will be less flexible.

In addition, one of the reasons can be contribute to increase accumulation of heavy metals (Pb, Cd) in the research area is the status of fertilizing and using muck manure. Through the survey in 2010, compost was less used and most households used fresh manure or compost to fertilize vegetables. Muck which was used mainly are pig manure and chicken manure. According to many reports, the concentrations of heavy metals in poultry manures correspondingly increased with the usage of the feed additives. Content in manure depends on the metal content of the main food or mixed food for livestock. Cd is often contained in popular additional food for chicken, therefore, chicken manure often contains a high concentration of Cd. Specifically, average contents of Pb and Cd in the types of pig and chicken manure in Vietnam's agricultural production respectively are 15 mg/kg and 0.7 mg/kg in pig manure; 15 mg/kg and 1.5 mg/kg in chicken manure (HMMVA, 2010).

Refer to research results of Hang (2007) showed that soil in Thai Nguyen city, Tuc Duyen ward has low pH which ranged from 4.8-5.6, acidic. Therefore, Cd content in soil is not at the level of pollution but due to high level of flexible Cd which can be caused of Cd accumulation in the research vegetables. Therefore, if it is necessary to lime, it must be noted to lime not only to soil but also to other sources such as irrigation water.

According to the results from field survey and interview farmers used formal questionnaires in 2010, farmers used chemical fertilizers include phosphorus and compound contain phosphorus. The addition of substances containing heavy metals into soil in recent years, including the use of fertilizer and phosphate (containing phosphorus) with the risk of containing high Cd level have been warned (HMMVA, 2010; Hang 2007). According to On *et al.* (2004), Cd concentration in soil is correlated linearly with the time of using phosphate, especially when phosphate is used on alkaline soil. In addition, Chien *et al*. (1996) reported that Cd accumulation in plants depends on the amount of phosphorus fertilizer and the amount of cadmium in phosphate fertilizer.

Besides, the significant of Pb and Cd accumulation in cultivated soil and vegetables explained by independents variables are still low as a result of there was not found enough factor variables (independent variables) strongly affecting heavy metal accumulation in soil and vegetables. New independent variables that have affecting Pb and Cd accumulation in cultivated soil and vegetables (dependent variable) should be studied further in order to increase statistical significance and reflection level of the model.

6.3 Recommendations

6.3.1 The accumulation of heavy metals (Pb, Cd) in cultivated soil and vegetables

To minimize problems on Cd and Pb accumulation in vegetables and the solubility of Pb and Cd in farmland at vegetable growing areas, a number of solutions are given:

- *Reduce the addition of substances*

Reduce the addition of substances which may cause heavy metal pollution into cultivated soil. Reduce the increase and accumulation of heavy metals (Pb and Cd) into the farmland, restrict the fertilization of manures containing photsphate, restrict the fertilization of fresh manures (pig manure, chicken manure) containing high content of heavy metals such as Pb and Cd.

- *Select suitable crops*

Different plants have different abilities to absorb heavy metals (Pb, cd). Some plants absorb more than others even within the same soil type. The trend is that researchers will choose easy growing plants which have low cost, high ability to suffer high level of pollution.

The method of changing crops which are able to adapt better to the environment, where has a high concentration of heavy metals and creates products with less ability of accumulating heavy metals is also one of management strategies and reduces the impact of heavy metals to plants (Tau *et al*., 2004).

• *Liming*

Lime will increase pH and create alkaline environment to reduce the mobility of heavy metals (Pb, Cd). Acidic soil increases the toxicity of metals in soil. So adding lime to acidic soils (pH <7) will significantly reduce the release of Cd and other heavy metals from soil. However, the effect of calcium decreases over time, so lime must be added again after a certain time. Approximate amount of high quality lime which used in agriculture needs to increase the pH up a unit in the first 15 cm of soil is: Sandy soil 1.5 - 3 tons of lime/hectare, rich soil 3 - 4.5 tons of lime/hectare and clay soil 4.5 - 6 tons of lime/hectare.

Many studies confirmed that the acidic of soil has great influence on the mobility of heavy metals. This is also the basis of measures to limit the mobility of heavy metals by precipitation method. Acidic soils contain much Fe, Al, Mn, organic matter so Cd is easily precipitated and reduced its mobility. In neutral or alkaline soil due to liming, Cd is precipitated as $CdCO_3$, in acid soil, Cd becomes most flexible with the range of pH from 4.4 to 5.5. Cd became less solubility in alkaline environment. According to Zupan *et al*. (1997), lime and mineral fertilizers for plants grown in contaminated soil reduced Cd absorption in plants, so pH of soil is one of the most important factors affecting the solubility of Cd in soil (Ashley *et al*., 2007; Hong *et al*., 2007; Jansson *et al*., 2002).

This measure was also applied to Pb. Liming can reduce the solubility of Pb (Han *et al*., 2004). At high pH level, Pb can be precipitated as hydroxide, phosphate, and carbonate and tends to form stable organic complexes. To reduce the mobility of Pb:

Maintain pH of soil at > 6.5, add more lime or organic matter into soil and plant crops far from roads or urban streets.

- *Increase levels of organic material*

Maintain or increase organic material in soil and reduce metal content that plants can absorb. This will reduce content of metals in plants. When adding organic material or strange organic materials was into soil, only select materials which contain low Cd content.

6.3.2 The accumulation of heavy metals (Pb, Cd) in irrigation water

To reduce the influence of heavy metal pollution (Pb) due to irrigation water source is affected by wastewater pollution, some following solutions are given.

- *Limit using contaminated water sources by other water sources*

People can use other water sources that likely to have less heavy metal contamination such as water well (ground water), tap water, rain-water, etc.

- *Liming*

Liming also to increase pH and create alkaline environment to reduce the mobility of heavy metals (Pb, Cd) in irrigation water.

- *Treating pollution by plants (Phytoremediation)*

Currently, in reducing heavy metal pollution, scientists are practicing cheaper methods and friendlier to the environment. It is a method of treating pollution by plants (Phytoremediation) which it is one of the important feasible solutions for the treatment of land and water contaminated heavy metals.

In Vietnam, some authors also proposed measurement to clean up heavy metal pollution in soil by using a number of plants which are able to accumulate toxic metals at high level such as chrysanthemum (Tau *et al*., 2004). Dog-tail seaweed and water lentil are able to reduce Pb, Zn, Fe and Cu in Bay Mau lake, Hanoi. Pineapple, guava and cucumber plants (Herterostrema villosum) are capable of absorbing high levels of Pb and Cd (Tu *et al*., 2004) as well.

Researchers on the world have been using water-fern (Echihornia crassipes) in the processing of heavy metal pollution treatments. In Vietnam, water-fern is often used as fertilizers and food of cattles. It is also possible to draw toxic substances and clean-up environement very effectively. The results of using water-fern and spinach on the soil contaminated Pb in Van Lam district, Hung Yen province showed that with the same biomass, ability to draw Pb of water hyacinth was 2.7 times higher than that of spinach and lead (Pb) content in soil reduced 39.5% after 60 days of releasing water-fern. Nhu *et al*. (2004) also tested water-fern in removing As, Pb, Cu from wastewater of mining areas in Thai Nguyen province and got good results.

6.4 Recommendations for further studies

1. For further research, other factors/new factors that affecting heavy metal accumulation in soil and vegetables (dependent variable) should be studied further in order to increase statistical significance and reflection level of the model. Besides, the research factors (independent variables) in the current model will be studied more concretely, deeply and accurately. Specifically, factors about the amount of fertilizers

used including inorganic fertilizers and organic fertilizers should be studied more in order to indicate their relationship to the accumulation of metals in soil and vegetables.

2. pH, amount of fertilizing lime and type of soil are the three factors that significantly affect the absorption/suction/metal accumulation of vegetables from cultivated soil and solubility, metabolism, accumulation of heavy metals in soil and water. Therefore, these factors which are related to the accumulation of heavy metals in farmland, irrigation water and vegetables should be studied further.

3. People in the research area also had initial awareness of the problem about heavy metal pollution in vegetables and their accumulation in the farming environment. Awareness and understanding of farmers about them can be one of the factors affecting routine practices, tillage (watering, fertilizing, spraying, cultivating soil), from which affecting heavy metal accumulation in vegetables in general and farming environment (land, water) in particular. To study the effects of awareness and practical habits of farmers to the accumulation of heavy metals in soil, water and vegetables is a matter of concern for further research.

4. Regular monitoring of Pb and Cd in Cau river at selected locations should be sponsored by the city and jointly analyzed by TUAF laboratory.