MINISTRY OF EDUCATION & TRAINING
THAI NGUYEN UNIVERSITY

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STUDY ON APPLICATION OF INTERVENTION MEASURES TO MITIGATE THE EFFECTS OF ENVIRONMENTAL POLLUTION ON HEALTH OF PEOPLE LIVING AROUND NON-FERROUS METAL MINING AREA IN THAI NGUYEN

Speciality: Social Hygiene and Health Organization
Code: 62.72.01.64

SUMMARY OF MEDICAL PhD. DISSERTATION

THAI NGUYEN - YEAR 2015

THE WORK WAS COMPLETED IN
COLLEGE OF MEDICINE & PHARMACY,
THAI NGUYEN UNIVERSITY

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The dissertation will be defended in Dissertation Committee in National Level held in College of Medicine & Pharmacy - TNU

At: ..... am, in....., year 2015

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INTRODUCTION

The problem of environmental pollution (EP) has become a concern of the community. Many toxic substances can pass the digestive, respiratory tract, skin and enter a tissue of the body, causing toxic to humans. The toxic metals cause EP such as Pb, Cd, Hg, As are always a high risk to the health... (Le Van Khoa, 2001)

The exploitation of minerals, especially the mining exploitation also means having to exchange, destroying the environment (envir) landscape on land as the forest vegetation associated with the natural beauty, the biodiversity, the envir landscape and the ecological envir.

In Thai Nguyen (TN), currently there are around 10,000 industrial manufacturing Enterprises. Of these, more than 100 industrial manufacturing Enterprises are large, the remaining are small and medium enterprises. The industrial production has an important contribution to the socio-economic development of the province. However, together the economic development, the problem of pollution, envir degradation is becoming more heating (General Association of Geology of Vietnam, 2010).

The study systematically and fully aims to assess the impact of EP due to the non-ferrous metal (NFM) mining in Thai Nguyen on the health of people living in the surrounding area, especially the application of the intervention solution aiming to protect the health of the people is necessary. So, we conduct the theme *"Study on application of intervention measures to mitigate the effects of environmental pollution on health of people living around non-ferrous metal mining area in Thai Nguyen" aiming at*:

1. Identify several indicators of EP, diseases of people living around the NFM mining Enterprise in TN in 2012.

2. Analyze some relevant risk factors between EP and the health of people living around the NFM mining Enterprise.

3. Apply and evaluate the effectiveness of interventions to mitigate the effects of EP on health of population living around the lead-zinc Enterprise in Hich Village, TN province.

NEW CONTRIBUTIONS OF THE DISSERTATION

1. The study has identified some factors causing EP in agricultural land, surface water, drinking water and in some NFM mining area in Thai Nguyen are Pb, Cd, As. Identified the status of the disease as well as knowledge, attitude and practice (KAP) of people on the sanitation and health protection due to the EP.

2. The study has identified the risk factors related to some common diseases in people living around the mining area such as digestive, nasopharyngeal (NP), skin, oral, urologic diseases.

3. Through surveying KAP of the people, the study has selected the communication interventions, the contents and how to implement; identify the feasibility of applying the communication intervention and to guide to build water tanks with sand filter and activated carbon in the area polluted by the mining exploitation.

4. The study showed some certain effectiveness of interventions through a reduced morbidity (effectiveness of interventions achieved from 8.15 to 60.83%) and improving people's KAP on the sanitation and the health protection (effectiveness of interventions achieved from 49.59 to 57.87%).

STRUCTURE OF DISSERTATION

The key part of dissertation is 110 pages, including the following parts:

- Introduction: 2 pages
- Chapter 1. Literature review: 29 pages
- Chapter 2. Subjects and methods: 22 pages
- Chapter 3. Results: 27 pages
- Chapter 4. Discussion: 27 pages

- Conclusions and recommendations: 3 pages

The dissertation has 105 references, including 71 Vietnamese and 34 documents in English. The dissertation includes 34 tables, 1 map, 1 diagrams, 6 figures, 6 boxes for. The appendix includes 5 subappendices with 18 pages.

Chapter 1. OVERVIEW

1.1. General idea on envir, EP and health

- The definition of EP: the EP is a change in the biological, chemical, physical properties of the envir which are greater than permitted standards, harmful effects on human health, the development of the organism or degrading the envir quality (Medical University - Thai Nguyen University, 2007).

- The envir and human health is closely linked together. If used or exploited logically it will bring great benefit.

1.2. Situation of metal mining in the world and Vietnam

1.2.1. The definition of heavy metal

A heavy metal is termed a metal with a specific gravity greater than about 5.0 g/cm^3. (Bjerrgaard P. et al, 1994). Heavy metals are dangerous pollutants for land ecosystems, and the food chain and human.

1.2.2. Situation of metal mining in the world

Around 40,000 BC, people had known to use everything around him, including the stone also used as a tool to exploit the mineral (Hartmann, 2007). Mining exploitations were developed strongly in the last decade in many resource-rich countries... The mining exploitation meet the growing demand for mineral raw materials. Owing to specific characteristics, the mining industries resulting in a degradation of land resources, forest resources, water resources... is very large (Hoang Thi Mai Anh, 2014).

1.2.3. Situation of metal mining in Vietnam

Vietnam is a country with rich and varied mineral resources with nearly 5,000 mines and points of ore with 60 different types of minerals. In recent years, the problem of serious envir pollution due to mining activities have been pressing issues happening around the country (Nguyen Thi Viet Tra, 2012).

1.2.4. Situation of metal mining in Thai Nguyen

Thai Nguyen is located in the metallogenic region of Northeast Vietnam, belonging to metallogenic belt of the Pacific. 177 points of ore and solid mineral deposits and a mineral water have been found in Thai Nguyen province. Thai Nguyen is also the province with many metals, metal mines with large deposits of lead and zinc mine in Hich village, Trai Cau iron mines, barite mines in Hop Tien I in Dong Hy, tin mines, pyrites in Ha Thuong in Dai Tu (Thai Nguyen Department of Natural Resources - Environment, 2007).

1.3. History of study on the risk factors, the impact of mining on the envir and health

1.3.1. Studies in the world

Scientists around the world have studied the envir-related diseases due to the mining exploitation very early. In Hypocrate time (fourth century BC), one has seen many miners who died early compared with other occupations (Do Ham, 2008).

Scientists in the world also have confirmed the content of some heavy metal elements, especially asen, mercury, manganese, lead, zinc too high in the habitat of many lands causing some characteristic diseases characteristics for human beings living in this area (Mattusch J. et al, 2000).

1.3.2. Studies in Vietnam

According to the Institute of Geology and Envir, in heavy metal mines and many metals are often prone to diseases for residents such as anemia, kidney problems, respiratory, digestive, nervous, cardiovascular diseases, cancer, memory loss, mutation... (Nguyen Duc Quy, 1999).

1.3.3. Studies in Thai Nguyen

The recent studies, reports by the Department of Science and Technology, Thai Nguyen University of Medicine - Pharmacy as well as medical facilities showed that many residents lived very near the heavy metal mines, the coal mine. At many mines, there are not boundaries between the mining zones and residential areas, particularly farmers participate in the ore exploitation in the leisure time. On the other hand, the understanding of the mining exploitation envir affecting on the health of workers as well as residents here are very limited (Luong Thi Hong Van, Nong Thanh Son, 2001), (Nguyen Thi Quynh Hoa, 2003).

1.4. Measures mitigating the impact of EP caused by mining exploitation on human health

1.4.1. Management measures and planning

(Vu Hoang Hoa and Phan Van Yen, 2014)

- *Some general measures*
- *Proposals on institution, policy*
- *Measures on envir management*

1.4.2. Some research results on absorption of heavy metals by plants

The method of using plants to treat heavy metals in soil has been a newly applied research method in the world since the 1990s. This method is environmentally friendly and promising replacing the traditional processing technology. However, the biggest limitation of this method is dependent on local ecological conditions (Vo Van Minh, 2009).

1.4.3. Environmental education

Forms of envir education are very diverse, rich such as education according to individual, group, according to the community; communication and education through the mass media, disseminating policy, envir law; implementation of envir protection projects; activities conducted through mass organizations, education in schools... (Nguyen Thi Dieu Lieng, 2010).

Chapter 2. SUBJECTS AND METHOD

2.1. Study subjects

2.1.1. Environment

- Water envir (including surface water, drinking water resource).
- Soil envir (agricultural land around the mining area).

2.1.2. Vegetables

Field cabbage or broccoli, mustard, (science name: Brassica juncea), growing period 40-45 days.

The test samples to evaluate the envir and vegetables are taken in the areas with the distance below 500 meters, 500 meters to 1000 meters and from 1000 to 1500 meters.

2.1.3. People

People living around the mining exploitation areas with the distance below 1500m from the pollution source.

- Leaders of authority, local mass organizations (including all mass organizations and health workers of commune).

2.2. Study settings

Population area living around 2 NFM mines: The Lead - Zinc Enterprise in Hich village in Tan Long commune of Dong Hy district and The Dai Tu Tin Enterprise at Ha Thuong commune in Dai Tu district of Thai Nguyen province.

2.3. Study duration

Between February, 2012 and May, 2014.

2.4. Study method

2.4.1. Study method and design

The combined study method used in the whole process of implementation of the theme. Including a descriptive study (combining quantitative and qualitative), a case-control study and an intervention study.

2.4.2. Sample size and sampling method

2.4.2.1. Sample size and sampling for a descriptive study

* Descriptive sample size for the people: total people who aged ≥ 18 years living in the area with a radius of 1.5 km were under 1,100. However, only 250 people in Ha Thuong commune and 430 people in Tan Long commune have continuously lived for ≥ 3 years. Therefore, we studied all people as mentioned above with a purposive sample.

A number of people meeting the assessment requirements of health and related factors is 654 people (Ha Thuong is 238 people and Tan Long is 416 people). This sample size is used for the study of diseases and KAP, the sanitation, the prevention of related diseases.

* Sample size and sampling for qualitative study: a purposive sampling is used.

- In-dept interview: in each commune, conducting the depth interview of one community leader and one health worker of commune.

- Group discussion: in each commune, organizing 2 group discussions for 2 groups: a commune leaders group (10 - 15 people including commune leaders and heads of branches); a people group (10 - 15 people including a head of village, VHWs and people).

Organization of in-dept interviews and group discussions before intervention in 2 communes and after intervention, a group discussion only conducted at in Tan Long commune

* The sample size and sampling for the envir study: 3 purposively selected sample represent the areas: close (<500m), medium (500-1000m), far (1000-1500m) than pollution source for each commune. Thus, the total test samples were 9 for one commune, and for each index.

2.4.2.2. The sample size and sampling for a case-control study

The sample size for a case-control study selected after a descriptive study. We chose specific diseases here to be an inorganic Pb poisoning. Owing to the origin of a disease has been identified as the Pb in both outside and inside the production location. A formular of a test sample size calculation used and we identify a sample size as 142. In reality, 271 people are checked and tested (179 people in Tan Long and 92 people in Ha Thuong), in whom, 32 people identified to have a disease and ALA ≥ 10mg/L, so that all these patients included in the study. Correspondingly, we select 32 healthy people, ALA below 5 mg/L in the control group to investigate, identifying some risk indicators.

2.4.2.3. The sample size and sampling for an intervention study

* The sample size for the intervention study and a general evaluation of improved KAP on the sanitation, prevention and miltigation of disease for exposed people as formular: $n = (Z_{1-\alpha/2} + Z_{1-\beta})^2 \frac{p_1 q_1 + p_2 q_2}{(p_1 - p_2)^2}$

Replacing the data into the formula, n calculated is equal to 160 people. But in reality, we choose 177 people in Tan Long commune and 190 people in Ha Thuong commune.

This sample size also used for the intervention evaluation of improved KAP and prevention of diseases in general.

* Sampling:

- The intervention group: The intervention group included people living inside polluted area in Tan Long commune intervened by communication of improved KAP on health protection and the sanitation, guiding to build water tanks with sand filter and activated carbon.

- The control group: The control group included people living in polluted area in Ha Thuong commune and subjects selected are similar to subjects in the intervention group but not be intervened.

2.4.3. Diagram and study contents

- Basis for building the contents and the intervention program.

- To establish a steering committee on envir protection, health care and prevention of disease due to pollution.

- Contents of the intervention included training, communication to improve KAP on the health protection and sanitation.

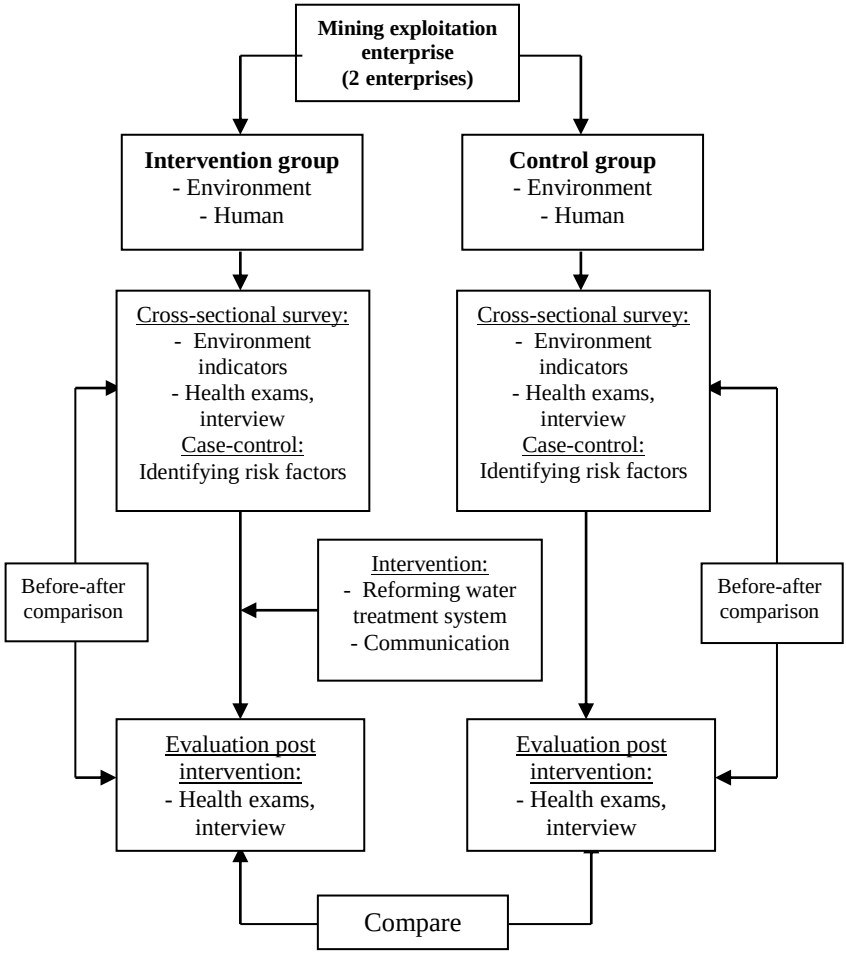

Figure 3.1. Model for intervention study design with before- after comparison and control comparison

- Establishment of the Steering Committee for envir protection, health care and prevention of disease due to pollution.

- Contents of intervention by training, communication to improve KAP on health protection and sanitation.

2.4.4. Study indicators

2.4.4.1. Indicators for descriptive study before intervention

- Test indicators about envir

+ Farmland: levels of Pb, As, Cd.

+ Drinking water: levels of Pb, As, Cd.

+ Surface water: levels of Pb, As, Cd, Zn, pH.

- Test indicators about vegetable growing in farmland: levels of Pb, As, Cd.

- Study indicators about human.

+ General information of residents: including indicators about age, sex, ethnicity, occupation, educational level, economic condition.

+ Disease of people: including the prevalence rates of common diseases such as: digestive, NP, skin, oral, urologic diseases; result of urinary ALA test (for inorganic Pb poisoning).

+ KAP on the sanitation and preventing diseases caused by EP: including indicators of knowledge, attitudes and practices.

2.4.4.3. Indicators about factors related to diseases

- A number of the Pb poisoning patients (urinary ALA $\geq$ 10 mg/L) in relation to risk factors: eating vegetables, eating aquatic animal, drinking water in contaminated areas; housing near contaminated areas within 500 meters.

- The prevalence of diseases related to the distance to the EP source: less than 500m, from 1000 to 1500m. This is the distance from home to the mine site and the mine waste.

- The prevalence of diseases related to exposure to local foods contaminated by nonferrous metals: regularly eating, irregularly eating vegetables, fruit and other types of livestock, poultry, waterfowl, aquatic plants near polluted areas (PA) (<500m).

2.4.4.4. Indicators on intervention efficacy (IE):

- Indicators on health, disease: The prevalence rates of common diseases are compared before and after the intervention.

- Indicators on KAP: The rate of people with a good knowledge, attitude, and practice are compared before and after the intervention.

- Efficacy index, intervention efficacy: comparison between an intervention group and a control group about disease and KAP.

2.4.5. Data collection technique and evaluation of study indicators

2.4.5.1. Data collection and evaluation of envir indicators

Taking test samples for analysis and envir evaluation using standards and specifications issued by Vietnam.

2.4.5.2. Data collection and evaluation of disease indicators

- Check the health of the people living around PA by the specialist doctors, using the tools: a medical certificate, the specialized medical instruments, 2D ultrasound.

- Test of urinary ALA: Using a chemical analytical method on photometric systems SPECL 11 and molecular adsorption spectroscopy UV-Vis by German production company Lamda 2010.

2.4.5.3. Data collection and evaluation of KAP indicators

To interview to assess KAP of people using pre-printed questionnaires, conducting a live interview.

2.4.6. Implementation of study

- Study steps
- The order of deployment
- To monitor and supervise the activities and diseases of people
- Evaluation of post-intervention

2.4.7. Method of data process and analysis

- Data processed and analyzed by SPSS 18.0 software.

- Algorithm used: comparing two rates by test χ^2 (Chi square), computing p, (p-value).

- Calculating the intervention efficacy index by formula:

$$EI_{(A)}(\%) = \frac{|P_1 - P_2|}{P_1} \times 100. \qquad EI_{(B)}(\%) = \frac{|P_1 - P_2|}{P_1} \times 100$$

P_1: Percentage of a study indicator before intervention.

P_2: Percentage of a study indicator after intervention.

The intervention efficacy calculated by the efficacy index (EI) in the intervention group ($EI_{(A)}$) minus the efficacy index (EI) in the control group ($EI_{(B)}$).

Chapter 3. STUDY RESULTS

3.1. Situation of some indicators of EP, diseases of people living around NFM mining enterprises in Thai Nguyen in 2012

Table 3.1. Concentrations of heavy metals in farmland

Level / *Indicator*	*Min (mg/kg)*	*Max (mg/kg)*	$\bar{X}$ *(mg/kg)*	*Rate over stand (%)*	*VN stand 03:2008*
Pb *(18 samples)*	102.74	432.11	267.01	100	≤ 70.0
Cd *(18 samples)*	13.00	51.86	33.57	100	≤ 2.0
As *(18 samples)*	17.15	55.03	35.49	100	≤ 12.0

The average level of all three kinds of heavy metal in the soil was higher than the Vietnam standard: the Pb level was 3.8 times higher; the Cd level was 16,8 times higher; the As level was 3.0 times higher. 100% soil samples had levels of Pb, Cd and As higher than the Vietnam standard.

Table 3.2. Concentrations of heavy metals in surface water

Level / *Indicator*	*Min (mg/L)*	*Max (mg/L)*	$\overline{X}$ *(mg/L)*	*Rate over stand (%)*	*VN stand 08:2008*
pH *(18 samples)*	3.54	4.28	3.90	100	5.5 - 9
Pb *(18 samples)*	0.03	0.39	0.16	66.7	≤ 0.05
Cd *(18 samples)*	0.00	0.03	0.02	61.1	≤ 0.01
As *(18 samples)*	0.02	0.44	0.19	77.8	≤ 0.05
Zn *(18 samples)*	0.21	2.47	1.02	33.3	≤ 1.50

Average levels of Pb, Cd and As in surface water were higher than the Vietnam standards: the Pb level was 3.2 times higher; the Cd level was 2 times higher; the As level was 3.8 times higher. The acidic pH was high and 100% samples pH did not meet the Vietnam standards. Most samples (from 61.1 to 77.8%) was higher than the Vietnam standards about Pb, Cd and As; 33,3% samples was higher than the Vietnam standards about Zn.

Table 3.3. Concentrations of heavy metals in drinking water

Level / *Indicator*	*Min (mg/L)*	*Max (mg/L)*	$\overline{X}$ *(mg/L)*	*Rate over stand (%)*	*VN stand 01:2009/BYT*
Pb *(18 samples)*	0.01	0.33	0.08	94.4	≤ 0.01
Cd *(18 samples)*	0.00	0.17	0.04	55.6	≤ 0.003
As *(18 samples)*	0.01	0.48	0.06	77.8	≤ 0.01

Average levels of all three types of heavy metals in drinking water are higher than the Vietnam standard: the Pb level was 8 times higher; the Cd level was 13 times higher; the As level was 6 times higher. 94.4% samples was higher than the Vietnam standards about Pb; 77.8% samples was higher than the Vietnam standards about As; 55.6% samples was higher than the Vietnam standards about Cd.

Table 3.4. Concentrations of heavy metals in vegetable

Level / *Indicator*	*Min (mg/L)*	*Max (mg/L)*	$\bar{X}$ *(mg/L)*	*Rate over stand (%)*	*QĐ99/2008/ QĐ-BNN*
Pb *(18 samples)*	2.40	11.76	5.47	100	≤ 0.3
Cd *(18 samples)*	0.14	4.24	2.04	100	≤ 0.1
As *(18 samples)*	0.49	4.61	1.37	50.0	≤ 1.0

Average levels of all three types of heavy metals in vegetables grown in the area were higher than the permitted standard (PS): the Pb level was 18.2 times higher; the Cd level was 20.4 times higher; the As level was 1.37 times higher. 100% samples was higher than the PS about Pb and Cd; 50.0 samples was higher than the PS about As.

Table 3.7. Prevalence of common diseases in people

Types of disease	*Tan Long (n=416)*	*Ha Thuong (n=238)*	*p*	*Total (n=654)*
Digestive	80 (19.2%)	48 (20.2%)	> 0.05	128 (19.6%)
Nose-throat	226 (54.3%)	137 (57.6%)	> 0.05	363 (55.5%)
Oral	137 (32.9%)	85 (35.7%)	> 0.05	222 (33.9%)
Eye	253 (60.8%)	140 (58.8%)	> 0.05	393 (60.1%)
Skin	158 (38.0%)	93 (39.1%)	> 0.05	251 (38.4%)
Urologic	114 (27.4%)	58 (24.4%)	> 0.05	172 (26.3%)

The prevalence rates of common diseases in adults around the mining area were quite high, especially for eye diseases (60.1%), ENT (55.5%). The diseases with a lower prevalence were skin diseases (38.4%), oral diseases (33.9%), urologic diseases (26.3%). The difference between the 2 communes was not found (p> 0.05).

Table 3.8 Percentage of exposure and Pb poisoning in people

Setting / *ALA indicator*	*Tan Long (n=138)*	*Ha Thuong (n=133)*	*p*	*Total (n=271)*
< 5 mg/L	89 (64.5%)	74 (55.6%)	> 0.05	163 (60.1%)
5-<10 mg/L	34 (24.6%)	42 (31.6%)	> 0.05	76 (28.0%)
≥ 10mg/L	15 (10.9%)	17 (12.8%)	> 0.05	32 (11.8%)

The prevalence rate of Pb poisoning (urinary ALA ≥ 10 mg/L) in people was 11.8%, the proportion of Pb exposure (urinary Ala 5- <10 mg/L) was 28.0% in people. The degree of Pb exposure and poisoning in 2 communes was equal.

Table 3.9. Knowledge on sanitation in people before intervention

Setting / *Knowledge*	*Tan Long (n=416)*	*Ha Thuong (n=238)*	*p*	*Total (n=654)*
Good	90 (21.6%)	56 (23.5%)	> 0.05	146 (22.3%)
Bad	326 (78.4%)	182 (76.5%)	> 0.05	508 (77.7%)

Most people with the knowledge on the sanitation was not good (77.7%), the proportion of people with a good knowledge was still low (22.3%). The degree of knowledge in two communes was equal.

Table 3.10. Attitude on sanitation in people before intervention

Setting / *Attitude*	*Tan Long (n=416)*	*Ha Thuong (n=238)*	*p*	*Total (n=654)*
Good	104 (25.0%)	55 (23.1%)	> 0.05	159 (24.3%)
Bad	312 (75.0%)	183 (76.9%)	> 0.05	495 (75.7%)

The attitude of most people on the sanitation was not good (75.7%), the good attitude accounted for 24.3%. The difference in the attitude level in 2 communes was not statistically significant.

Table 3.11. Practice on sanitation in people before intervention

Setting / *Practice*	*Tan Long (n=416)*	*Ha Thuong (n=238)*	*p*	*Total (n=654)*
Good	94 (22.6%)	59 (24.8%)	> 0.05	153 (23.4%)
Bad	322 (77.4%)	179 (75.2%)	> 0.05	501 (76.6%)

The practice of the people on sanitation mainly was not good (76.6%), the good practice accounted for 23.4%. Differences in practice in two communes were not statistically significant.

3.2. Some relevant risk factors between EP and health of residents living around NFM mining enterprises

Table 3.12. Several risk factors related to Pb poisoning in residents living in two communes in polluted areas (PA)

Pb poisoning / *Risk group*		*Diseased*		*P*
		Yes (n=32)	*No* (n=32)	
Eating vegetable in PA	Yes	21	7	p<0.01
	No	11	25	
Eating aquatic animals in PA	Yes	19	8	p<0.01
	No	13	24	
Drink water in PA	Yes	20	10	p<0.05
	No	12	22	
Living in PA	Near	17	14	p>0.05
	Far	15	18	

Eating vegetables in PA with a disease risk was higher than not eating vegetables in PA ($p<0.01$); eating small aquatic animals in PA with a disease risk was higher than not eating in PA ($p<0.01$); drinking water in PA with a disease risk was higher than not drinking in PA ($p<0.05$); Have not identified disease risk of living near or far from PA.

Table 3.13. Association between frequently eating animal and plants grown in mining area and digestive disease

DigestiveDisease / *Eating frequency*	*Yes*		*No*	
	n	*%*	*n*	*%*
Eating frequently (389)	90	23,1	299	76.9
Not eating frequently (265)	38	14,3	227	85.7
Total (n=654)	128	19,6	526	80.4
p<0.01				

The prevalence of digestive diseases in the group who ate frequently the animals, plants grown in the mining areas was high (23.1%), compared with the group not often eat (14.3%). The difference was statistically significant with $p<0.01$.

Table 3.20. Association between the distance to the pollution source and the nasopharyngeal disease

NP disease / *Distance*	*Yes*		*No*	
	SL	*%*	*SL*	*%*
Distance ≤ 500 m (258)	156	60.5	102	39.5
Distance from 1000 to 1500 m (396)	207	52.3	189	47.7
Total (n=654)	363	55.5	291	44.5
p<0.05				

The prevalence rate of NP diseases in the group living near the mining area (60.5%) was higher than those living far from the mining area (52.3%). The difference was statistically significant with $p<0.05$.

3.3. Intervention efficacy (IE) mitigating the impact of EP on health of people living around the Hich village lead-zinc Enterprise

Table 3.25. Intervention efficacy changing in knowledge on sanitation

Good knowledge / *Commune*	*Before intervention (n)*	*After intervention (n)*	*Efficacy index (%)*
Tan Long (n=177)	38	56	47.37
Ha Thuong (n=190)	45	44	-2.22
Intervention efficacy	49.59		

The efficacy index for the knowledge on the sanitation in Tan Long reached 47.37%, higher than that in Ha Thuong (2.22%). The IE was high and reached 49.59%.

Table 3.26. Intervention efficacy changing in attitude on sanitation

Good attitude / *Commune*	*Before intervention (n)*	*After intervention (n)*	*Efficacy index (%)*
Tan Long (n=177)	44	72	63.64
Ha Thuong (n=190)	44	49	11.36
Intervention efficacy	52.28		

The efficacy Index for attitudes on the sanitation in Tan Long reached 63.64%, higher than that in Ha Thuong (11.36%). The IE was high and reached 52.28%.

Table 3.27. Intervention efficacy changing in practice on sanitation

Good practice / *Commune*	*Before intervention (n)*	*After intervention (n)*	*Efficacy index (%)*
Tan Long (n=177)	40	64	60.00
Ha Thuong (n=190)	47	48	2.13
Intervention efficacy	57.87		

The efficacy index for the practice on the sanitation in Tan Long reached 60.0%, higher than that in Ha Thuong (2.13%). The IE was high and reached 57.87%.

Table 3.28. Intervention efficacy for digestive disease

Diseased / *Commune*	*Before intervention (n)*	*After intervention (n)*	*Efficacy index (%)*
Tan Long (n=177)	34	16	52.94
Ha Thuong (n=190)	38	41	- 7.89
Intervention efficacy	60.83%		

The efficacy index for digestive disease in Tan Long reached 52.94%, higher than that Ha Thuong (- 7.89%). The IE was high and reached 60.83%.

Table 3.32. Intervention efficacy for oral disease

Diseased / *Commune*	*Before intervention (n)*	*After intervention (n)*	*Efficacy index (%)*
Tan Long (n=177)	58	54	6.90
Ha Thuong (n=190)	68	77	-13.24
Intervention efficacy	20.14%		

The efficacy index for oral disease in Tan Long reached 6.9%, higher than that in Ha Thuong (-13.24%). The IE reached 20.14%.

Table 3.34. Intervention efficacy for Pb poisoning (ALA ≥ 10 mg/L)

Diseased / *Commune*	*Before intervention (n)*	*After intervention (n)*	*Efficacy index (%)*
Tan Long (n=179)	23	14	39.13
Ha Thuong (n=92)	9	8	11.11
Intervention efficacy	28.02%		

The efficacy index for Pb poisoning disease (urinary ALA ≥ 10 mg/L) in Tan Long reached 39.13%, higher than in Ha Thuong (11.11%). The IE reached 28.02%.

Box 3.6. Results from group discussions on entervention efficacy in Tan Long commune

Opinions from leaders of branches in commune: "*The majority of people were in favor of intervention activities. Through training and communication, staffs and residents had been provided with more knowledge about the harmful effects of EP due to mining. The people also know how to choose the kind of food and clean water. Results of urine tests had detected many people with Pb poisoning...*"

(Leaders of branches group in Tan Long commune).

Opinions from residents: *"Before, people did not know how to filter water to remove toxic substances from EP. Now a example water tank taken to the commune by doctor Son, He had guided and built water tanks together the people. Households that used the water filter were more comfortable. The communication of health workers has helped us understand the effects of EP, know how to prevent illness…"*

(Residents group - Dong Mau village,Tan Long commune).

The Intervention program have brought staffs and people knowledge about the impact of EP due to mining and health protection measures, knowning how to choose the food and safe drinking water. The tests have identified people with the Pb poisoning caused by exposure to the envir. The people have supported and jointly contributed to building water filtration tanks to remove toxic substances, and they feel comfortable when using a clean water.

Chapter 4. DISCUSSIONS

4.1. Situation of some indicators of EP and diseases in people living around NFM mining enterprises in Thai Nguyen in 2012

Results analyzing some heavy metals as Pb, As, Cd in soil, surface water and drinking water are quite high, many samples had the concentration were higher than the permitted standards. Obviously, the EP have taken place on a large scale. Heavy levels in this study area were high equivalent to those around the NFM mining in China (Ping Zhuang et al, 2014) and much higher than the agricultural soil envir, irrigation and unpolluted areas in Korea as well as in Vietnam.

The average level of all three types of heavy metal in vegetables grown the region was higher than the permitted standards. The concentration of heavy metals here was similar to the mining and the metallurgical areas in China as well as in Thai Nguyen and much higher than vegetables grown in farmland in Ho Chi Minh city (Nguyen Thi Ngoc An, 2007). Thus, vegetables grown in areas contaminated by heavy metals is quite serious, especially Pb and Cd.

Findings of the study showed that the prevalence rate of some common diseases in residents living around the mining area was quite high, comparable to the prevalence of disease in workers and laborers exposed to the other hardworking environments.

The study results showed that the proportion of people living around the mining areas with a good KAP on the sanitation was quite low. KAP on the sanitation at two communes before intervention was equal and equivalent to the percentage of people with a good knowledge on the sanitation in some other areas.

4.2. Some relevant risk factors between EP and health of people living around NFM mining enterprises

Some risk factors for disease in people were determined to be to eat vegetables, to eat small aquatic animals and to drink water at the PA.

Several factors related to the disease were often eat the animals and plants cultivated in the mining areas and living near mining areas. However, these factors were only related to specific diseases.

4.3. Intervention efficacy mitigating the impact of EP on health of people living around the lead-zinc enterprise in Hich village

The prevalence rate of some diseases such as digestive, ear, nose, throat, eyes, and skin in the intervention commune was improved after the intervention as compared to before the intervention. The difference was statistically significant with $p < 0.01$ and 0.05. Meanwhile, the prevalence rate of some diseases was not improved in the control commune.

For some diseases such as digestive, nasopharyngeal, oral the IE was rather high; On the contrary, the IE for skin, eye, and urological diseases. was lower.

The IE for KAP improvement on the sanitation was very good in terms of knowledge, attitude and practice of the people.

The Intervention program have brought staff and people knowledge on the sanitation, communication skills, to be examined and tested. In addition, the example water filter tanks was built as a model for people to follow in order to reduce the harmful effects of water pollution.

CONCLUSSIONS

1. Situation of some indicators of EP and diseases in people living around NFM mining enterprises in Thai Nguyen in 2012

* The average level of some heavy metals in the environments:

- Agricultural land: the Pb levels was 3.8 times higher; the Cd was 16.8 times higher; the As was 3 times higher than the Vietnam standard.

- Surface water: the Pb levels was 3.2 times higher; the Cd was 2 times higher; the As was 3.8 times higher than the Vietnam standard; the pH value was highly acidic.

- Drinking water Source: the Pb level was 8 times higher; the Cd was 13 times higher; the As was 6 times higher than the Vietnam standard.

* The average level of some heavy metals in vegestables: the Pb levels was 18.2 times higher; the Cd was 20.4 times higher; the As was 1.37 times higher than the permitted standard.

* The average level of some heavy metals in the environments: the farmland, surface water, drinking water, vegetables grown in the distance near the pollution source was significant higher as compared to the distance far the pollution source.

* The prevalence rate of some diseases in adults living round the mining area: eye (60.1%), nose-throat (55.5%), skin (38.4%), oral (33.9%), urologic diseases (26.3%).

* The prevalence rate of Pb poisoning in people was 11.8%, the rate of Pb exposure was 28.0%.

* The rate of people with a good knowledge, attitude, practice as required was low: knowledge 22.3%; attitude 24.3%; practice 23.4%.

2. Some risk and related factors between EP and health of people living around NFM mining enterprises

* Some risk factors for disease in people living in PA:

- Eating vegetables in PA with a disease risk was higher than not eating vegetables in PA ($p < 0.01$)

- Eating small aquatic animals in PA with a disease risk was higher than not eating in PA ($p < 0.01$)

- Drinking water in PA with a disease risk was higher than not drinking in PA ($p < 0.05$);

* The prevalence rate of some diseases in the people group often eating animals and plants in the mining area was higher than that in the person group not often eating: digestive, NP, skin, oral, urologic diseases.

* The prevalence rate of some diseases in the people group living near polluted sources (< 500m) was higher than those who live not near the pollution source (1000-1500m): NP, skin diseases.

3. Intervention efficacy mitigating the impact of EP on health of people living around the Hich village lead-zinc Enterprise

* The prevalence rate of diseases: digestive, NP, eye, skin in the intervention commune (Tan Long) was lower than before entervention. The difference was statistically significant with $p < 0.01$ and 0.05.

* The prevalence rate of digestive, NP, oral diseases in the intervention commune was lower than that in the control commune. The difference was statistically significant with $p < 0.01$ and 0.05.

* The IE changing in KAP on the sanitation after communication and to guide to build water tanks with sand filter and activated carbon: IE in knowledge: 45.15%; IE in attitude: 52.27%; IE in practice: 57.87%.

* The IE for some diseases: digestive disease: 60.83%; NP disease: 30,5%; skin disease: 15.63%; eye disease: 14.35%; oral disease: 20.14%; urologic disease: 8.15%.

RECOMMENDATIONS

1. The relevant Agencies should cooperate with local authorities and mining units to deploy mitigation measures of pollution levels of heavy metal in soil, water and vegetables grown in the locality, paying a special attention to the area near pollution sources.

2. The health sector, mining units and local authorities should have plans for health exams and assessments of exposure to toxic substances periodically for workers and people living around the mining area, aiming to mitigate the prevalence of related diseases.

3. It is necessary for the propaganda to improve knowledge, attitude and practice of people about preventing diseases due to EP. To avoid eating or drinking foods has a high risk polluted by heavy metals.

4. Encouraging combined with support for people in the construction of sanitary facilities like the water filtration tanks and advanced technologies to treat the envir, food in the community.It is necessary to replicate a model of water tanks filtrated by sand and activated carbon.

PUBLISHED PAPERS RELATED TO DISSERTATION

1. Ha Xuan Son (2014), "The situation of some common diseases in adults around the Hich Village lead-zinc Enterprise and the Dai Tu tin Enterprise, Thai Nguyen", *Journal of Labor Protection*, No. 231, pp. 38-41.

2. Ha Xuan Son, Do Van Ham (2015), "Some related factors affect to illnesses of people around the non-ferrous mining area in Thai Nguyen", *Journal of Labor Protection*, No. 242, pp. 18-21.

3. Ha Xuan Son, Do Van Ham (2015), "Effectiveness of interventions to minimize the effects of environment pollution on some illness in people around the non-ferrous metal mining area in Thai Nguyen", *Journal of Practical Medicine*, No. 6 (969), pp. 27-29.