ENVIRONMENT, HEALTH AND SAFETY MANAGEMENT IN MINING AND OTHER INDUSTRIES

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ENVIRONMENT, HEALTH AND SAFETY MANAGEMENT IN MINING AND OTHER INDUSTRIES

A

THESIS

Presented to the Faculty

of the University of Alaska Fairbanks

in Partial Fulfillment of the Requirements

for the Degree of

DOCTOR OF PHILOSOPHY

By

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Fairbanks, Alaska

May 2014

ABSTRACT

While environment and health and safety may appear to be two different areas, they may be integrated into Environment, Health and Safety (EHS). This study is to investigate the impact of the environment and Occupational Health and Safety Management System (OHSMS) on health and safety. Three case studies were conducted. The first one is to study the impact of abandoned mines on soils, water and crops. The second one is to examine the effect of OHSMS implementation on reducing occupational safety risk. The third one is examine the impact of environment on health. The abstracts of these three case studies are as follow:

THE INVESTIGATION OF ARSENIC AND HEAVY METAL CONCENTRATIONS IN SOIL, WATER AND CROPS AROUND ABANDONED METAL MINES

Soils, water and crops around abandoned metal mines can be contaminated by heavy metals from adjacent tailings and waste rocks accumulated during mining operations. The results indicate that the As, Zn, Cd and Cr concentrations exceed the soil contamination standard in many soil samples of the nearby farmlands as well as the tailings sites. In the case of water quality, the As concentrations in the Okgae and Youngchen Mines show a decreasing trend with increasing distance from the mine, which is similar to that of the soil samples. The Cd and Pb concentrations in the crops near the Okgae Mine show a decreasing trend with increasing distance from the mine which is also similar to that of soil samples. In addition, the Cd and Pb concentrations in the rice samples and the Cd concentration in the corn samples increase with the Cd and/or Pb concentrations in the soil.

EFFECT OF OHSMS ON WORK-RELATED ACCIDENT RATE AND DIFFERENCES OF OHSMS AWARENESS BETWEEN MANAGERS IN SOUTH KOREA's CONSTRUCTION INDUSTRY

The study was conducted to investigate the status of the occupational health and safety management system (OHSMS) in the construction industry and the effect of OHSMS on accident rates. Differences of awareness levels on safety issues among site general managers and occupational health and safety (OHS) managers are identified through surveys. The accident rates for the OHSMS-certified construction companies from 2006 to 2011, when the construction OHSMS became widely available, were analyzed to understand the effect of OHSMS on the work-related injury rates in the construction industry. The Korea Occupational Safety and Health Agency (KOSHA) 18001 is the certification to these companies performing OHSMS in South Korea. The questionnaire was created to analyze the differences of OHSMS awareness between site general managers and OHS managers of construction companies. The implementation of OHSMS among the top 100 construction companies in South Korea shows that the accident rate decreased by 67% and the fatal accident rate decreased by 10.3% during the period from 2006 to 2011. The survey in this study shows different OHSMS awareness levels between site general managers and OHS managers. The differences were motivation for developing OHSMS, external support needed for implementing OHSMS, problems and effectiveness of implementing OHSMS. Both work-related accident and fatal accident rates were found to be significantly reduced by implementing OHSMS in this study. The differences of OHSMS awareness between site general managers and OHS managers were identified through a survey. The effect of these differences on safety and other benefits warrants further research with proper data collection.

THE ASSOCIATION BETWEEN CHILDHOOD ASTHMA AND RESIDENTIAL ENVIRONMENTAL RISK FACTORS THROUGH CASE-CONTROL STUDY IN ANDONG, KOREA

Using the International Society for Augmentative and Alternative Communication (ISAAC) questionnaire, we surveyed the childhood asthma prevalence and related socioeconomic and residential environment on 887 elementary schoolchildren in Andong, Korea. We selected asthma case group (29) and control group (26) and performed the exposure assessment for the personal exposure for Volatile Organic Compounds (VOCs) and formaldehyde level for 3 days. As a result, 814 schoolchildren completed the questionnaire. It was found that the asthma prevalence was 19.9% and gender (male, OR; Odds Ratio=1.55), age (younger, OR=1.60), family history of asthma (OR=3.70), passive smoking (OR=1.53), and odor from nearby house (OR=2.01) were affective factors. There was no significant difference between the case and control groups in VOCs and formaldehyde exposure level. In the logistic regression analysis, family income (aOR; adjusted OR =3.20, 95% CI=1.41-7.24) and amount of house sunlight (aOR=2.14, 95% CI; Confidence Interval =1.00-4.58) were significant after adjusting gender, age, and family history of asthma. In conclusion, socioeconomic factors including family income and residential environmental factors such as passive smoking, odor from nearby household, and amount of house sunlight are associated with the prevalence of childhood asthma.

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LIST OF ABBREVATIONS

Abbreviation	Meaning
AMSs	Abandoned Mine Sites
APAU	Accident Prevention Advisory Unit
EHS	Environment, Health and Safety
GDP	Gross Domestic Product
GM	Geometric Mean
GSD	Geometric Standard Deviation
HSE	Health and Safety Executive
ISAAC	International Society for Augmentative and Alternative Communication
KAB	Korean Accreditation Board
KOSHA	Korea Occupational Safety and Health Agency
NIOSH	National Institute for Occupational Safety and Health
OHS	Occupational Health and Safety
OHSMS	Occupational Health and Safety Management System
OHSAS	Occupational Health and Safety Assessment Series
PDCA	Plan-Do-Check-Act
ISO	International Standard Organization
TSP	Total Suspended Particulate
VOCs	Volatile Organic Compounds

ACKNOWLEDGMENTS

I would like to express my gratitude to Dr. Hsing Lin, my advisory committee chair, for scrupulous academic guidance and humane consideration that marked the beginning and end of my thesis. The gratitude also extends to Dr. Gang Chen, my advisory committee co-chair, for providing the opportunity to study at University of Alaska Fairbanks as well as continued guidance. Also, thanks to Dr. David Barnes, an advisory committee member, who has taught me the significance of a doctoral degree and Environmental Science. Much appreciation for Professor Daniel Walsh, who, continued beyond his retirement to give advice on my thesis.

I extend my thanks to Dr. Jaewook Choi of Korea University who gave his support to completion of the thesis, Director Shinjea Lee of Korea Occupational Safety and Health Agency, Deputy Director Gyuseok Hwang of Ministry of Employment and Labor, and my colleagues including my friends, Hyukseung Yang, Zhenhua Rui, Deachul Kang and Hyokchun Chi.

Lastly, I want to express gratitude to my parents who have given me courage and support to make it to the end. I dedicate this thesis to my loving wife for her unyielding 5-year support, and my two sons

GENERAL INTRODUCTION

OVERVIEW OF ENVIRONMENT, HEALTH AND SAFETY

Organizations all over the world that work on environmental protection, reduction of occupational health and safety risks at work are to control and improve their business operations, while satisfying the needs and expectations of interested parties. In the recent past, more and more areas in the organizations, including Environment Management Systems (ISO 14001) and Occupational Health and Safety Management Systems (OHSMS; OHSAS 18001), have been certified, while their role in adding value to performance and management success has been proven (Santos et al., 2011). Thus, while environment and health and safety may appear to be two different areas, they may be integrated into Environment, Health and Safety (EHS). For example, mining activities are among the most common sources of toxic element contamination in the surface environment (Adriano, D.C., 2001). And pollutants influence the environment of soil and water system, which in turn pollute farm products, thus ultimately affecting the health of the people who eat those products (Shanker et al., 2005).

The general approach to EHS management as per international standards ISO 14001 and OHSAS 18001 is based on the methodology called "Plan-Do-Check-Act" (PDCA), made popular by W. Edwards Deming (Matias and Coelho, 2002). The management that is promoting these revenue-improving objectives is also capable of producing undesirable outcomes such as EHS (Rahimi, M., 1995). EHS management is an important issue in business management, thus it is necessary to carry out a systematic study of the industrial benefits of EHS management. Today EHS is recognized not only as a moral issue but also an approach that improves the transparency, productivity, and competitiveness of business. In order to make EHS management essential in decision-making and effective in protecting environment and preventing accidents, it is necessary to study the EHS management.

OBJECTIVES AND SCOPE OF THE STUDY

This dissertation is comprised of three peer-reviewed EHS related journal articles: 1. The investigation of arsenic and heavy metal concentrations in soil, water and crops around abandoned metal mines. 2. The effect of OHSMS on work-related accident rate and differences of OHSMS awareness between managers in South Korea's construction industry. and 3. The association between childhood asthma and residential environmental risk factors through case-control study. The objectives of each study are as follows:

1. **The Investigation of Arsenic and Heavy Metal Concentrations in Soil, Water and Crops around Abandoned Metal Mines.**

The EHS-related problems arising from the production of minerals in the mining industry that supplies resources are examined. Heavy metal contaminations of the soil (topsoil and subsoil), water (groundwater and surface water) and crop samples around two abandoned metal mines were investigated to examine the correlation between the soil heavy metal concentration and the distance from the mine. The correlation of heavy metal concentrations between the soil and crop samples was also examined.

2. **The Effect of OHSMS on Work-Related Accident Rate and Differences of OHSMS Awareness between Managers in South Korea's Construction Industry.**

The effect of EHS management in the construction industry is investigated. The research is to study the status of the Occupational Health and Safety Management System (OHSMS) in the construction industry and effect of OHSMS on accident rate.

Differences of awareness levels on safety issues among site general managers and Occupational Health and Safety (OHS) managers are to be identified through surveys. The effect of these difference of awareness levels on accident rate is an important subject in the future study.

3. **The Association between Childhood Asthma and Residential Environmental Risk Factors through Case-Control Study.**

The association between childhood asthma and residential environmental risk factors was investigated through case-control study. The risk factors include household with smokers, humidity of the house, outdoor chemical odors, amount of house sunlight, volatile organic compounds and others.

STRUCTURE OF THE THESIS

The thesis splits into chapters, each of which has been published by peer-reviewed professional journals.

Chapter 1: The Investigation of Arsenic and Heavy Metal Concentrations in Soil, Water and Crops around Abandoned Metal Mines.

Chapter 2: The Effect of OHSMS on Work-Related Accident Rate and Differences of OHSMS Awareness between Managers in South Korea's Construction Industry.

Chapter 3: The Association between Childhood Asthma and Residential Environmental Risk Factors through Case-Control Study.

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CHAPTER 1: THE INVESTIGATION OF ARSENIC AND HEAVY METAL CONCENTRATIONS IN SOIL, WATER AND CROPS AROUND ABANDONED METAL MINES[1]

1.1 ABSTRACT

Soils, water and crops around abandoned metal mines can be contaminated by heavy metals from adjacent tailings and waste rocks accumulated during mining operations. The results indicate that the As, Zn, Cd and Cr concentrations exceed the soil contamination standard in many soil samples of the nearby farmlands as well as the tailings sites. In the case of water quality, the As concentrations in the Okgae and Youngchen Mines show a decreasing trend with increasing distance from the mine, which is similar to that of the soil samples. The Cd and Pb concentrations in the crops near the Okgae Mine show a decreasing trend with increasing distance from the mine which is also similar to that of soil samples. In addition, the Cd and Pb concentrations in the rice samples and the Cd concentration in the corn samples increase with the Cd and/or Pb concentrations in the soil.

[1]Yoon, S., Lin, H.K., Chen, G. and Hwang, G., ‘The investigation of arsenic and heavy metal concentrations in soil, water and crops around abandoned metal mines’, *International Journal of Mining and Mineral Engineering, Vol. 5, No. 2, 2014*

1.2 INTRODUCTION

In Korea, mineral resources have been exploited in the course of industrialisation starting from the Japanese colonial period to 1980s. These mineral resources played an important role in the economic growth, but most mines have been closed since 1980s due to the change of industrial structure and decrease in mine productivity. Data from the Ministry of Commerce, Industry and Energy indicated a status of the abandoned mine and environmental contamination in Korea as of 1998. Among the 936 metal mines across the country, 127 mines (14%) were experiencing impacts such as land subsidence, heavy metal contamination from tailings, and mine water discharge due to the lack of appropriate environmental remediation after the closure. In a survey and analysis of about 3000 soil contamination monitoring network operated by country and local governments, it was found that the heavy metal contamination levels in abandoned metal mine areas are 2–5 times higher than other areas. In Korea, approximately 80% in all closed metal mines were gold (Au) and silver (Ag) mines (The Ministry of Environment of Korea, 2007a).

Mining causes soil erosion and other environmental issues by generating waste during extraction, beneficiation, and processing of ores. After closure, mines can still impact the environment by contaminating air, water, soil and wetland sediments from the scattered tailings and discharged leachate, unless proper remediation is conducted. Heavy metal contamination of agricultural soils and crops surrounding the mining areas is a serious environmental concern in many countries (Steinborn and Breen, 1999). Soil contamination by metals represents one of the major environmental impacts from Abandoned Mine Sites (AMSs). Not only is soil commonly contaminated within the boundaries of AMSs, but also metal compounds may be carried to soil in the vicinity of an AMS by wind or by water including surface runoff, seasonal groundwater seepage and surface water overflow in the floodplains (Aslibekian and Moles, 2003). Wastes such as tailings and waste rocks have been piled up around the mines, and plenty of heavy metals and acidic leachate discharged as infiltrating rainwater reacts with the sulphides contained in the wastes (Saria et al., 2006).

Farmlands around the mines can be easily contaminated by mine wastes and mine water, and that the crops grown on the contaminated soils can contain moderate to excessive levels of heavy metals compared to the crops grown on uncontaminated soils. Contaminated crops affect health when they are constantly consumed (Fergusson, 1990). Studies have been conducted on the effects and mechanism of the heavy metal contents in plants on human health (Shanker et al., 2005). Specifically, the heavy metals not only inhibit the growth of plants, but also lead to diseases in human body such as the neurological disorder, speech disorder, perception disorder, osteomalacia, and mucocutaneous disorder through accumulation when ingested. Numerous studies have been undertaken on trace element contamination derived from mining activities, in soils, plants, waters and sediments in various countries (Moreno-Jimenez et al., 2009; Franssen, 2008; Kim et al., 2002; Kang et al., 2008; Pestana et al., 1997). Some studies of heavy metal concentrations at abandoned mines have been carried out in Korea (Laurinolli and Bendell-Young, 1996; Mayan et al., 2006; Kot et al., 2009; Gorgievski et al., 2009; Kim et al., 2002; Kang et al., 2008). However, few studies of a comprehensive survey of the soil (topsoil and subsoil), water (groundwater and surface water), and crop contaminations in the same abandoned mine areas, and the relevant correlation among them have been conducted.

In this study, heavy metal contaminations of the soil (topsoil and subsoil), water (groundwater and surface water) and crop samples around two abandoned metal mines were investigated to examine the correlation between the soil heavy metal concentration and the distance from the mine. The correlation of heavy metal concentrations between the soil and crop samples was also examined.

1.3 MATERIALS AND METHODS

1.3.1 Site description

1.3.1.1 Okgae Mine

The Okgae Mine is located near Gangneung City, Gangwon-do Province with the longitude of 129°03’10.0”E and latitude of 37°33’18.5”N (Figure 1.1). This mine has two open pits for gold, silver, and zinc productions with an area of 131 ha, and was in operation from 1929 to 1998.

The deposit contains silicates as the predominant gangue minerals while sulphide minerals including pyrite, sphalerite, galena and enargite are present. Jusue Creek flows through the AMS. A waste rock dump is located at upstream hillside while a tailings pond sits downstream. Farmlands are located along Jusue Creek. A half-sealed pit, abandoned mill, and waste rocks were found in the field. A tailings pond confined by a dam is located downstream of the Okgae Mine. A small amount of leachate is believed to be generated by rainfall infiltrating into the waste rocks, rather than by mine water or groundwater passing through the tailing area. Hence, it is expected that the effect on groundwater is insignificant. The waste rocks are mostly located in the upstream hillside, and there is a high possibility that the waste rocks were transported by rainfall. In the case of the soil within the mine sites (e.g., mill) and the farmland soil around the mine sites, heavy metal contamination is expected. The soil located in the downstream of tailings and waste rocks in particular, may be exposed to continuous heavy metal contamination as the tailings and contaminated soil were swept away when the mine was in operation and closed down.

1.3.1.2 Youngchen Mine

The Youngchen Mine is located near Gapyeong-gun, Gyeonggi-do Province with the longitude of 127°23’26.94”E and latitude of 37°51’43.14”N (Figure 1.1). This mine has four open pits for gold, silver, and fluorite productions with an area of 922 ha, and was in operation from 1934 to 1988.

The deposit contains silicates as the predominant gangue minerals while a lesser amount of sulphide minerals including pyrite, sphalerite and galena exist. Mail Creek flows through the AMS. A waste rock dump and tailings are located at upstream hillside. Farmlands are located along Mail Creek. The status of leachate and the actual condition of management after the closure of the Younchen mine are very similar to that of the Okgae Mine.

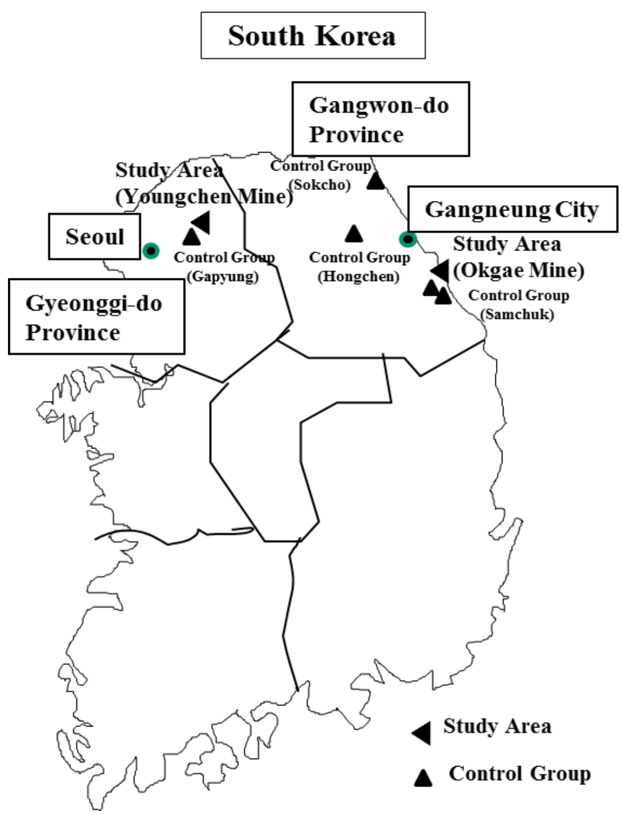


Figure 1.1 Location of the study area.

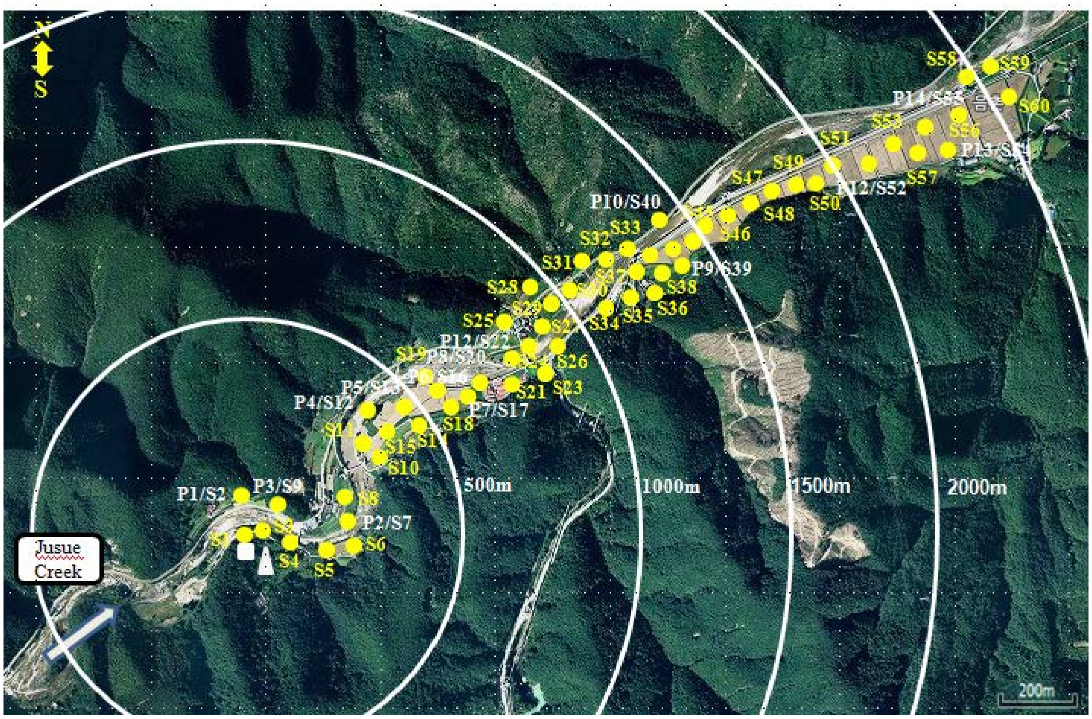
1.3.2 Analytical procedures

1.3.2.1 Soil samples

1.3.2.1.1 Soil sampling

Both topsoil (top 0–30 cm soil layer) and subsoil (sub 30–60 cm soil layer) samples were collected at the same spots within a sampling site using an auger centred around the farmlands located within 4 km downstream of pits and tailings sites. The soil samples from 5 to 10 spots of a zigzag pattern within a sampling site were collected and mixed well in order to obtain a representative sample. Topsoil and subsoil samples were treated separately.

As shown in Figure 1.2, representative topsoil and subsoil samples at the tailings site of the Okgae Mine (S1) and 59 sites centred at the farmlands in the downstream along Jusue Creek (S2–S60) were collected.

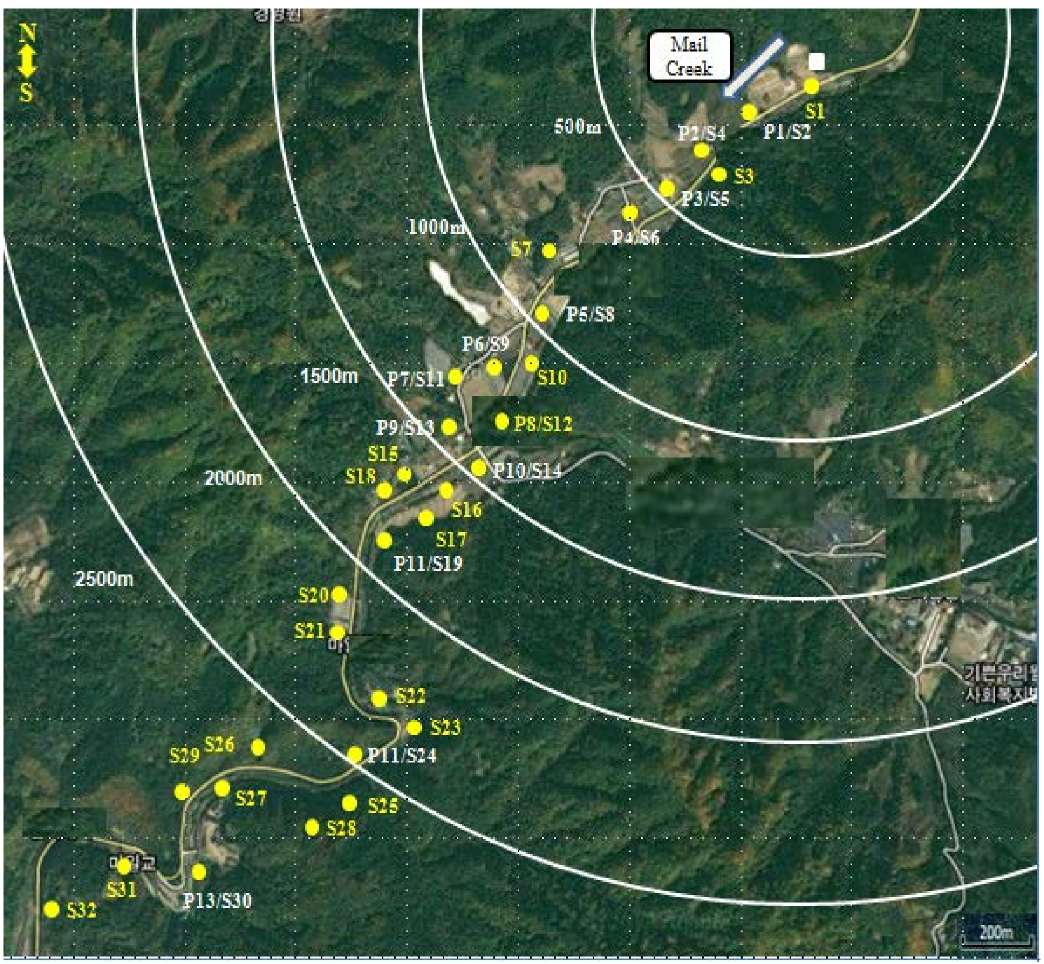


△: Pit, □: Tailings site, S: Soil Sampling Sites, P: Crop Sampling Sites

Figure 1.2 Soil and crop sampling sites at the Okgae Mine and along Jusue Creek.

As shown in Figure 1.3, representative topsoil and subsoil samples at the tailings site of the Youngchen Mine (S1) and 31 sites at the farmlands in the downstream along Mail Creek (S2–S32) were collected.

As the pre-mining era data of soil in the study areas are not available, four control groups of topsoil and subsoil samples in Ganwon-do Province and one in Gyeonggi-do Province were used. The control groups were selected due to the similarity of their climate, topography, population and farm corps to the mine sites but without the presence of mines. The locations of the control groups are indicated in Figure 1.1.



□: Tailings site, S: Soil Sampling Sites, P: Crop Sampling Sites

Figure 1.3 Soil and crop sampling sites at the Youngchen Mine and along Mail Creek.

1.3.2.1.2 Analysis of soil samples

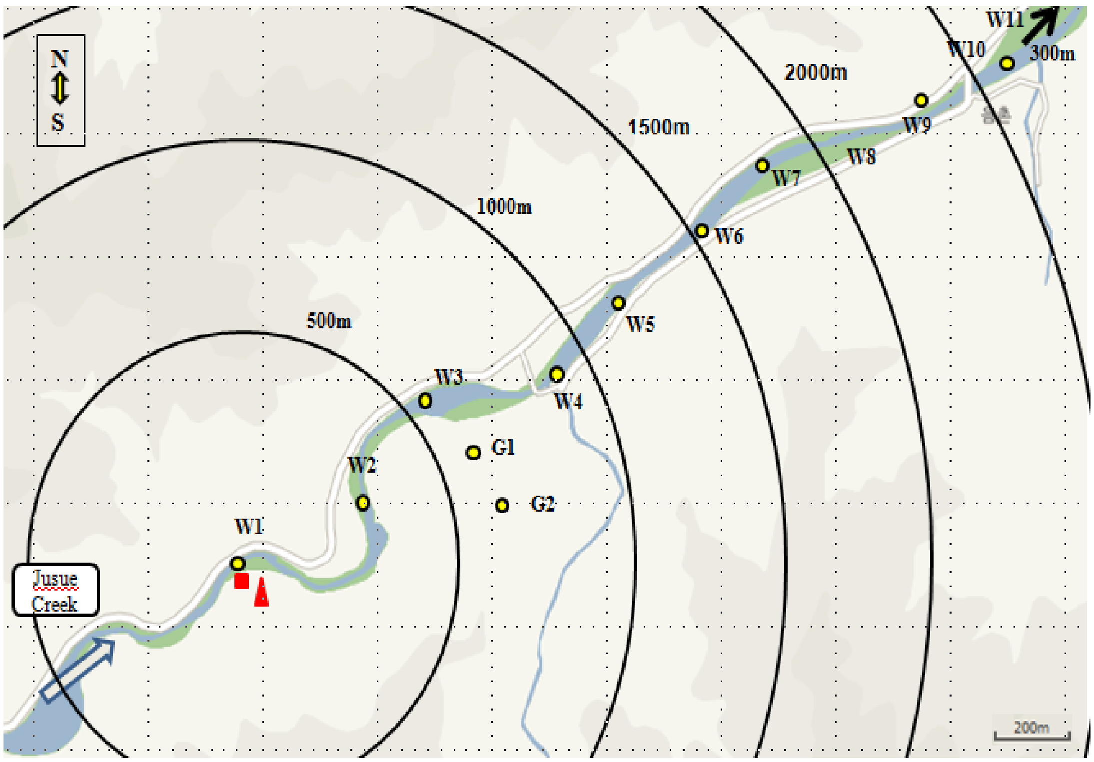
Each representative soil sample was placed in a polyethylene vat at a uniform thickness and air dried in a well-ventilated place with no direct sunlight. For the analysis of As, Cd, Pb, Cu, Cr, Zn and Hg, the dried sample was pulverised with a wooden hammer and passed through a 2-mm standard sieve (8 mesh). The sample was well mixed. Each prepared sample of 10.000 g was weighted and placed in a 100-ml Erlenmeyer flask. After adding 50 ml of hydrochloric acid solution [1M for As; 0.1M for Zn, Cu, Cd, Pb and Cr] or aqua regia [for Hg], the flask was shaken for one hour while maintaining at 30^{o} C in a constant-temperature horizontal shaker (100 times/minute, amplitude 10 cm). The slurry was filtered through a Toyo 5B filter paper and the filtrate analyzed by using ICP or AA. For pH measurements, distilled water was used to replace the acids (Soil Contamination Official Test Method by The Ministry of Environment of Korea (2009)).

1.3.2.2 Water samples

1.3.2.2.1 Water sampling

Both groundwater and surface water samples were taken along Jusue Creek (Figure 1.4) and Mail Creek (Figure 1.5). As shown in Figure 1.4, 11 surface water samples at the Okgae Mine tailings site (W1) and (W2–W11) along Jusue Creek were collected. Two groundwater samples (G1 and G2) were also collected from two communal wells with the locations indicated in Figure 1.4.

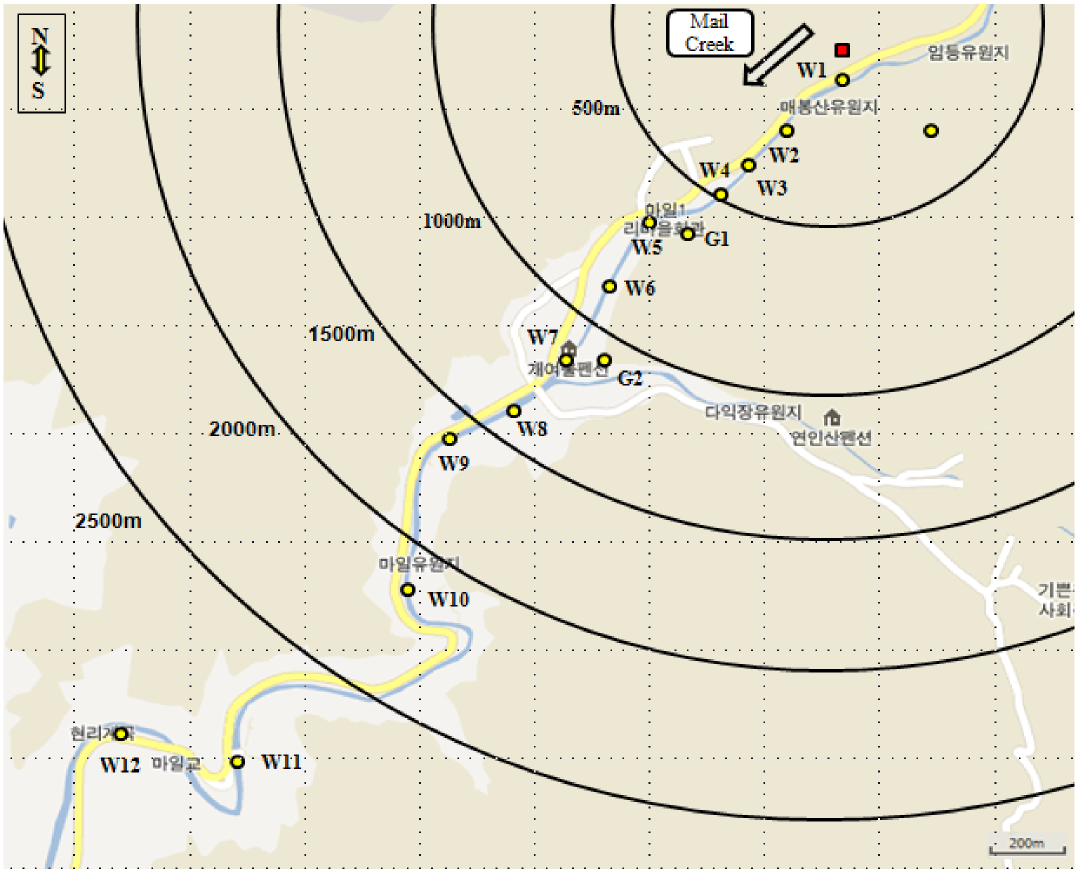
The groundwater samples were properly collected by following the procedure of collecting stagnant water. At each sampling site, several samples were taken until the pH and electrical conductivity of the samples stabilised. The sample with the stable pH and electrical conductivity was analyzed for heavy metal contamination. Surface water samples were collected from the creeks. At each sampling site, four samples were taken to make a composite sample with each sample taken at 30 min apart (Water Contamination Official Test Method by The Ministry of Environment of Korea (2004)).



△: Pit, ☐ Tailings site, ○: Water sampling sites (G: ground water, W: surface water)

Figure 1.4 Water sampling sites along Jusue Creek.

As shown in Figure 1.5, 12 surface water samples at the Youngchen Mine tailings site (W1) and (W2–W12) along Mail Creek were collected. Two groundwater samples (G1 and G2) were also collected from two communal wells with the locations indicated in Figure 1.5.



□: Tailings site, ○: Water sampling sites (G: ground water, W: surface water)

Figure 1.5 Water sampling sites along Mail Creek.

1.3.2.2.2 Analysis of water samples

A small amount of nitric acid was added to preserve the water samples when they were collected. Each water sample was then filtered through a 0.45 μm membrane filter before analyzed by using ICP. However, no acid was added when the sample was measured for pH value.

1.3.2.3 Crop samples

1.3.2.3.1 Crop sampling

The crop samples were collected from some of the soil sampling sites. Edible portions of rice and corn, which are the commonly raised crops in the study areas, were collected from each site when they were available. More than five samples of each crop were taken and mixed in order to make a single representative sample. The crop samples were collected from 14 and 7 sites along Jusue (Figure 1.2) and Mail Creeks (Figure 1.3), respectively.

The crop samples of rice and corn were also collected from the same soil control group sites.

1.3.2.3.2 Analysis of crop samples

In natural conditions, dozens of metallic elements are found in soils, and they exist as ions or various compounds. Among the metallic elements, Cu, Fe, Zn, Mn, Mo, etc. are classified as the trace elements which are necessary for the crops in small amount (ppm level). Therefore, the heavy metal contamination level was investigated for only Cd and Pb. Both Cd and Pb in crops are regulated in Korea.

When the samples were collected from the study area, the edible portions was taken and washed with water, dried for 2–3 days at $40\,^{o}$ C in an oven and pulverised. The pulverised sample of 0.500 g was placed into a glass tube reactor with 20 ml of H_2SO_4. The reactor was then heated to $300\,^{o}$ C for 1 h while adding 2–3 ml of H_2O_2. The product was filtered through a No.42 filter paper to fill a 100-ml mass flask by adding distilled water. The metal concentration of the resulting solution was quantified by using AA.

1.4 RESULTS AND DISCUSSION

1.4.1 Soil sample analysis result

The heavy metal concentration in the control group soil samples is shown in Table 1.1. Also shown in Table 1.1 are the major concern (The level of soil contamination, which is likely to obstruct the health of human beings, animals or plants, and accordingly would necessitate countermeasures) and concern levels (The level of soil contamination, which may obstruct the health of animals or plants) of the Soil Environment Conservation Act in Korea (The Ministry of Environment of Korea, 2007b).

Table 1.1 Heavy metal concentration in the control group soil samples

Sampling sites	pH	Mean of heavy metal concentration of soils (mg/kg)						
		As	Cd	Pb	Cu	Cr	Zn	Hg
Natural abundance for crop farmland soil	-	0.4	0.2	3.0	3.1	0.4	-	0.1
Concern level	-	6	1.5	100	50	4	300	4
Major concern level	-	15	4	300	125	10	400	10
Control Group(5)	6.22	0.45	0.003	1.74	0.39	0.00	56.22	0.00

The results of soil pH and heavy metal concentrations at the tailings site of the Okgae Mine and along Juesue Creek and the control group are given in Figure 1.6. The result indicates that the soil heavy metal concentrations for the mine area are mostly higher than those of the control group area while the heavy metal contents in the control group are similar to those of the natural abundance of crop farmland soil. In other words, it is believed that the soil contamination in the mine area is affected by the mine waste water and/or the dispersion of tailings and waste rocks (Davies, 1983). Therefore, the soils in the control group areas which are not influenced by the mines show lower heavy metal concentrations compared to the soils in the mine areas. As described in a previous section of this paper, the Okgae Mine deposit contained heavy metal sulphide minerals, which could be the source of contamination of soil, water and crops. As shown in Figure 1.6, at the tailings site, marked as distance 0, As, Cd, Pb, Cu, Cr, Zn and Hg concentrations in both the topsoil and subsoil were all high, exceeding those in the control group soils and the concern level. These sulphide minerals produce acid mine drainage when exposed to air and water in nature although it may take a relatively long period of time (Marcus, 1997). Due to the high concentration of the sulphide minerals in the deposit, and hence in tailings, the topsoil and subsoil pH at the tailings site is low at 3.1. The soil pH increases steeply initially and then moderately for the samples taken further away from the tailings site. The changes of the soil sample pH suggest that the tailings are the source of the contamination of the soils along Juesue Creek. The sulphide mineral-containing tailings dust may be transported by flood water or wind and deposit on the farmlands at the downstream of Juesue Creek. The steeper pH increase of the topsoil samples than that of the subsoil samples may indicate the transport mechanism. Concentrations of As, Cd, Cr and Hg in both the topsoil and subsoil samples also see a steep decrease initially (Figure 1.6) and reach the natural abundance levels at the sites beyond 1000 m from the tailings sites. The relatively low Cu concentration in tailings site soil sample, which is close to the natural abundance, may explain why Cu concentration in the soil samples does not decrease with the distance away from the tailings site.

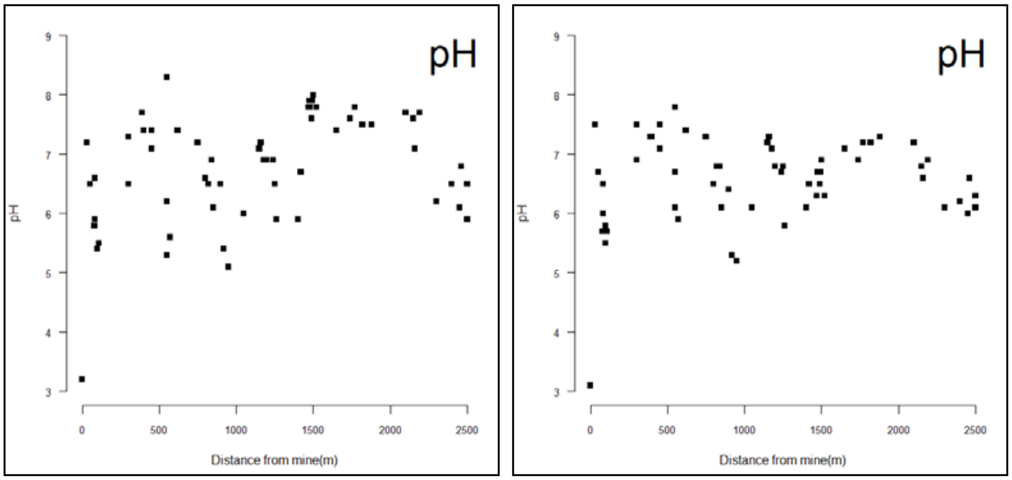


Fig. 1.6(a)

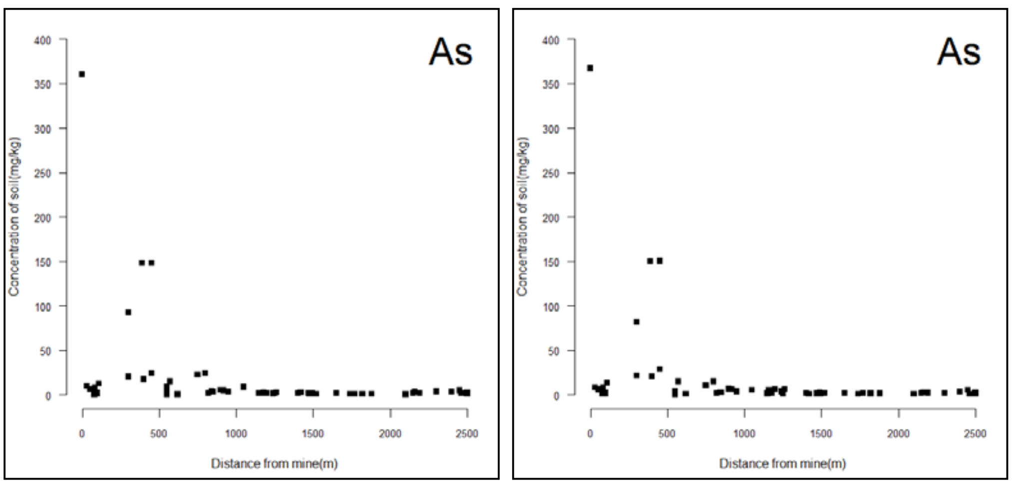


Fig. 1.6(b)

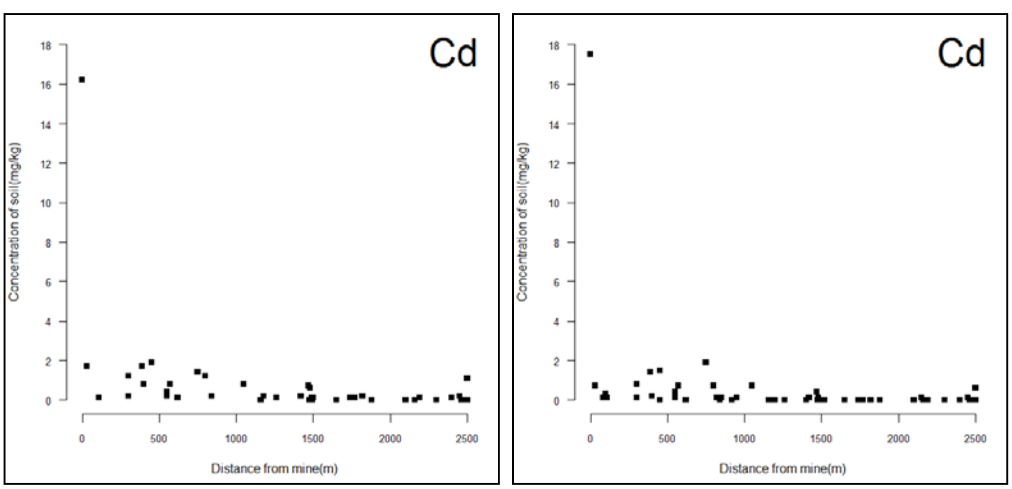


Fig. 1.6(c)

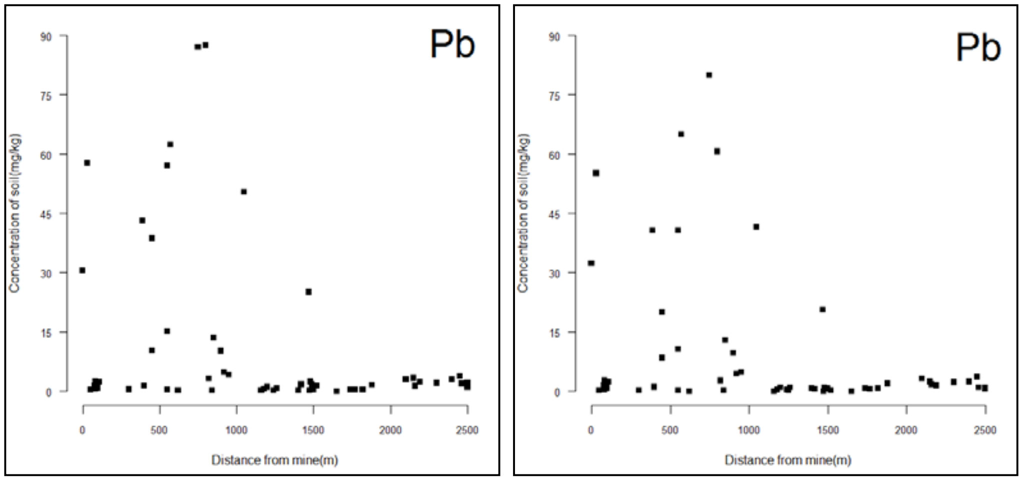


Fig. 1.6(d)

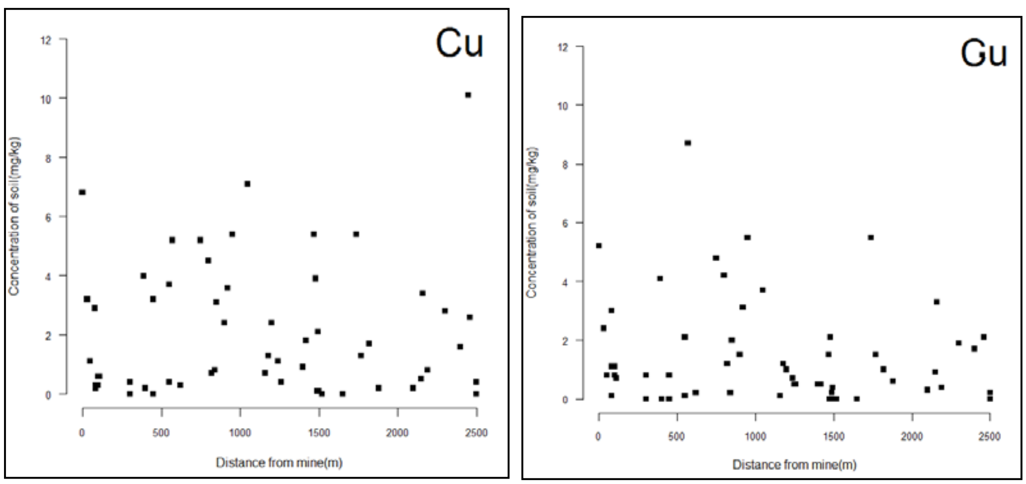


Fig. 1.6(e)

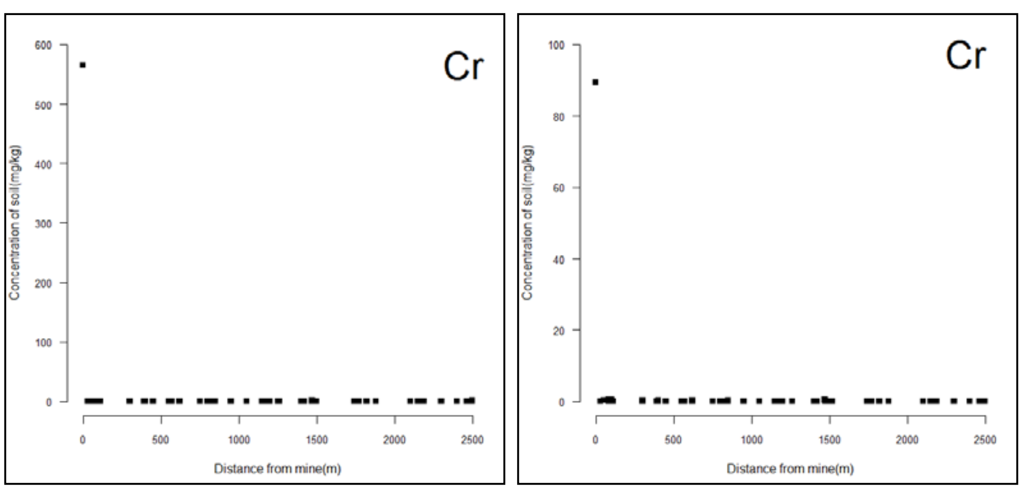
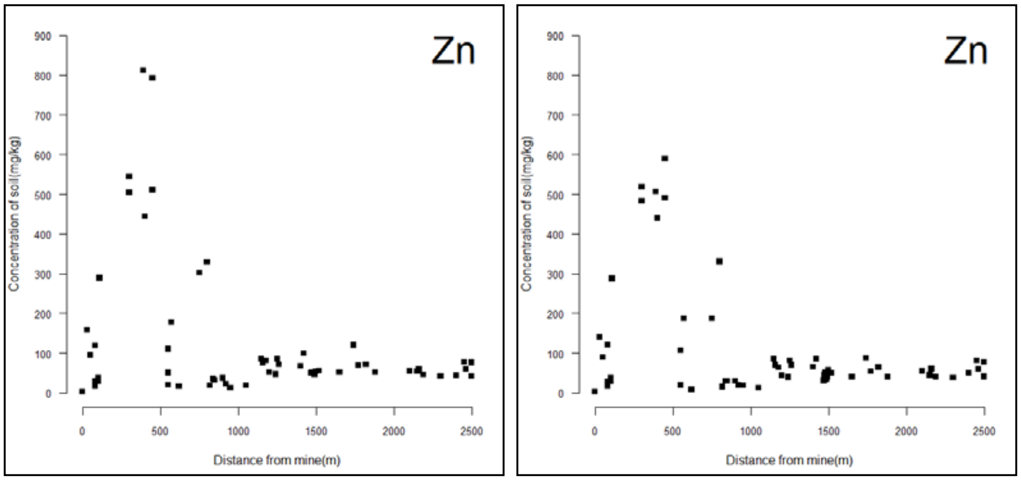


Fig. 1.6(f)



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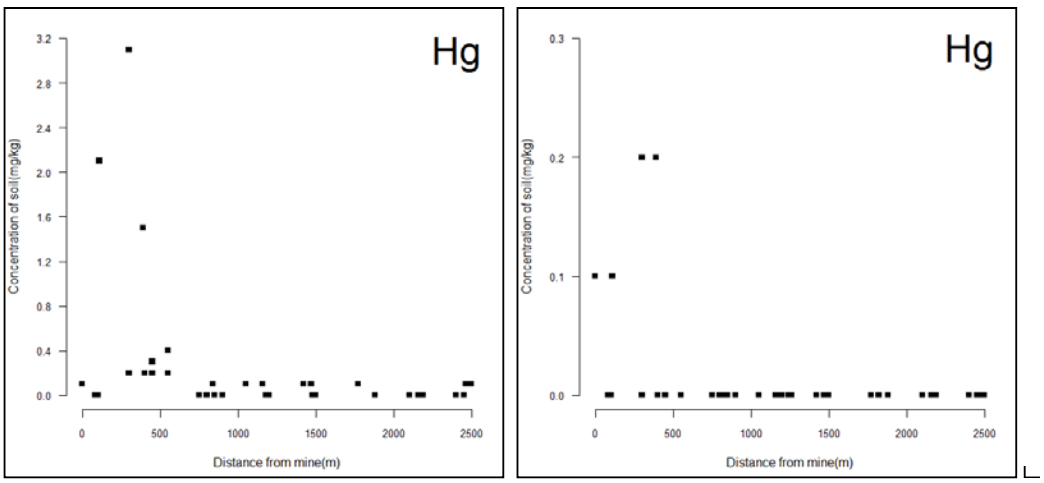


Fig. 1.6(h)

Top soil Sub soil

Figure 1.6 Plots of heavy metal concentrations in soil samples with respect to the distance from the Okgae Mine: (a) pH; (b) As; (c) Cd; (d) Pb; (e) Cu; (f) Cr; (g) Zn and (h) Hg

The results of soil pH and heavy metal concentrations at the tailings site of the Youngchen Mine and along Mail Creek are given in Figure 1.7. As described in a previous section of this paper, the Youngchen deposit contained a lesser amount of heavy metal sulphide minerals, which could be the source of contamination of soil, water and crops. The topsoil pH at the tailings site is low at 5.1 indicating the presence of sulphide mineral in the tailings. However, this pH is higher than the pH of 3.1 observed at the topsoil sample of the Okgae tailings site. This higher pH is consistent with the lower sulphide mineral content in the tailings than in the Okgae tailings. In fact, As and heavy metals, usually in the form of sulphide, in the Youngchen tailings are much lower than that in the Okgae tailings (Figures 1.6 and 1.7). Therefore, the decrease of the As and heavy metal concentration with respect to the distance from the tailings site in the Youngchen Mine study area is less obvious than that in the Okgae Mine study area.

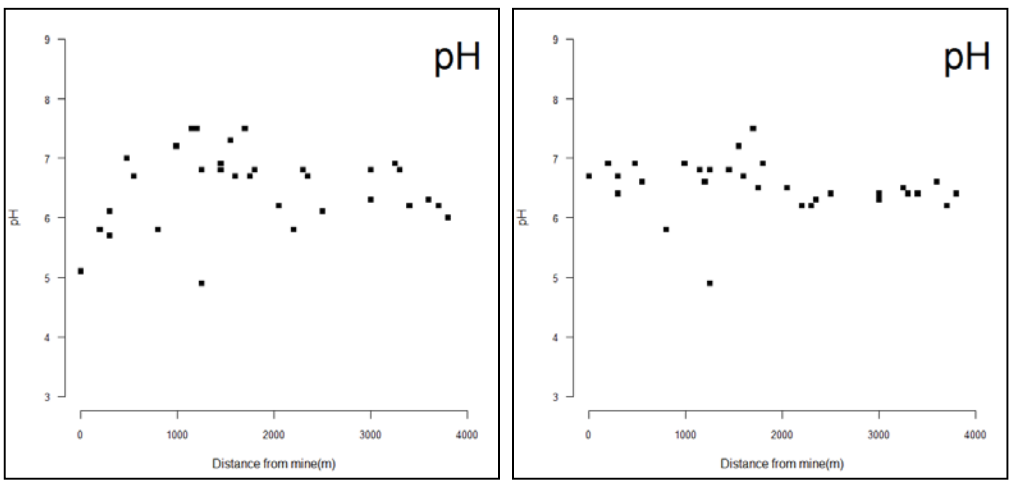


Fig. 1.7(a)

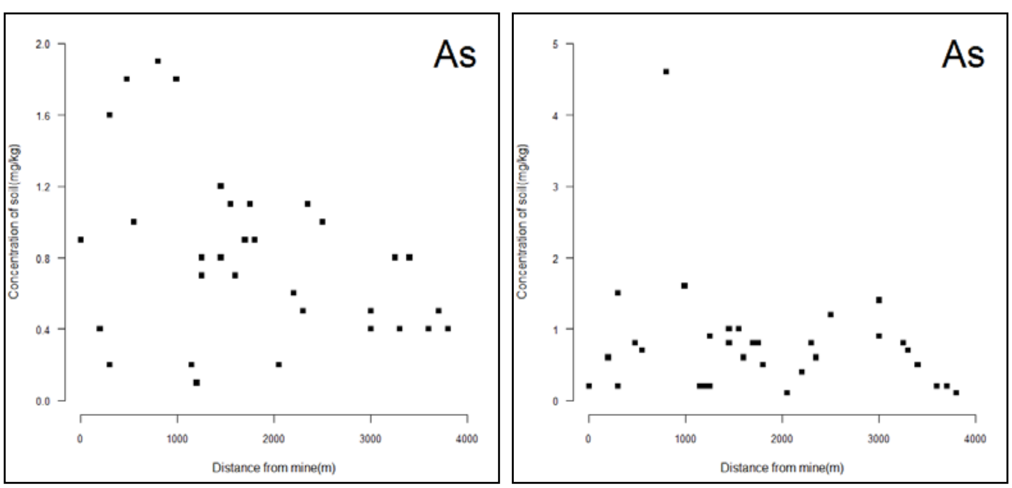
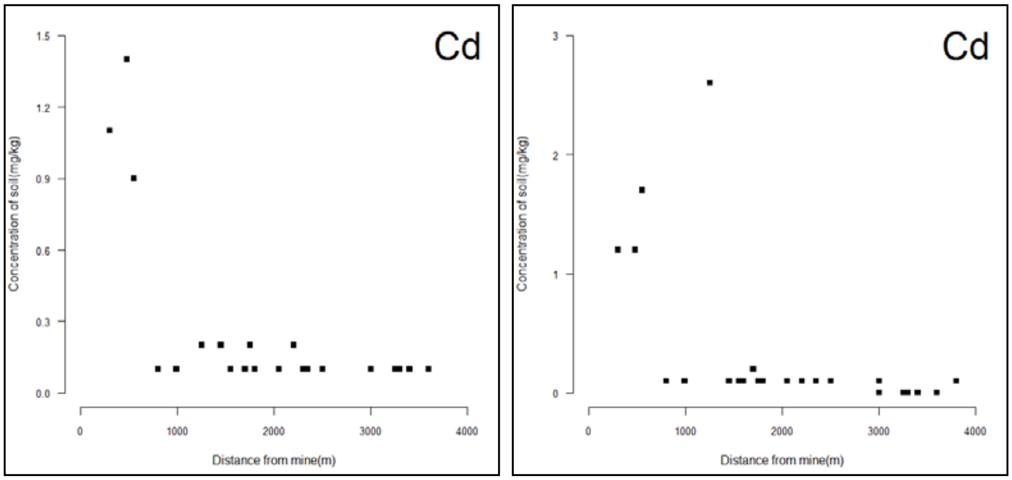


Fig. 1.7(b)



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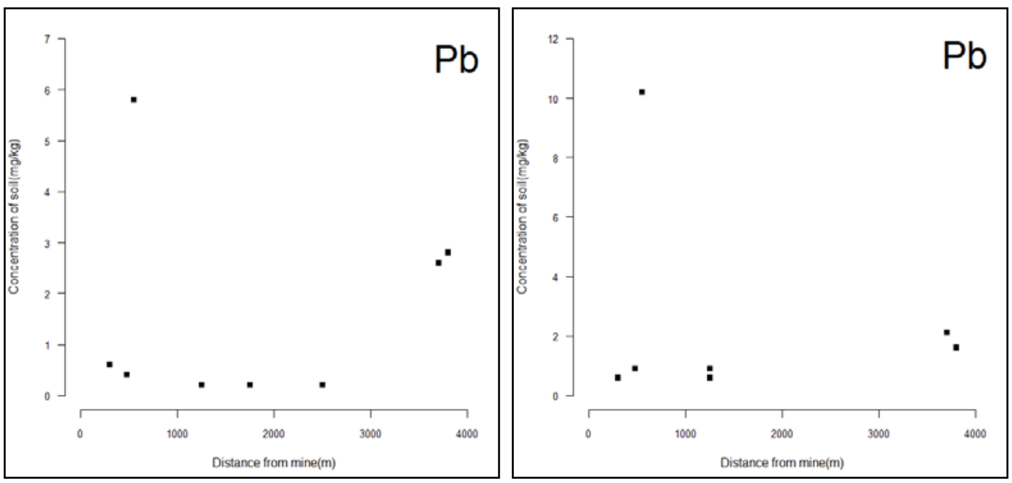

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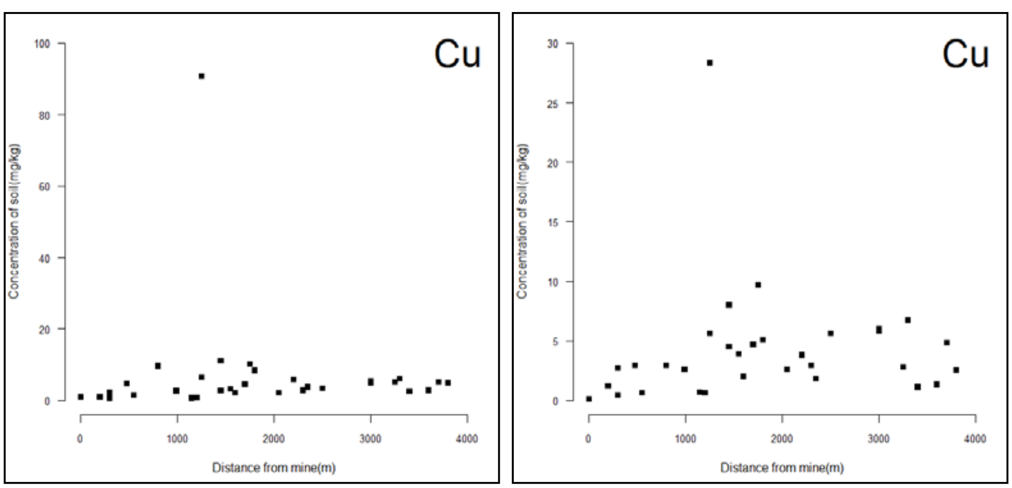

Fig. 1.7(e)

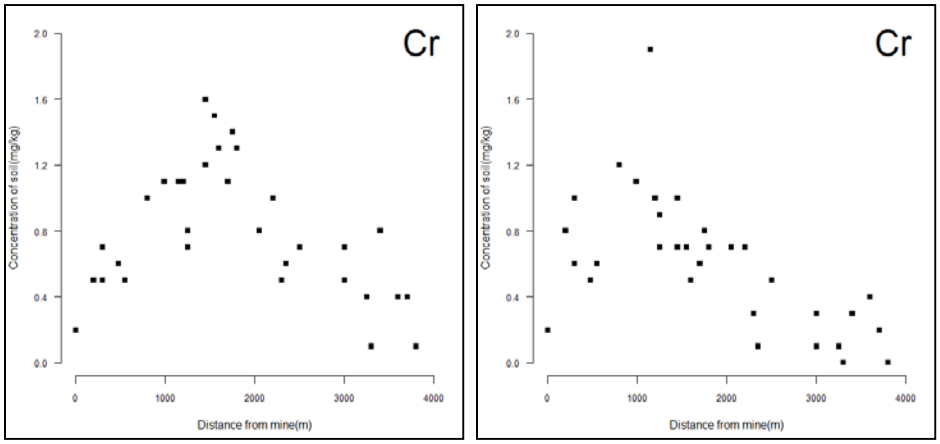

Fig. 1.7(f)

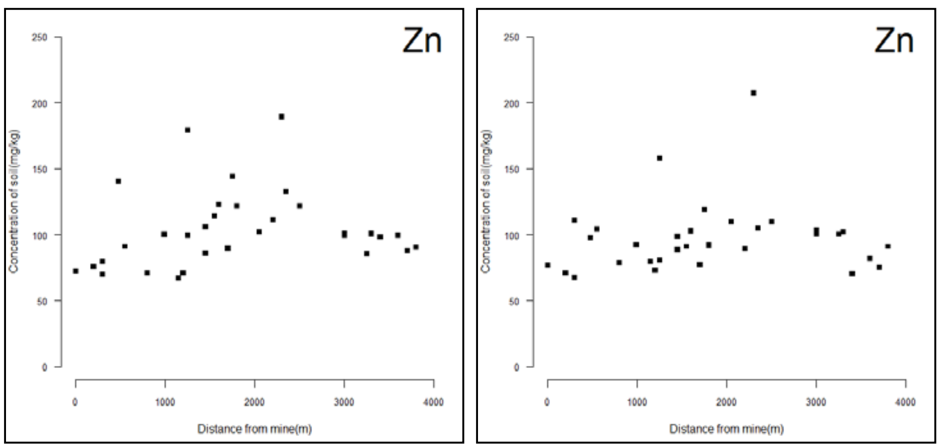

Fig. 1.7(g)

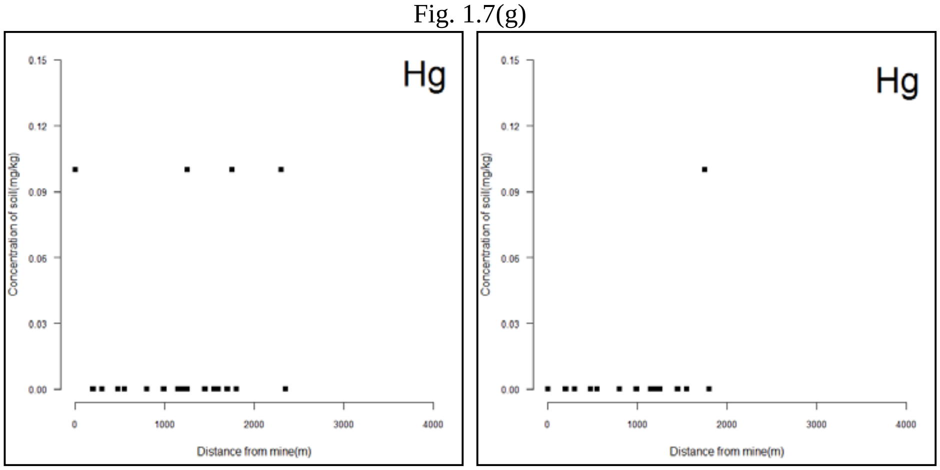

Fig. 1.7(h)

Top soil Sub soil

Figure 1.7 Plots of heavy metal concentrations in soil samples with respect to the distance from the Youngchen Mine: (a) pH; (b) As; (c) Cd; (d) Pb; (e) Cu; (f) Cr; (g) Zn and (h) Hg

1.4.2 Water sample analysis result

The surface water pH increases from 7.6 to 8.2 initially from the Okgae Mine tailings site and from 5.0 to 7.5 from the Youngchen Mine tailings sites (Figures 1.8 and 1.9). The increase is much less significant than that of the Okgae Mine soil sample (Figure 1.6), likely due to the dilution effect of the creek water. Most heavy metals have high mobility in strongly acidic oxidising environment. At pH of 7–9, most heavy metals precipitate as hydroxides. Given this pH profile, heavy metal concentrations in the water samples were expected to be very low. In fact, very low concentrations of Cd, Pb, Cu and Zn were detected of the samples at tailings sites and the concentrations were undetectable for the samples taken away from the tailings sites. However As precipitates as arsenite or arsenate and the precipitation is less effective than Cd, Hg, Cu, Pb and Cr at neutral pH (Modrow and Kimball, 1996). Unfortunately for the purpose of data analysis, only the samples taken within 300 m of the tailings site are detectable for As while the rest of samples show undetectable As. With limited data points, the decrease of As concentration is indicated in Figures 1.8 and 1.9, nonetheless. The impact of the tailings on the groundwater is less than on the surface water. Only trace amounts of Zn were detected on two groundwater samples, which were taken at locations very close to the tailing sites.

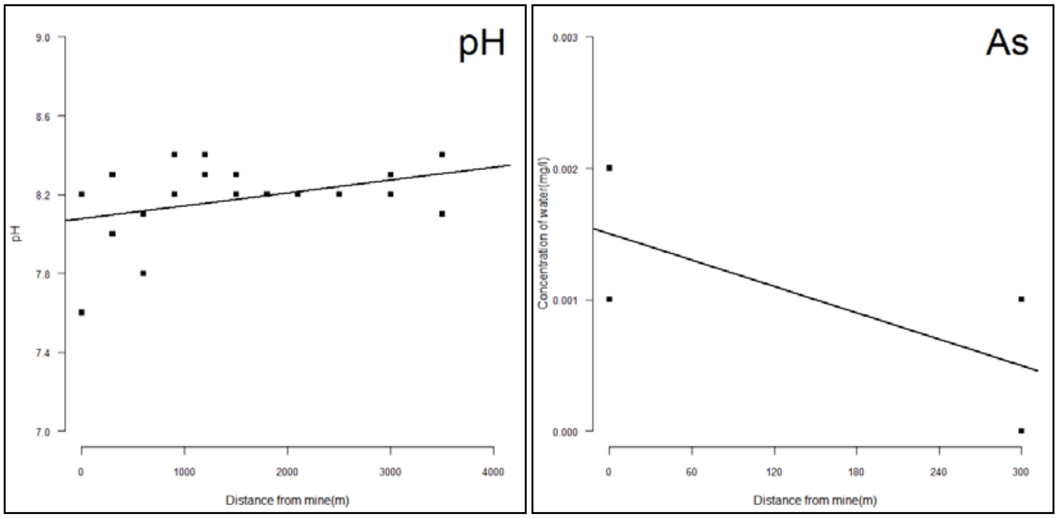

Figure 1.8 Plots of surface water heavy metal concentrations with respect to the distance from the Okgae Mine.

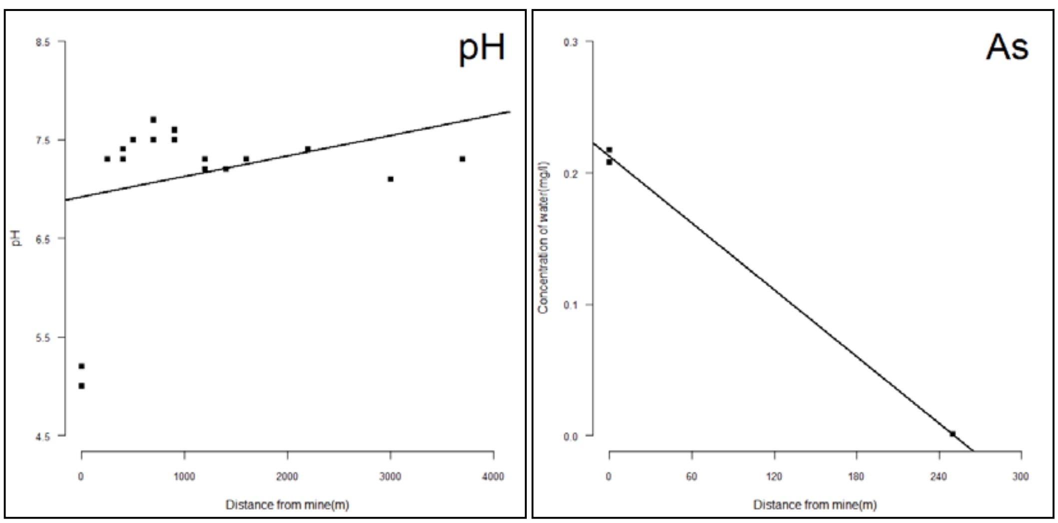

Figure 1.9 Plots of surface water heavy metal concentrations with respect to the distance from the Youngchen Mine.

1.4.3 Crop sample analysis result

The Korea's rice safety limit is 0.2 mg/kg for both Cd and Pb while the corn limits are 0.2 and 0.1 mg/kg for Cd and Pb, respectively (KFDA, 2009). The Cd content in the control groups is 0.00 mg/kg for both rice and corn. Many crop samples from this study contain higher Cd and Pb concentrations than that of control groups and one exceeds the Pb safety limit.

The Cd and Pb concentrations of the rice and corn samples vs. the distance from the tailings site were plotted. For the Okgae Mine and along Jusue Creek, the Cd and Pb concentrations in the samples show a decreasing trend with respect to the distance from the tailings site (Figure 1.10). The decreasing trend is similar to that of the soil samples (Figure 1.6). As shown in Figure 1.10, many samples taken at the Okgae Mine and along Jusue Creek contain higher concentrations of Cd and Pb than that of the control group samples. The Pb concentration in the corn sample taken at a location very close to the tailings site is higher than the Korea's safety limit, while the other samples taken further away from the tailings site contain an undetectable amount of Pb.

For the Youngchen Mine and along Mail Creek, insufficient rice and corn data were obtained partially due to the lower concentrations of Cd and Pb in the soil than that of the Okgae Mine, resulting undetectable Cd and Pb concentrations in the rice and corn samples (Figures 1.6 and 1.7).

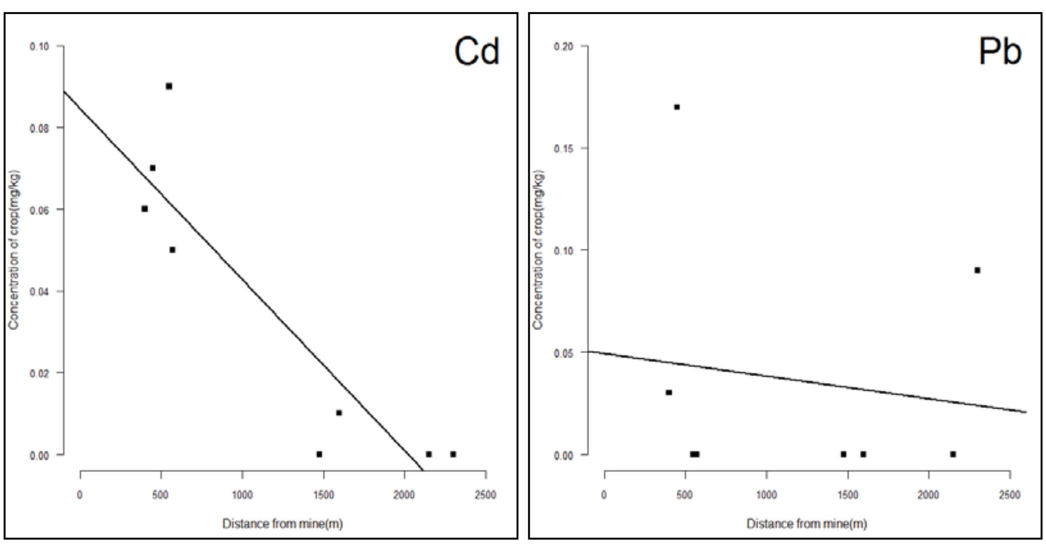

Fig. 1.10(a) Rice

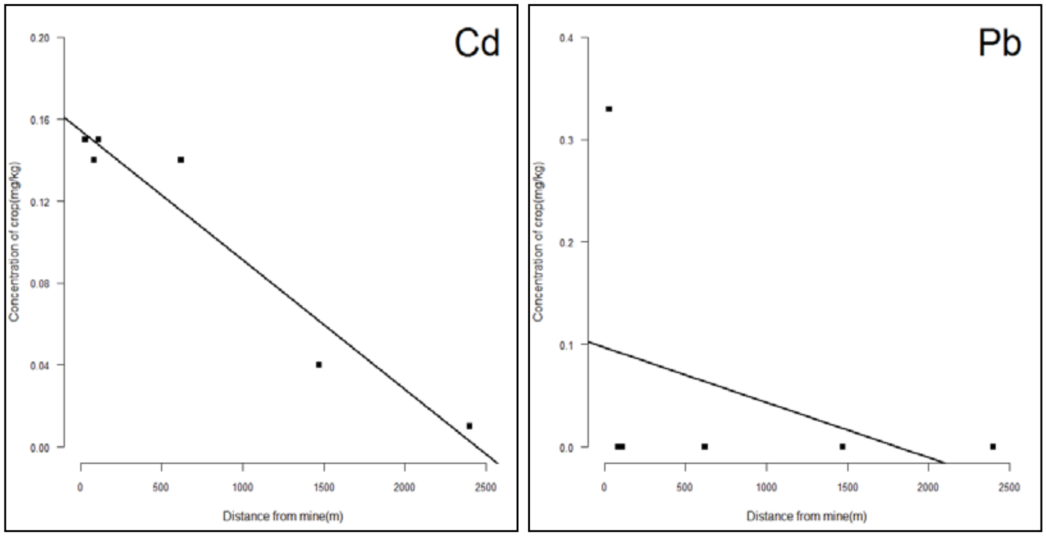

Fig. 1.10(b) Corn

Figure 1.10 Plots of heavy metal concentrations in rice and corn with respect to the distance from the Okgae Mine: (a) rice and (b) corn

1.4.4 Correlation between the soil and crop samples

As the Cd and Pb concentrations are undetectable for almost all the water samples taken away from the tailings sites, only the correlation of Cd and Pb concentrations between the soil and crop samples was investigated. The soil sample heavy metal concentrations and crop sample heavy metal concentrations were compared to examine the correlation between the soil and crop samples (Figure 1.11).

As shown in Figure 1.11, with limited data points, a positive correlation between the Cd and Pb contents of the rice samples and the soil samples is indicated. A somewhat positive correlation is also shown for the Cd and Pb content in corn samples.

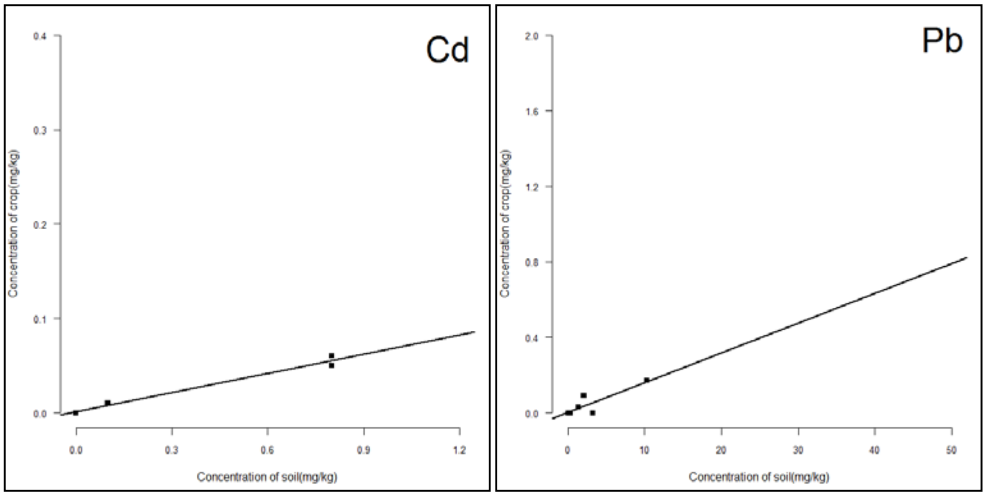

Fig. 1.11(a) Rice

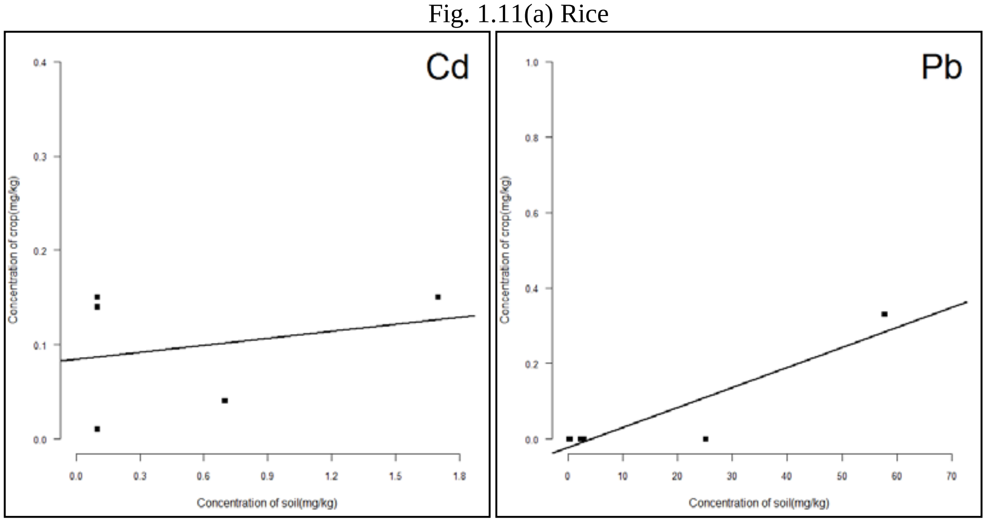

Fig. 1.11(b) Corn

Figure 1.11 Plots of the Cd and Pb concentrations in rice and corn vs. soil samples for the Okgae Mine and along Juesue Creek: (a) rice and (b) corn

1.5 CONCLUSIONS

This study examined the heavy metal content for the soil (topsoil and subsoil), water (groundwater and surface water), and crops from the tailings sites and farmlands close to the two abandoned metal mines (Okgae and Youngchen Mines). The soil, water and crop samples within 4 km of the mines were analyzed. The correlation between the heavy metal concentration and the distance from the mine was analyzed. The correlation between the soil and crop samples was also investigated for Cd and Pb.

The soil pH is low for the samples of both tailings sites and initially increases rapidly to the neutral level with an increased distance from the sites. The initial change of surface water pH was less significant likely due to the dilution effect of the creek water. Heavy metal concentration is undetectable in almost all the water samples taken beyond the tailings sites as they precipitate as hydroxides in a pH range of 7–9. The rapid decrease of heavy metal concentration in the water samples to undetectable levels makes the modelling or meaningful quantification of analysis of the contamination with distance from the tailings site very difficult in this study. A sampling plan with a higher sampling density within a closer distance from the tailings site is warranted. However, arsenic precipitates less effectively and it can be detected in water samples more easily. However, except for the surface water at the Youngchen mine site, the arsenic concentration in the surface water samples is less than the Korea's drinking water standard of 0.05 mg/l.

The factors affecting the environmental impact by abandoned mines include the scale of the abandoned mine, topography, geography and hydrology of the area. This study found that As and heavy metal contents in water and soil decrease to natural levels when the sites are beyond 1000 m from the mines.

Many soil sample taken from this study areas contain heavy metals exceeding that of the control group and concern levels. In general, the arsenic and heavy metal concentrations in the soil sample decrease with an increased distance from the tailings site. The concentrations of Cd and Pb in the rice and corn samples grown in the study area shows a positive correlation with the Cd and Pb concentrations in the soil samples of the farmland.

It is possible that the contamination of soil, water and crops can occur through natural weathering of the deposit and the pre-mining era data can and should be used to compare with the post-mining era ones to determine the cause of the contamination. Unfortunately, the data are not available. Nonetheless, the low pH and high arsenic and heavy metal concentrations of the soil and water samples taken around the tailings sites lead us to believe that the tailings likely contribute to the soil, water and crop contamination. A proper mine closing procedure needs to be followed to prevent the contamination.

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CHAPER 2: EFFECT OF OHSMS ON WORK-RELATED ACCIDENT RATE AND DIFFERENCES OF OHSMS AWARENESS BETWEEN MANAGERS IN SOUTH KOREA'S CONSTRUCTION INDUSTRY[1]

2.1 ABSTRACT

Background: The study was conducted to investigate the status of the occupational health and safety management system (OHSMS) in the construction industry and the effect of OHSMS on accident rates. Differences of awareness levels on safety issues among site general managers and occupational health and safety (OHS) managers are identified through surveys.

Methods: The accident rates for the OHSMS-certified construction companies from 2006 to 2011, when the construction OHSMS became widely available, were analyzed to understand the effect of OHSMS on the work-related injury rates in the construction industry. The Korea Occupational Safety and Health Agency (KOSHA) 18001 is the certification to these companies performing OHSMS in South Korea. The questionnaire was created to analyze the differences of OHSMS awareness between site general managers and OHS managers of construction companies.

Results: The implementation of OHSMS among the top 100 construction companies in South Korea shows that the accident rate decreased by 67% and the fatal accident rate decreased by 10.3% during the period from 2006 to 2011. The survey in this study shows different OHSMS awareness levels between site general managers and OHS managers.

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[1]Seok J. Yoon, Hsing. K. Lin, Gang Chen, Shinjea Yi, Jeawook Choi and Zhenhua Rui, 'Effect of OHSMS on Work-related Accident Rate and Differences of OHSMS Awareness between Managers in South Korea's Construction Industry', *Safety and Health at Work 4 (2013) pp. 201-209*

The differences were motivation for developing OHSMS, external support needed for implementing OHSMS, problems and effectiveness of implementing OHSMS.

Conclusion: Both work-related accident and fatal accident rates were found to be significantly reduced by implementing OHSMS in this study. The differences of OHSMS awareness between site general managers and OHS managers were identified through a survey. The effect of these differences on safety and other benefits warrants further research with proper data collection.

2.2 INTRODUCTION

In most industrialized countries, the construction industry is one of the most significant in terms of contribution to gross domestic product (GDP). It also has a significant impact on the health and safety of the workers. The construction industry is both economically and socially important. In South Korea, the construction industry contributed approximately 7% to its GDP in 2007. As of late 2012, after the financial crisis, it contributed approximately 5% of the GDP (US$116.35 billion) and ranked 15th among the construction industries in the world. The construction industry presents a substantial portion of South Korea's economy (The Bank of Korea, 2013). Its employment rate ranged from 24.8% to 33.6% of all industries in a 10-year period to late 2011. The construction industry accident rate (work-related victims/100 workers) in Korea was similar to the all-industry accident rate. The construction industry had the accident rate of 0.64-0.95, compared with all-industry accident rate of 0.65-0.90 during this period. However, the construction industry fatal accident rate (fatal accident/10,000 workers) in Korea (1.89-3.97/10,000 workers) was higher than the all-industry fatal accident rate (1.47-2.76/10,000 workers) during the same period (Korea Occupational Safety and Health Agency, 2013). The industry provides homes, buildings, infrastructures, and plants. However, in the construction industry, there were many accidental deaths or the workers had serious injuries. More workers were killed or injured each year in the construction industry than in any other industries. In the United States, the industry employs 5-6% of the labor force, but has 15% of the fatal injuries and well over 9% of all workdays are lost due to injuries. Construction workers who are disabled or killed each year by work-related injuries are believed to number in the tens of thousands (Ringen and Seegal, 1995). In addition, unlike other industries, the construction industry is project based, and the accident rates vary from one project to another. Each project is unique, and each project type (e.g., housing and office, transportation, and plant) has its own characteristics, which may include methods of working, materials used, and techniques applied for construction. These characteristics may also vary from project to project in the construction industry in South Korea.

Work-related accidents cause a loss to the company as well as the employees. Accordingly, the Accident Prevention Advisory Unit (APAU) of the Health and Safety Executive (HSE) in the United Kingdom (UK), which passed the world's first Occupational Health and Safety Act, surveyed the costs of work-related accidents in 1989. The results indicated that the loss for the companies from work-related accident was 5-10% of the profit for all industries and 8.5% of the tender price for the construction industry. The ratio of the direct cost to the indirect cost of the work-related accidents is 1:11 (Davies and Teasdale, 1993). The indirect costs are product and material damage, loss of production time, legal costs, overtime and temporary labor, investigation time, supervisor's time, fines, loss of expertise and experience, loss of morale, and bad publicity. The occupational health and safety management system (OHSMS) was first prepared by the HSE's APAU in the UK in 1991 as a practical guide for directors, managers, health and safety professionals, and employee representatives who wanted to improve health and safety in their organization (Health and Safety Executive, 1991). The OHSMS is part of the overall management system that facilitates the management of the occupational health and safety (OHS) risks associated with the business of the organization. It includes the organizational structure, planning activities, responsibilities, practices, procedures, processes, and resources for developing, implementing, achieving, reviewing, and maintaining the organization's OHS policy (British Standards Institution, 1999, a). A variety of OHSMS-based standards, guidelines, and audits since then have been developed within public, private, and not-for-profit sectors. Many of these have been adopted by various workplaces (Robson et al., 2007). In South Korea, the Korea Occupational Safety and Health Agency (KOSHA) and the Korean Accreditation Board have also developed KOSHA 2000 (revised to KOSHA 18001 in 2003) and K-OHSMS 18001 in 1999 and 2001, respectively. The OHSMS was created to enable an organization to control its OHS risks and to improve its OHS performance (OHSAS Project Group, 2007). The OHS is an important issue in business management, and thus, it is necessary to carry out a systematic study of the costs and benefits of OHSMS. Today, OHSMS has been recognized as not citation and moral issue but as an approach to improve the transparency, productivity, and competitiveness of business. To make OHS an essential element in decision making and effective in preventing occupational accidents, it is necessary to examine the effects of an OHSMS. Although the OHSMS has been developed and implemented by many major companies in South Korea, studies on their implementation and effect have rarely been carried out.

This study tests the following: First, reducing the accident rate is one of the most important purposes of developing and implementing OHSMS. Hence, the construction company in which the OHSMS is established will have low accident rate. Second, in the case of South Korean construction industry, the large companies are generally aware of the need for OHSMS, but most small- and medium-sized construction companies are at an early stage in terms of the practical aspect such as the health and safety investment. The health and safety as well as the quality and productivity play an important role in the success and development of business management. Thus, the value-added management can be accomplished by providing an outstanding health and safety service. The OHS managers in the company also need to make continuous efforts to manage the work performance and cost within the scope of their tasks to improve the added value of health and safety service. It is difficult for most OHS managers to be directly involved in chief business management positions such as strategies, evaluations, organization operations, planning, and audits. For management, the decision making is generally determined at the directors' meeting by the authority of chief executive officer, and is notified to the front-line manager. The directors' meeting is responsible for establishing the business strategy, and the line manager is responsible for carrying out the business plan to perform the strategy. Therefore, the OHS manager also needs to develop the service strategy for the best value-added business (Deacon, 1997). However, in the case of South Korea's construction industry, there are not many opportunities for the OHS manager to participate in the strategy development for the added value of business. Accordingly, the awareness of site general manager and OHS manager for OHSMS is expected to be different. Third, unlike other industries (e.g., manufacturing industry, service industry), the construction industry is not involved in the continuous production activity at a single location. The construction industry is project based, and depending on the project, it performs the tasks in the fields of housing and office, transportation, and plant. Each field has its own characteristics and working procedures. Consequently, the OHSMS for the construction industry is expected to differ among those fields.

The objectives of this study are as follows: (1) understanding the effect of OHSMS through the analysis of accident rates for the construction companies in which the OHSMS is established; (2) understanding the differences of OHSMS awareness between the site general managers and OHS managers through statistical analysis; and (3) understanding the differences among various construction types.

2.3 MATERIALS AND METHODS

2.3.1 Analysis of health and safety data

Since the establishment of KOSHA 18001 OHSMS in 1999 by the KOSHA, 876 companies had maintained the certification as of late 2011. Among these, 17 companies were in the construction industry. Although there were more than 1,000 construction companies in South Korea at the time of this study, all 17 OHSMS-certified construction companies were among the top 100 construction companies. None of the small- and medium-sized construction companies were OHSMS certified. To examine the effect of OHSMS certification on work-related accident rate, companies of a similar size with and without OHSMS certification are to be selected. The small- and medium-sized companies cannot be included as none of them were OHSMS certified, although they represented approximately 70% of the construction workers. The top 100 companies were selected for this study. By doing so, the effect of company size on the work-related accident rate can also be mitigated as all the selected companies are in the similar size (top 100 companies). The accident rates for the construction companies from 2006 to 2011, when the construction OHSMS become widely available, were analyzed to understand the effect of OHSMS on the work-related injury in the construction industry.

2.3.2 Survey on OHSMS awareness of site general managers and OHS managers of construction companies

KOSHA 18001 is the certification to these companies performing OHSMS in South Korea. The questionnaire (see the “Appendix” section) was created to analyze the differences of OHSMS awareness between site general managers and OHS managers of construction companies. This survey was performed on approximately 60 OHSMS-certified construction workplaces of the 17 companies by e-mail and phone. The research participants were the site general managers and OHS managers of each construction workplace. Among the 60 workplaces surveyed, 36 workplaces, where both site general manager and OHS manager responded to the questionnaire, were selected as the research areas.

2.3.3 Statistical analysis

All values are presented as a number of participants and percentage for categorical variables. The differences between participant's demographics and the awareness between groups were tested using Fisher exact test or Pearson Chi-square test. All statistical analyses were performed with SPSS (version 19.0; SPSS, Inc., Chicago, IL, USA). A two-sided $p < 0.05$ was considered to be statistically significant.

2.4 RESULTS AND DISCUSSION

2.4.1 Effect of OHSMS on work-related accident rate

All companies in Korea report their work-related accidents and organization information to KOSHA. This database was used for analyzing the accident rates in this study. The comparison of the work-related victims of all companies and all OHSMS-certified companies from 2006 to 2011 is shown in Fig. 2.1. It clearly shows that the certified companies have a lower work-related accident rate. However, due to the fact that large companies have a higher possibility to be OHSMS certified, the size of the company (number of workers) may be a factor contributing to the accident rate. To mitigate this factor, the top 100 largest construction companies were selected from more than 1,000 construction companies in South Korea to analyze the effect of OHSMS certification on the work-related accident rate in this study. These 100 top companies were competing for similar projects. Although the comparison of accident rate for small-and medium-sized companies with and without OHSMS certification was also intended, however, as mentioned earlier, none of the small- and medium-sized construction companies were OHSMS certified. Therefore, the comparison cannot be made to examine the effect of OHSMS certification on the accident rate.

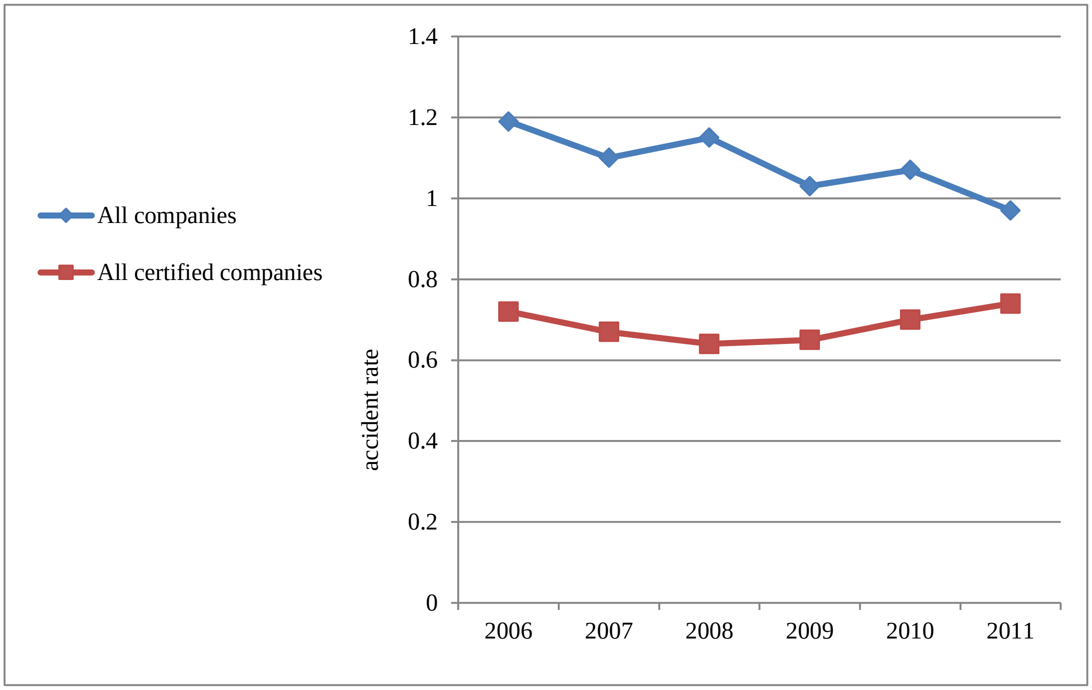

Figure 2.1 Accident rate (work-related victims per 100 workers)

The data collected from KOSHA (Korea Occupational Safety and Health Agency, 2013) indicate that from 2006 to 2011, the number of workers in the certified construction companies ranges from 135,981 to 322,696, whereas it ranges from 329,396 to 616,220 for the noncertified construction companies. As shown in Fig. 2.2, the accident rate, among the top 100 largest construction companies, is much lower for the certified companies than that for the noncertified companies. The average annual accident rates during this period were 0.30 and 0.18 victims/100 workers for the noncertified and certified companies, respectively. The average accident rate is lowered by 67% when certified companies were compared with noncertified construction companies. This reduction is likely to due to the implementation of OHSMS, because the influencing factor of the company size has been mitigated.

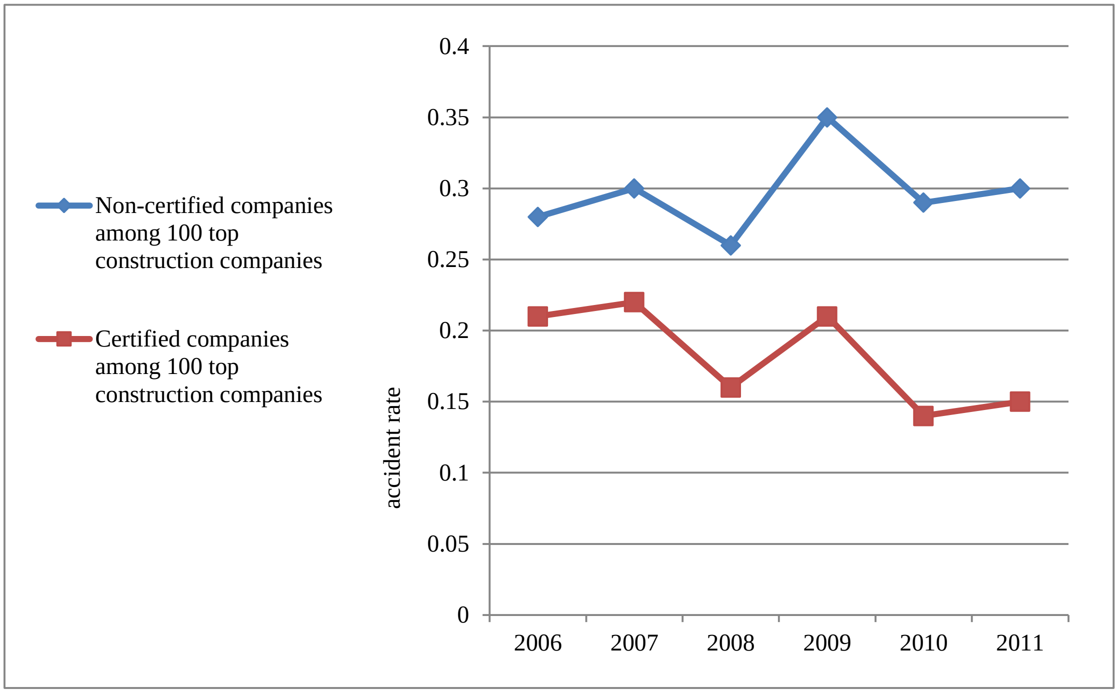

Figure 2.2 Accident rate (work-related victims per 100 workers)

As shown in Fig. 2.3, the fatal accident rate of the certified companies, among the top 100 largest construction companies, is also lower than that of the noncertified companies. The average annual accident rates during this period were 2.03 and 1.82 victims/10,000 workers for the noncertified and certified companies, respectively. The average fatal accident rate of the certified companies is lowered by 10.3% when compared with that of noncertified construction companies.

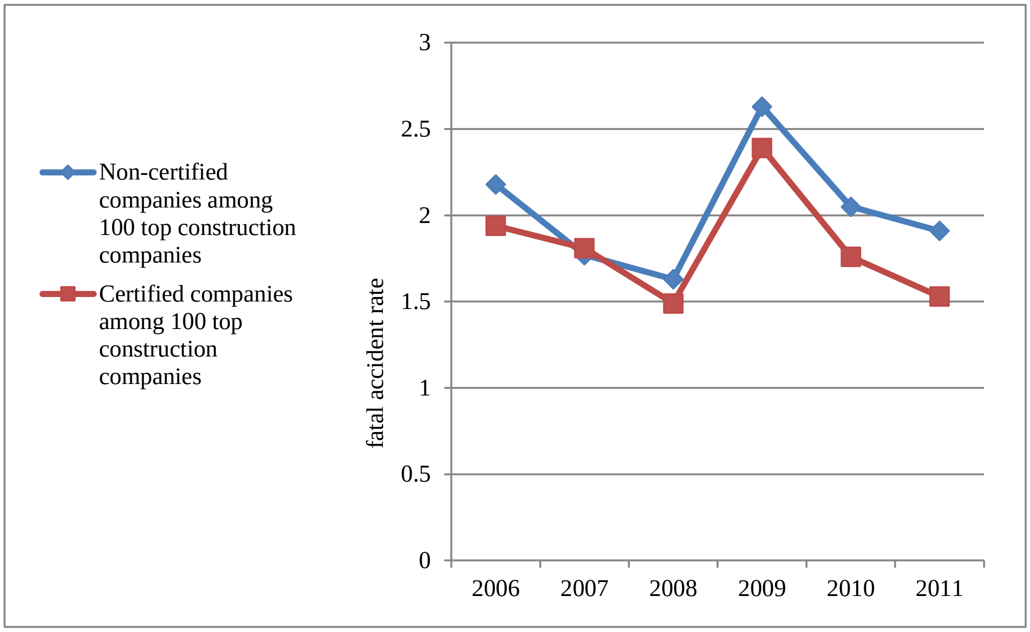

Figure 2.3 Fatal accident/10000 workers

There may be other less important factors that can affect the work-related accident rate. However, these factors are likely to similarly affect both the OHSMS-certified and OHSMS-noncertified companies selected in this study. It is clear that the OHSMS-certified companies have a lower accident rate and fatal accident rate among the top 100 construction companies in Korea. The implementation of OHSMS has also been reported to reduce accident rate in a study (Choi et al., 2008). A similar effect of OHSMS is expected for small- and medium-sized construction companies in Korea and it can be examined when a number of Korea’s small- and medium-sized construction companies are OHSMS certified and their safety records are available.

2.4.2 The differences of OHSMS awareness between site general managers and OHS managers

In September 2010, KOSHA 18001-certified construction companies were asked to take our questionnaire survey. There were 72 samples from 36 workplaces, where both site general managers and OHS managers responded to the questionnaire. The 36 workplaces surveyed were classified into three types of constructions. The housing and office construction includes construction of apartments, offices, and commercial buildings. The transportation construction is responsible for building ports, highways, roads, and subways. Plant construction includes construction of water-treatment plants, power plants, chemical plants, and other plants. Table 2.1 shows characteristics of the companies and the managers who responded to the survey.

Statistically significant differences were found between the two groups on age and professional background ($p < 0.05$). The site general managers were mostly in their 40s, and the OHS managers were generally in their 30s. As for their professional background, engineering was 97.2% for the site general manager group, while safety was 66.7% and engineering 25.0% for the OHS manager group. There was no OHS manager who majored in health or hygiene. Unlike other industries such as the manufacturing industry, there were no managers with health or hygiene major in the construction industry. No other characteristics were found to be significantly different.

Table 2.1 General characteristics of the respondents (n=72)

Characteristics		Job Position				P-value†
		Site general manager		OHS manager		
		N	%	N	%	
Construction types	housing & office	24	66.7	24	66.7	-
	transportation	10	27.8	10	27.8	
	plant	2	5.6	2	5.6	
SEX	M	36	100.0	35	97.2	>.9999†
	F	0	0.0	1	2.8	
Age group	30<	0	0.0	6	16.7	<.0001†
	30-39	0	0.0	24	66.7	
	40-49	29	80.6	6	16.7	
	50-59	7	19.4	0	0.0	
No. of workers	100<	6	16.7	6	16.7	-
	100-199	5	13.9	5	13.9	
	200-399	14	38.9	14	38.9	
	400-599	8	22.2	8	22.2	
	>600	3	8.3	3	8.3	
Major	environment	0	0.0	2	5.6	<.0001†
	safety	0	0.0	24	66.7	
	health or hygiene	0	0.0	0	0.0	
	engineering	35	97.2	9	25.0	
	management	0	0.0	0	0.0	
	other	1	2.8	1	2.8	
OHSMS training	yes	35	97.2	35	97.2	>.9999†
	no	1	2.8	0	0.0	
	unknown	0	0.0	1	2.8	
Necessity of OHSMS	yes	36	100.0	35	97.2	>.9999†
	no	0	0.0	1	2.8	

† P-value by Fisher exact test.
Fisher exact test and Pearson Chi-square test were performed to examine the statistical difference for the participant's demographic factors and awareness between site general managers and OHS managers. For reference, the Pearson Chi-square test is generally conducted for the comparison between the groups of categorical variables, but when the sample number is small (i.e., when the frequency in the cell is small), the Pearson Chi-square test could lead to incorrect result. In that case, the Fisher exact test was carried out.
OHS, occupational health and safety; OHSMS, occupational health and safety management system

The motivation for developing OHSMS showed statistically significant differences between the site general manager group and the OHS manager group ($p < 0.05$; Table 2.2). With regard to the motivation for developing OHSMS, “lack of health and safety management system” was the highest percentage for both groups. “Elimination and management of health and safety risks” was the second highest percentage for the site general manager group, and the response of “social responsibility and legal issues” was the second highest percentage for the OHS manager group. Many surveyed companies did not have their OHSMS in place and they needed it to manage their own health and safety issues. Shearn (Shearn, 2003) examined many cases of business benefits arising from health and safety interventions, but provided no explanation of business motivations for implementing OHS interventions (Lanoie and Trottier, 1998), although it could be assumed that the businesses involved have a proactive attitude toward OHS (British Standards Institution, 1999, b). With regard to the motivation for developing OHSMS, it was found that the site general manager group believed more highly of “elimination and management of health and safety risks” than “social responsibility and legal issues.”

Table 2.2 Motivation for developing company’s own OHSMS (n=72)

Factors	Job Position				P-value†
	Site general manager		OHS manager		
	N	%	N	%	
Motivation of developing OHSMS					
lack of health and safety management system	15	41.7	24	66.7	0.0002†
social responsibility and legal issues	7	19.4	5	13.9	
elimination and management of health and safety risks	12	33.3	4	11.1	
reduce the cost of health and safety management	1	2.8	2	5.6	
responding and complying with interested party	1	2.8	1	2.8	

† P-value by Fisher's exact test

Regarding the implementation of OHSMS, the factors that had statistically significant differences between the two groups were “external support needed for implementing OHSMS,” “any problem with the implementation of OHSMS,” and “if you have problems, what kind of problem” ($p < 0.05$). The “cost of OHSMS implementation and certification” did not show statistically significant differences (Table 2.3). For external support needed for implementing OHSMS, the site general manager group mostly selected “risk assessment,” and the OHS manager group selected various factors in the order of “risk assessment,” “goals and plans,” and “management review.” In other words, 91.7% of the site general manager group responded that the external support is the most necessary for “risk assessment,” but the OHS manager group suggested that the external support is needed for various reasons including the “risk assessment.” For the external support needed for OHSMS implementation, “risk assessment” was the predominant support needed for the site general manager group, whereas the OHSMS group selected various needs. The risk assessment takes into account the cost, time, and an availability of reliable data. The company determines what its OHS risks are, taking into account the inputs and outputs associated with its current and relevant past activities, processes, products, and services. A company with no OHSMS needs to establish the risk assessment (Lanoie and Trottier, 1998). For the factor of “any problem with the implementation of OHSMS,” 33.3% of the site general manager group responded that there were problems with the implementation of OHSMS, and 69.4% of the OHS manager group responded that there were problems with the implementation of OHSMS, showing a significant difference between the two groups. While OHS managers focus on health and safety issues, site general managers also have to pay attention to many other issues including logistics, cost, completion of projects on time, etc. It is clear that the two groups have different opinions on the problems of OHSMS implementation or have poor communication between them. In addition, when there was a problem, the site general manager group responded that “complicated organization and operation” was the most serious problem, and the OHS manager group responded that “complicated documentation management” is the most serious problem. An effective OHSMS structure simplifies organization, operation, and documentation, and thus, after the implementation of OHSMS, the problems of complicated documentation management, noncompliance with existing OHSMS, and more complicated issues (organization, operation, etc.) may be eliminated or mitigated. For the implementation methods, there were no differences between the two groups and the response of “itself” showed the highest percentage as 50%. When developing and implementing OHSMS, many companies had difficulty in risk assessment and operation management and needed help from external professional organizations. However, 50% of the companies implemented OHSMS themselves. Although implementing OHSMS by the companies themselves may be cost saving, risk assessment and operational management in implementing OHSMS could become more difficult and less effective. With regard to the cost of OHSMS implementation and certification, “reasonable cost” showed the highest percentage. As a result, for the implementation of OHSMS, it is necessary for the site general manager or general manager to comprehensively understand the problems that the OHS manager is faced with, and to provide support for various needs including the “risk assessment.”

Table 2.3 Implementation of OHSMS (n=72)

Parameters	Job Position				P-value†‡
	Site general manager		OHS manager		
	N	%	N	%	
Implementation methods					
itself	18	50.0	18	50.0	-
part of support from consulting firm	12	33.3	12	33.3	
support from consulting firm	6	16.7	6	16.7	
Cost of OHSMS implementation and certification					
inexpensive	10	27.8	8	22.2	
reasonable cost	24	66.7	20	55.6	0.2214†
expensive	1	2.8	6	16.7	
other	1	2.8	2	5.6	
External support needed implementing for OHSMS					
policy	1	2.8	2	5.6	
risk assessment	33	91.7	20	55.6	
legal compliance	1	2.8	2	5.6	
goals and plans	0	0.0	7	19.4	
organization and responsibility	0	0.0	0	0.0	
training and communication	0	0.0	1	2.8	0.0007†
documentation	0	0.0	1	2.8	
implementation management	1	2.8	0	0.0	
inspection and correction	0	0.0	0	0.0	
audit	0	0.0	0	0.0	
management review	0	0.0	3	8.3	
Any problem with the implementation of OHSMS					
yes	12	33.3	25	69.4	0.0022‡
no	24	66.7	11	30.6	
If you have problems; what kind of problem					
complicated documentation management	0	0.0	10	40.0	
non-compliance with existing OHSMS	4	33.3	6	24.0	
more complicated (organization, operation etc.)	7	58.3	3	12.0	
no measurement of visible achievements	0	0.0	3	12.0	0.0029†
nominal certification	0	0.0	2	8.0	
excessive cost of obtaining and maintaining certification	1	8.3	0	0.0	
no needs of external buyers	0	0.0	0	0.0	
no incentives	0	0.0	1	4.0	

† P-value by Fisher's exact test
‡ P-value by Pearson's Chi-square test

As shown in Table 2.4, regarding the benefits of OHSMS, all items showed statistically significant differences between the site general manager and OHS manager group ($p < 0.05$). For the effectiveness of implementing OHSMS, the site general manager group believed that the OHSMS implementation is most effective in “prevention of accidents,” but the OHS manager group believed that the effectiveness is in the order of “legal compliance,” “prevention of accidents,” and “effective on-site safety and health management.” With regard to the management benefits of OHSMS, the site general manager group selected, in order, “products,” “production,” and “process,” and the OHS manager group selected, in order, “process,” “production,” and “marketing.” The site general manager group considered that “products,” “production,” and “process” were the most important management benefits of OHSMS, whereas the OHS manager group believed that “process” was the most important management benefit of OHSMS.

Table 2.4 Effectiveness of implementing and management benefits of OHSMS (n=72)

Factors	Job Position				P-value
	Site general manager		OHS manager		
	N	%	N	%	
Effectiveness of implementing OHSMS					
prevention of accidents	17	47.2	11	30.6	0.0326†
legal compliance	5	13.9	12	33.3	
effective on-site safety and health management	5	13.9	8	22.2	
improving quality	3	8.3	5	13.9	
improving productivity	5	13.9	0	0.0	
reducing management costs	0	0.0	0	0.0	
improving safety consciousness of management	1	2.8	0	0.0	
improving safety consciousness of workers	0	0.0	0	0.0	
improving company's image	0	0.0	0	0.0	
Management benefits of OHSMS					
products	10	27.8	3	8.3	0.0317†
process	8	22.2	17	47.2	
production	9	25.0	9	25.0	
marketing	2	5.6	4	11.1	
loss control	7	19.4	2	5.6	

† P-value by Fisher's exact test

2.4.3 The OHSMS awareness of various construction types

Table 2.5 shows the statistically significant differences of OHSMS awareness among the two groups for various construction types ($p < 0.05$). In the case of the motivation for developing OHSMS, “lack of health and safety management system” showed the highest percentage for housing and office and transportation constructions, whereas “elimination and management of health and safety risks” was the top selection for plant construction. It was found that “elimination and management of health and safety risks” was the top motivation for developing OHSMS for plant construction rather than “lack of health and safety management system.” In the case of the implementation methods of OHSMS, “itself” showed the highest percentage for housing and office and plant construction, whereas “part of support from consulting firm” and “support from consulting firm” showed high percentages for transportation construction. Regarding the cost of OHSMS implementation and certification, the response on “reasonable cost” was the highest percentage, and there were no significant differences among the three groups. As for the effectiveness of implementing OHSMS, for housing and office construction, “prevention of accident” had the highest percentage, whereas “improving quality” was the top selection for the transportation construction. With regard to the management benefits of OHSMS, “process” had the highest percentage for both housing and office and transportation constructions. Because of the nature of the plant construction, “production” and “loss control” were found to be the most important management benefits of OHSMS rather than “process.” The difference can be used to examine the effectiveness of the factor. For example, “prevention of accidents” is the higher selection for the effectiveness of implementing OHSMS in housing and office construction (47.9%) than in the transportation (20.0%) and plant construction (25.0%; Table 2.5). It is our plan to collect the accident rate data of these three types of construction companies and analyze the difference between the accident rates of these companies to examine the correlation between the selection and the actual accident rate.

Differences in OHSMS awareness between the site general manager and OHS manager groups were identified. Attempts to correlate some of these differences in cost saving, work-related accident rate, and other benefits were unsuccessful due to the limited availability of related data. However, investigations on the correlations are warranted.

Table 2.5 OHSMS awareness of various construction types (n=72)

Factors	housing & office N	housing & office %	transportation N	transportation %	plant N	plant %	P-value
Motivation of developing OHSMS							
lack of health and safety management system	29	60.4	9	45.0	1	25.0	0.0191†
social responsibility and legal issues	5	10.4	7	35.0	0	0.0	
elimination and management of health and safety risks	12	25.0	2	10.0	2	50.0	
reduce the cost of health and safety management	2	4.2	1	5.0	0	0.0	
responding and complying with interested party	0	0.0	1	5.0	1	25.0	
Implementation methods							
itself	30	62.5	4	20.0	2	50.0	0.0025†
part of support from consulting firm	14	29.2	8	40.0	2	50.0	
support from consulting firm	4	8.3	8	40.0	0	0.0	
Cost of OHSMS implementation and certification							
inexpensive	16	33.3	2	10.0	0	0.0	0.0448†
reasonable cost	26	54.2	16	80.0	2	50.0	
expensive	3	6.3	2	10.0	2	50.0	
other	3	6.3	0	0.0	0	0.0	
Effectiveness of implementing OHSMS							
prevention of accidents	23	47.9	4	20.0	1	25.0	0.0051†
legal compliance	11	22.9	4	20.0	2	50.0	
effective on-site safety and health management	10	20.8	3	15.0	0	0.0	
improving quality	3	6.3	5	25.0	0	0.0	
improving productivity	1	2.1	4	20.0	0	0.0	
reducing management costs			-				
improving safety consciousness of management	0	0.0	0	0.0	1	25.0	
improving safety consciousness of workers			-				
improving company's image			-				
Management benefits of OHSMS							
products	12	25.0	1	5.0	0	0.0	0.0338†
process	17	35.4	8	40.0	0	0.0	
production	12	25.0	4	20.0	2	50.0	
marketing	4	8.3	2	10.0	0	0.0	
loss control	2	4.2	5	25.0	2	50.0	
R&D	1	2.1	0	0.0	0	0.0	

† P-value by Fisher's exact test

2.5 CONCLUSIONS

To sum up, an investigation on the effect of OHSMS on the workrelated accident rate was conducted in this study. To mitigate the possible bias due to company size on the work-related accident rate, the top 100 largest construction companies were selected for the analyses. The average annual accident rates during the period from 2006 to 2011 were 0.30 and 0.18 victims/100 workers for the noncertified and the certified companies, respectively, with a reduction rate of 67% for the certified. The average annual fatal accident rates in the same period were 2.03 and 1.82/10,000 workers for the noncertified and the certified companies, respectively, with a reduction rate of 10.3% for the certified. Both work-related accident and fatal accident rates were found to be significantly reduced by implementing OHSMS in this study.

The survey in this study shows different OHSMS awareness levels between site general managers and OHS managers. The differences were motivation for developing OHSMS, external support needed for implementing OHSMS, problems, and effectiveness of implementing OHSMS. The effect of the differences on accident rate reduction and cost saving can be investigated with proper data collection and it warrants further studies in the future.

2.6 CONFLICTS INTEREST

No conflicts interest are involved by any other authors.

2.7 ACKNOWLEDGMENTS

The authors appreciate the KOSHA for providing the data on the OHSMS-certified companies, and Hwang Gyu-Seok, an officer at the Ministry of Employment and Labor, for helping with the survey.

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2.9 Appendix; Questionnaire

General Information

ID (name of site)		Construction Types	
Sex		No. of workers	
Age		Job position	

1. What is your major?

□ 1) Environment □ 2) Safety

□ 3) Health or hygiene □ 4) engineering

□ 5) management □ 6) other (____________)

2. Did you receive a proper OHSMS training?

□ 1) Yes □ 2) No

3. Necessity of OHSMS

□ 1) Yes □ 2) No

Motivation of developing their own OHSMS

4. Motivation of developing OHSMS?

□ 1) lack of health and safety management system

□ 2) social responsibility and legal issues

□ 3) elimination and management of health and safety risks

□ 4) reduce the cost of health and safety management

□ 5) responding and complying with interested party

Implementation of OHSMS

5. Implementation method?

□ 1) itself □ 2) part of support from consulting firm

□ 3) support from consulting firm

6. Cost of OHSMS implementation and certification

□ 1) cheaper □ 2) reasonable cost

□ 3) expensive □ 4) other

7. External support needed implementing for OHSMS

□ 1) policy □ 2) risk assessment

□ 3) legal compliance □ 4) goals and plans

□ 5) organization and responsibility □ 6) training and communication

□ 7) documentation □ 8) implementation management

□ 9) inspection and correction □ 10) audit

□ 11) management review

8. Any problem with implementation of OHSMS

□ 1) yes (to question 9) □ 2) no (to question 10)

9. If you have problems; what kind of problem

□ 1) complicated documentation management

□ 2) non-compliance with existing OHSMS

□ 3) more complicated (organization, operation etc.)

□ 4) no measurement of visible achievements

□ 5) nominal certification

□ 6) excessive cost of obtaining and maintaining certification

□ 7) no needs of external buyers □ 8) no incentives

Effectiveness of implementing and management benefits of OHSMS

10. Effectiveness of implementing OHSMS

□ 1) prevention of accidents　　□ 2) legal compliance

□ 3) effective on-site safety and health management

□ 4) improving quality　　□ 5) improving productivity

□ 6) reducing management costs

□ 7) improving safety consciousness of management

□ 8) improving safety consciousness of workers

□ 9) improving company's image

11. Management benefits of OHSMS

□ 1) products　　□ 2) process

□ 3) production　　□ 4) marketing

□ 5) loss control　　□ 6) R&D

CHAPTER 3: THE ASSOCIATION BETWEEN CHILDHOOD ASTHMA AND RESIDENTIAL ENVIRONMENTAL RISK FACTORS THROUGH CASE-CONTROL STUDY IN ANDONG, KOREA[1]

3.1 ABSTRACT

Using ISAAC questionnaire, we surveyed the childhood asthma prevalence and related socioeconomic and residential environment on 887 elementary schoolchildren in Andong, Korea. We selected asthma case group (29) and control group (26) and performed the exposure assessment for the personal exposure for the VOCs (Volatile Organic Compounds) and formaldehyde level for 3 days. As a result, 814 schoolchildren completed the questionnaire. It was found that the asthma prevalence was 19.9% and gender (male, OR; Odds Ratio=1.55), age (younger, OR=1.60), family history of asthma (OR=3.70), passive smoking (OR=1.53), and odor from nearby house (OR=2.01) were affective factors. There was no significant difference between the case and control groups in VOCs and formaldehyde exposure level. In the logistic regression analysis, family income (aOR; adjusted OR =3.20, 95% CI=1.41-7.24) and amount of house sunlight (aOR=2.14, 95% CI; Confidence Interval =1.00-4.58) were significant after adjusting gender, age, and family history of asthma. In conclusion, socioeconomic factors including family income and residential environmental factors such as passive smoking, odor from nearby household, and amount of house sunlight are associated with the prevalence of childhood asthma.

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[1]Seok J. Yoon, H. K. Lin, G. Chen, and Gyuseok Hwang, ‘The Association between Childhood Asthma and Residential Environmental Risk Factors through Case-Control Study in Andong, Korea’, The Korean Journal of Public Health, 50(1):37-45, 2013

3.2 INTRODUCTION

With global industrialization and urbanization, the prevalence of childhood asthma has increased rapidly and remains high (Eder et al., 2006; Lee et al., 2008). Korea also shows sharp increase of the prevalence of childhood asthma with fast industrialization and excessive urbanization. For Korea, its prevalence of childhood asthma was reported as 5.7% in 1983, 10.3% in 1997, and 10.5% in 2006 (Lee et al., 1983; Son et al., 1997; Jee et al., 2009). The childhood asthma is a disease bringing great national economic damages and a major cause that interferes normal learning and physical activities. It is also imposing a heavy economic load to their families (Lozano et al., 1999). Children with asthma have 3 times higher absence rate (Fowler et al., 1992) and 30% of them are restricted in physical activities while only 5% of healthy children are restricted in physical activities. In the United States, expense paid directly in 1985 for asthma was estimated as $460 million (Taylor and Newacheck, 1992; Weiss et al., 1992).

The childhood asthma is affected by residential environmental factors. A number of studies on the relationship between childhood asthma and pollutants such as TSP (Total Suspended Particulate), NO2, CO and O3 have been performed. And many studies on conditions of residential environment such as house dust mites, cockroach allergen, dampness, ventilation, and pets also have been conducted (Second International Workshop, 1992; Wang et al., 1999; Tsai et al., 2006). In addition, difference of the prevalence of childhood asthma depending on socioeconomic conditions of their parents has been studied and it was identified that their poverty, unemployment and low education affected the childhood asthma (Crain et al., 1994; Lin et al., 1999).

Since 1980s, the economical and residential environments in Korea have changed greatly. Accordingly, many studies have been performed to investigate the association between air pollutants such as ozone, TSP, SO2, and NO2, indoor air pollutants, and the childhood asthma (Im et al., 2000; Koh et al., 2009; Hwang et al., 2011). However, the childhood asthma is also complexed by factors such as humidity, passive smoking, pets, number of family members, education level of their parents, income level, and family history of asthma (Tsai et al., 2006; Lin et al., 2008). Comprehensive studies on the association of childhood asthma with residential environment are still lacking. The environmental factors are influenced by local features. Accordingly, there is a need for studies focusing more on local features in provincial cities where less study was performed as compared with metropolitan areas. Therefore, the purpose of this study is to identify the prevalence of childhood asthma in children in a semirural city and to estimate residential environmental risk factors including quantitative assessment for their exposure to VOCs (Volatile Organic Compounds) and formaldehyde.

3.3 MATERIALS AND METHODS

To assess the relationship between childhood asthma and residential environmental risk factors, we surveyed the socioeconomic factors using questionnaire, and measured the amount of exposure for VOCs and formaldehyde.

3.3.1 Subjects

The survey was conducted for all grades of 2 elementary schools in a semirural city, Andong of Korea in May 2010. We surveyed the prevalence of asthma using a standardized questionnaire, as proposed by the ISAAC (International Society for Augmentative and Alternative Communication) Steering Committee. We also surveyed the relevant residential environment and socioeconomic status. The questionnaires were distributed by school teachers to the students and answered by the students' parents. The students were classified into an asthma case group and a control group on the basis of the results of the survey. For measurements of exposure to VOCs and formaldehyde for the children in the asthma case group and the control group, written messages were sent to their parents and performed for children who submitted written consents.

3.3.2 Questionnaire

The questionnaire for this study consisted of three parts. The 1st part was organized to elicit the birth date, gender, height, and weight as anthropometric information. In the 2nd part, the students were asked if they had asthma symptoms, and if yes, what the symptoms were and if they had been diagnosed as asthma by a physician. This part was adopted from the criteria of the American Thoracic Society and previous studies (Ferris, 1978; Clark and Joseph, 2002). In the 3rd part, the survey was performed on the residential environment and socioeconomic background. The questions concerned with socioeconomic and residential environments in the 3rd part were prepared based on the existing domestic and foreign studies (Tsai et al., 2006; Lin et al., 2008).

3.3.3 Exposure Assessment for VOCs and Formaldehyde

For the case and control groups, VOCs and formaldehyde concentrations were measured. For the measurement of VOCs, a charcoal-based sampler (3M 3500, 3M, Ontario, Canada) was used. For these measurements, researchers provided instructions for personal measurements, such as always attaching the equipment to his/her body and placing the front side of the sampler face out. During sleep, the equipment for indoor measurement was suspended in the air distant from the wall or the floor near their head. Each sampling was performed for 3 working days (approximately 72 hr), not including weekends and holidays. For measurements of formaldehyde, a passive sampler (3M 3721, 3M, Ontario, Canada) was also used and the measurement method was identical for the VOCs. Eight common solvents (benzene, toluene, ethylbenzene, stylene, m,p-xylene, o-xylene, cyclohexane, and n-hexane) were identified and quantified by the external standard technique. The extraction solvent was carbon disulfide and all extracts were analyzed by gas chromatography (Agilent-6890 Plus; USA) with a flame ionization detector (HP 7683 series) using a supelco fused silica capillary column (30.0 m/250 μm i.d./1μm). Analytical and internal standards were prepared, and VOC concentrations were calculated (Chung et al., 1999a; Chung et al., 1999b). The collection media for formaldehyde were 3M Model 3721 formaldehyde diffusion monitors, designed to measure the time-weighted average concentration of formaldehyde gas. Formaldehyde samples were analyzed by UV spectrophotometer (UV mini 1240; Shimadzu, Japan) at 580 nm, in accordance with NIOSH(National Institute for Occupational Safety and Health) method 3500 (NIOSH, 1994).

3.3.4 Statistical Analysis

Demographic, socioeconomic, and residential environmental conditions between the case group and the control group were compared using chi-square analysis and a t-test. Visual examination of frequency distribution graphs indicates that the data are log-normally distributed, therefore the analysis results were converted in logarithm and geometric mean (GM) and standard deviation (GSD) were used in the statistical summary. Multiple logistic regression analysis was performed to investigate the associated demographic, socioeconomic, and environmental factors with asthma in children after considering confounding factors such as age, gender, and the family history of asthma. All statistical analyses were performed with SPSS (version 12.0; SPSS, Inc., Chicago, IL). A 2-sided $p < 0.05$ was considered as the minimum level of statistical significance.

3.4 RESULTS AND DISCUSSION

3.4.1 Subjects and asthma prevalence

The total number of respondents was 814 of 887 (91.8%) in two elementary schools in Andong of Korea. The percentage of boys was 48.6% (396) and girls 51.4% (418). The average age was 11.4 years for male students and 11.6 years for female students. The average height was 140.5 cm for boys and 142.7 cm for girls. The average body weight of boys was 36.9 kg and 36.0 kg for girls. The overall prevalence of asthma was 19.9% with 23.5% for boys and 16.5% for girls (Table 3.1).

Table 3.1 Demographic characteristics in respondents & asthma prevalence

Characteristics	Total	Male	Female	*p*
N (%)	814 (100.0)	396 (48.6)	418 (51.4)	-
Age (year), Mean(SD)	11.5 (1.3)	11.4 (1.3)	11.6 (1.2)	0.043
Height (cm) , Mean(SD)	141.7 (10.0)	140.5 (11.8)	142.7 (10.7)	0.041
Weight (kg) , Mean(SD)	36.3 (9.0)	36.9 (9.6)	36.0 (9.8)	0.160
Asthma prevalence, n (%)	162 (19.9)	93 (23.5)	69 (16.5)	0.014

$p < 0.05$ indicates statistically significant difference between male and female.

3.4.2 Demographic and socioeconomic factors

Table 3.2 shows the relationship between demographic and socioeconomic factors and asthma prevalence. It was suggested that asthma prevalence was significantly associated with gender, age, and family history of asthma ($p< 0.05$). Among these factors, it was found that the unadjusted OR of a family history of asthma was strongly associated with asthma (3.70, 95% CI = 2.30-5.97) (Table 3.2).

Table 3.2 Demographic and socioeconomic factors and family history of asthma

Variables		Asthma (%)	Non-asthma (%)	OR (95% CI)	*p*
Gender	Male	93 (23.5)	303 (76.5)	1.55 (1.10-2.10)	0.014
	Female	69 (16.5)	349 (83.5)		
Age	8-10	36 (26.7)	99 (73.3)	1.60 (1.04-2.45)	0.034
	11-13	126 (18.6)	553 (81.4)		
Size of the house (m^2)	≤66	45 (24.3)	140 (75.7)	1.38 (0.93-2.04)	0.117
	>66	115 (18.9)	494 (81.1)		
Home ownership	Rented	73 (23.5)	238 (76.5)	1.38 (0.97-1.96)	0.071
	Own	87 (18.2)	392 (81.8)		
Family income (Million KRW)	≤ 20	49 (24.6)	150 (75.4)	1.45 (0.98-2.14)	0.063
	>20	100 (18.4)	444 (81.6)		
Parents' education	High school	58 (20.9)	220 (79.1)	1.02 (0.71-1.47)	0.492
	College	100 (20.5)	387 (79.5)		
Medical Insurance	No	12 (15.6)	65 (84.4)	0.69 (0.36-1.32)	0.299
	Yes	141 (21.0)	529 (79.0)		
Family history of asthma	Yes	36 (43.9)	46 (56.1)	3.70 (2.30-5.97)	<0.001
	No	123 (17.4)	582 (82.6)		

$p < 0.05$ indicates that odds ratio is statistically significant.

OR indicates the increased (or decreased) odds of asthma associated with demographic and socioeconomic factors and family history

3.4.3 Residential Environmental Factors

Table 3.3 shows the association of residential environmental factors with asthma prevalence. It was suggested that the asthma prevalence had a significant association with passive smoking and outdoor chemical odors ($p < 0.05$). For these factors, it was found that the unadjusted OR of nearby harmful facilities had a strong association with asthma prevalence (2.01, 95% CI = 1.32-3.06) (Table 3.3).

Table 3.3 Residential environmental risk factors between asthmatic and non-asthmatic groups

Variables		Athmatic	Non-asthmatic	OR (95% CI)	p
Type of house	Single family	35 (19.4)	145 (80.6)	0.95 (0.63-1.45)	0.916
	Multifamily	124 (20.2)	490 (79.8)		
Construction within 1 year	Yes	12 (24.0)	38 (76.0)	1.28 (0.65-2.52)	0.467
	No	145 (19.8)	589 (80.2)		
House repair during last 12 months	Yes	38 (19.5)	157 (80.5)	0.93 (0.62-1.40)	0.838
	No	124 (20.6)	478 (79.4)		
New furniture	Yes	42 (23.0)	141 (77.0)	1.24 (0.83-1.85	0.294
	No	116 (19.3)	484 (80.7)		
Amount of house sunlight	Little	20 (26.7)	55 (73.3)	1.94 (1.00-3.77)	0.053
	Much	26 (15.8)	139 (84.2)		
Humidity of house	Much	15 (30.6)	34 (69.4)	1.92 (0.99-3.73)	0.058
	Little	65 (18.7)	283 (81.3)		
Distance from bus within 100 m	Yes	97 (22.0)	344 (78.0)	1.34 (0.94-1.90)	0.113
	No	65 (17.4)	308 (82.6)		
Number of residents in the household	≤4	125 (21.4)	459 (78.6)	1.30 (0.85-1.98)	0.255
	≥5	33 (17.4)	157 (82.6)		
Use of air cleaner	Yes	34 (26.6)	94 (73.4)	1.48 (0.96-2.30)	0.094
	No	122 (19.6)	500 (80.4)		
Use of air conditioner	Yes	96 (23.2)	317 (76.8)	1.41 (0.99-2.00)	0.063
	No	65 (17.7)	302 (82.3)		
Laundry cycle	≤4 weeks	20 (24.1)	63 (75.9)	1.25 (0.73-2.14)	0.392
	>4 weeks	135 (20.2)	532 (79.8)		
Indoor pet	Yes	30 (19.4)	125 (80.6)	0.93 (0.60-1.45)	0.824
	No	132 (20.5)	513 (79.5)		
Household with smokers	Yes	101 (23.0)	339 (77.0)	1.53 (1.07-2.18)	0.022
	No	61 (16.3)	313 (83.7)		
Outdoor chemical odors	Yes	40 (30.5)	91 (69.5)	2.01 (1.32-3.06)	0.002
	No	119 (18.0)	543 (82.0)		
Nearby harmful facility	Yes	9 (30.0)	21 (70.0)	1.74 (0.78-3.88)	0.169
	No	150 (19.8)	609 (80.2)		

$p < 0.05$ indicates that odds ratio is statistically significant.

OR indicates the increased (or decreased) odds of asthma associated with residential environmental risk factors

3.4.4 VOCs and formaldehyde levels of the case and control groups

In a comparison of personal sampling results it was found that in terms of VOCs there was no significant difference between the case and control groups. The concentrations of benzene were 0.67 μg/m3 and 0.59 μg/m3 for the case and control groups respectively and the concentrations of toluene were 20.01 μg/m3 and 23.74 μg/m3 for the case and control groups respectively. The concentrations of ethylbenzene were 4.83 μg/m3 and 4.55 μg/m3 for the case and control groups and the concentrations of stylene were 3.94 μg/m3 and 3.36 μg/m3 for the case and control groups respectively. The concentrations of m,p-xylene were 7.28 μg/m3 and 7.02 μg/m3 for the case and control groups and the concentrations of o-xylene were 3.82 μg/m3 and 3.50 μg/m3 for the case and control groups. The concentrations of cyclohexane were 2.93 μg/m3 and 3.30 μg/m3 for the case and control groups and the concentrations of n-hexane were 3.34 μg/m3 and 3.64 μg/m3 for the case and control groups. The concentrations of formaldehyde were 6.96 μg/m3 and 8.31 μg/m3 for the case and control groups (Table 3.4).

3.4.5 Predictor of childhood asthma

Table 3.5 includes the results of logistic regression on the prevalence of asthma. After adjusting for gender, age, and family history of asthma, the prevalence of childhood asthma in the lower income family was 4.01 times higher than the prevalence of childhood asthma in higher income family (95% CI=1.42-11.34). And the prevalence of childhood asthma in the house with little amount of house sunlight was 2.14 times higher than the prevalence of childhood asthma in the house with much amount of house sunlight (95% CI=1.00-4.58).

Table 3.4 VOCs exposure levels between asthmatic and non-asthmatic groups [μg/m3, GM(GSD)]

Variables	Asthmatic group (n=29)	Non-asthmatic group (n=26)	*p*
Benzene	0.67 (1.83)	0.59 (1.84)	0.441
Toluene	20.01 (2.12)	23.74 (2.06)	0.398
Ethylbenzene	4.83 (1.59)	4.55 (1.43)	0.596
Stylene	3.94 (1.42)	3.36 (1.29)	0.062
m,p-xylene	7.28 (1.53)	7.02 (1.51)	0.744
o-xylene	3.82 (1.39)	3.50 (1.40)	0.346
Cyclohexane	2.93 (1.48)	3.30 (1.99)	0.433
n-hexane	3.34 (1.39)	3.64 (1.87)	0.516
Formaldehyde	6.96 (2.26)	8.31 (1.66)	0.342

GM: Geometric Mean, GSD: Geometric Standard Deviation $p < 0.05$ indicates statistically significant difference asthmatic and non-asthmatic groups.

Table 3.5 Logistic regression analysis for childhood asthma

Variables	B	aOR	95% CI	*p*
Gender	0.20	1.22	0.59-2.53	0.590
Age	0.17	1.18	0.44-3.18	0.740
Family history of asthma	-1.01	0.37	0.14-0.93	0.034
Family income	1.16	3.20	1.41-7.24	0.005
Amount of house sunlight	0.76	2.14	1.00-4.58	0.049
Distance from bus within 100 m	0.72	2.06	0.95-4.43	0.066
Household with smokers	-0.12	0.89	0.41-1.91	0.761
Outdoor chemical odors	0.36	1.44	0.51-4.07	0.495

‡Adjusted for gender, age and family history of asthma and all other respective factors in tables.

$p < 0.05$ indicates that adjusted odds ratio is statistically significant.

OR indicates the increased (or decreased) odds of asthma associated with risk factors

3.5 CONCLUSIONS

As a result of the study for 814 students in 2 elementary schools located in Andong, Korea, it was found that the prevalence of childhood asthma was 19.9%. This result is considerably higher as compared with the prevalence rate of childhood asthma 10~20 years ago and even somewhat higher as compared with the recent studies in Korea (Lee et al., 1983; Son et al., 1997; Jee et al., 2009). According to the result that was investigated among 2,580 students of an elementary school in Seongnam, Korea in 1997, the prevalence of asthma was 10.3% (Son et al., 1997). A study which was investigated through ISAAC questionnaire among 37,365 children living in major cities showed that the asthma symptom prevalence was 10.5% and physician diagnosed prevalence was 7.8% in 2006 (Jee et al., 2009). The study that was performed among 2,535 children in Ilsan through ISAAC questionnaire revealed that the asthma symptom prevalence was 18.2%. While the prevalence of asthma in 2 elementary schools in urban area were 16.2% and 16.8%, respectively, the prevalence of asthma in school located in agricultural region reached 21.5% (Son et al., 2007), which showed a similar trend as resulted in this study. It indicates that there is a difference in prevalence between urban and rural areas and it is considered that there is a need for additional studies on residential environment and air pollutants.

In comparison of prevalence between males and females, the prevalence of 23.5% and 16.5% for males and females, respecting, suggesting that males had higher prevalence than that of females. This result agreed with the previous studies. It has been reported that the asthma prevalence of boys was 19.9% and that of girls was 12.0% in Taiwan (Tsai et al., 2006). In a study performed in large cities of United States, boys had the prevalence 1.19 times higher than that of girls (Lin et al., 2008). The prevalence of low age group (8-10 yr) was shown to be 1.60 times higher than that of high age group

(Crain et al., 1994; Wang et al., 1999; Tsai et al., 2006) as 26.7% vs. 18.6%. It was reported that current asthma prevalence of 6-11 year old children was higher (5.1%) than that of 12-17 year old group (4.5%, Aligne et al., 2000). The study results also suggested that the prevalence of asthma in rented houses was higher than that of children in their own houses with the prevalence of 23.5% vs. 18.2%. The prevalence of asthma for children in low-income family was higher than that of children in high- income family with the prevalence of 24.6% vs. 18.4%. This also agrees with previous studies which concluded that difference between socioeconomic factors was shown to be relatively apparent. The asthma prevalence of children in poor families was reported to be higher than that of children in families which were better off (Aligne et al., 2000). It was reported that the children who lived in small houses in United States had higher prevalence of childhood asthma (Weitzman et al., 1990). This study showed that the prevalence of childhood asthma with family history of asthma was 3.70 times higher. It was reported that the OR was 3.47 in those with a brother or sister with asthma, and the OR was 3.13 in those with a mother with asthma (Jenkins et al., 1997). It was also reported that the OR was 1.21 in those with a mother having asthma history (Maffei et al., 2001). Other studies showed similar results for the association between family history of asthma and childhood asthma (Whu et al., 2007; Lin et al., 2008). This study indicated that the asthma prevalence was 1.53 times higher in case of a smoker in the household. These results were consistent with the results of a study in the US which reported that household smoking had a connection with a high risk of childhood asthma, excluding the effect of air pollution or socioeconomic factors (Goodwin and Cowles, 2008). And other studies have confirmed the effects of passive smoking to the childhood asthma (Maffei et al., 2001; Whu et al., 2007). The study found that the asthma prevalence was 1.94 times higher in those who lived in the house with little amount of sunlight. With adequate sunlight in the house, it may be easy to control humidity and reduce the allergens such as house dust mites, thus reducing exposure to allergens. The major source of vitamin D for most humans is exposure to sunlight. An increasing tendency to stay indoors and the promotion of sunshine avoidance to prevent skin cancer by covering up and using sun block are the most likely reasons for inadequate vitamin D status. When time is spent indoors, there is less exposure to sunlight, leading to vitamin D deficiency, subsequently resulting in more asthma and allergies (Litonjua and Weiss, 2007; Devereux et al., 2007). In this study, in order to identify an association between traffic pollution and childhood asthma, the distance from the nearest bus route and the traffic volume of the road were compared. There was no significant difference in the prevalence of asthma according to traffic volume. But other studies which found that children living along busy streets had a higher prevalence of respiratory symptoms than children living along quiet streets (Oosterlee et al., 1996; Ryan et al., 2005). The causes to these differences are still uncertain, as traffic pollution, wind direction, and the living period all need to be considered. In addition, it was considered that because Andong is a city which was formed naturally and had severely curved and complex road shape, it was impossible to distinguish the effect of traffic pollution exactly.

In a case-control study performed among children from 6 months after birth to 3 year old in Australia, it was found that the patient group was exposed to VOCs and formaldehyde in significant high levels (Rumchev et al., 2002; Rumchev et al., 2004). In this study, it was found that there was no significant difference in exposure to VOCs and formaldehyde between the case and control groups. The study was performed for children who visited emergency room for asthma conditions instead of questionnaire. In other words, when a child showed very severe symptoms of asthma, the concentration of VOCs and formaldehyde within 3 days was measured. It was considered that because this study used a questionnaire for selecting patient group and the measurement was not performed at that time when the asthma symptoms occurred, exposure difference of both groups was not notable.

In the results of logistic regression analysis corrected for gender, age, and family history of asthma, it was found that there was significant difference in their parents income (aOR=3.20, 95% CI=1.41-7.24) and amount of house sunlight (aOR=2.14, 95% CI=1.00-4.58).

In conclusion, socioeconomic factor such as family income and residential environmental factors such like passive smoking, odor from nearby household, and amount of house sunlight are associated with the prevalence of childhood asthma.

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GENERAL CONCLUSIONS

1. The Investigation of Arsenic and Heavy Metal Concentrations in Soil, Water and Crops around Abandoned Metal Mines.

Abandoned metal mine pollution is insidious and stealthy. With every rain, tailings piles can leach heavy metals and other toxins into streams and groundwater. With strong winds, dust laden with arsenic, lead and other metals may be churned up and carried away from the mine site (MeBroom, 2004). Heavy metal contamination of agricultural soils and crops surrounding the mining areas is a serious environmental concern in many countries (Steinborn and Breen, 1999). Soil contamination by metals represents one of the major environmental impacts from Abandoned Mine Sites (AMSs). AMS severely degrades water quality and can kill aquatic life. Farmlands around the mines can be easily contaminated by mine wastes and mine water, and that the crops grown on the contaminated soils can contain moderate to excessive levels of heavy metals compared to the crops grown on uncontaminated soils. Contaminated crops affect health when they are constantly consumed (Fergusson, 1990). Studies have been conducted on the effects and mechanism of the heavy metal contents in plants on human health (Shanker et al., 2005). First of all, the results of this study indicate that the As, Zn, Cd and Cr concentrations exceed the soil contamination standard in many soil samples of the nearby farmlands as well as the tailings sites. In the case of water quality, the As concentrations in the Okgae and Youngchen Mines show a decreasing trend with increasing distance from the mine, thereby registering similarity to the soil samples. The Cd and Pb concentrations in the crops near Okgae Mine show a decreasing trend with increasing distance from the mine, also shadowing the case of soil samples. In addition, the Cd and Pb concentrations in the rice samples and the Cd concentration in the corn samples increase with the Cd and/or Pb concentrations in the soil. It is possible that the contamination of soil, water and crops can occur through natural weathering of the deposit and the pre-mining era data can and should be used to compare with the post-mining era ones to determine the cause of the contamination. Unfortunately, the data are not available. Nonetheless, the low pH and high arsenic and heavy metal concentrations of the soil and water samples taken around the tailings sites lead us to believe that the tailings likely contribute to the soil, water and crop contamination.

A proper mine closing procedure needs to be followed to prevent the contamination. Futhermore, the mine closeing proceduce has to be approved by govement agencies during mine permitting process.

2. The Effect of OHSMS on Work-Related Accident Rate and Differences of OHSMS Awareness between Managers in South Korea's Construction Industry.

The OHSMS is part of the overall management system that facilitates the management of the occupational health and safety (OHS) risks associated with the business of the organization. It includes the organizational structure, planning activities, responsibilities, practices, procedures, processes, and resources for developing, implementing, achieving, reviewing, and maintaining the organization's OHS policy (British Standards Institution, 1999). A variety of OHSMS-based standards, guidelines, and audits since then have been developed within public, private, and not-for-profit sectors. Many of these have been adopted by various workplaces (Robson et al., 2007). The OHSMS was created to enable an organization to control its OHS risks and to improve its OHS performance (OHSAS Project Group, 2007). The OHS is an important issue in business management, and thus, it is necessary to carry out a systematic study of the costs and benefits of OHSMS. To make OHS an essential element in decision making and effective in preventing occupational accidents, it is necessary to examine the effects of an OHSMS. Although the OHSMS has been developed and implemented by many major companies in South Korea, studies on their implementation and effect have rarely been carried out. The implementation of OHSMS among the top 100 construction companies in South Korea shows that the accident rate decreased by 67% and the fatal accident rate decreased by 10.3% during the period from 2006 to 2011. The survey in this study shows different OHSMS awareness levels between site general managers and OHS managers. The differences include motivation of developing OHSMS, external support needed in implementing for OHSMS, problems, and effectiveness of implementing OHSMS. Both work-related accident and fatal accident rates were found to be significantly reduced by implementing OHSMS in this study.

This study supports that the implemention of OHSMS significantly reduces accident rates in the South Korea's construction industry. Companies should be encouraged to be OHSMS-certified and government agencies should be encouraged to promote the implementation of OHSMS. The effect of OHSMS on other industries should also be investigated. The differences of OHSMS awareness between site general managers and occupational health and safety managers were identified via survey. The effect of these differences on safety warrants further research with proper data collection.

3. The Association between Childhood Asthma and Residential Environmental Risk Factors through Case-Control Study

With global industrialization and urbanization, the prevalence of childhood asthma has increased rapidly and remains high (Eder et al., 2006; Lee et al., 2008). Korea also shows sharp increase of the prevalence of childhood asthma with fast industrialization and excessive urbanization. The childhood asthma is affected by residential environmental factors. The environmental factors are influenced by local features. Accordingly, there is a need for studies focusing more on local features in provincial cities where less study was performed as compared with metropolitan areas. Therefore, the purpose of this study is to identify the prevalence of childhood asthma in children in a semirural city and to estimate residential environmental risk factors including quantitative assessment for their exposure to VOCs (Volatile Organic Compounds) and formaldehyde. The association between childhood asthma and residential environmental risk factors through case-control study can be summarized as follow: As a result, 814 schoolchildren completed the questionnaire. It was found that the asthma prevalence was 19.9% and gender (male, OR; Odds Ratio=1.55), age (younger, OR=1.60), family history of asthma (OR=3.70), passive smoking (OR=1.53), and odor from nearby house (OR=2.01) were affective factors. There was no significant difference between the case and control groups in VOCs and formaldehyde exposure level. In the logistic regression analysis, family income (aOR; adjusted OR =3.20, 95% CI=1.41-7.24) and amount of house sunlight (aOR=2.14, 95% CI; Confidence Interval =1.00-4.58) were significant after adjusting gender, age, and family history of asthma. In conclusion, socioeconomic factors including family income and residential environmental factors such as passive smoking, odor from nearby household, and amount of house sunlight are associated with the prevalence of childhood asthma.

It is recommended that these important factors are to be examined in other cities or rural residential areas. If similar results are found, government agencies are enouraged to establilsh policies to minimize the effect of these factors.

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