

# ENVIRONMENTAL HEALTH RISK MANAGEMENT BASED ON STAKEHOLDER' QUALITATIVE RISK ASSESSMENT: A CASE OF MAPTAPHUT MUNICIPALITY, RAYONG PROVINCE, THAILAND

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**ABSTRACT:** Difference in risk judgments among stakeholders potentially contributes to barriers in environmental risk communication and management. This study had explored how each stakeholder judged risks associated with Volatile Organic Compounds (VOCs) in the area adjacent to Maptaphut industrial estate complex in Thailand, and proposed a guideline for sustainable environmental risk communication and management by integrating stakeholders' risk judgments. The study has three research objectives. The first objective is to review the situation of environmental contamination and health impacts on people living in Maptaphut area, Rayong province, Thailand. The second objective is to examine the degree of industrial impacts judged by stakeholders, and to investigate stakeholder's fundamental understanding of risk-related judgment. The last objective is to discuss how risks judged by stakeholders are related to the current environmental situations. Field observations and in-depth interviews with 27 persons belonging to five parties such as lay people, public authorities, public health sector, academia and NGOs were conducted. The survey results illustrated that stakeholders have different fundamental understandings of risk-related judgment. The results of risk assessment done by lay people, NGOs, and university are similar to the result of quantitative risk assessment. The study suggests that a qualitative understanding of stakeholder's qualitative risk assessment could play an important role in improving risk communication and developing a sustainable environmental risk management.

**KEYWORDS:** Environmental Health Risk, Risk Management, Qualitative Risk Assessment

## 1. INTRODUCTION

Industrial development, a major force of national economic development, has generated vast damages to environments and human. In Thailand, industrial estate development in Maptaphut district, Rayong province has become a critical issue since 2004. The most important issue is air contamination which has been assumed as a cause of a high number of cancer and respiratory disease patients in the area. Evaporation of Volatile Organic Compounds (VOCs)

such as Benzene, 1,3-Butadiene and 1,2-Dichloroethane were found over the standard. In the same period, the number of cancer patients in the area was increasing as well. This situation scared both industrial investors and people living in the area, and brought many conflicts among industrial sector, public authorities and lay people. Although governments and public authorities have put many efforts to solve the problem, contaminated air in the area still concerns many stakeholders. An effective environmental risk management, a method for

assessing, evaluating and managing risks as well as information sharing systems, a way to communicate information related to health risks among stakeholders is really needed in the area.

Currently, environmental risk management has become increasingly difficult because of the nature of risk which is tremendously uncertain (Gattig and Hendrickx, 2007) and hard to quantify. People in a society have different beliefs and understandings of risks associated with environmental contamination. Margolis, (1996) stated that lay people looks at risk more broadly than the expert whose expertise is narrow and therefore likely to “miss something” of importance to the boarder community. The public is more concerned about what experts do not know and have a much stronger belief in the existence of “unknown effects” (Sjoberg, 2004). Difference in risk judgments among stakeholders has given rise to barriers in risk communication and decision on mitigation options. In addition, ignorance of involved stakeholders’ risk judgments in decision making may cause misidentification of underlying impacts of industrial activities.

To bridge the gap of risk perceptions, policymakers always decide to educate lay people with the experts’ hard facts. This may not give rise to sustainable and long-term environmental risk management (Kajenthira et al, 2012). As stated by Kajenthira (2012), a remediation solution for managing environmental pollution cannot be maintained in the long-term without the interest and engagement of local stakeholders. Understanding stakeholders’ thought can give ideas on what their stake are. In this way, a qualitative understanding of stakeholder risk perception and/or constructed risk is significantly needed.

This study aims at investigating how

stakeholders judged risks associated with contaminated air and how their judgments can contribute to the improvement of environmental risk communication and development of remediation solutions. Maptaphut industrial development area, located in Rayong province, Thailand, was selected as a case study. Five primary stakeholders, who are mainly impacted and impact on environmental risk management were selected as the target group of this study. Those stakeholders are lay people, NGOs, academia, public health sector, and environmental and health protection agencies. There are four research objectives as follows:

1. *To explore potential risks associated with industrial activities in Maptaphut area.*
2. *To investigate the degree of industrial risks judged by stakeholders who are impacted and impact on health risk management in Maptaphut industrial area.*
3. *To examine fundamental understanding of risk-related judgment of each stakeholder*
4. *To propose a guideline for development of collaborative information sharing among stakeholders and risk management.*

In conducting this research, the study first provides further background on air contamination in Maptaphut area as well as impacts of contaminated air on human health such as respiratory illness, physical illness, and psychological impacts. Then, qualitative risk assessments of selected stakeholders and fundamental understanding of risk-related judgments are observed. Finally, discussions on difference in risk judgments among stakeholders and their implications to the improvement of risk communication and development of remediation actions are carried out.

## 2. MAPTAPHUT INDUSTRIAL ESTATE DEVELOPMENT

The Maptaphut Industrial Estate is located in the Rayong province, and is one of the 29 industrial estates in Thailand. It was developed in 1989 by state enterprises, under the management of the Industrial Estate Authority of Thailand (IEAT) and the Ministry of Industry. Map Ta Phut Industrial Estate began operation in 1990 and occupies a land area of 2,768 acres. The estate consists of 117 industrial plants which include 45 petrochemical factories, eight coal-fired power plants, 12 chemical fertilizer factories and two oil refineries.

The pollution suffered by Maptaphut Panphittayakarn School was brought to public attention in 1997. Around 1,000 pupils and teachers suffered from illnesses after inhaling the toxic emissions from plants and factories located at the Maptaphut Industrial Estate, and had to be hospitalized for breathing difficulties, headaches, nasal irritation and nausea. In 2005, the Ministry of Education approved of the school's relocation to a site 5 km away from the original compound.

A test carried out in 2005 by US-based Global Community Monitor (GCM) environmental organization demonstrated that airborne cancerous toxic chemicals such as benzene and chloroform released by Maptaphut Industrial Estate exceeded standards of developed nations by 60 to 3,000 times. These toxic chemicals are known to cause cancer, birth defects and other severe illnesses. In 2007, health assessments conducted on 2,177 Maptaphut residents between June and August depicted that 329 of them had unusually high levels of benzene. The level of two airborne pollutants namely, nitrogen dioxide and sulphur dioxide were 200 to 500 times of the legally permitted standards per year.

## 2.3. THEORETICAL CONTEXT

### 3.1 Environmental Risk Management

A risk management is a formal method for assessing and managing health risks. Risk frameworks have been devised by several organizations in Canada, the United States and elsewhere (McCull et al., 2000). All are intended to provide a structured approach to health risk assessment, evaluation, and management. In the United States, the earliest and most elaborate risk framework for environmental health was developed by the U. S. National Research Council in 1983. In the case of Canada, a model for risk assessment and Risk Management was developed in the early 1990s by the Health Protection Branch (HPB) in Canada. It has served as a guideline to assist Health Canada in protecting Canadians against environmental hazards such as chemical pollutants and food contaminants and other public health activities to control disease and injury. Under the HPB framework, risk Assessment is structured to include both consideration of scientific evidence in a Risk Analysis step, and analysis of socioeconomic concerns in an Option Evaluation stage (see Figure 1).

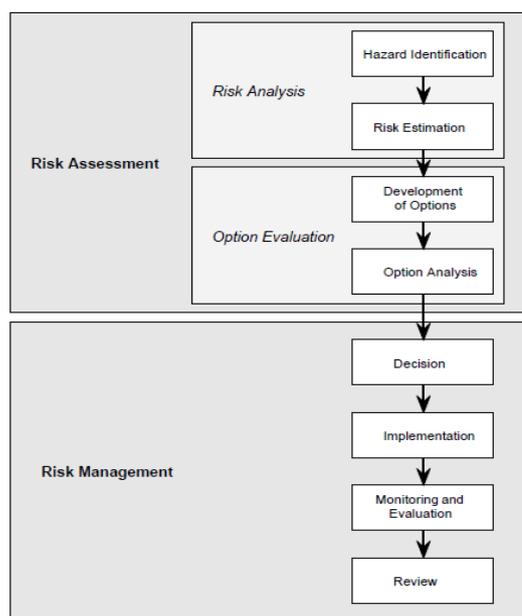


Fig 1. A Model for Risk Assessment and Risk Management

Sources: Health Canada, 1990

To effectively assess risks associated with environmental contaminations, risk concepts must be well understood. Currently, risk concepts are diverse. Lash & Wynne (1992) addressed that risks are defined as the probabilities of physical harm due to given technological or other processes. Otway and Thomas (1982) addressed that there are at least 2 major risk concepts. The first one is the realist approach which views risk as a physical reality existing independently of our knowledge of it. The other one is risk as a social construct, with emphasis on the contrasting definitions about the risks in social reality. Crawford-Brown (1999) conceptualized risk into three broad notions revolving around our experiences: objective, subjective, and perception approaches. The objective approach refers to risk as a product of scientific research, where the hazards can be measured indefinitely via research and experimentation. In contrast, the subjective approach claim that risk is not solely objective. They argue that risk varies depending on our state of mind which changes through our experiences, social norms and uncertainties. The last approach is perception approach. According to this approach, risk is defined as the set of all adverse outcomes which a rational person might believe to be possible when confronted with evidence about the frequency, severity and variability of effects (Crawford-Brown, 1999). Fischhoff (1984) however, stated that no risk definition can be put forward as ultimately correct as there is no one suitable definition which applies to all problems.

### **3.2 Significance of Qualitative Risk Assessment in Risk Communication and Management**

Traditional risk conclusions based upon science alone are becoming ever more questioned as risks to society are exhibiting far more diverse aspects to what a risk actually is. Ropeik (2011) stated that although, scientific risk assessment is thoroughly

conducted by using reliable methods, results will conflict with the inherent way the human animal perceives and responds to danger because the way normal people live is not well understood. In this study, stakeholders' qualitative risk assessment is focused. It is the set of all adverse outcomes which a rational person might believe to be possible when confronted with evidence about frequency, severity, and variability of effects (Crawford-Brown, 1999). It may be influenced by scientific risk assessment or individual's own risk assessment, and perceptual factors such as dread and fear. Significance of stakeholder risk perception or qualitative risk assessment can be summarized as follows;

#### *1) Improvement of Risk Communication*

Each stakeholder has different way to judge risks. Crawford-Brown (1999) mentioned that stakeholder's perceived risk might be deepened on their possessed evidence about the frequency, severity and variability of effects. To communicate risk with all related parties, risk communicators should know what evidence people have, and how they interpret available information related to risks. In another point, Ropeik (2011) stated that risk estimation based on science can be interpreted based on affective, emotional, and instinctive psychological cues. This is why stakeholders may have different understandings of risks. If stakeholders' risk assessment is well understood by policymakers, the effective way to communicate risk can be carried out.

#### *2) Development of Environmental Actions*

Understanding stakeholders' perceived or judged risks can contribute to proper development of environmental actions for mitigating environmental health risks in two aspects. First, the inclusion of the perception aspect is important in determining how various stakeholders prioritize certain risks (Douglas and Wiledevsky, 1982). This can give an idea for

policymakers on how to provide mitigation measures. Many scholars believe that some groups of stakeholders, particularly lay people, may judge risks more broadly than the expert whose expertise is narrow and therefore likely to “miss something” of importance to the boarder community. If what lay people perceived is taken into account, it is possible that mitigation measures can be properly provided. Second, stakeholders’ perceived risk can be related to the way they act for risk mitigation. By understanding how stakeholders construct risks and what they act, policymakers can establish strategies to solve environmental problems by including participation from other relevant stakeholders.

### 3) Long-term Public Engagement in Environmental Risk Management

As stated by Kajenthira (2012), difference in risk perception among stakeholders can cause a barrier to successful risk management because a remediation solution cannot be maintained in the long-tem without the interest and engagement of local stakeholders. Stakeholders’ perceived risk can exhibit their stake and concerns. If what stakeholders are concerned about is taken into consideration, this can potentially motivate those groups of persons to take part in environmental risk management.

### 3.3 Study Design

The conceptual idea of this study can be shown in Figure 2. First, the study reviewed the results of air quality monitoring in the study area. Several types of

VOCs contaminated in the area during 2008-2012 are presented. In addition, statistics pertaining to physical and mental health of people in Maptaphut area are analyzed in order to reveal impacts of industrial activities on people health and well-being. Second, qualitative risk assessment is conducted. In this study, qualitative risk assessment means how each stakeholder judge degree of impacts of industrial activities on human and well-beings. Possible impacts of industrial activities can be classified into 5 aspects: 1) Lifestyle disruption which means negative change in local people’s daily life, local customs, or tradition 2) Psychological effects referring to a possibility that a person will have high anxiety, feel panic, or suffer with mental disorder 3) Respiratory health referring to a possibility that a person might get disease related respiratory system 4) Physical health referring to a possibility that a person might get disease related to immunity system 5) Nuisance effects which means a sort of noise pollution or smell. Additionally, the study also investigates fundamental understanding of risk-related judgment which means how stakeholders think about each components of risk such as probability of health impacts, severity or potential damage, and capacity to tackle with polluted air. Finally, results of quantitative risk assessment and qualitative risk assessment are discussed on its implication for the improvement of risk communication and development of environmental actions for risk mitigation.

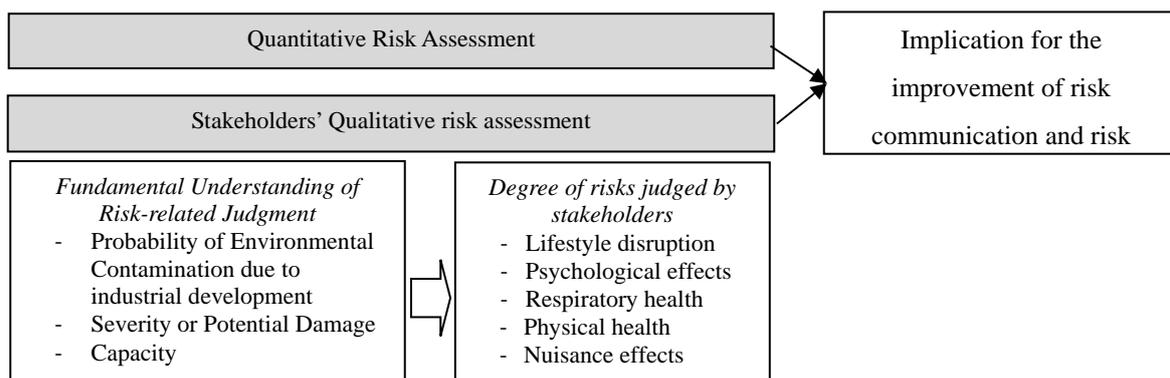


Fig.2 Conceptual Idea of the Study

### 3.4. METHOD

#### 3.4.1.1 Case Study and Sample Group

The area of this study is Maptaphut industrial development area located in Rayong province, Thailand. It is geographically located at around 12.5 N (lat.), 101.5 E (long.), adjacent to the Gulf of Thailand (See fig. 3). It is also home to the largest industrial complex of Thailand, which currently includes up to five industrial estates (IEs): Maptaphut, East Hemaraj, Asia, Padaeng, and RIL, having about 1,800 factories (SST, 2010) and a seaport with nine berths (IEAT, 2010). There has been a considerable concern about air pollutants distributed over the area, including nitrogen dioxide (NO<sub>2</sub>), sulfur dioxide (SO<sub>2</sub>), carbon monoxide (CO), particulate matter (PM<sub>10</sub>), and VOCs. Currently, there are 38 communities in Maptaphut area (Maptaphut municipality, 2012). The number of population is 56,591 persons: 28,504 male and 28,087 female, and the number of households is 42,295. The number of sample groups for this study is 27 persons belonging five parties such as lay people, NGOs, academic sector, environmental and health protection agency, and health care service (See Table 1).

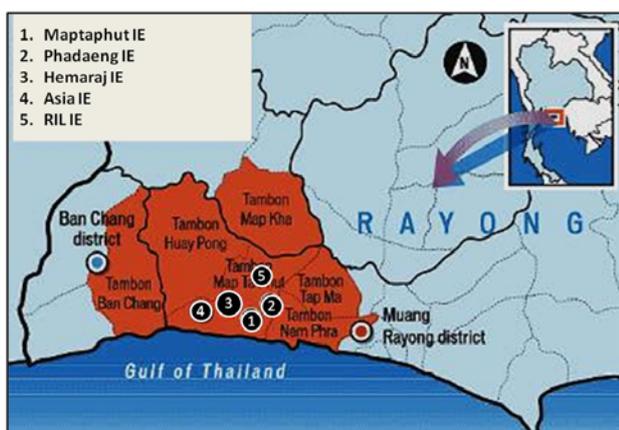


Fig 3. Maptaphut Industrial Development Area

Source: <http://www.hydrocarbons-technology.com/>

Table 1 Primary Stakeholders

Primary Stakeholders	No.
Lay people	13
Environmental and Health Protection Agencies	3
Academia	4
NGOs	5
Health Care Service	2
<b>Total</b>	<b>27</b>

#### 4.2 Data Collection

This study is based on a combination of field observation and in-depth interviews conducted with primary stakeholders associated with Maptaphut industrial development in March 2012. The collected data can be classified into 2 types.

##### 3.1.14.1.1 Data Required for Quantitative Study

To demonstrate health risks in Maptaphut area, the study employs data related to types of compounds contaminated in the area. Air quality in Maptaphut is annually monitored by the department of pollution control, ministry of natural resource and environment. The result of monitoring on VOCs will be reviewed and analyzed on their potential impacts on human health. Additionally, to identify potential impacts of industrial activities on human health and well-being, the study also employs data related to several types of patients collected by the ministry of public health during 2003-2011. The number of three kinds of patients found during 2003-2011 is reviewed. Those are respiratory disease patients, patients with physical health problems, and patients with psychological illness.

##### 3.1.24.1.2 Data Required for Qualitative Risk Assessment

The qualitative component of this study is based on a total of twelve semi-structured in-depth interviews conducted with five different stakeholder groups. Types of questions can be shown in table 2. In each

question, respondents were asked to answer freely, and also asked to identify one of alternative choices.

### 3.24.2 Data Analysis

In the first part of the study, rate of patients with three types of diseases (numbers of cases per 1,000 persons) is calculated. To see considerable impacts of industrial activities on health of people living in Maptaphut area, rates of patients in Rayong province, location of Maptaphut municipality, is compared with those in Nakornpathom province which is considered as one of industrial provinces as well. In the second part of the study, content analysis is conducted by summarizing data gained from the interviews with key stakeholders. In addition, to reveal degrees of risk judged by each stakeholder, descriptive statistics such as mean is also calculated.

ambient air in Maptaphut municipality have been over the annual standard. According to the monitoring system settled by pollution control department, there are seven monitoring spots located in Maptaphut area. Those are Maptaphut hospital, Machalood temple, Nuangfab school, Muangmai, Banplong community, Bantakuan public health center, and Noppaket community. The monitoring results show that four types out of nine types of monitored VOCs were found over the annual standard in many monitoring spot (See Fig. 3). Those compounds are Benzene which has been found over annual standard at every monitoring spot, except at Nuangfab school, 1,3- Butadiene which has been over the standard at Maptaphut hospital, Muangmai, and Bantakuan public health center, 1,2-Dichloroethane which has been over the

Table 2 Derived Questions

<i>Qualitative Risk Assessment</i>	<i>Indicators</i>	<i>Questions</i>	<i>Alternative Choices</i>
Degree of risk judged by stakeholders	Life style disruption	Do you think that people's life style has been changing since the establishment of industrial estate in your area?	0=Not at all 1= Less 2= Medium 3= High 4= Very high
	Psychological effects	As a result of industrial development, do you think how much people feel worried about their health? As a result of industrial development, do you think how much people feel worried about your income and your future?	
	Respiratory health	Do you think that air quality in the area has caused respiratory disease among residents?	
	Physical health	Do you think that air quality in the area has caused several kinds of cancer among residents? Do you think that air quality in the area has caused disease related to self-immunity systems such as immunity disorder, fever, etc.?	
	Nuisance effects	Do you think that industrial activities have caused nuisance such as noise, smell, etc.?	
Fundamental Understanding of Risk-related Judgments	Probability	What do you think about possibility that industrial activities have contaminated air and the contamination exceeds the level that human body can accept? What do you think about possibility that human will be influenced by contaminated air?	
	Severity	How severe does contaminated air in the area have effects on human health?	
	Capacity	Do you think people in Maptaphut know how to protect themselves from contaminated air?	

## 4.5. RESULTS AND DISCUSSION

### 4.5.1 Air Contamination in Maptaphut Area and Health Risks

The results of air quality monitoring during 2007-2013 showed that some kinds of compounds in

standard at Maptaphut hospital, Muangmai, and Banplong community, and Chloroform which was found over the standard at Nuangfab school during 2010-2011 and 2012-2013.

According to United state environmental protection agency (US' EPA), VOCs potentially

cause several kinds of disease such as eye, nose, and throat irritation; headaches, loss of coordination, nausea; damage to liver, kidney, and central nervous system. The ability of organic chemicals to cause health effects varies greatly from those that are highly toxic, to those with no known health effect. As with other pollutants, the extent and nature of the

disease in Rayong province had considerably increased. Patients with respiratory illness such as acute upper respiratory infections, asthma and acute severe asthma, and other diseases of the respiratory system considerably increased in 2004 which was the year that environmental crisis first happened in Maptaphut. In 2006 rate of patients was dramatically

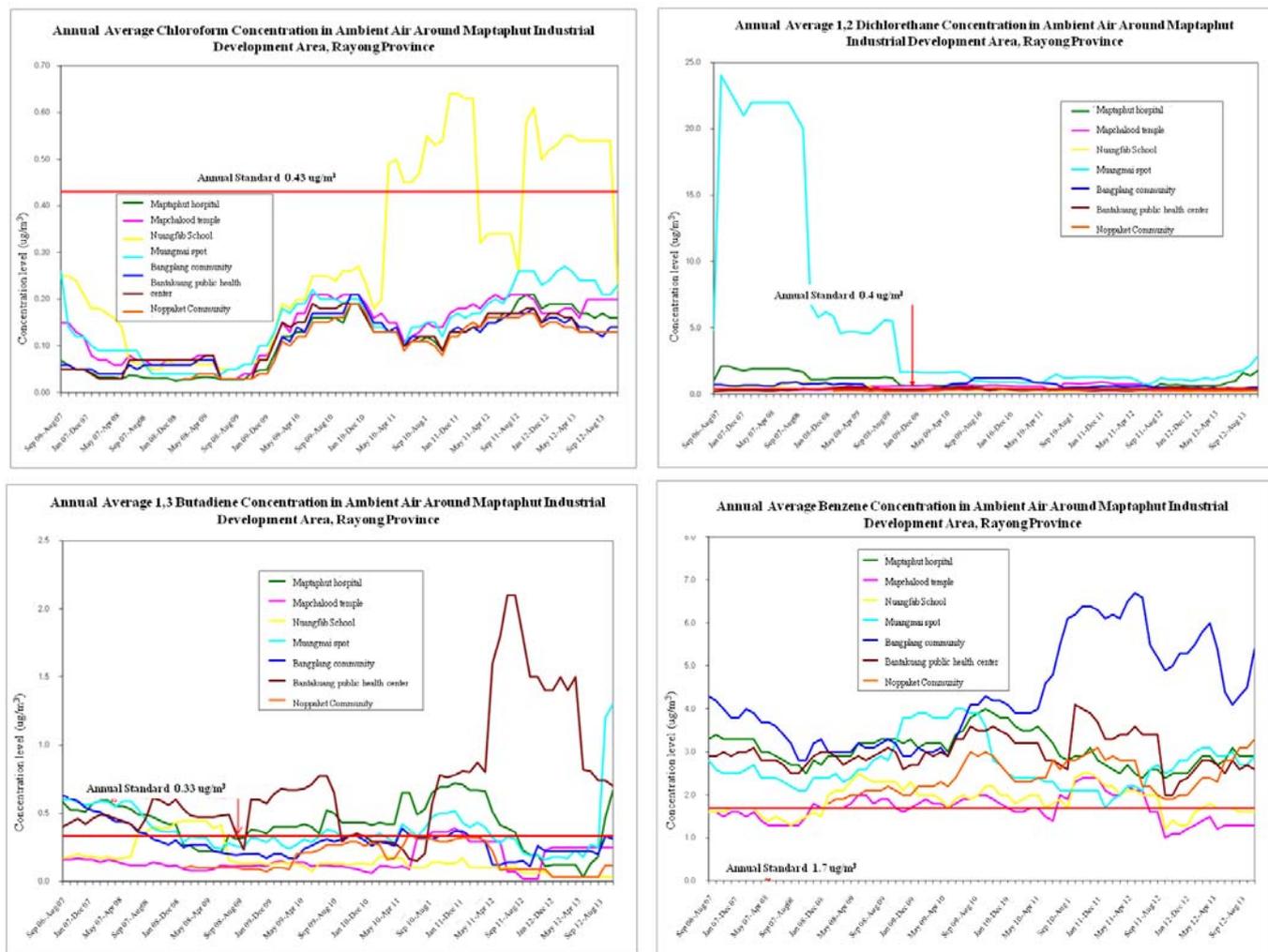


Fig. 3 VOCs concentration in Maptaphut area during 2007-2013

health effect will depend on many factors including level of exposure and length of time exposed. Eye and respiratory tract irritation, headaches, dizziness, visual disorders, and memory impairment are among the immediate symptoms that some people have experienced soon after exposure to some organics.

Considering rate of patients with diseases caused by environments during 2003-2011 (See Table 3), it was found that rate of patients with each type of

reduced, and then kept stable until 2011. However, when compared to the case of Nakornpathom province, number of patients was still far higher than that in Nakornpathom province. Considering rate of patients with physical illness in Rayong province, it was found that the number of patients had been increased since 2003. Until in 2011, the number of patients per 1,000 people was 14.5 cases. This was far higher than the number of cases found in Nalornpathom province. In the case of rate of patients

with psychological illness, the number of patients in 2011 was not much different from 2003. However, when compared to the case in Nakornpathom, rate of patients with psychological illness was still higher and tended to increase since 2007. Rate of patients with disease related to environments in Rayong province can imply to health problems in Maphaphut area where quality of air has been found deteriorated. Though causes of diseases may depend on several factors, it seemed hardly denied that environments in Maphaphut area will not be one of

protection agencies and public health sector viewed the impacts of industrial activities lower than lay people, NGOs, and academic sector in all aspects. Difference in risk judgment among stakeholders may contribute to problems in risk managements. For instance, decision making for selection of mitigation measures cannot be done with satisfaction of all stakeholders. Consensus building among stakeholders can be hardly achieved. In addition, environmental actions created based on risks judged by a group of people who have an official authority

Table 3 Rate of Patients with Disease Caused by Environments during 2003-2011

Type of Disease	Province	Number of patients per 1,000 people								
		2003	2004	2005	2006	2007	2008	2009	2010	2011
<b>Respiratory Illness</b> (Acute upper respiratory infections , Pneumonia, Chronic lower respiratory diseases, Asthma and acute severe asthma, and Other diseases of the respiratory system)	Rayong	15.17	26.13	25.35	17.60	17.13	18.80	18.28	18.67	18.73
	Nakornpathom	10.47	11.53	12.55	11.03	11.35	11.51	10.59	11.29	10.73
<b>Physical Illness</b> (Ca liver, Ca lung, Ca breast, Ca cervix, Diseases of the blood and blood forming organs and certain disorders involving the immune mechanism)	Rayong	2.66	3.56	4.76	4.67	6.60	7.86	11.99	12.31	14.54
	Nakornpathom	1.64	1.85	2.67	3.70	5.09	5.82	6.35	6.82	9.21
<b>Psychological Illness</b> (Mental disorders, Mental and behavioral disorders due to psychoactive substance use, Schizophrenia, schizotypal and delusional disorders, Mood (affective) disorders, Neurotic, stress-related and somatoform disorders)	Rayong	2.13	2.06	2.07	1.93	1.73	1.97	2.40	2.51	2.62
	Nakornpathom	1.03	1.47	1.38	1.03	2.12	2.12	1.38	1.19	1.23

Source: Calculated from statistic data reported by ministry of public health, Office of the Permanent Secretary for Public Health Thailand, 2012

those factors.

#### 4.25.2 Stakeholder's Qualitative Risk

##### Assessment

##### 5.2.1 Degree of Risk Judged by Stakeholders

According to the results of observations (See Table 4), stakeholders have various opinions on impacts of industrial activities on human health and well-being. Lay people, NGOs, and academic sector thought that pullulated air in the area has very high impact on human's respiratory system and high impact on physical health. While environmental and health

may not be able to minimize risks judged by the public. However, all groups of stakeholders believe that risks still exist in the area. To bridge the gap of perception difference, risk communication and information sharing among those stakeholders can play an important role.

##### 5.2.2 Fundamental Understanding of Risk-related Judgment

Considering fundamental understanding of risk-related judgment of each stakeholder (See Table 5), all stakeholders have well understood how atmosphere can be contaminated, but some groups

may not well understand how sensitive local communities are. Though, some kinds of VOCs are not found over the standard, lay people still feel that the probability that they will be influenced is still high. For the viewpoints on severity, it was found that beside of the ambiguity of chemical impacts itself that make people perceived high severity, unclear explanation of causes of disease patients in

the area also make people worry. In addition, many stakeholders also think that people in the area do not have high capacity to tackle with polluted air. This may contribute to high perceived risks.

### 4.35.3 Implications for Development of Risk Communication and Risk Management

The results of survey showed that industrial risks

Table 4 Degree of Risks Judged by Stakeholders

Stakeholders (persons)	Degree of Industrial Risks Judged by Stakeholders				
	Life Style Disruption	Psychological effects	Respiratory health	Physical health	Nuisance effects
Lay people (13)	High	High	Very high	High	Moderate
	Many people have to change their career from agriculture to service sector, labor, and factories 'workers. People cannot use natural resources for their leisure activities anymore.	People feel panic when seeing back smoke released from factories 'stacks. They are afraid of touching rain. When touching rain, some people develop skin rashes. They feel unsecured to live in this community.	The number of respiratory disease patients in the area has increased over time. People can feel irritated in their eyes and nose.	Compared to the past, people are nowadays easy to get sick. A lot of people have got serious sickness such as cancer.	In the night time, people can still hear the sound of operated machine. People can hear the sound of traffic all the times. It became crowded in communities. People feel that they have lost their privacy.
NGOs(5)	Very high	Very high	Very high	High	High
	Previously, a major career of Maptaphut people was agriculture. It has changed since the establishment of factories. Change of career structure significantly impacts on life style of people	Many people in Maptaphut have got cancer, and many of them died. This situation makes people nervous and feeling unsecure to live in environment.	Air has been contaminated with several kinds of hazardous gases such as benzene, 1,3 –Butadiene, and 1,2 Dichloroethane. These kinds of compounds still exceed EPA standard.	Long term accumulation of released hazardous gas potentially causes several kinds of diseases such lung disease, self-immunity disease and cancer.	Rapid increase in the number of population destroyed communities' quiet atmosphere. Increase in volume of traffic are also annoying residents.
Academia(3)	Very high	Moderate	Very high	High	High
	People's life is tied with their environments, so deterioration of environments in the area must change the way they live.	People feel panic when seeing back smoke released from factories 'stacks	Increase in the number of local clinics can imply to health problems of Maptaphut people. Several kinds of released compounds such as benzene, 1,3 –Butadiene and 1,2 Dichloroethane potentially impact on respiratory system.	Many kinds of released compounds found in this area can ruin several parts of human body. For instance, Vinyl Chloride can impact on human lung, blood, brain and skin.	Previously, local people had quite and slow life. Rapid increase in population and traffic volume may annoy them.
Environmental and Health Protection Agency(3)	Moderate	Moderate	High	Moderate	Moderate
	More people work in factories. Some change their career due to the deterioration of environment.	Some people feel panic when they can smell chemicals that may be evaporated from factories	Most factories use chemicals that potentially cause cancer, such as chemicals in group 1, group 2A, and group 2B. During manufacturing, those chemicals can accidently release.	The urgent impact may not manifest immediately. However, accumulated hazardous compounds in human body can cause serious sickness.	Smell and noise of traffic sometimes annoy people. There are a lot of trucks in the area.
Public Health Sector(2)	Moderate	Moderate	Moderate	Moderate	Less
	More people work in factories, and some open a small shop instead of fishery and agriculture	People feel nervous when they were found exceeding substance in their body.	Some kinds of VOCs, are still found over the standard in the area.	Long term accumulation of released hazardous gas potentially causes several kinds of diseases such lung disease, self-immunity disease and cancer.	It may have some extents

Source: In-depth interviews with stakeholders during Febuary-March 2013

judged by stakeholders are different in some aspects particularly in terms of life style disruption, impacts on physical health and psychological effects. Lay people, academic sector, and NGOs have similar

quality monitoring. Based on this finding, the study suggests that to bridge the gap of judged risks, information sharing among those stakeholders is essential, particularly communicating information

Table 5 Fundamental Understanding of Risk-Related Judgment

Stakeholders	Fundamental Understanding of Risk-Related Judgment		
	Probability	Severity	Capacity
Lay people(13)	Very High	Very High	Moderate
	<ul style="list-style-type: none"> <li>- Increase in the number of factories may increase probability of contamination.</li> <li>- Many factories have kept operating the whole day-and night. Even the night time, I can see bright lights at factories</li> <li>- Based on people's experiences in smelling chemicals around factories, probability of contamination is considered high for them.</li> </ul>	<ul style="list-style-type: none"> <li>- Some people's relatives passed always without clear reasons provided by the doctors. They assumed that they must get some influences from industrial activities. For instance, a people working as a security for an industry, died without clear explanation.</li> <li>- Responsible organization cannot provide people with clear understanding of relationship between sickness and polluted air.</li> </ul>	<ul style="list-style-type: none"> <li>- Many people still do not know clear impacts of hazardous chemicals.</li> <li>- People have learnt from the past experiences. Some can recognize when air quality is worse.</li> </ul>
NGOs(5)	Very High	Very High	Low
	<ul style="list-style-type: none"> <li>- Many heavy industries are still allowed to construct in the area. The more industries expand, the more environmental problems can occur.</li> <li>- Many factories solely consider the standard. What they think is maximum point that they can release. If all factories think the same things, the area may not have enough capacity to tackle with pollution. Possibility of contamination must be high.</li> <li>- Many factories use hazardous chemical as main material for manufacturing such as Methyl Tertiary Butyl Ether ( MTBE. Some type of chemicals is prohibited to use in some developed countries.</li> </ul>	<ul style="list-style-type: none"> <li>- Several kinds of gases found in the area potentially damage human body. For instance, long term accumulation of VOCs can cause damage to liver, kidney, and central nervous system. Some substances are suspected or known to cause cancer in humans.</li> <li>- Considering statistics, cancer rate patients in Rayoug province was revealed high.</li> <li>- The number of respiratory disease patients in Rayong hospital is still high, and increase every year.</li> </ul>	<ul style="list-style-type: none"> <li>- People do not know what to do when facing serious contamination due to chemical accidents.</li> <li>- People do not have enough capability to fully understand air quality because evaporation of hazardous gas is invisible.</li> <li>- Impacts of VOCs on health are still ambiguous, so it must be hard for people to decide to take some actions</li> </ul>
Academia(3)	High	Very High	Moderate
	<ul style="list-style-type: none"> <li>- VOCs can be generated from various point sources such as combustion, transportation, or evaporation from fugitive sources at various components in the piping system such as joints and valves.</li> <li>- When air and water are polluted, there is high possibility that people will get impacts. They live there 24 hours.</li> <li>- In Maptaphut, the density of factories is very high, and many of them are located nearby communities</li> </ul>	<ul style="list-style-type: none"> <li>- The impact of heavy metals and VOCs can lead to many health problems, which may not appear immediately, but will occur from accumulation in the body over time.</li> <li>- 1,3 Butadiene can cause eye, nose and throat irritation.</li> <li>- 1,2 Dichloroethane can cause damage to liver, kidney, and lung</li> </ul>	<ul style="list-style-type: none"> <li>- According to education program provided by local government, NGOs, and universities, people have more understanding about chemicals.</li> </ul>
Environmental Protection Agency(3)	Moderate	High	Low
	<ul style="list-style-type: none"> <li>- Benzenze, 1,2 dichloroethane, 1,3 butadiene were found exceeding the standard. Those compounds could be evaporated from tanks or during oil refinery.</li> <li>- Some factories have expanded the volume of manufactures. For instance, they first asked to expand 30% of manufacture. 4 Years later, they ask to increase 30% more.</li> </ul>	<ul style="list-style-type: none"> <li>- If receiving those contaminated air in a certain amount, people potentially get a serious sickness such as respiratory disease, cancer</li> </ul>	<ul style="list-style-type: none"> <li>- People do not have enough capability to fully understand the air quality because evaporation of hazardous gas is invisible.</li> </ul>
Public Health Sector(2)	Moderate	High	Moderate
	<ul style="list-style-type: none"> <li>- In general, amount of hazardous gas and VOCs tend to decrease. Factories are more active to take action to reduce a chance of accidents.</li> </ul>	<ul style="list-style-type: none"> <li>- At high levels of exposure, many VOCs can cause central nervous system depression. All can be irritating upon contact with the skin, or to the mucous membranes if inhaled.</li> </ul>	<ul style="list-style-type: none"> <li>- People have more understanding of chemicals and their impacts</li> </ul>

Source: Source: In-depth interviews with stakeholders during February-March 2013

judgments on these aspects because of frequent communication among them. For these three parties, industrial activities do not have only high impacts on human's respiratory system but also human's well-being. However, though the degrees of industrial impacts judged by stakeholders are different, all stakeholders believe that people in the area are still facing health risks. This is related to the results of air

related to communities' sensitivity such as the way people live, their original career, their culture, and their lifestyle. When considering the results of investigations on stakeholders' fundamental understanding of risk-related judgments, it was found that: 1) probability of health impacts was judged based on possibility that industrial activities may contaminate air, but community's sensitivity, a factor

contributing to probability that people will be impacted by contaminated air, was not much considered by some stakeholders. This may cause the difference in risk judgments among those parties. So, information related to sensitivities of communities should be communicated to relevant parties. 2) Severity of health risks was perceived high due to ambiguity of chemical impacts itself and unclear explanation of causes of disease patients in the area. Lay people viewed severity based on the current situation of health problems and what they have experienced. Information related to development of each disease should be deliberately educated. 3) Lay people's limited capacity to cope with industrial risks contributes to high risks judged by stakeholders. If lay people are well educated and prepared with preventative measures, actual risks and perceived risks can be reduced. This study suggests that stakeholder's qualitative risk assessment can play important roles in risk communication and risk management. Understanding how they judge risks can provide ideas what they need to be communicated and what kinds of mitigation measures they need.

## 5.6. CONCLUSION

The study reviewed environmental situation and health risks associated with contaminated air in Maptaphut industrial development area. The results illustrated that some types of VOCs concentrations in Maptaphut has been still over the standard, and rates of patients with diseases caused by environments are still high. The study also investigated stakeholder's risk judgments. It was found that risks judged by lay people, NGOs, academics sector are higher than those judged by environmental protection agency and public health sector. Information related to community sensitivities such as local customs and life style is not well understood by some stakeholders. This may cause difference of stakeholder's perceived risk. Additionally, severity of contaminated air is

perceived high because of unclear explanation of health problems suffered by many. People need more capacity to cope with contaminated air in the area. The study proposes 1) communication platform should be established, and 2) to support long-term risk management with collaboration of local community, both health problems and well-being of people should be seriously concerned.

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