การประเมินความเสี่ยงจากการรับสัมผัสสารคาร์บอนิลผ่านทางการหายใจของคนงานในสถานประกอบการน้ำมันในกรุงเทพมหานคร ประเทศไทย

นายสุคท นพรัตนบัณฑิต

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาสาธารณสุขศาสตรมหาบัณฑิต

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ปีการศึกษา 2553

HEALTH RISK ASSESSMENT ASSOCIATED WITH INHALATION EXPOSURE OF CARBONYL COMPOUNDS TO GASOLINE WORKERS IN BANGKOK, THAILAND

Mr.Sucot Nopparatbundit

A Thesis Submitted in Partial Fulfillment of the Requirements
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Thesis Title	HEALTH RISK ASSESSMENT ASSOCIATED WITH INHALATION EXPOSURE OF CARBONYL COMPOUNDS TO GASOLINE WORKERS IN BANGKOK, THAILAND
By	Mr.Sucot Nopparatbundit
Field of Study	Public Health
Thesis Advisor	Wattasit Siriwong, Ph.D.

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สุคท นพรัตนบัณฑิต: การประเมินความเสี่ยงจากการรับสัมผัสสารคาร์บอนิลผ่านทางการหายใจของคนงานในสถานประกอบการน้ำมันในกรุงเทพมหานคร ประเทศไทย (HEALTH RISK ASSESSMENT ASSOCIATED WITH INHALATION EXPOSURE OF CARBONYL COMPOUNDS TO GASOLINE WORKERS IN BANGKOK, THALAND) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: อ.ดร.วัฒน์สิทธิ์ ศิริวงศ์, 92 หน้า.

การประเมินความเสี่ยงสุขภาพจากการรับสัมผัสสารอินทรีย์ระเหยง่าย (กลุ่มคาร์บอนิล) ผ่านทางการรับสัมผัสทางการหายใจของคนงานในสถานประกอบการน้ำมันในกรุงเทพมหานคร ประเทศไทย ได้ดำเนินการศึกษาในเดือนกุมภาพันธ์ 2554 โดยมีจุดประสงค์ คือ เพื่อตรวจวัดปริมาณสารคาร์บอนิลภายในสถานประกอบการน้ำมันและประเมินความเสี่ยงทางสุขภาพของคนงานในสถานประกอบการน้ำมันจำนวน 4 สถานประกอบการ คือ ในตัวเมืองจำนวน 2 สถานประกอบการและชานเมืองจำนวน 2 สถานประกอบการ และทำการสุ่มคนงานในสถานประกอบการละ 2 คน ผลการศึกษาพบว่าคนงานในกลุ่มนี้มีอายุระหว่าง 18 ถึง 36 ปี น้ำหนักเฉลี่ยเท่ากับ 56.7 ± 8.1 กิโลกรัม ชั่วโมงทำงานเฉลี่ยของคนงานในสถานประกอบการน้ำมันในตัวเมืองและชานเมืองเท่ากับ 9.3 และ 10.0 ชั่วโมงต่อวัน ตามลำดับ การประเมินค่าการรับสัมผัสการรับสัมผัสสูงสุดของคนงานต่อวันที่ระดับ 95 เปอร์เซ็นต์ไทล์ พบว่า ค่าการรับสัมผัสสารกลุ่มคาร์บอนิลทางการหายใจต่อวันสำหรับสารกลุ่มที่อาจจะก่อให้เกิดมะเร็ง คือ ฟอร์มาลดีไฮด์และอะซิตาลดีไฮด์ มีค่าอยู่ระหว่าง 1.90×10^{-5} ถึง 4.11×10^{-4} มิลลิกรัม/กิโลกรัม/วัน ส่วนการบ่งชี้ความเสี่ยงการเกิดมะเร็งพบว่า คนงานที่อาจจะมีความเสี่ยงอยู่ระหว่าง 2 คนในสิบล้านคน ถึง 2 คนในหนึ่งแสนคน สำหรับสารในกลุ่มที่ไม่ก่อให้เกิดมะเร็ง ได้แก่ ฟอร์มาลดีไฮด์ อะซิตาลดีไฮด์ เบนซาลดีไฮด์ วาลีราลดีไฮด์ โพรพีโอนาลดีไฮด์ และบิวทิราลดิไฮด์ พบว่าค่าการรับสัมผัสสารกลุ่มคาร์บอนิลทางการหายใจมีค่าอยู่ระหว่าง 4.88×10^{-3} to 1.16 ไมโครกรัม/ลูกบาศก์เมตรและทำการระบุความเสี่ยงโดยใช้ค่าดัชนีบ่งชี้อันตราย (Hazard Index, HI) พบว่ากลุ่มคนงานอาจจะไม่ได้รับความเสี่ยงจากการรับสัมผัสสารกลุ่มคาร์บอนิลทางการหายใจ เนื่องจากมีค่าดัชนีบ่งชี้อันตรายของคนงานน้อยกว่า 1 (HI<1)

สาขาวิชา สาธารณสุขศาสตร์ ลายมือชื่อนิสิต ....

ปีการศึกษา 2553 ลายมือชื่อ อ.ที่ปรึกษาวิทยานิพนธ์หลัก ....

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KEYWORDS: CARBONYL GROUP/ INHALATION EXPOSURE/ GASOLINE WORKER/ RME

SUCOT NOPPARATBUNDIT: HEALTH RISK ASSESSMENT ASSOCIATED WITH INHALATION EXPOSURE OF CARBONYL COMPOUNDS TO GASOLINE WORKERS IN BANGKOK, THAILAND.ADVISOR: WATTASIT SIRIWONG, Ph.D., 92 pp.

Human risk assessment of volatile organic compounds (carbonyl group) via inhalation exposure route in gasoline workers was studied during February 2011 in Bangkok, Thailand. The objectives were to measure carbonyl concentrations in gasoline station and to assess health risk of gasoline workers in 4 gasoline stations located in urban area and suburb area. Of each gasoline station, 2 workers were randomly recruited. The results showed the participants age was in the range of 18-36 years old. The average weight (mean ± SD) was 56.7 ± 8.1 kg. The average working time of urban and suburb area was 9.3 and 10.0 h/day, respectively. Exposure assessment of gasoline worker was calculated using reasonable maximum exposure (RME) at the 95th percentile; the inhalation intake of carcinogenic carbonyl i.e. formaldehyde and acetaldehyde in workers was in the range of 1.90×10^{-5} to 4.11×10^{-4} mg/kg/day. Risk characterization of cancer was in the range of 2 workers in 10 million to 2 workers in one hundred thousand. For non-carcinogenic carbonyl i.e. formaldehyde, acetaldehyde, benzaldehyde, valeradehyde, propionaldehyde, and butyraldehyde, the inhalation intake of non-carcinogenic carbonyl in workers was in the range of 4.88×10^{-3} to 1.16 μg/m^3. To assess non-carcinogenic health effects, the Hazard Index (HI) was used; the results showed that gasoline workers may not at risk regarding inhalation exposure of non-carcinogenic health because the HI was not greater than the acceptable level (HI < 1).

Field of Study : Public Health .... Student's Signature Sucot Nopparatbundit
Academic Year : 2010 .... Advisor's Signature Wattasit Siriwong

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CONTENTS

Page

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AT	Averaging Time
ATSDR	The Agency for Toxic Substances and Disease Registry
BTEX	Benzene Toluene Ethylbenzene Xylene
BW	Body Weight
CCs	Carbonyl Compounds
CSF	Cancer Slope Factor
ED	Exposure Duration
ET	Exposure Time
EF	Exposure Frequency
HPLC	High Performance Liquid Chromatography
IARC	International Agency for Research on Cancer
IR	Inhalation Rate
IRIS	Integrated Risk Information System
OSHA	Occupational Safety and Health Administration
PPE	Personal Protective Equipment
RfC	Reference Concentration
RME	Reasonable Maximum Exposure
SF	Slope factor
US.EPA	U.S. Environmental Protection Agency
VOCs	Volatile Organic Compounds

CHAPTER I
INTRODUCTION

1.1 Background and Rationale

In the past, Methyl Tertiary Butyl Ether (MTBE) is mixed with gasoline in order to increase the octane number. However MTBE emits Volatile Organic Compounds (VOCs), toxics and nitrogen oxide, which affect to air quality (Fontaras et al., 2010).

In the U.S., later Congress passed legislation that both removed the reformulated gasoline and required increased use of renewable fuels. Thus since 2006, there has been a large increase in the use of ethanol in the U.S. (EPA, 2009a). By this time most of the MTBE bans were in place so alcohol use in Reformulated Gasoline (RFG) was highest. The use of MTBE was slowly declining until the oxygenate mandate was removed by the Energy Policy Act of 2005 (EPA, 2009a). Since 2004, alternative fuels such as gasohol and biodiesel have been introduced and used in Thailand (Morknoy, Khummongkol, and Prueaksasit, 2010).

Carbonyl compounds (CCs) which are common constituents of the atmosphere are generally known as a toxic for human health. Moreover, vehicle emission is believed to be the most important source of CCs. Also, atmospheric photochemical reaction is another important source (Lü et al., 2006). By product in fuel ethanol (gasohol), it releases formaldehyde, acetaldehyde. (EPA, 2009a) Formaldehyde and acetaldehyde are two most abundant in urban air (Báez et al., 2003). Also formaldehyde and acetaldehyde are suspected carcinogen (Yu et al., 2008). Recently, a working group, convened by the IARC Monographs Programme concluded that formaldehyde is carcinogenic to humans and acetaldehyde is classified by IARC as group 2B, a possible human carcinogen based on sufficient evidence in animals and inadequate evidence in human (Cavalcante et al., 2006). Another example of CC, butyraldehyde, is found in exhaust from diesel engines (Luttrell, 2011).

CCs are common component of rural and urban atmosphere and are of particular interest due to their potential impact on health (Báez et al., 2008). In large urban area, CCs can be emitted from a variety of emission sources such as motor vehicles and gasoline stations (Seo, 2011).

This study aimed to assess the health risk of gasoline workers who work in gasoline station in Bangkok and expose to carbonyl compounds via inhalation. After all, such study rarely operates in Bangkok area. Author focused on formaldehyde and acetaldehyde and other CCs e.g. acetone, propionaldehyde, crotonaldehyde, butyraldehyde, benzaldehyde, isovaleraldehyde, valeraldehyde, o-tolualdehyde, hexanaldehyde, and 2,5-dimethylbenzaldehyde.

1.2 Research Questions

1. Are gasoline workers at risk from carbonyl compounds exposure via inhalation pathway?

2. What are the health risk factors associated with carbonyl compounds exposure among workers in urban and suburb area of Bangkok metropolitan of Thailand?

1.3 Hypotheses

Hypothesis 1

H_o : Gasoline workers may not at risk from CCs exposure via inhalation pathway.

H_1 : Gasoline workers may at risk from CCs exposure via inhalation pathway.

Hypothesis 2

H_o : There is no association among health risk factors and symptoms occurrence in gasoline workers.

H_1 : There is association among health risk factors and symptoms occurrence in gasoline workers.

1.4 Purpose of the study

The main objective of this study was to estimate the carbonyl compounds. The specific objective was:

1. To assess human risk associated with inhalation exposure to CCs in gasoline workers in both urban area and suburb area of Bangkok metropolitan of Thailand.

Specific objectives:

1. To describe the socio-demographic characteristics of gasoline workers in urban and suburb area of Bangkok metropolitan of Thailand.

2. To evaluate risk associated with CCs exposure for gasoline workers in urban and suburb area of Bangkok metropolitan of Thailand.

3. To investigate the health risk factors associated with symptom occurrence of gasoline workers.

1.5 Benefit of this study

The concentration of carbonyl compounds and gasoline workers exposure were estimated. Human health risk related to inhalation exposure in gasoline workers were assessed. The suggested recommendation was mentioned based on the results.

1.6 Operational Definitions

Carbonyl Compounds (CCs) refer to formaldehyde, acetaldehyde, acetone, propionaldehyde, crotonaldehyde, butyraldehyde, benzaldehyde, isovaleraldehyde, valeraldehyde, o-tolualdehyde, hexanaldehyde and 2,5 dimethylbenzaldehyde.

Carcinogenic effects refer to cancer that may be caused from formaldehyde and acetaldehyde related with slope factor (SF).

Non-carcinogenic effects refer to non-cancer effect or acute effect or lifetime non-carcinogenic effect related to reference concentration (RfC).

Slope Factor (SF) refers to an upper bound, approximating a 95% confidence limit, on the increased cancer risk from a lifetime exposure to an agent. This estimate, usually expressed in units of proportion (of a population) affected per mg/kg-day, is generally reserved for use in the low-dose region of the dose-response relationship, that is, for exposures corresponding to risks less than 1 in 100 (IRIS, 2011).

Chronic Reference Concentration (RfC) refers to an estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure for a chronic duration (up to a lifetime) to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. It can be derived from a NOAEL, LOAEL, or benchmark concentration, with uncertainty factors generally applied to reflect limitations of the data used. Generally used in EPA's non cancer health assessments (IRIS, 2011).

Exposure factors refer to exposure time (ET), exposure frequency (EF), exposure duration (ED), averaging time (AT) carbonyl concentration (C), inhalation rate (IR) and body weight (BW).

Gasoline workers refer to the workers in which he/she routinely responses and services for filling gasoline in each gasoline stations.

Reasonable Maximum Exposure (RME) refers to the highest exposure that is reasonably expected to occur at a site. RMEs are estimated for individual pathway. If a population is exposed via more than one pathway, the combination of exposures across pathways also must represent an RME (EPA, 1989).

Gasoline workers' symptoms refer to drowsiness, dizziness, headaches, eye, skin irritation, respiratory tract irritation, unconsciousness, fatigue, nausea, sore throat or throat irritation, lack of muscle coordination and confusion.

Hazard quotient (HQ) refers to the ratio of the potential exposure to the substance and the level at which no adverse effects are expected. If the HQ is calculated to be equal to or less than 1, then no adverse health effects are expected as a result of exposure. If the HQ is greater than 1, then adverse health effects are possible. The HQ cannot be translated to a probability that adverse health effects will occur and it is unlikely to be proportional to risk. It is especially important to note that an HQ exceeding 1 does not necessarily mean that adverse effects will occur (EPA, 2011).

Hazard index (HI) refers to the sum of hazard quotients (HQs) for substances that affect the same target organ or organ system. Because different pollutants can cause similar adverse health effects, it is often appropriate to combine HQs associated with different substances. EPA has drafted revisions to the national guidelines on mixtures that support combining the effects of different substances in specific and limited ways. Ideally, HQs should be combined for pollutants that cause adverse effects by the same toxic mechanism. However, because detailed information on toxic mechanisms was not available for most of the substances in this assessment, EPA aggregates the effects when they affect the same target organ regardless of the mechanism. The hazard index (HI) is only an approximation of the aggregate effect on the target organ, (i.e., lungs) because some of the substances might cause irritation by different, (i.e., non-additive,) mechanisms. As with the HQ, aggregate exposures equal to or below an HI of 1.0 derived using target organ specific hazard quotients likely will not result in adverse non cancer health effects over a lifetime of exposure and would ordinarily be considered acceptable. However, an HI greater than 1.0 does not necessarily suggest a likelihood of adverse effects. Because of the inherent conservatism of the reference concentration (RfC) methodology, the acceptability of exceedances must be evaluated on a case-by-case basis, considering such factors as the confidence level of the assessment, the uncertainties, the slope of the dose-response curve (if known), the magnitude of the exceedance, and the numbers or types of people exposed at various levels above the RfC. Furthermore, the HI cannot be translated to a probability that adverse effects will occur and is not likely to be proportional to risk (EPA, 2011).

1.7 Brief Descriptive of the Study Area

In this study, the study areas are in an urban and suburb of Bangkok, Thailand, in which all gasoline stations were located nearby roadside and mostly crowded with traffic on daytime. Four gasoline stations were purposively separated into urban site (P1 and P2) which located on the Sukhumvit road and suburb site (P3 and P4) located on the Bangna-Trad road (P3 and P4) (Figure 1.1). Both are residential, commercial and traffic jam area.

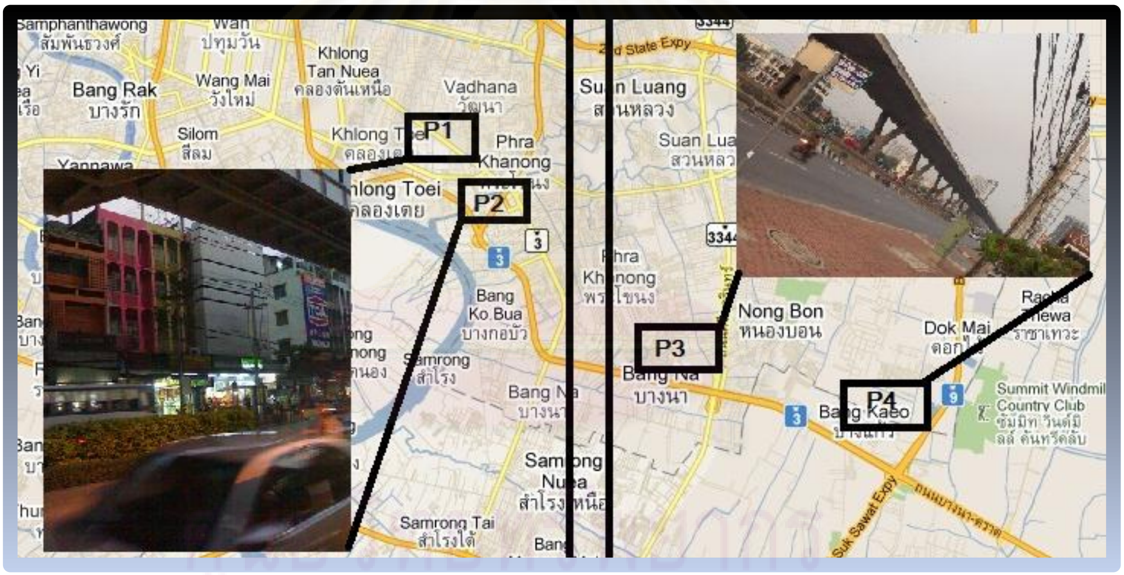

Figure 1.1 The study area, urban (P1 and P2) and suburb (P3 and P4) areas, Bangkok, Thailand.

1.8 Conceptual framework

Independent variable		Dependent Variable
Socio-demographic data* -Gender -Height -Age -Income -PPE usage **Risk factors** -Gender -Location of study areas -Gasoline workers duty and responsibility -Marital status -Education level -Workers' awareness of VOCs -Workers' Symptom occurrence in the last three month -Chronic disease -Smoking behavior **Exposure factors** -concentration of CCs** -exposure duration (ED)* -exposure frequency (EF)* -exposure time (ET)* -averaging time (AT) -Body weight (BW)*	→	**Exposure Assessment** - Inhalation intake for lifetime non-carcinogenic effects - Inhalation intake for lifetime carcinogenic effect **Risk Characterization** - Non-carcinogenicity - Carcinogenicity **Worker's symptoms*** Drowsiness, dizziness, headaches, eye, skin irritation, Respiratory tract irritation, Unconsciousness, Fatigue, Nausea, Sore throat or throat irritation, Lack of muscle

* Obtained data from face to face questionnaires

** Obtained data from laboratory analysis

CHAPTER II
LITERATURE REVIEW

2.1 Gasoline and oxygenated additives

Gasoline is the generic name for the complex flammable mixture of paraffins, olefins, naphthenes, and aromatic hydrocarbon that serves as principal fuel for the spark-activated internal combustion engine. In 1992 the world's apparent consumption of gasoline was 267 billion gallons (Weaver, 2001). Gasoline also contains a number of additives; those commonly used and propose they serve are shown in table 2.1. Oxygenates, including such compounds as MTBE, Ethanol, methanol are adding in gasoline as octane enhancers and antiknock agents (Weaver, 2001).

Table 2.1: Additives typically used in motor gasoline

Agent	**Purpose**
tetraethyl/tetramethyl lead	Antiknock
ethylene dichloride/dibromide	Lead scavengers
Amines	Detergents
Sulfonates	Antirust agents
Aminophenols	Antioxidants
Light mineral oils	Upper cylinder lubricants
MTBE,ethanal,methanol	Oxygenates

(Adopt from Weaver, 2001)

In 2000 Thailand was tasted gasohol for vehicles the result found that gasohol release the air pollution, in-expensive and did not harm the car's engine. After that the governments of Thailand push forward and promote people to using gasohol (Ministry of energy 2009, 2010).

2.2 Chemical reaction of alcohols in gasohol

The atmospheric chemistry of alcohols, which are widely used as motor vehicle fuels (e.g. ethanol in Brazil) and as industrial solvents, has been reviewed with focus on kinetic data and on reaction mechanisms. Oxidation of alcohols in the atmosphere involves their reaction with the hydroxyl radical (OH). Alcohol-OH reaction rate constants are presented for 33 saturated alcohols including monofunctional and difunctional compounds. Major products are formaldehyde from methanol, acetaldehyde from ethanol, acetone from 2-propanol, 2-butanone and acetaldehyde from 2-butanol and acetone and formaldehyde from t-butyl alcohol (Grosjean, 1997).

The reaction of OH with alcohols involves H-atom abstraction from C-H bonds; H-atom abstraction from the O-H bond is negligible. The alkyl radicals (R) and a-hydroxyalkyl radicals thus formed react with oxygen. This reaction involves addition for alkyl radicals ($R + O_2 \rightarrow RO_2$) and H-atom abstraction for a-hydroxyalkyl radicals (e.g. ethanol + OH $\rightarrow$ CH_3CHOH, $CH_3CHOH + O_2 \rightarrow HO_2 + CH_3CHO$). The reaction sequence ethanol $\rightarrow$ acetaldehyde $\rightarrow$ peroxyacetyl nitrate (PAN, $CH_3C(O)OONO_2$) is described and is relevant to urban air pollution in Brazil (Grosjean, 1997). For another reference, by products in fuel ethanol compose to formaldehyde, acetaldehyde, furfural, 2-furancarboxaldeyde, acrolein, benzene, methanol, ethanol, glycerol, styrene, lactic acid and acetic acid (EPA, 2009a).

In addition, formaldehyde, acetaldehyde, diesel particulate matter, and 1,3-butadiene are not present in fuel but are by-products of incomplete combustion. Formaldehyde and acetaldehyde are also formed through a secondary process when other mobile source pollutants undergo chemical reactions in the atmosphere (EPA, 1994).

2.3 What is risk assessment?

Risk assessment, as applied to toxic hazards, is the process of evaluating the nature and likelihood of adverse effects that may occur following exposure to a chemical (Dalefield, Oehme, and Krieger, 2001). The risk assessment process seeks to assign an objective measurement of risk to a certain exposure so decisions on chemical exposure based on reason rather than on fear, prejudice, or the skills of interested parties in manipulating the media or applying political pressure.

Current systems for risk assessment

Currently, risk-assessment procedures can be divided into a) risk assessment for non-cancer toxic effects, b) cancer risk assessment, c) risk assessment for reproductive and developmental toxicity, and d) neurotoxicity risk assessment (Dalefield, Oehme, and Krieger, 2001). However, this research were assessed for non-cancer toxic effects because the gasoline workers in gasoline station, most of them were became to gasoline workers in gasoline station for a long time.

Risk assessment process for toxic effects

The primary default process was used by the EPA for quantitative risk assessment of non-cancer effects. The process aims to identify a safe exposure level that does not cause any adverse effect on human health. RfC (include RfD), formerly known as an acceptable daily intake (Dalefield, Oehme, and Krieger, 2001), is measured in mg/kg/day (concentration units depend on types chemical substance such as mg, ppm, ppb).

The risk assessment process (Figure. 2.1) for non-cancer effects and cancer effects includes the following 4 steps, hazard identification, dose-response assessment, exposure assessment, and risk characterization.

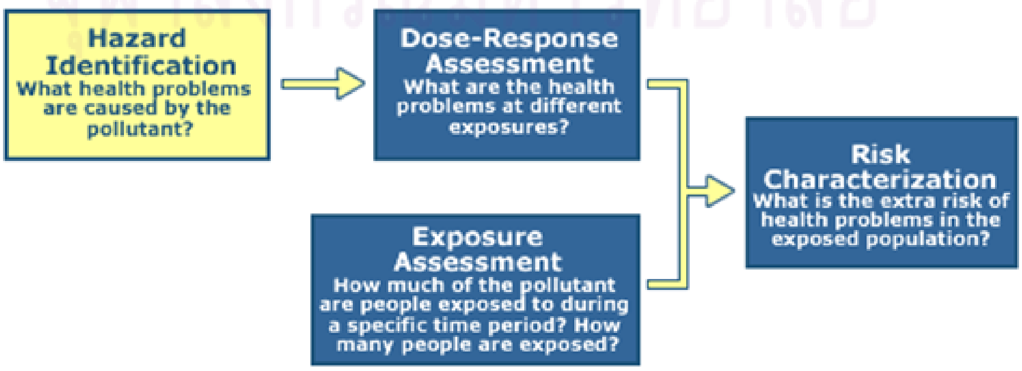

Figure 2.1: The risk assessment process (EPA, 2010a)

2.3.1 Hazard Identification

Hazard Identification is the process of determining whether exposure to a stressor can cause an increase in the incidence of specific adverse health effects (e.g., cancer, birth defects) and whether the adverse health effect is likely to occur in humans. In the case of chemical stressors, the process examines the available scientific data for a given chemical (or group of chemicals) and develops a weight of evidence to characterize the link between the negative effects and the chemical agent.

Exposure to a stressor may generate many different adverse effects in a human: diseases, formation of tumors, reproductive defects, death, or other effects (EPA, 2010a).

Based on this study, the Researcher mainly focused on carbonyl compounds such as formaldehyde and acetaldehyde,acetone, propionaldehyde, crotonaldehyde, butyraldehyde, benzaldehyde, isovaleraldehyde, valeraldehyde, o-tolualdehyde, hexanaldehyde, and 2,5-dimethylbenzaldehyde).

Acetaldehyde

Acetaldehyde is a colorless, liquid and flammable. The chemical structure is shown below in Figure 2.2. For acute health effects about this chemical are irritation of the eyes, skin, and respiratory tract. For chronic effects, EPA divides this chemical into group B2 (probable to carcinogen for human) because lack of studies (EPA, 2000a). Fontaras et al. (2010) mentioned that acetaldehyde is classified as a suspected carcinogen.

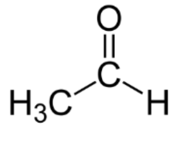

Figure 2.2 Structure of Acetaldehyde

Formaldehyde

Formaldehyde is a nearly colorless gas with a pungent, irritating odor even at very low concentrations (below 1 ppm). Its vapors are flammable and explosive. Most formaldehyde exposures occur by inhalation or by skin/eye contact, gasoline workers in gasoline station still expose the formaldehyde on their workplace. Formaldehyde vapor is readily absorbed from the lungs. In cases of acute exposure, formaldehyde will most likely be detected by smell. Persons who are sensitized to formaldehyde may experience headaches and minor eye and airway irritation (ATSDR, 2010a). But present IARC classify as carcinogenic (Fontaras et al., 2010). The chemical structure is shown below (Figure 2.3).

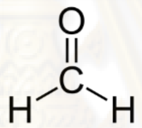

Figure 2.3 Structure of formaldehyde

Acetone

Acetone is a manufactured chemical that is also found naturally in the environment. It is a colorless liquid with a distinct smell and taste. It evaporates easily, is flammable, and dissolves in water. Acetone is used to make plastic, fibers, drugs, and other chemicals. It is also used to dissolve other substances. It occurs naturally in plants, trees, volcanic gases, forest fires, and as a product of the breakdown of body fat. It is present in vehicle exhaust, tobacco smoke, and landfill sites. Industrial processes contribute more acetone to the environment than natural processes (ATSDR, 2010b). The chemical structure is shown below (Figure 2.4).

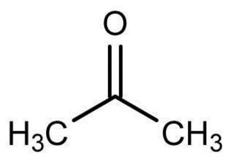

Figure 2.4 Structure of acetone

Propionaldehyde

Propionaldehyde is used in the manufacture of plastics, in the synthesis of rubber chemicals, and as a disinfectant and preservative. Limited information is available on the health effects of propionaldehyde. No information is available on the acute (short-term), chronic (long-term), reproductive, developmental or carcinogenic effects of propionaldehyde in humans. Animal studies have reported that exposure to high levels of propionaldehyde, via inhalation, results in anesthesia and liver damage, and intraperitoneal exposure results in increased blood pressure. EPA has not classified propionaldehyde for carcinogenicity (EPA, 2000b). The chemical structure is shown below (Figure 2.5).

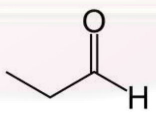

Figure 2.5 Structure of Propionaldehyde

Crotonaldehyde

Crotonaldehyde has been used as a warning agent in fuels, as alcohol denaturant, as stabilizer for tetraethyl-lead, in the preparation of rubber accelerators, and in leather tanning. Crotonaldehyde is emitted from the combustion of gasoline, the burning of wood and the burning of tobacco. Therefore, the general population may be exposed to crotonaldehyde through inhalation of tobacco smoke, gasoline and diesel engine exhausts, and smoke from wood burning. Crotonaldehyde in the air can irritate eyes, nose, throat, and lungs, possibly causing cough and experience chest tightness and shortness of breath. High levels of crotonaldehyde can cause a build-up of fluid in lungs (ATSDR, 2002). The chemical structure is shown below (Figure 2.6).

Figure 2.6 Structure of crotonaldehyde

Butyraldehyde

Butyraldehyde liquid and vapor can damage eyes and irritate the skin. Generally, the chemical has low acute lethality to laboratory animals (EPA, 1994). The chemical structure is shown below (Figure 2.7).

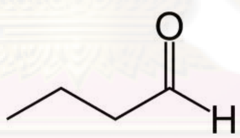

Figure 2.7 Structure of butyraldehyde

Benzaldehyde

Benzaldehyde may cause irritation to the respiratory tract. Symptoms may include coughing, sore throat, labored breathing, and chest pain. Other health hazard such as forestomash lesions, kidney toxicity, necrotic and degenerative lesions of the brain, renal tubular necrosis and epithelial hyperplasia and hyperkeratosis of the forestomash in rat (Fontaras et al., 2010). The chemical structure is shown below (Figure 2.8).

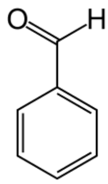

Figure 2.8 Structure of benzaldehyde

Isovaleraldehyde

Isovaleradehyde can irritation of eyes, skin, mucous membranes, respiratory system; chest tightness, cough, dyspnea; dizziness, headache, lethargy, anorexia, nausea, vomiting, diarrhea; sweating; tachycardia (OSHA, 2008). The chemical structure is shown below (Figure 2.9).

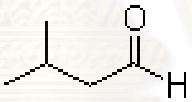

Figure 2.9 Structure of isovaleraldehyde

Valeraldehyde

Valeraldehyde has been shown to be a severe irritant to the skin of guinea pigs and to the eyes of rabbits. Even though its irritation properties are considerable, it has low systemic toxicity. The dermal $LD_{50}$for guinea pigs and the oral $LD_{50}$for rats and mice are several grams per kilogram of body weight. The $LC_{50}$was reported to be about 48,000 ppm for rats in a 1.2-h inhalation experiment (OSHA, 2011). The chemical structure is shown below (Figure 2.10).

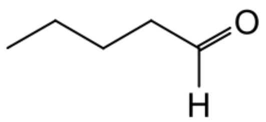

Figure 2.10 Structure of valeraldehyde

o-Tolualdehyde

o-Tolualdehyde may cause respiratory tract irritation. The toxicological properties of this substance have not been fully investigated. Aspiration may lead to pulmonary edema. Inhalation at high concentrations may cause central nerve system (CNS) depression and asphixiation. For skin exposure, may cause irritation and dermatitis. Eyes contacts cause eye irritation (Chemical dictionary, 2009). The chemical structure is shown below (Figure 2.11).

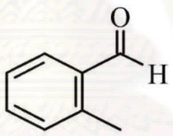

Figure 2.11 Structure of o-tolualdehyde

Hexanaldehyde

Hexanaldehyde may be harmful when inhaled, swallowed or absorbed through the skin. It is skin, eye and respiratory irritant (MSDS, 2003). The chemical structure is shown below (Figure 2.12).

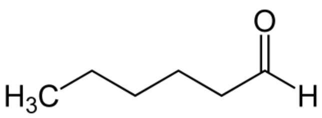

Figure 2.12 Structure of hexanaldehyde

2,5-Dimethylbenzaldehyde

2,5-Dimethylbenzaldehyde can be irritating to eyes, respiratory system and skin. It may cause sensitization by skin contact (Guide chem, 2011). The chemical structure is shown below (Figure 2.13).

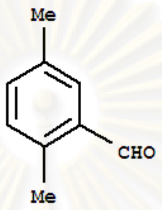

Figure 2.13 Structure of 2,5-dimethylbenzaldehyde

2.3.2 Dose-response assessment

A dose-response relationship describes how the likelihood and severity of adverse health effects (the responses) are related to the amount and condition of exposure to an agent (the dose provided). Although this webpage refers to the "dose-response" relationship, the same principles generally apply for studies where the exposure is to a concentration of the agent (e.g., airborne concentrations applied in inhalation exposure studies), and the resulting information is referred to as the "concentration-response" relationship. The term "exposure-response" relationship may be used to describe either a dose-response or a concentration-response, or other specific exposure conditions (EPA, 2010b). This research were used the RfC values from many sources to evaluate health risk for gasoline workers, follow table 2.2.

Table 2.2 Lists of Reference Concentration (RfC) and cancer slope factor (SF)

Compounds	**Non-cancer RfC (µg/m3)**	**Reference Source**	**Cancer SF $(mg/kg/day)^{-1}$**	**Reference Source**
Formaldehyde	9.8	EPA, 2009b	0.0455	Huang et al.,2010
Acetaldehyde	9	IRIS, 1991	0.0077	Huang et al.,2010
Benzaldehyde	9	EPA, 2009b	-	
Valeraldehyde	420	EPA, 2009b	-	
Propionaldehyde	8	EPA, 2009b	-	
Butyraldehyde	15	EPA, 2009b	-	

2.3.3 Exposure assessment

EPA defines exposure as 'contact between an agent and the visible exterior of a person (e.g. skin and openings into the body)'. Exposure assessment is the process of measuring or estimating the magnitude, frequency, and duration of human exposure to an agent in the environment, or estimating future exposures for an agent that has not yet been released. An exposure assessment includes some discussion of the size, nature, and types of human populations exposed to the agent, as well as discussion of the uncertainties in the above information. Exposure can be measured directly, but more commonly is estimated indirectly through consideration of measured concentrations in the environment, consideration of models of chemical transport and fate in the environment, and estimates of human intake over time (EPA, 2010c).

Exposure assessment for carcinogenic

Because formaldehyde and acetaldehyde in this study is classified to carcinogenic compounds, so the exposure assessment for cancer compound is generally estimated follow the equation 1 (EPA, 2003),

$$I = \frac{CA \times IR \times ET \times EF \times ED}{BW \times AT} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where; I = Intake (mg/kg/day)

CA = Contaminant Concentration in Air (mg)

IR = Inhalation Rate (m^3/h)

ET = Exposure Time (h/day)

EF = Exposure Frequency (days/year)

ED = Exposure Duration (years)

BW = Body Weight (Kg)

AT = Averaging Time (days)

Exposure assessment for non-carcinogenic

In this study, 6 CCs i.e. formaldehyde, acetaldehyde, benzaldehyde, valeraldehyde, propionaldehyde, butyraldehyde are non-carcinogenic compounds. The exposure assessment for non-cancer compound is estimated follow the equation 2 (Yimrungruang et al., 2008).

$$I = \frac{CA \times ET \times EF \times ED}{AT} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Where; I = intake ($\mu g/m^3$)

CA = Contaminant Concentration in Air ($\mu g/m^3$)

ET = Exposure Time (hours/day)

EF = Exposure Frequency (days/year)

ED = Exposure Duration (years)

AT = Averaging Time (days)

2.3.4 Risk characterization

A risk characterization conveys the risk assessor's judgment as to the nature and presence or absence of risks, along with information about how the risk was assessed, where assumptions and uncertainties still exist, and where policy choices will need to be made. Risk characterization takes place in both human health risk assessments and ecological risk assessments. In practice, each component of the risk assessment (e.g. hazard assessment, dose-response assessment, exposure assessment) has an individual risk characterization written to carry forward the key findings, assumptions, limitations, and uncertainties. The set of these individual risk characterizations provide the information basis to write an integrative risk characterization analysis. The final, overall risk characterization thus consists of the individual risk characterizations plus an integrative analysis (EPA, 2010d).

For the last step, risk characterization, the potential of carcinogenic effects, follow the equation 3 (EPA, 2003) and non-carcinogenic effects follow the equation 4 (EPA, 2003).

Carcinogenic risk characterization

Cancer Risk = CSF x I……………………………………...(3)

Where; CSF = Cancer Slope Factor for inhalation $(mg/kg/day)^{-1}$

I = Inhalation intake (mg/kg/day)

Non-carcinogenic risk characterization

HQ = I/RfC ……………………….(4)

Where; HQ = Hazard Quotient

I = Inhalation intake ($\mu g/m^3$)

RfC = Reference Concentration ($\mu g/m^3$)

When; HQ > 1 means adverse lifetime non-carcinogenic effects of concern

HQ ≤ means acceptable level

After HQ calculated, Hazard Index (HI) was used to estimate adverse health effect in this study, follow the equation 5:

Hazard Index (HI) = ∑HQi……………………………………..(5)

Where; HI = The sum of hazard quotients.

HQi = Summation of HQ of non-carcinogens in each site

HI > 1 means adverse lifetime non-carcinogenic effects of concern

HI ≤ means acceptable level

Sum of hazard quotients for substances may affect the same target organ or organ system and may cause similar adverse health effects (EPA, 2005).

2.4 Reasonable Maximum Exposure (RME)

The reasonable maximum exposure (RME) is defined as the highest exposure that is reasonably expected to occur at a site. It is likely to approximate the worst-case scenario and estimates for individual pathways. The aim of the RME is to estimate a conservative exposure case that is still within the range of possible exposures. The concentration term in the intake equation is the arithmetic average of concentration. It is contacted over the exposure period. However, this concentration does not indicate the maximum concentration that could be contacted at any one time. It is a reasonable estimate of the concentration likely to be contacted over time. In most situations, long-term contact with the maximum concentration is not assumed as reasonable. The uncertainty associated with any estimate of exposure concentration, the upper confidence limit (such as, the 95 percent upper confidence limit) on the arithmetic average will be used for this variable. If there is great variability in measured or modeled concentration values (such as too few samples), the upper confidence limit on the average concentration will be high, and possibly could be above the maximum detected or modeled value. In these cases, the maximum detected or modeled value should be used to estimate exposure concentrations (Siriwong, 2009). In addition to concentration, exposure time, exposure frequency and exposure duration were taken into consideration for this study.

2.5 Analysis of Carbonyl Compounds

CCs in atmosphere can be kept as sample in order to analyze via HPLC. In sampling, sampling tubes were used for gathering 2,4-DNPH at targeted area. In addition, mini pumps setting at appropriate flow rate 0.1 (Morknoy et al., 2010; Viskari, Vartiainen, and Pasanen, 2000) L/min were used for air sampling. After sampling, each specimen was to be sent back to laboratory immediately so as to be extracted using ACN 5ml (Morknoy et al., 2010; Bakeas, Argyris, and Siskos, 2003). Afterwards, the extracted solution was injected, by 25 µL (Morknoy et al., 2010), to HPLC which combined UV Detector and HPLC Column.

2.6 Related Articles

Zhou et al. (2010) found that, personal exposures for 12 participants as well as residential indoor/outdoor, workplace and in vehicle VOCs concentrations were measured simultaneously in Tianjin, China. All VOCs samples were collected using passive samplers for 5 days and were analyzed using Thermal Desorption GC-MS method. U.S. Environmental Protect Agency's Inhalation Unit Risks were used to calculate the inhalation cancer health risk and assess uncertainty of health risk estimate. For Results, the cancer risk analysis of personal exposure, benzene, chloroform, carbon tetrachloride and 1, 3 -butadiene had median upper-bound lifetime cancer risks that exceeded the U.S. EPA benchmark of 1 per one million, and benzene presented the highest median risks at about 22 per one million populations. The median cumulative cancer risk of personal exposure to 5 VOCs was approximately 44 per million, followed by indoor exposure (37 per million) and in vehicle exposure (36 per million).

Majumdar et al. (2008) reported ambient air quality at five busy petrol stations in Kolkata, India is monitored for mono-aromatic hydrocarbons and carbonyls. Among the measured volatile organic compounds, toluene and formaldehyde were the most abundant. Source apportionment using chemical mass balance identified exhaust from roadway and refueling as the major sources. Monitoring of the service station workers revealed that the average exposure level for benzene and toluene were 3.9

and 5.5 fold higher than the ambient air. The integrated lifetime cancer risks due to benzene, ethylbenzene, formaldehyde and acetaldehyde and the overall hazard index due to chronic exposure to some hazardous volatile organic compounds are 1.48×10^{-4} and 2.3 indicating the probability of cancer as well as chronic health effect on the workers exposed.

Durmusoglu et al. (2007) said that, this study focuses on a health risk assessment related to chemical exposure via inhalation for workers in a tire factory. Specifically, several volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs) were measured in the four different points of the vulcanization unit. A chemical transport model was developed in order to better represent the workers' exposure to the chemicals. Then, a risk assessment methodology was employed to evaluate the potential adverse health effects of the chemicals according to their carcinogenicities. Concentrations measured near the milling machine and press in the vulcanization unit was generally higher than the respective occupational exposure limit values. The corresponding estimated cumulative cancer risks for the carcinogens at the each sampling point were higher than the designated acceptable risk level of 1×10^{-4}. With respect to non-carcinogenic risks, the hazard indexes, both individually and cumulatively, were lower than the specified level of one. The high cancer risk estimated in this study suggests that the VOCs and Semi-VOCs exposure for workers in the vulcanization unit should not be neglected. The results obtained in this study are valuable to plant managers, government officials, and regulators in the risk evaluation process.

Lee et al. (2002) found that, the assessment of volatile organic compounds (VOCs) has become a major issue of air quality network monitoring in Hong Kong. This study is aimed to identify, quantify and characterize volatile organic compounds (VOCs) in different urban areas in Hong Kong. The spatial distribution, temporal variation as well as correlations of VOCs at five roadside sampling sites were discussed. Twelve VOCs were routinely detected in urban areas. The concentrations of VOCs ranged from undetectable to 1396 lg/m3. Among all of the VOC species, toluene has the highest concentration. Benzene, toluene, ethylbenzene and xylenes (BTEX) were the major constituents (more than 60% in composition of total VOC detected), mainly contributed from mobile sources. Similar to other Asian cities, the

VOC levels measured in urban areas in Hong Kong were affected both by automobile exhaust and industrial emissions. High toluene to benzene ratios (average T/B ratio) was also found in Hong Kong as in other Asian cities. In general, VOC concentrations in the winter were higher than those measured in the summer (winter to summer ratio > 1). As toluene and benzene were the major pollutants from vehicle exhausts, there is a necessity to tighten automobile emission standards in Hong Kong.

Morknoy et al. (2010) investigated concentration level of carbonyl compounds in Bangkok ambient air were measured in five road sites and five residential sites during July to April 2008. Formaldehyde and acetaldehyde were the most abundant. Other compounds showed low concentration. The concentrations of formaldehyde and acetaldehyde were low during the rainy season due to rain washout since these compounds are water soluble. The concentrations were high during the cold season due to stable conditions during these months. The concentrations slightly decreased during the summer due to photochemical reaction and photolysis under extreme temperature.

Ongwandee et al. (2011) said that, to conserve energy, office buildings with air-conditioning systems in Thailand are operated with a tight thermal envelope. This leads to low fresh-air ventilation rates and is thought to be partly responsible for the sick building syndrome symptoms reported by occupants. The objectives of this study are to measure concentrations and to determine sources of 13 volatile organic compounds (VOCs) in office buildings with air-conditioning systems in the business area of Bangkok. Indoor and outdoor air samples from 17 buildings were collected on Tenax-TA_ sorbent tubes and analyzed for individual VOCs by thermal desorption-gas chromatography/mass spectrometry (TDeGC/MS). Building ventilation was measured with a constant injection technique using hexafluorobenzene as a tracer gas. The results show that the VOC concentrations varied significantly among the studied buildings. The two most dominant VOCs were toluene and limonene with average concentrations of 110 and 60.5 $\mu g/m^3$, respectively. A Wilcoxon sum rank test indicated that the indoor concentrations of aromatic compounds and limonene were statistically higher than outdoor concentrations at the 0.05 level, while the indoor concentrations of chlorinated compounds were not. Indoor emission factors of toluene and limonene were found to be highest with the average values of 80.9 and 18.9

μg/m^2 /h, respectively. Principal component analysis was applied to the emission factors of 13 VOCs, producing three components based on source similarities. Furthermore, a questionnaire survey investigation and field measurements of building air exchange pointed to indoor air complaints related to inadequate ventilation.

Kim et al. (2008) reported that, the emission concentrations of carbonyl compounds in air were quantified from a total of 195 man-made source units within 77 individual companies at a large industrial complex in Korea. The measurement data were evaluated both by absolute magnitude of concentration and by their relative contribution to malodor formation such as malodor degree (MD) derived from empirical formula. It was found that formaldehyde exhibited the highest mean concentration of 323 ppb with a median value of 28.2 ppb, while butyraldehyde recorded the highest contribution to odor formation with an MD value of 3.5 (186 (mean) and 9.8 ppb (median)). The relative intensity of carbonyl emission, when compared by the sum of MD, showed the highest source strength from the food and beverage (industry sector) and scrubber (source unit). A comprehensive evaluation of the carbonyl data from diverse industrial facilities thus allowed us to describe the fundamental patterns of their emission.

Seo et al. (2011) reported that purpose of this study was to characterize spatial and temporal variations of carbonyl compounds in Gumi city, where a number of large electronic-industrial complexes are located. Carbonyl samples were collected at five sites in the Gumi area: three industrial, one commercial, and one residential area. Sampling was carried out throughout a year from December 2003 to November 2004. At one industrial site, samples were taken every six days, while those of the other sites were for seven consecutive days in every season. Each sample was collected for 150 minutes and at intervals of three times a day (morning, afternoon, and evening). A total of 476 samples were analyzed to determine 15 carbonyl compounds by the USEPA TO-11A (DNPH-cartridge/HPLC) method. In general, acetaldehyde appeared to be the most abundant compound, followed by formaldehyde, and acetone&acrolein. Mean concentrations of acetaldehyde were two to three times higher in the industrial sites than in the other sites, with its maximum of 77.7 ppb. In contrast, ambient levels of formaldehyde did not show any significant difference between the industrial and non-industrial groups. Its concentrations peaked in summer probably due to the enhanced volatilization and photochemical reactivity. These results indicate significant emission sources of acetaldehyde in the Gumi industrial complexes. Mean concentrations of organic solvents (such as acetone+acrolein and methyl ethyl ketone) were also significantly high in industrial areas. In conclusion, major sources of carbonyl compounds, including acetaldehyde, are strongly associated with industrial activities in the Gumi city area.

Christensen et al. (2000) studied the atmospheric concentrations of formaldehyde, acetaldehyde and acetone were measured by the DNPH-technique at the semi-rural site Lille Valby, Denmark between May to July 1995. The average concentrations were observed tobe 1.2 ppbv (part per billion by volume) for formaldehyde, 0.8 ppbv for acetaldehyde and 1.9 ppbv for acetone. For the set of carbonyl compounds, concentrations were found to be highly correlated, though only during daytime. The weak correlations observed during nighttime are believed to be caused by the dry deposition of especially formaldehyde. During periods with low photochemical activity the carbonyl compounds also correlated with SO_2 and the levels of carbonyl compounds were mainly controlled by meteorological parameters. The highest concentration levels were coincident with episodes of long-range transport from central Europe. A pronounced diurnal profile similar to those observed for PAN and ozone during high-pressure episodes also indicated that photochemical production was a major controlling factor. Here the highest concentrations of carbonyl compounds were observed in air masses with the highest photochemical age (PCA) and a likely source was determined to be the oxidation of hydrocarbons during long-range transport. Especially, the concentration levels of acetone showed a pronounced seasonal variation with the highest levels observed during summertime and lowest in winter and spring. The seasonal variation in the concentration levels of formaldehyde and acetaldehyde were small, thus indicating a low net photochemical production of these components. The measurements were validated by a laboratory inter comparison and good agreement was observed.

CHAPTER III
RESEARCH METHODOLOGY

3.1 Research design

The research design of this study is a cross-sectional study. All samples and questionnaire were collected in February 2011 during dry season.

3.2 Study area and location

The gasoline station in both urban and suburb area were purposive selected close to main road i.e. Sukhumvit and Bangna-trad. Environment around gasoline station in urban areas is surrounded with buildings and closed to sky train. On the other hand, the suburb area is less amount of buildings and far from commercial areas. Most of the gasoline stations in suburb are located under large highway.

In each location, there were two stations of urban area (P1 and P2) and two stations of suburb area (P3 and P4). Each gasoline station was collected triplicate sampling on the first week, second week, and third week of February 2011. At the sampling site, 2 refuel workers and one ambient stationary monitoring in front of gasoline station (figure 3.1 and 3.2) were induced to samples collected. (see Table 3.1)

Table 3.1 Characteristics of the sampling sites (P1, P2, P3, and P4)

Sampling sites	**N**	**Sampling Station**
P1 (Urban)	6 3	Gasoline Workers Roadside
P2 (Urban)	6 3	Gasoline Workers Roadside
P3 (Suburb)	6 3	Gasoline Workers Roadside
P4 (Suburb)	6 3	Gasoline Workers Roadside
	n = 36 samples	

P1 and P2 were located in the urban areas (Sukhumvit road, Phra-kranong district). For environment, P1 closes to sky train and building P2 is 2 kilometers away from P1. The inbound and outbound roadways were located in front of P1 and P2, 3 lanes for inbound and 3 lanes for outbound.

P3 and P4 were located in suburb areas (Bangna-Trad road, Bangna district). The environment is different from urban area. There are less building but there are a number of road lanes, 3 lines for inbound, 3 lanes for outbound and 4 lanes in middle of the main road and located under the highway.

Figure 3.1 Environment around the sample sites (P1, P2, P3, and P4)

3.3 Sampling and analysis

Air sampling were collected by drawing air using a mini pump (Sibata Sigma30, Japan) through the active DNPH cartridge (Wako, Japan) following the procedures of U.S.E.P.A. Compendium Method- TO11A (EPA, 1991). Samples were collected for 8 h in all sampling sites at a flow rate of 100 ml/min. After sampling, the samples were fitted by their cap, stored in ice box and then brought to laboratory for extraction and analysis. In the laboratory the sample was extracted with 5 ml acetonitrile (ACN) (HPLC-grade, J/T. Baker, UK). The extract was collected in a 5 ml volumetric flask (grade A SCHOTT DURAN®, 5 ml

±0.025 ml) and the final volume adjusted to 5 ml by acetonitrile (HPLC-grade, J/T. Baker, UK). After extraction, the samples were took in refrigerator (-80 degree Celsius) until analyzing phase. High Performance Liquid Chromatography (HPLC) (model Shimazu LC-20A) was used to analyze samples eluted from cartridges. A 25µl aliquot was injected to the HPLC through an autosampler. The HPLC column was Discovery RP Amide C16 reverse column 25cm x 4.6mm, 5 µm. Detector UV-VIS (model SPD-20A) was used at wavelength 360 nm. The gradient mobile phase 55/45% ACN/water and the flow rate was 1 ml/minutes. (Morknoy et al., 2010).

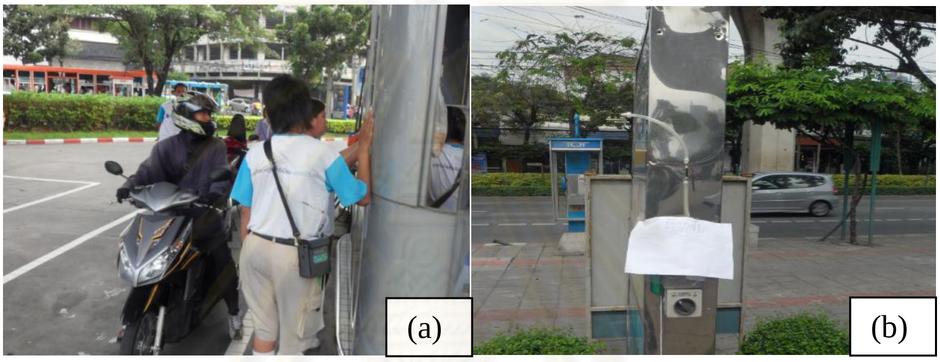

Figure 3.2 Sample collections (individual gasoline workers (a) and roadside (b))

3.4 Inclusion criteria

Refuel gasoline workers were included to this study for measuring the carbonyl exposure via inhalation route. They spent most time in dispensing areas (refueling field). Their work shift must be covered the period of this study (in February). Gasoline workers did not use any perfume, spray, and/or lotion while they are working. The age of gasoline workers were more or at least18 years old.

3.5 Exclusion criteria

Non-refuel position gasoline workers who spent most time in indoor areas. The pregnant workers were excluded.

3.6 Data Analysis

The licensed SPSS version 17 was performed as follows: Descriptive and Inferential statistics of mean, range, percentage, 95^{th} percentile of each chemical. For quantitative statistics, Pearson's correlation was done. Chi-square test was used for association between symptoms occurrence and areas. Independent T-Test was used to compare mean differences between carbonyls concentration in 2 areas.

3.7 Ethical Consideration

The experimental protocol was approved by the committee on human rights related to human experimentation of Chulalongkorn University with the certified code no. 76/2554.

CHAPTER IV
RESULTS

This chapter provides a detailed description of the results obtained from the sites, both of questionnaire and carbonyls concentration. The variables are described as simple percentages, mean, standard deviations, range as appropriateness depends on the nature of the variables and propose of each variable.

4.1 Socio – Demographic characteristics of workers and gasoline stations environment

In this study, they were 21 participants (13 men and 8 women). All of them were interviewed face to face by author. The results showed that the age of male and female in the study ranged 18 to 36 years old, most of them age ≤ 22 years old, the mean (±SD) of urban area was 24.2 ± 5.2 years old, suburb area was 24.8±8.5 years old. Of all area, the mean of age was 24.3± 6.4. Height of participants ranged 150 to 172 centimeters, the mean (±SD) of urban area was 159.1 ± 7.4 centimeters and suburb area was 163.2 ± 5.0 centimeters; the mean (±SD) of both areas was 160.6 ± 6.8 centimeters. Body weight ranged 38 to 70 kilograms, the mean (±SD) of urban area was 56.3 ± 9.0 kilograms, suburb area was 57.5 ± 6.9 kilograms; the mean (±SD) of both areas was 56.7 ± 8.1 kilograms. Income of participants was around 4,500 to 8,600 baht per month, the mean (±SD) of urban area was 6,746 ± 956 baht and suburb area was 6,296 ± 803 baht; the mean (±SD) of both areas was 6575±908 baht. For present smoking behavior, there were 4 smoking workers and 17 non-smoking workers. In addition, they were not smoking while they were working in gasoline station because of the general regulation of each station. For Personal Protective Equipment (PPE) using behavior e.g. use of mask, all gasoline workers in all sites were not used PPE. This behavior should be reconsidered in order to protect gasoline workers' health. Marital status, the result showed 14 single workers and 7 married workers. Socio-demographic data were showed in table 4.1

From the observation, the number of refuel stalk on tanks was found; P1 was 48 refuel stalks (6 main tanks customer service), P2 was 18 refuel stalks (3 main tanks customer service), P3 was 32 refuels stalk (4 main tanks customer service) and P4 was 32 refuel stalks (4 main tanks customer service).

Table 4.1 Distribution of the respondents by socio-demographic characteristics

Characteristics	Number (n=21)	Percentage (%)
Gender		
Male	13	61.9
Female	8	38.1
Age (years)		
Urban areas		
≤ 22	6	28.6
23-30	6	28.6
≥ 30	1	4.8
	Range = 18 to 36	
	Mean ± SD = 24.2±5.2	
Suburb areas		
≤ 22	6	28.6
23-30	-	0
≥ 30	2	9.4
	Range = 18 to 36	
	Mean ± SD = 24.8±8.5	
All Areas		
	Range = 18 to 36	
	Mean ± SD = 24.3±6.4	
Height (Centimeters)		
Urban areas		
	Range = 150 to 172	
	Mean ± SD = 159.1±7.4	
Suburb areas		
	Range = 157 to 170	
	Mean ± SD = 163.2±5.0	
All areas		
	Range = 150 to 172	
	Mean ± SD = 160.6±6.8	

Characteristics		Number (n=21)	Percentage (%)
Body Weight (Kilograms)			
Urban areas		Range = 38 to 67 Mean ± SD = 56.3±9.0	
Suburb areas		Range = 47 to 70 Mean ± SD = 57.5±6.9	
All areas		Range = 38 to 70 Mean ± SD = 56.7±8.1	
Income (Baht)			
Urban areas		Range = 5,500 to 8,600 Mean ± SD = 6,746.2±956.2	
Suburb areas		Range = 4,500 to 7,000 Mean ± SD = 6,295.6±802.5	
All areas		Range = 4,500 to 8,600 Mean ± SD = 6574.5±907.9	
Present smoking behavior			
	All Areas		
	Yes	4	19
	No	17	81
PPE Using			
	All Areas		
	Yes	0	0
	No	21	100
Marital status			
	All Areas		
	Single	14	
	Married	7	

4.2 Results of quality control

Each sample, triplicate injection by auto sampler to HPLC was done in analyzes. The calibration curve used for quantification consisted of five levels ranging from 0.005 to 0.5 µg/ml and $R^2 \geq 0.999$ for all the carbonyl compounds in this study. Instrument detection limit (IDL) and instrument quantification (IQL) were determined by injection ten replicates of 0.01 µg/ml mix carbonyl standard solution. The SD was calculated and 3SD was set as IDL and 10SD was set as IQL. The IDL under this study range from 0.001 to 0.012 µg/ml; the IQL range from 0.001 to 0.027 µg/ml. The value of IQL of each carbonyl compound was used as the detection limit for the quantification of samples.

Mini pumps were calibrated to 0.100 l/min (Dry-cal calibration pump) before every sampling period and results of %RSD were < 5%. The range of total air flowed through cartridge from 48.05 to 51.09 L/8h.The range of sampling time from 460 min to 514 min.

The chromatogram of the carbonyl compounds from HPLC-UV-VIS and retention time showed in figure 4.1 and table 4.2).

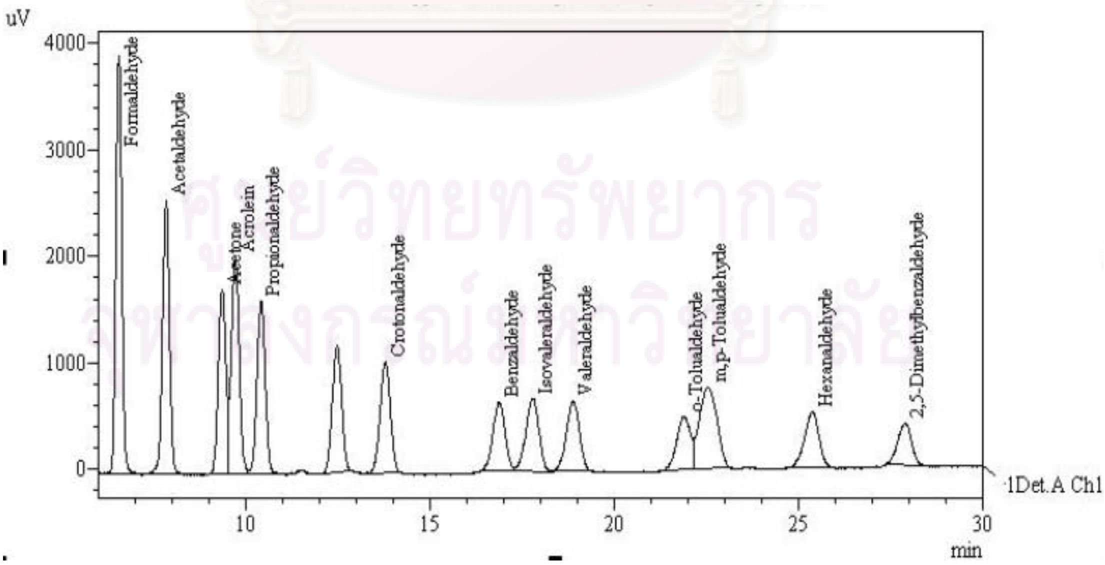

Figure 4.1 The chromatogram of the carbonyl compounds from HPLC-UV-VIS

Table 4.2 Retention time of carbonyl compound from HPLC-UV-VIS

Carbonyl compound	Ret. Time (min)
Formaldehyde	6.571
Acetaldehyde	7.847
Acetone	9.365
Propionaldehyde	10.418
Crotonaldehyde	12.469
Butyraldehyde	13.781
Benzaldehyde	16.862
Isovaleraldehyde	17.745
Valeraldehyde	18.852
o-Tolualdehyde	21.837
Hexanaldehyde	25.344
2,5-Dimethylbenzaldehyde	27.834

The retention time of formaldehyde, acetaldehyde, acetone, propionaldehyde, crotonaldehyde, butyraldehyde, benzaldehyde, isovaleraldehyde, valeraldehyde, o-tolualdehyde, hexanaldehyde and 2,5 dimethylbenzaldehyde were 6.571 min, 7.847 min, 9.365 min, 10.418 min, 12.469 min, 13.781 min, 16.862 min, 17.745 min, 18.852 min, 21.837 min, 25.344 min and 27.834 min, respectively.

4.3 Concentration of carbonyl compounds in each gasoline station according to gasoline workers and roadside

CCs concentration from worker’s breathing zone and roadside derived from HPLC UV-VIS analysis. In case that the concentration of some compounds was not found or below the LOQ (Limit of Quantification), the LOQ was used to quantify the samples. This study used triplicate sampling ensuring the accuracy of concentration.

All station found that the most abundant of chemicals concentration were formaldehyde, acetaldehyde and acetone. For another remarkable, butyraldehyde was found in 4 gasoline stations.

The results of P1 (urban) showed that the mean ± SD of formaldehyde was 14.23 ± 1.82 µg/m^3 for the gasoline workers and 19.55 ± 10.57 µg/m^3 for the roadside; acetaldehyde was 5.88 ± 1.94 µg/m^3 of gasoline workers and 13.96 ± 5.26 µg/m^3 for the roadside; acetone was 20.76 ± 5.60 µg/m^3 for the gasoline workers and 19.55 ± 11.83 µg/m^3 for the roadside. The results of P2 (urban) showed that the mean ± SD of formaldehyde was 14.98 ± 4.63 µg/m^3 for the gasoline workers and 13.96 ± 5.26 µg/m^3 for the roadside; acetaldehyde was 10.13 ± 1.20 µg/m^3 of gasoline workers and 8.92 ± 1.11 µg/m^3 for the roadside; acetone was 15.31 ± 4.42 µg/m^3 for the gasoline workers and 15.22 ± 1.96 µg/m^3 for the roadside. The results of P3 (suburb) showed that the mean ± SD of formaldehyde was 17.68 ± 9.14 µg/m^3 for the gasoline workers and 14.70 ± 8.0 µg/m^3 for the roadside; acetaldehyde was 9.17 ± 2.86 µg/m^3 of gasoline workers and 6.88 ± 4.42 µg/m^3 for the roadside; acetone was 25.45 ± 17.87 µg/m^3 for the gasoline workers and 14.78 ± 7.64 µg/m^3 for the roadside. The results of P4 (suburb) showed that the mean ± SD of formaldehyde was 13.80 ± 0.95 µg/m^3 for the gasoline workers and 14.70 ± 2.32 µg/m^3 for the roadside; acetaldehyde was 12.20 ± 0.47 µg/m^3 of gasoline workers and 5.32 ± 4.10 µg/m^3 for the roadside; acetone was 12.54 ± 1.66 µg/m^3 for the gasoline workers and 10.23 ± 3.14 µg/m^3 for the roadside. For other chemical concentrations were showed in table 4.3.

Table 4.3 Concentration of carbonyl compounds (±SD) (μg/m^3) collected from gasoline workers and roadside stationary (P1, P2, P3, and P4)

Chemical's name	**Location**							
	Urban (P1)		**Urban (P2)**		**Suburb (P3)**		**Suburb (P4)**	
	Gasoline Workers	**Roadside**	**Gasoline Workers**	**Roadside**	**Gasoline Workers**	**Roadside**	**Gasoline Workers**	**Roadside**
Formaldehyde	14.23 ± 1.82	19.55 ±10.57	14.98 ± 4.63	13.96 ± 5.26	17.68 ± 9.14	14.70 ± 8.0	13.80 ± 0.95	14.70 ± 2.32
Acetaldehyde	5.88 ± 1.94	7.63 ± 6.38	10.13 ± 1.20	8.92 ± 1.11	9.17 ± 2.86	6.88 ± 4.42	12.20 ± 0.47	5.82 ± 4.10
Acetone	20.76 ± 5.60	11.83 ± 5.37	15.31 ± 4.42	15.22 ± 1.96	25.45 ± 17.87	14.78 ± 7.64	12.54 ± 1.66	10.23 ± 3.14
Propionaldehyde	1.32 ± 0.44	1.54 ± 0.80	1.90 ± 0.37	1.64 ± 0.14	2.88 ± 2.84	1.38 ± 0.72	1.31 ± 0.09	1.22 ± 0.34
Crotonaldehyde	0.67 ± 0.30	1.15 ± 0.61	0.66 ± 0.13	0.82 ± 0.26	0.71 ± 0.26	0.90 ± 0.62	<0.52*	0.80 ± 0.14
Butyraldehyde	5.50 ± 2.62	6.14 ± 2.84	4.93 ± 2.51	5.26 ± 0.70	4.07 ± 2.96	3.00 ± 1.32	3.16 ± 1.16	2.60 ± 0.27
Benzaldehyde	<1.16*	<1.16*	1.24 ± 0.09	<1.16*	<1.16*	<1.16*	<1.16*	<1.16*
Isovaleraldehyde	1.00 ± 0.11	1.36 ± 0.42	1.00 ± 0.10	1.36 ± 0.21	1.01 ± 0.15	<0.94*	<0.94*	<0.94*
Valeraldehyde	1.40 ± 0.54	1.02 ± 0.53	0.88 ± 0.64	2.28 ± 1.92	1.25 ± 1.15	2.50 ± 1.88	<0.52*	2.78 ± 0.80
o-Tolualdehyde	<2.64*	<2.64*	<2.64*	<2.64*	<2.64*	<2.64*	<2.64*	<2.64*
Hexanaldehyde	2.68 ± 1.36	2.28 ± 0.82	2.10 ± 0.72	2.30 ± 0.82	3.08 ± 1.62	1.98 ± 0.87	2.36 ± 0.34	1.84 ± 0.36
2,5-Dimethylbenzaldehyde	<2.84 *	<2.84*	<2.84*	<2.84*	<2.84*	<2.84*	<2.84*	<2.84*

* reported as the limit of detection (LOQ) of each CCs

4.4 Concentration of carbonyl compounds in each area according to gasoline workers and roadside.

Considering the average, SD and range for urban and suburb using information from the combination of P1, P2 (urban) and P3, P4 (suburb). The results showed that formaldehyde, acetaldehyde, and acetone were mostly found in every gasoline station both urban and suburb area. Focusing on mostly found CCs, formaldehyde concentration in urban areas were 14.61 ± 3.38 µg/m^3 for gasoline workers and 16.76 ± 8.07 µg/m^3 for the roadside; in suburb area were 15.64 ± 6.52 µg/m^3 for gasoline workers and 14.70 ± 5.27 µg/m^3 for the roadside. Acetaldehyde concentration in urban areas were 8.00 ± 2.70 µg/m^3 for gasoline workers and 8.27 ± 4.16 µg/m^3 for the roadside; in suburb area were 10.68 ± 2.52 µg/m^3 for gasoline workers and 6.35 ± 3.86 µg/m^3 for the roadside. Acetone concentration in urban areas were 18.04 ± 5.60 µg/m^3 for gasoline workers and 13.53 ± 4.06 µg/m^3 for the roadside; in suburb area were 19.00 ± 13.86 µg/m^3 for gasoline workers and 12.50 ± 5.78 µg/m^3 for the roadside. For other chemical concentrations were showed in table 4.4

Table 4.4 Concentration of carbonyl compounds (±SD) (μg/m^3) and range according to gasoline workers and roadside in each area (urban areas and suburb areas)

Chemical's name	Urban site				Suburb site			
	Gasoline Workers	Range	Roadside	Range	Gasoline Workers	Range	Roadside	Range
Formaldehyde	14.61 ± 3.38	7.78-19.81	16.76 ± 8.07	7.88-31.24	15.64 ± 6.52	11.65-35.78	14.70 ± 5.27	8.83-23.82
Acetaldehyde	8.00 ± 2.70	2.46-12.28	8.27 ± 4.16	0.95-13.67	10.68 ± 2.52	4.54-13.58	6.35 ± 3.86	1.48-11.54
Acetone	18.04 ± 5.60	9.22-30.45	13.53 ± 4.06	5.82-17.38	19.00 ± 13.86	10.48-59.99	12.50 ± 5.78	6.65-22.02
Propionaldehyde	1.60 ± 0.50	0.81-2.43	1.58 ± 0.51	0.74-2.32	2.10 ± 2.08	0.91-8.51	1.30 ± 0.51	0.77-2.18
Crotonaldehyde	0.66 ± 0.22	0.53-1.30	0.98 ± 0.46	0.53-1.85	0.62 ± 0.20	0.53-1.09	0.84 ± 0.41	0.53-1.62
Butyraldehyde	5.22 ± 2.46	0.47-7.88	5.70 ± 1.91	3.54-9.18	3.62 ± 2.20	0.81-8.73	2.79 ± 0.88	2.01-4.50
Benzaldehyde	1.20 ± 0.07	1.16-1.37	<1.16*	NR	<1.16*	NR	<1.16*	NR
Isovaleraldehyde	1.00 ± 0.10	0.95-1.23	1.36 ± 0.30	0.95-1.79	0.98 ± 0.10	0.95-1.32	<0.94	0.94-0.94
Valeraldehyde	1.14 ± 0.62	0.53-2.22	1.65 ± 1.44	0.53-4.47	0.90 ± 0.86	0.53-3.52	2.64 ± 1.30	1.16-4.64
o-Tolualdehyde	<2.64*	2.64-2.64	<2.64*	NR	<2.64*	2.64-2.64	<2.64*	2.64-2.64
Hexanaldehyde	2.40 ± 1.08	1.48-5.38	2.28 ± 0.74	1.48-3.13	2.72 ± 1.18	1.72-6.16	1.91 ± 0.60	1.48-2.99
2,5-Dimethylbenzaldehyde	<2.84*	NR	<2.84*	NR	<2.84*	NR	<2.84*	NR

* reported as the limit of detection (LOQ) of each CCs

NR not reported because of concentration less than LOQ

4.5 Concentration of carbonyl compounds in overall areas in this study according to gasoline workers and roadside

The major chemicals in overall areas were formaldehyde, acetaldehyde and acetone found at both of dispensing and roadside area. The results showed mean, standard deviation and range of these chemicals concentration as follow the average of formaldehyde concentration of dispensing area was 15.18 ± 5.11 $\mu g/m^3$ (range of 7.78 - 35.78 $\mu g/m^3$) and roadside was 15.72 ± 6.60 $\mu g/m^3$(range of 7.88 - 31.24$\mu g/m^3$) ; acetaldehyde concentration of dispensing area was were 9.34 ± 2.90$\mu g/m^3$ (range of 2.46 - 13.58 $\mu g/m^3$) and roadside was 7.31 ± 3.95$\mu g/m^3$ (range of 0.95 - 13.67$\mu g/m^3$) ; acetone concentration of dispensing area was 18.52 ± 10.34$\mu g/m^3$ (range of 9.22 - 59.99$\mu g/m^3$) and roadside was 13.02 ± 4.80$\mu g/m^3$ (range of 5.82 - 22.02$\mu g/m^3$).
For other carbonyl concentrations were showed in table 4.5

4.6 Comparison of carbonyl concentration in gasoline workers in urban and suburb area

This result was tested for normal distribution by Kolmogorov-Smirnov goodness fit test (two-tailed test, $P<0.05$) before using t-test. The result showed that the almost of carbonyl compounds were not statistical significant differences between gasoline station workers working in urban and suburb area ($P > 0.05$) except acetaldehyde was statistical significant differences. (see Appendix D.)

4.7 Comparison of carbonyl concentration to roadside in urban and suburb area

The results showed that the almost of carbonyls compounds were not statistical significant differences ($P > 0.05$) between roadside in urban areas and suburb areas but the level of butyraldehyde was highly significant different ($P =0.01$) (see Appendix D).

Table 4.5 Average concentration of carbonyl compounds (±SD) (μg/m^3) according to gasoline workers and roadside in all areas

Chemical's name	Sampling Location			
	Gasoline Workers (n = 24)	Range	Roadside (n=12)	Range
Formaldehyde	15.18 ± 5.11	7.78-35.78	15.72 ± 6.60	7.88-31.24
Acetaldehyde	9.34 ± 2.90	2.46-13.58	7.31 ± 3.95	0.95-13.67
Acetone	18.52 ± 10.34	9.22-59.99	13.02 ± 4.80	5.82-22.02
Propionaldehyde	1.85 ± 1.50	0.81-8.51	1.44 ± 0.51	0.74-2.32
Crotonaldehyde	0.64 ± 0.20	0.53-1.30	0.92 ± 0.42	0.53-1.85
Butyraldehyde	4.42 ± 2.42	0.47-8.73	4.24 ± 2.08	2.01-9.18
Benzaldehyde	1.18 ± 0.05	1.16-1.37	<1.16*	NR
Isovaleraldehyde	0.98 ± 0.10	0.95-1.32	1.16 ± 0.30	0.95-1.79
Valeraldehyde	1.02 ± 0.74	0.53-3.52	2.14 ± 1.40	0.53-4.64
o-Tolualdehyde	<2.64*	NR	<2.64*	NR
Hexanaldehyde	2.56 ± 1.12	1.48-6.16	2.10 ± 0.67	1.48-3.13
2,5-Dimethylbenzaldehyde	<2.84*	NR	<2.84*	NR

* reported as the limit of detection (LOQ) of each CCs

NR not reported because of concentration less than LOQ

4.8 Exposure assessment and risk characterization

In this part, author separated into 2 part. (1) carcinogenic risk and (2) non-carcinogenic risk. Exposure factors were obtained by questionnaires for exposure duration and exposure time. Exposure frequency interviewed from gasoline stations manager, all gasoline stations provided only 1 holiday/week for gasoline workers**.** In addition, RME was separately calculated between urban and suburb areas. The RME exposure factor variables were concentration of CCs, exposure time, and exposure duration. The author calculated separately urban and suburb areas. Exposure frequency was acquired by gasoline station manager interview. The result showed that every gasoline station has the same regulation; there was only one day-off for each gasoline workers. All exposure factors were shown in table 4.6

Considering at the mean level, exposure time (ET) in urban and suburb areas was 9.33±1.97 h/day and 10.0 ± 2.14 h/day, respectively. Exposure frequency (EF) was 300 days/year for every gasoline stations. The mean level of exposure duration (ED) was 1.96 ± 2.56 years ranged from 0.08 (1 month) to 10 years. Averaging time (AT) was 70 years. Body weight (BW) in urban and suburb area were 56.31 ± 9.05 kg and 57.5 ± 6.9 kg, respectively. Inhalation rate was 0.83 m^3/h.

At the RME level, exposure time (ET) both areas were 12 h/day. Exposure frequency (EF) was 300 days/year for every gasoline stations. The average of exposure duration (ED) was 10 years in urban and 5 years for suburb area. Averaging time (AT) was 70 years. Body weight (BW) in urban and suburb area were 56.31 ± 9.05 kg and 57.5 ± 6.9 kg, respectively. Inhalation rate was 0.83 m^3/h.

Table 4.6 Exposure factors related to carbonyl compounds exposure of gasoline workers

Exposure Factors	Mean	RME	Source
Exposure Time (Urban)	9.33 h/day	12 h/day	Questionnaires
Exposure Time (Suburb)	10 h/day	12 h/day	Questionnaires
Exposure Frequency (All areas)	300 days/year	300 days/years	Gasoline station manager interviewed
Exposure Duration (Urban)	2 years	10 years	Questionnaires
Exposure Duration (Suburb)	1.92 years	5 years	Questionnaires
Averaging Time (All areas)	70 years	70 years	EPA, (2003)
Body weight (Urban)	56.31 kg	56.31 kg	Questionnaires
Body weight (Suburb)	57.50 kg	57.50 kg	Questionnaires
Inhalation rate	0.83 m^3/h	0.83 m^3/h	EPA, (2000c)

4.8.1 Carcinogenic risk characterization

The carcinogenic risks on chronic exposure to the carbonyls were assessed in this study. The probability of developing cancer from a lifetime of continuous exposure to a carbonyl is calculated by daily intake after that the lifetime cancer hazard risk is calculated by cancer risk formula from last chapter. In this calculation, author calculated at both level of average mean and RME. The results in table 4.7 and 4.8 showed the cancer risk of formaldehyde and acetaldehyde via inhalation exposure. For urban area, cancer risk approximately ranged from 2 workers in 10 million to 2 workers in one hundred thousand. For suburb area, cancer risk ranged 3 workers in 10 million to 2 workers in one hundred thousand.

At the average mean level, carcinogenic risk characterization for formaldehyde was 3 workers in million for all gasoline workers; acetaldehyde was 2,3 and 4 workers in 10 million for P1, P2, P3 and P4 respectively. At the RME level, the carcinogenic risk was higher than the mean levels, carcinogenic risk for formaldehyde was 2 workers in one thousand in P1, P2 and P3 while 8 workers in million was found in P4.

4.8.2 Non-carcinogenic risk characterization

The results of non-cancer risk characterization in table 4.9 and 4.10 showed that both HQ and HI were less than 1. The maximum HI was 2.56×10^{-1} in P2. At the average mean level of HQ, the highest risk or highest HQ was formaldehyde. HQ ranged from 1.32×10^{-2} (suburb P4) to 1.69×10^{-2} (suburb P3). The lowest non-carcinogenic risk was valeraldehyde. HQ was 1.16×10^{-5} in P4. At the RME level of HQ, the highest risk or highest HQ was formaldehyde. HQ ranged from 4.58×10^{-2} (suburb P4) to 1.19×10^{-1} (urban P2). The lowest non-carcinogenic risk was valeraldehyde. HQ was 1.16×10^{-5} in P4.

At the average mean level of HI. The maximum HI was 3.37×10^{-2} in P3 while the minimum HI was 2.53×10^{-2} in P1. At the RME level of HI, The maximum HI was 2.56×10^{-1} in P2 while the minimum HI was 1.06×10^{-1}.

Table 4.7 Results of cancer risk characterization in urban area

Chemical's name	Urban (P1)						Urban (P2)					
	Arithmetic mean (µg/m3)	Intake (mg/kg/day)	Cancer Risk	RME (µg/m3)	RME Intake (mg/kg/day)	Cancer Risk	Arithmetic Mean (µg/m3)	Intake (mg/kg/day)	Cancer Risk	RME (µg/m3)	RME Intake (mg/kg/day)	Cancer Risk
Formaldehyde	14.23	4.60×10^{-5}	2.09×10^{-6}	16.22	3.37×10^{-4}	1.53×10^{-5}	14.98	4.84×10^{-5}	2.20×10^{-6}	19.8	4.11×10^{-4}	1.87×10^{-5}
Acetaldehyde	5.88	1.90×10^{-5}	1.46×10^{-7}	6.61	1.37×10^{-4}	1.06×10^{-6}	10.13	3.27×10^{-5}	2.52×10^{-7}	12.28	2.55×10^{-4}	1.96×10^{-6}

(Location)

Table 4.8 Results of cancer risk characterization in suburb area

Chemical's name	Suburb (P3)						Suburb (P4)					
	Arithmetic Mean (µg/m3)	Intake (mg/kg/day)	Cancer Risk	RME (µg/m3)	RME Intake (mg/kg/day)	Cancer Risk	Arithmetic Mean (µg/m3)	Intake (mg/kg/day)	Cancer Risk	RME (µg/m3)	RME Intake (mg/kg/day)	Cancer Risk
Formaldehyde	17.68	5.75×10^{-5}	2.62×10^{-6}	35.78	3.64×10^{-4}	1.66×10^{-5}	13.8	4.49×10^{-5}	2.04×10^{-6}	15.3	1.56×10^{-4}	7.08×10^{-6}
Acetaldehyde	9.17	2.98×10^{-5}	2.30×10^{-7}	13.58	1.38×10^{-4}	1.06×10^{-6}	12.2	3.97×10^{-5}	3.06×10^{-7}	12.88	1.31×10^{-4}	1.01×10^{-6}

(Location)

45

Table 4.9 Results of non-carcinogenic risk characterization for urban area (P1 and P2)

Chemical's name	Location											
	Urban (P1)						Urban (P2)					
	Arithmetic mean (µg/m^3)	Intake (µg/m^3)	HQ	RME (µg/m^3)	RME Intake (µg/m^3)	HQ	Arithmetic mean (µg/m^3)	Intake (µg/m^3)	HQ	RME (µg/m^3)	RME Intake (µg/m^3)	HQ
Formaldehyde	14.23	1.30×10^{-1}	1.33×10^{-2}	16.22	9.52×10^{-1}	9.72×10^{-2}	14.98	1.37×10^{-1}	1.40×10^{-2}	19.80	1.16	1.19×10^{-1}
Acetaldehyde	5.88	5.37×10^{-2}	5.96×10^{-3}	6.16	3.62×10^{-1}	4.02×10^{-2}	10.13	9.25×10^{-2}	1.03×10^{-2}	12.28	7.21×10^{-1}	8.01×10^{-2}
Propionaldehyde	1.32	1.21×10^{-2}	1.51×10^{-3}	2.08	1.22×10^{-1}	1.53×10^{-2}	1.90	1.73×10^{-2}	2.17×10^{-3}	2.42	1.42×10^{-1}	1.78×10^{-2}
Butyraldehyde	5.50	5.02×10^{-2}	3.35×10^{-3}	7.88	4.63×10^{-1}	3.08×10^{-2}	4.93	4.50×10^{-2}	3.00×10^{-3}	7.82	4.59×10^{-1}	3.06×10^{-2}
Benzaldehyde	1.16	1.06×10^{-2}	1.18×10^{-3}	1.16	6.81×10^{-2}	7.57×10^{-3}	1.24	1.13×10^{-2}	1.26×10^{-3}	1.37	8.04×10^{-2}	8.94×10^{-3}
Valeraldehyde	1.40	1.28×10^{-2}	3.04×10^{-5}	2.22	1.30×10^{-1}	3.10×10^{-4}	0.88	8.03×10^{-3}	1.91×10^{-5}	2.18	1.28×10^{-1}	3.05×10^{-4}
Hazard Index (HI)			2.53×10^{-2}			1.91×10^{-1}			3.07×10^{-2}			2.56×10^{-1}

Table 4.10 Results of non-carcinogenic risk characterization for suburb area (P3 and P4)

Chemical's name	Location											
	Suburb (P3)						Suburb (P4)					
	Arithmetic mean (µg/m^3)	Intake (µg/m^3)	HQ	RME (µg/m^3)	RME Intake (µg/m^3)	HQ	Arithmetic mean (µg/m^3)	Intake (µg/m^3)	HQ	RME (µg/m^3)	RME Intake (µg/m^3)	HQ
Formaldehyde	17.68	1.66×10^{-1}	1.69×10^{-2}	35.78	1.05	1.07×10^{-1}	13.80	1.30×10^{-1}	1.32×10^{-2}	15.30	4.49×10^{-1}	4.58×10^{-2}
Acetaldehyde	9.17	8.61×10^{-2}	9.57×10^{-3}	13.58	3.99×10^{-1}	4.43×10^{-2}	12.20	1.15×10^{-1}	1.27×10^{-2}	12.88	3.78×10^{-1}	4.20×10^{-2}
Propionaldehyde	2.88	2.71×10^{-2}	3.38×10^{-3}	8.51	2.50×10^{-1}	3.12×10^{-2}	1.31	1.23×10^{-2}	1.54×10^{-3}	1.48	4.34×10^{-2}	5.42×10^{-3}
Butyraldehyde	4.07	3.82×10^{-2}	2.55×10^{-3}	8.72	2.56×10^{-1}	1.71×10^{-2}	3.16	2.97×10^{-2}	1.98×10^{-3}	4.32	1.27×10^{-1}	8.45×10^{-3}
Benzaldehyde	1.16	1.09×10^{-2}	1.21×10^{-3}	1.16	3.41×10^{-2}	3.78×10^{-3}	1.16	1.09×10^{-2}	1.21×10^{-3}	1.16	3.41×10^{-2}	3.78×10^{-3}
Valeraldehyde	1.25	1.17×10^{-2}	2.80×10^{-5}	3.52	1.03×10^{-1}	2.46×10^{-4}	0.52	4.88×10^{-3}	1.16×10^{-5}	0.52	1.53×10^{-2}	3.63×10^{-5}
Hazard Index (HI)			3.37×10^{-2}			2.04×10^{-1}			3.07×10^{-2}			1.06×10^{-1}

4.9 Results of carbonyl compounds correlation

4.9.1 Correlation between formaldehyde acetaldehyde and acetone of total gasoline workers

The correlation between these CCs (i.e. formaldehyde acetaldehyde and acetone) was calculated from their concentrations acquired by all gasoline workers. The results showed that there was very low correlation between each compound ($P > 0.05$). The direction of association between formaldehyde and acetaldehyde was positive as same as formaldehyde and acetone. But the direction of association between acetone and acetaldehyde was negative. (Shown in table 4.11)

Table 4.11 Correlation between formaldehyde acetaldehyde and acetone of total gasoline workers

Chemical's name	Correlation	Formaldehyde	Acetaldehyde	Acetone
Formaldehyde	Pearson's Coefficient (r)	1		
	Sig. (2-tailed)			
Acetaldehyde	Pearson's Coefficient (r)	0.28	1	
	Sig. (2-tailed)	0.19		
Acetone	Pearson's Coefficient (r)	0.15	-0.15	1
	Sig. (2-tailed)	0.48	0.49	

4.9.2 Correlation between formaldehyde acetaldehyde and acetone of total roadside

To find the correlation between these compounds of total roadside, the author used the same method as 4.9.1, The results showed that there was high correlation between formaldehyde and acetaldehyde (P < 0.01). Very low correlations were found between acetaldehyde:acetone and formaldehyde:acetone (P > 0.05). The direction of association between formaldehyde and acetaldehyde was positive as same as acetaldehyde and acetone. But the direction of association between acetone and formaldehyde was negative. (shown in table 4.12)

Table 4.12 Correlation between formaldehyde acetaldehyde and acetone of roadside.

Chemical's name		Formaldehyde	Acetaldehyde	Acetone
Formaldehyde	Pearson's Coefficient (r)	1		
	Sig. (2-tailed)			
Acetaldehyde	Pearson's Coefficient (r)	.778	1	
	Sig. (2-tailed)	0.003**		
Acetone	Pearson's Coefficient (r)	-0.095	0.205	1
	Sig. (2-tailed)	0.769	0.522	

** Statistically significant correlation at 0.01 Level

4.10 Association between symptom occurrences of gasoline workers and risk factors

Association between 11 symptom occurrences of gasoline workers and their risk factors were calculated by Chi-square test. The list of risk factors was education level, gender, study areas, gasoline workers responsibility and duty, marital status, workers' awareness of VOCs, workers' symptom occurrence in the last three month, chronic disease and smoking behavior (see Appendix E). The results showed that there was no association statistically significant between symptom occurrences and any risk factors except association between symptom occurrences and workers' symptom occurred in the last three month, interested for respiratory tract irritation (P <0.05) (see Appendix E).

The questionnaires were classified into primary school and secondary school to find the association among symptoms occurs between **education level** of primary school and secondary school. The result showed that more than 50% of gasoline workers' symptoms occurrence of this risk factor were drowsiness, respiratory tract irritation, fatigue and eye skin irritation while other symptoms which were less than 50% were dizziness, headaches, unconsciousness, nausea, sore throat irritation, lack of muscle control and confusion. These symptoms may come from CCs via inhalation exposure, resulting in worse health of gasoline workers.

The questionnaires were separated into male and female to find the associations among symptoms occur between **genders**. The results showed that more than 50% of gasoline workers' symptom occurrences of this risk factor were drowsiness, respiratory tract irritation, fatigue, eye skin irritation and confusion while other symptoms which were less than 50% were dizziness, headaches, unconsciousness, nausea, sore throat irritation and lack of muscle control.

Gasoline workers were asked about their responsibilities to find the associations among symptoms occur between **responsibilities and duty of gasoline workers**. The results showed that more than 50% of gasoline workers' symptoms occurrences of this risk factor were drowsiness, dizziness, headaches, respiratory tract irritation, fatigue, and eye skin irritation while other symptoms which were less than 50% were unconsciousness, nausea, sore throat irritation, confusion and lack of muscle control.

Furthermore, the author asked gasoline workers about their vaporize of VOCs in gasoline awareness to find the association among symptoms occur between **knowledge about vaporize of VOCs in gasoline**. The results showed that more than 50% of gasoline workers' symptoms occurrences of this risk factor were drowsiness, dizziness, respiratory tract irritation, fatigue, and eye skin irritation while other symptoms which were less than 50% were unconsciousness, headaches, nausea, sore throat irritation, confusion and lack of muscle control.

Gasoline workers were asked about health symptom in the last three months as well. The objective was to find the associations among symptoms occur between **symptoms occurrence among gasoline workers in the last three month**. The results showed that more than 50% of gasoline workers' symptoms occurrences of this risk factor were drowsiness and headaches while other symptoms which were less than 50% were eye skin irritation, dizziness, respiratory tract irritation, fatigue, unconsciousness, nausea, sore throat irritation, confusion and lack of muscle control.

The author asked gasoline workers about their chronic disease to find the association among symptoms occur between **chronic disease of gasoline workers**, the results showed that more than 50% of gasoline workers' symptoms occurrence of this risk factor were drowsiness, dizziness, eye skin irritation and respiratory tract irritation while other symptoms which were less than 50% were headaches, fatigue, unconsciousness, nausea, sore throat irritation, confusion and lack of muscle control.

Gasoline workers had to answer about their smoking behavior too to find the associations among symptoms occur between **smoking behavior among workers**. The results showed that more than 50% of gasoline workers' symptoms occurrences of this risk factor were drowsiness, eye skin irritation, fatigue and respiratory tract irritation while other symptoms which were less than 50% were dizziness, headaches, unconsciousness, nausea, sore throat irritation, confusion and lack of muscle control.

Marital status was involved in the questionnaires as well to find the association among symptoms occur between **marital status among workers**, the results showed that more than 50% of gasoline workers' symptoms occurrence of this risk factor were drowsiness, dizziness, eye skin irritation, headaches, fatigue and respiratory tract irritation while other symptoms which were less than 50% were unconsciousness, nausea, sore throat irritation, confusion and lack of muscle control.

Last but not least, the author separated the questionnaires into two areas which were urban and suburb to find the associations among symptoms occur between **urban and suburb areas**. The results showed that more than 50% of gasoline workers' symptoms occurrences of this risk factor were drowsiness, dizziness, eye skin irritation, headaches, confusion, fatigue and respiratory tract irritation while other symptoms which were less than 50% were unconsciousness, nausea, sore throat irritation and lack of muscle control.

CHAPTER V
DISCUSSION

5.1 Socio – Demographic characteristics of workers and gasoline stations environment

According to the result, the number of participants, more than 50 percent, was male workers who were responsible for filling the oil including other works at dispensing area. However, the author also found female workers who were most responsible for cashier and taking care of customers. The age ranged 18 - 36 years old with 24.3 ± 6.4 years old on mean level, while another study measured gasoline workers in Bangkok that found 28.1 ± 10 years old on mean (± SD). All of gasoline workers were below undergraduate degree. Most of gasoline workers were immigrants from other countries such as Laos, Myanmar and Cambodia in which they are cheap hired workers. The most highest salary was around 6,574 Baht in 2011 as low as other gasoline station in Bangkok (mean 6,673 Baht in 2009) (Tunsarinkarn et al., 2011.) Gasoline station employer, thus, should increase their salary for the good quality of life.

The BMI (Body Mass Index) is a measure of body fat based on height and body weight that applied to adult men and women (U.S. Department of Health and Human Service, 2011). BMI was calculated by used data from this study. The mean of body weight and height of gasoline workers at all sites were used for this BMI calculation. The formula was [Body weight (kg) / Height^2 (meters)]. If the result from BMI is out the normal range (18.5-24.9), these workers would have health risk e.g. heart diseases, hypertension and respiratory disease, as calculated below.

$$BMI = [56.7/ (1.606)^2], BMI = 22.0$$

The result was 22.0 which it is within normal range. Thus, participants may not have health risk from their body fat. The BMI result in this study was similar to Tunsaringkarn et al. (2011) which measured the BMI of gasoline workers in Bangkok (BMI = 21.9).

Using an open-ended question to gasoline workers, the result indicated as follow. Daily activities of gasoline workers were watching movie, listening to music, housekeeping, sleeping, motorcycling, reading a book, shopping, singing a song, traveling and playing game. Low education levels were found among their gasoline workers (under bachelor degree). PPE usages among gasoline workers were observed. The results showed no gasoline workers used PPE (such as the mask) in study sites. Responsibility of gasoline workers were oil refuel, glass cleaner, place cleaner, cashier, filling and oil's engine checking and pure water checking. A one worker had more than one responsibility in gasoline station. Attitude of health status of gasoline workers were found. They said they exhausted, tried and inhalation obstruction since they got this job. Period of oil refueling each service was around 2 to 10 minutes depending on customers. Period time working in gasoline station around 1 month to 10 years and duration time about working hours per day was 8 hours to 12 hours. Health care consume were observed. When gasoline workers get some disease, they go to nearby hospital and always used health care insurance. Source of healthcare information, gasoline workers get health care information by television, handbill, newspaper and radio. For other problems about their health, ergonomic complained about refuel stalk from some gasoline workers. Most of all gasoline workers were migrants e.g. from Myanmar, Cambodia and Laos.

5.2 Association among symptoms and risk factors

21 respondents of questionnaires were 13 gasoline workers from urban area and 8 gasoline workers from suburb. Questionnaires were used for observing the association between gasoline workers' symptom occurrence which effect from CCs inhalation exposure and risk factors. The results showed there was no statistically significant association (P-value >0.05) except the association between symptoms occurrence and workers' symptom occurrence in the last three month related to respiratory tract irritation was significantly different ($P <0.05$).

More than 60% of gasoline workers' symptoms occurrence were drowsiness, respiratory tract irritation, fatigue and eye skin irritation while other symptoms which were less than 60% were dizziness, headaches, unconsciousness, nausea, sore throat irritation, lack of muscle control and confusion. These symptoms may come from CCs via inhalation exposure, resulting in worse health of gasoline workers.

5.3 Source of carbonyl compounds related to gasoline workers exposure in this study

For any concentration of carbonyl compounds, source possibly come from vehicular emission, mostly formaldehyde is released in the background (Huang et al., 2011). However formaldehyde can be easily diluted in the high layer of atmosphere (Bono et al., 2010). This study was measurement carbonyl compounds on the ground of the gas station which the source of VOCs in gasoline station can vapor formaldehyde and acetaldehyde from fuels containing methanol or ethanol (Morknoy et al., 2010). Compare with ingestion and dermal absorption, inhalation is a major pathway for intake of VOCs by human (Huang et al., 2011).

At the roadside areas, formaldehyde and acetaldehyde in Bangkok have high concentrations as high traffic volumes (Morknoy et al., 2010). Unfortunately, this study did not measure for traffic volume while doing air sampling measurement. For other studies, in metropolitan areas, formaldehyde is always the predominant aldehyde emitted by automobiles (Corrêa et al., 2003). Majumdar et al. (2008) said that percentage source contributions of VOCs at petrol station (in Kolkata, India) greatest contribute from vehicular exhaust emissions which was adjacent roadways in high traffic density. In Beijing ambient air, including formaldehyde, acetaldehyde, acetone, propionaldehyde, benzaldehyde, butyraldehyde, hexaldehyde, tolualdehyde and valeraldehyde (Pang et al., 2007), this study found the same carbonyl compounds not only inside gasoline station but also in roadside stationary.

P1 (urban) site in this study, the concentration of formaldehyde at roadside was the highest site of this study. Báez et al. (1995) mentioned that the influence may come from meteorological conditions especially wind speed as well as in this area P1 was located around a number of high buildings. However, the difference among level of carbonyl compounds at roadside between urban and suburb areas did not find the statistical significant difference For the gasoline workers in this study, the result found that the difference level of butyraldehyde inside gasoline station in urban and suburb areas was statistically significant association levels at 0.05. Source of butyraldehyde in each may come from vehicles exhaust (Báez et al., 2003).

Benzaldehyde was also found to be the dominant carbonyl in the exhaust of vehicles fueled by gasoline (Pang et al., 2007). In this study, this compound was found 1.61 – 1.37 μg/m^3. Cerón et al. (2007) reported propionaldehyde is emitted from vehicles while this study did not find propionaldehyde. Báez et al. (2003) reported that butyraldehyde has been detected in exhaust emissions from diesel engines; this study found that butyraldehyde is the fourth found concentration. It could be assumed that butyraldehyde was released from diesel vehicles in gasoline station and/or from vehicles on road.

5.4 Concentration of carbonyl compound compare to other studies

Formaldehyde and acetaldehyde concentration differed from other studies due to sampling approach, timeframe, sampling place, environment depended on study objective. In this study, formaldehyde and acetaldehyde concentration in roadside stationary were higher than other studies, because the chosen roadsides-Sukhumvit road and Bangna-Trad road – have high traffic congestion that most cars are unwell-conditioned without installing catalytic converters which VOCs emitted more VOCs (Morknoy et al., 2010) (see Table 5.1)

5.5 Carcinogenic and non-carcinogenic risk characterization

According to carcinogenic risk characterization calculation, at mean and RME level, carcinogenic risk of gasoline workers ranged 2 workers in 10 million to 2 workers in one thousand which were slightly different for each gasoline station while non-carcinogenic risk characterization calculation showed that, at mean and RME level, it may have no severe acute risk such as unconsciousness but slight acute risk e.g. dizziness, fatigue, respiratory tract irritation. Those slight acute symptoms may mainly affect the health later. To reduce the effect of CCs exposure in gasoline station, all vapor recovery system in Thailand need to be reconsidered including monitoring concentration of VOCs from gasoline transportation especially transferring gasoline to background tank. Additionally, gasoline workers use PPE such as flu mask, gloves or glasses in order to reduce CCs exposure.

In addition to gasoline station, another study found a health risk from exposing formaldehyde and acetaldehyde such as shopping centers, supermarkets, railway station, bus station, furniture store, ballroom and office (Weng et al., 2009). The author suggests that these areas be part of further researches.

5.6 Carbonyl compounds correlation

At roadside stationary monitoring found significantly high positive correlation at roadside (r=0.778) (P<0.01) between formaldehyde and acetaldehyde. Because the major source of formaldehyde and acetaldehyde was the product of incompleted combustion of old engine without installing catalytic converter (morknoy et al., 2010), causing air pollution in traffic-congested roadside. Therefore, without proper protection, people living close to roadside and gasoline station may have a higher risk from CCs exposure. However, the health risk depends on other factors as well, such as concentration level, exposure duration.

5.7 Exposure period of gasoline workers

In this study, gasoline workers at all sites have only one holiday per week, while another study result was 6.2 of working day per week (Tunsaringkarn et al., 2011). It was similar to result from this study. The working hour per day in this study was 9.3 hours for urban and 10.0 hours for suburb, while 10.6 ± 1.7 hours per day on Tunsaringkarn study. The cancer risk characterization in this study was found at mean and RME levels. Gasoline station managers, thus, should provide more holidays to gasoline workers in order to reduce the exposure period.

Table 5.1 Comparison of the concentrations of CCs (μg/m^3)

Location	Formaldehyde		Acetaldehyde		Acetone		Environment	Reference
	Range	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD		
Xalapa, Mexico	6.0-38	22.0 ± 9.0	5.0-32.0	17.0 ± 8.0	1.0-28.0	14.0 ± 7.0	Urban	Báez. et al. (2003)
Athens, Greece	0.05-33.3	10.7 ± 15.6	2.7-21.3	12.3 ± 7.5	1.0-136	6.5 ± 18.3	Urban	Bakeas et al. (2003)
Schauinsland, Germany	0.5-2.8	1.2	0.2-3.2	1.26	0.5-11.4	6.2	Rural	Slemr et al. (1996)
Rio de Janeiro, Brazil	6.8-34.6	10.8 ± 4.1	3.4-20.6	10.4 ± 4.6	1.6-10.7	4.1	Industrial/Urban	Grosjean et al. (2002)
Sẩo Paulo, Brazil	4.0-27.7	10.7	9.3-178.0	33.8	NR	NR	Industrial/Urban	Miguel et al. (1995)
CachaPregos, Brazil	0.24-3.1	1.5	0.7-4.1	2.2	NR	NR	Rural	de Andrade et al. (1998)
Kuopio, Finland	1.3-2.8	NR	1.1-3.2	NR	NR	NR	Highway	Viskari et al. (2000)
Fortaleza, Brazil	0.9-5.1	2.8 ± 1.8	0.1-3.4	0.7 ± 1.3	0.1-9.0	8.4 ± 4.6	Suburb	Cavalcante et al. (2006)
Bangkok, Thailand	5.14-17.2	11.53	1.59-7.95	3.51	NR	NR	Roadside	(Morknoy et al. 2010)
Bangkok, Thailand	7.88-31.24	16.76 ± 8.07	0.95-13.67	8.27 ± 4.16	5.82-17.38	13.53 ± 4.06	Urban roadside	This study
Bangkok, Thailand	8.83-23.82	14.70 ± 5.27	1.48-11.54	6.35 ± 3.86	10.48-59.99	12.50 ± 5.78	Suburb roadside	This study

Adopt from Cavalcante et al., 2006. NR = Not Reported.

57

CHAPTER VI
CONCLUSION

6.1 Conclusion

This study measured 12 carbonyl compounds at 4 gasoline stations. In each station was measured by roadside stationary and gasoline workers working in gasoline station. Questionnaires were used to collect the socio-demographic and symptoms occur among gasoline workers. 6 chemical substances were assessed for carcinogenic and non-carcinogenic effect.

1. The results showed the participants age was in the range of 18-36 years old. The average weight (mean ± SD) was 56.7 ± 8.1 kg.

2. PPE using in gasoline station should be used in gasoline station because several of duty in gasoline station can add more exposure to gasoline workers.

3. Exposure assessment of gasoline worker was calculated using reasonable maximum exposure (RME) at the 95^{th} percentile; the inhalation intake of carcinogenic carbonyl i.e. formaldehyde and acetaldehyde in workers was in the range of 1.90×10^{-5} to 4.11×10^{-4} mg/kg/day. Risk characterization for cancer was in the range of 2 workers in 10 million to 2 workers in one hundred thousand. For non-carcinogenic carbonyl i.e. formaldehyde, acetaldehyde, benzaldehyde, valeradehyde, propionaldehyde, and butyraldehyde, the inhalation intake of non-carcinogenic carbonyl in workers was in the range of 4.88×10^{-3} to 1.16 $\mu g/m^3$. To assess non-carcinogenic health effects, the Hazard Index (HI) was used; the results showed that gasoline workers may not be at risk via inhalation exposure of non-carcinogenic health because the HI was not greater than the acceptable level (HI < 1).

4. High positive correlation between formaldehyde and acetaldehyde was found in roadside stationaries but not among workers inside gasoline stations. Assume that, higher risk to whom always working nearby roadside than whom working inside gasoline station.

5. There was no association between symptom occurrence and health risk factors except respiratory tract irritation and last-three-month workers' symptom

6.2 Suggested recommendation

In general, it is known that Risk = Hazard × Exposure (EPA, 2010e). Although, we may not reduce the hazard of CCs, but we may reduce exposure by encouraging the gasoline workers to give high priority on their health by wearing personal protective equipment (PPE) such as appropriate gas mask, gloves and safety goggles while working at the gasoline stations.

6.3 Limitation of this study

At first, this study was decided to collect 6 gasoline station samples but due to technical difficulties that was some gasoline stations did not allowed to collect the samples and canceled to be part of this study because they worried about the safety of gasoline station. So the number of gasoline station samples, personal collection, and questionnaire were reduced.

REFERENCES

Agency for Toxic Substances and Disease Registry (ATSDR). 2010b. **Toxic Substances Protal for Acetone.** [Online]. Available from: http://www .atsdr.cdc.gov/substances/ toxsubstance.asp?toxid=1. [2010, November 5].

Agency for Toxic Substances and Disease Registry (ATSDR). 2002. **Toxicological Profile of Crotonaldehyde**. [Online]. Available from: http://www.atsdr. cdc.gov/tfacts180.pdf. [2011, April 1].

Báez, A., Padilla, H., García, R., Torres, C., and Belmont, R. 2008. Measurement of Carbonyl in Three Urban Zones of the Mexico City Metropolitan Area and One Rural Zone. **Open Atmospheric Science Journal**. 2: 61-67.

Báez, A., et al. 2003. Carbonyl levels in Indoor and Outdoor Air in Mexico City and Xalapa, Mexico. **Science of the Total Environment**. 302: 211-226.

Báez, A., Padilla, H., and Belmont, R. 1995. Measurement of formaldehyde and acetaldehyde in the Atmosphere of Mexico City. **Environmental Pollution**. 89(2): 163-167.

Bakeas, E.B., Argyris, D.I., and Siskos, P.A. 2003. Carbonyl Compounds in the Urban Environment of Athens, Greece. **Chemosphere**. 52: 805-813.

Bono, R., Degan, R., Pazzi, M., Romanazzi, V., and Rovere, R. 2010.Benzene and formaldehyde in Air of Two Winter Olympic Venues of “Torino 2006”. **Environment International**. 36: 269-275.

Cavalcante, R.M., et al. 2006. Determination of Carbonyl Compounds in Air and Cancer Risk Assessment in an Academic Institute in Fortaleza, Brazil. **Atmospheric Environment**. 40: 5701-5711.

Cerón, R.M., Cerón, J.G., and Muriel, M. 2007. Diurnal and Seasonal Trends in Carbonyl Levels in a Semi-Urban Coastal Site in the Gulf of Campeche, Mexico. **Atmospheric Environment**. 41: 63-71.

Chemical Dictionary Organization. 2009. **Chemcal dictionary online for o-Tolualdehyde**. [Online]. Available from: http://www.chemicaldictionary. org/dic/O/o-Tolualdehyde_13.html. [2011, April 15].

Christensen, C.S., Skov, H., Nielsen, T., and Loshe, C. 2000. Temporal Variation of Carbonyl Compound Concentrations at a semi-rural site in Denmark. **Atmospheric Environment**. 34: 287-296.

Corrêa, S.M., Martin, E.M., and Arbilla, G. 2003. Formaldehyde and Acetaldehyde in a High Traffic Street of Rio de Janeiro, Barzil. **Atmospheric Environment**. 37: 23-29.

Dalefield, R.R., Oehme, F.W., and Krieger, G.R. "Principles of Risk Assessment," in **Clinical Environmental Health and Toxic Exposures**, John B. Sullivan, Jr and Krieger, G.R., 2nd editors (Philadelphia, PA: Lippincott Williams and Wilkins, 2001), pp. 77-91.

de Andrade, J.B., Andrade, M.V., and Pinheiro, H.L.C.. 1998. Atmospheric Levels of formaldehyde and acetaldehyde and their relationship with Vehicular Fleet Composition in Salvador, Bahia, Brazil. **Journal of the Brazilion Chemical Society**. 9: 219-223.

Durmusoglu, E., Aslan, S., Can, E., and Bulut, Z. 2007. Health Risk Assessment of Workers Exposure to Organic Compounds in a Tire Factory. **Human and Ecological Risk Assessment: An International Journal**. 13(1): 209-222.

Fontaras, G., et al. 2010. Effect of Low Concentration Biodiesel Blends Application on the Modern Passenger Cars. Part 2: Impact on Carbonyl Compound Emissions. **Environmental Pollution**. 158: 2496-2503.

Grosjean, D., Grosjean, E., and Moreira, L.F.R. 2002. Speciated Ambient Carbonyls in Rio de Janeiro, Brazil. **Environmental Science and Technology**. 36: 1389-1395.

Grosjean, D. 1997. Atmospheric Chemistry of Alcohols. **Journal of the Brazilian Chemical Society**. 4(8): 433-442.

Guild Chem. 2011. **2,5-Dimethylbenzaldehyde**. [Online]. Available from: http://www.guidechem.com/dictionary/93-02-7.html. [2011, April 15].

Huang, Y., et al. 2011. Characteristics and Health Impacts of VOCs and Carbonyls Associated with Residential Cooking Activities in Hong Kong. **Journal of Hazardous Material**. 186: 344-351.

Integrated Risk Information System (IRIS). 2011. **Glossary**. [Online]. Available from: http://www.epa.gov/air/toxicair/community/glossary.html. [2011, April 20].

Integrated Risk Information System (IRIS). 1991. **Acetaldehyde (CAS # 75-07-0)**. [Online]. Available from: http://www.epa.gov/iris/subst/0290.htm. [2011, April 10].

Kim, K.H., et al. 2008. Investigation of Carbonyl Compounds in Air from Various Industrial Emission Sources. **Chemosphere**. 70: 807-820.

Lü, H., et al. 2006. Indoor and Outdoor Carbonyl Compounds and BTEX in the Hospitals of Guangzhou, China. **Science of the Total Environment**. 368: 574-584.

Lee, S.C., Chiu, M.Y., Ho, K.F., Zou, S.C., and Wang, X. 2002.Volatile organic compounds (VOCs) in urban atmosphere of Hong Kong. **Chemosphere**. 48: 375-382.

Majumdar, D., Dutta, C., Mukherjee, A.K., and Sen, S. 2008. Source Apportionment of VOCs at the Petrol Pumps in Kolkata, India; Exposure of Workers and Assessment of Associated Health Risk. **Transportation Research Part D**. 13: 524-530.

Material Safety Data Sheet (MSDS). 2003. **Safety Data for Hexanal**. [Online]. Available from: http://msds.chem.ox.ac.uk/HE/hexanal.html. [2011, April 15].

Ministry of Energy of Thailand. 2010. **Gasohol**. [Online]. Available from: http://www.energy.go.th/index.php?q=node/384. [2010, November 14].

Ministry of Energy of Thailand. 2009. **Energy Policy**. [Online]. Available from: http://www.energy.go.th/?q=th/energy_policy. [2010, November 12].

Miguel, A.H., et al. 1995. Characterization of indoor air quality in the cities of Sao Paulo and Rio de Janeiro, Brazil. **Environmental Science and Technology**. 29: 338-345.

Morknoy, D., Khummongkol., and Prueaksasit, T. 2010. Seasonal and Diurnal Concentration of Ambient Formaldehyde and Acetaldehyde in Bangkok. **Water Air & Soil Pollution**. 216: 693-702.

Occupational Safety and Health Administration (OSHA). 2011. **Valeraldehyde**. [Online]. Available from: http://www.osha.gov/dts/sltc/methods /organic/org085/org085.html. [2011, April 15].

Occupational Safety and Health Administration (OSHA). 2008. **Chemical Sampling Information for Isovaleraldehyde (CAS # 590-86-3)**. [Online]. Available from: http://www.osha.gov/dts/chemicalsampling/data/CH_248730.html. [2011, April 15].

Ongwandee, M., Moonrinta, R., Panyametheekul, S., Tangbanluekal, C., and Morrison, G. 2011. Investigation of Volatile Organic Compounds in Office Buildings in Bangkok, Thailand: Concentrations, Sources, and Occupant Symptoms. **Building and Environment**. 46: 1512-1522.

Pang, X., and Mu, Y. 2007. Seasonal and Diurnal Varations of Carbonyl Compounds in Beijing Ambient Air. **Atmospheric Environment**. 40: 6313-6320.

Seo, Y.K., and Baek, S.O. 2011. Characterization of Carbonyl Compounds in the Ambient Air of an Industrial City in Korea. **Sensors**. 11: 949-963.

Siriwong, W., et al. 2009. DDT and derivatives in indicator species of the aquatic food web of Rangsit agricultural area, Central Thailand. **Ecological Indicators**. 9: 878-882.

Slemr, J., Junkermann, W., and Volz-Thomas, A. 1996. Temporal Variations in formaldehyde, acetaldehyde and acetone and budget of formaldehyde at a rural site in southern Germany. **Atmospheric Environment**. 30: 3667-3676.

Tunsaringkarn, T., Zapaung, K., Rugsiyothin, A., Soogarun, S., and Chapman, R.S. 2011. Health Status of Gasoline Station Workers in Pathumwan Area, Bangkok, Thailand, In 2004 and 2009. **Journal of Health Research**. 25(1): 15-19.

United State Department of Health and Human Service. 2011. **Calculate your Body Mass Index**. [Online]. Available from: http://www. nhlbisupport.com/bmi/ bmi-m.htm. [2011, May 15].

United State Environmental Protection Agency (US EPA). 2011. **National-Scale Air Toxics Assessments, Glossary of key terms**. [Online]. Available from: http://www.epa.gov/nata/gloss1.html. [2011, April 14].

United State Environmental Protection Agency (US EPA). 2010a. **Step 1 Hazard identification**. [Online]. Available from: http://www.epa.gov/risk_assessment/ hazardous-identification.htm. [November 1, 2010].

United State Environmental Protection Agency (US EPA). 2010b. **Step 2 Dose-Response Assessment**. [Online]. Available from: http://www.epa.gov/risk_assessment/dose-response.htm. [2010, November 1].

United State Environmental Protection Agency (US EPA). 2010c. **Step 3 Exposure Assessment**. [Online]. Available from: http://www.epa.gov/risk_assessment/exposure.htm. [2011, April 5].

United State Environmental Protection Agency (US EPA). 2010d. **Step 4 Risk Characterizations**. [Online]. Available from: http://www.epa.gov/risk_assessment/risk-characterization.htm. [2010, November 1].

United State Environmental Protection Agency (US EPA). 2010e. **Publication-Air Pollution Health Risk**. [Online]. Available from: http://www.epa.gov/air/oaqps/air_risc/3_90_022.html. [2011, April 1].

United State Environmental Protection Agency (US EPA). 2009a. **Composition and Behavior of Fuel Ethanol**. [Online]. Available from: http://www.epa.gov/athens/publications/reports/Weaver_EPA600R09037_Composition_Fuel_Ethanol.pdf. [2010, November 1].

United State Environmental Protection Agency (US EPA). 2009b. **Appendix H Derivation of AGCs for Aldehyde Compounds**. [Online]. Available from: http://www.epa.gov/ttnamti1/files/20052006csatam/tonawanda/AppendixH.pdf. [2011, April 1].

United State Environmental Protection Agency (US EPA). 2005. **Human Health Risk Assessment Protocol: Chapter 7**. [Online]. Available from: http://www.epa.gov/osw/hazard/tsd/td/combust/finalmact/ssra/05hhrap7.pdf. [2011, April 16].

United State Environmental Protection Agency (US EPA). 2003. **Regio/Ord Workshop on Inhalation Risk Assessment: A Superfund Focus**. [Online]. Available from: http://www.epa.gov/oswer/riskassessment/pdf/finalinhalationriskworkshop.pdf . [2011, April 1].

United State Environmental Protection Agency (US EPA). 2000a. **Acetaldehyde (CAS #75-07-0)**. [Online]. Available from: http://www.epa.gov/ttn/atw /hlthef/acetalde.html. [2010, November 7].

United State Environmental Protection Agency (US EPA). 2000b. **Propionaldehyde (CAS # 123-38-6)**. [Online]. Available from: http://www.epa.gov/ttnatw01 /hlthef/propiona.html. [2011, April 15].

United State Environmental Protection Agency (US EPA). 2000c. **RCRA Delisting Technical Support Document: Chapter 3**. [Online]. Available from: http://www.epa.gov/earth1r6/6pd/rcra_c/pd-o/chap3.pdf. [2011, April 16].

United State Environmental Protection Agency (US EPA). 1994. **Environmental Fact Sheet : Air Toxics from Vehicles**. [Online]. Available from: http://www.epa.gov/oms/f02004.pdf. [2010, November 5].

United State Environmental Protection Agency (US EPA). 1994. **Butyraldehyde (CAS # 123-72-8)**. [Online]. Available from: http://www.epa.gov/chemfact /butyr- sd.txt. [2011, April 15].

United State Environmental Protection Agency (US EPA). 1991. **Compendium Method TO-11A**. [Online]. Available from: http://www.epa.gov/ttnamti1 /files /ambient/airtox/to-11ar.pdf. [2011, April 7].

United State Environmental Protection Agency (US EPA). 1989. **Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual Part A**. [Online]. Available from: http://www.epa.gov/oswer/riskassessment/ragsa/. [2011, April 7].

Viskari, E., Vartiainen, M., and Pasanen, P. 2000. Seasonal and Diurnal Variation in formaldehyde and acetaldehyde concentrations along a highway in Eastern Finland. **Atmospheric Environment**. 34: 917-923.

Weaver, N.K. "Gasoline and Oxygenated Additives," in **Clinical Environmental Health and Toxic Exposures**, John B. Sullivan, Jr and Krieger, G.R., 2nd editors (Philadelphia, PA: Lippincott Williams and Wilkins, 2001), pp. 832-847.

Weng, M., Zhu, L., Yang, K., and Chen, S. 2009. Levels and Health Risks of Carbonyl Compounds in Selected Public Places in Hangzhou, China. **Journal of Hazardous Materials**. 164: 700-706.

Yimrungruang, D., Cheevaporn, V., Boonphakdee, T., Watchalayann, P., and Helander, H. 2008. Characterization and Health Risk Assessment of Volatile Organic Compounds in Gas Service Station Workers. **Environment Asia**. 2: 21-29.

Yu, Y., et al. 2008. Characteristics of Atmospheric Carbonyls and VOCs in Forest Park in South China. **Environmental Monitoring and Assessment**. 137: 275-285.

Zhou, J., et al. 2010. Health Risk Assessment of Personal Inhalation Exposure to Volatile Organic Compounds in Tianjin, China. **Science of the Total Environment**. 409: 452-459.

APPENDICES

APPENDIX A

SCHEDULE OF STUDY

Project procedure	**Time Frame (Month)**											
	June 10	**July 10**	**Aug 10**	**Sep 10**	**Oct 10**	**Nov 10**	**Dec 10**	**Jan 11**	**Feb 11**	**Mar 11**	**Apr 11**	**May 11**
1. Literature review and write Thesis proposals	↔	↔	↔	↔	↔	↔	↔					
2. Proposal exam and contact with gas station companies						↔	↔					
3. Ethic consideration from Chulalongkorn University (CPHS)								↔	↔	↔		
4. Research tool (Set-up and Pre-test)								↔	↔	↔	↔	↔
6. Data collection											↔	↔
8. Data analysis											↔	↔
9. Discussion report writing											↔	↔
10.Thesis defense and public to journal												↔

APPENDIX B

ESTIMAITED BUDGET

Laboratory and Analysis	100,000 Baht
Document and Questionnaire	5,000 Baht
Transportation	5,000 Baht
Worker's incentive	5,000 Baht
Others	15,000 Baht
Total	**130,000 Baht**

APPENDIX C

QUESTIONNAIRES

Participant code _______

How to create a code? = Day: month: Workers who give health risk evaluation (W), General workers (G) : company, PTT (P), Shell (S), Caltex (C) : Urban (U) : Suburb (B)

Example 4 Feb, general worker, working in Shell company, gas station stay in Urban area = 42GSU

Example 4 Feb, workers who give health risk evaluation, working in PTT company, gas station stay in suburb area = 42WPB

Thesis topic: Health Risk Assessment Associated with Inhalation Exposure to Gasoline Workers in Bangkok, Thailand

This questionnaire is part of master degree curriculum (M.P.H), College of public health sciences Chulalongkorn University. All results which give from this questionnaire will be used for education only, please mark X on ___ which this questionnaire approved from proposal examination committee already on January 2011

Part I: General Information

1. Gender __Male __Female
2. Body weight ____________________Kg and height __________centimeters
3. Age ____________________________years
4. Education level ____________________________
5. Income__________________________ baht/month
6. Smoking behavior __yes __no and amount____________ pieces/day
7. Marital status __married __single
8. Do you have congenital disease? Please define….

    8.1_______________________________________

    8.2_______________________________________

9. Your hobbit? Please define…

    9.1 ____

    9.2____

10. When you have a space time, what your habitually activities? ____________________

11. In the last three month ago, did you have health problems? Please define…

11.1____

11.2____

12. What your responsibility or duties in this gas station? Please define…

12.1____

12.2____

Part II: Usability of Personal Protection Equipment (PPE) data

13. __Use (Normal cloth)

__Use (Reliable Mask e.g. guarantee by EPA serial number for PPE)

__Not use

Part III: General Information of gas station

14. The number of main distributes tank refuel___________________________units

15. The number of mini tank refuels for customers' service__________________units

Part IV: Attitude for health status in gas station

16. Do you know about volatile compounds in gasoline, it harmful for health?

__Know __Don't know, If you know please define______________________

Which ways almost to exposure? : __inhalation __ingestion __dermal

17. Did you have some symptoms since you started this job? Please define

____

Part V: Inhalation exposure data

18. Frequency of refuel the gasoline or gasohol

_____________________________________ Times/day

_____________________________________ Times/week

_____________________________________ Times/month

19. Duration of refuel the gasoline or gasohol ___________ minutes/time

20. How long you work_______ months or _______ days/year

21. Work shift _________________________________ hours/day

Part VI: Health care consume

22. Normally, if you have some disease, where you choose to treat your disease

22.1 Government’s hospital, please define________________________

22.2 Private’s hospital, please define____________________________

22.3 Health care center, please define____________________________

22.4 Private clinic, please define________________________________

22.5 Other, please define______________________________________

23. What your Insurance coverage? ____________________________________

24. Which ways you give the information about health insurance? ___________

25. Did you get symptoms which show below?

Symptoms	**Yes**	**Never**
Drowsiness		
dizziness		
headaches		
Eye, skin irritation		
Respiratory tract irritation		
Unconsciousness		
Fatigue		
Nausea		
Sore throat or throat irritation		
Lack of muscle coordination		
Confusion		

Thanks for your cooperate and interest for answers

Researcher will not reveal the private data in public, conference meeting or others for the human right

แบบสอบถาม

รหัสผู้ตอบแบบสอบถาม__________________

<u>** การเข้ารหัส**</u> วันที่ : เดือน : ผู้มีส่วนร่วมวิจัยที่ได้รับการประเมินความเสี่ยง(W), ผู้มีส่วนร่วมวิจัยทั่วไป General(G) : เครือบริษัท PTT(P), Shell(S), Caltex(C) : เมืองหลวง(U) : ชานเมือง(B)

ตัวอย่างเช่น วันที่ 4 กุมภาพันธ์ คนงานทั่วไป ปั๊มน้ำมันเครือ Shell บริเวณเมืองหลวง
รหัสผู้ตอบแบบสอบถาม 42GSU
วันที่ 4 กุมภาพันธ์ คนงานที่ได้รับการประเมินความเสี่ยง ปั๊มน้ำมันเครือ PTT
บริเวณชาน-
เมือง รหัสผู้ตอบแบบสอบถาม 42WPB

<u>วิทยานิพนธ์ เรื่อง</u> การประเมินความเสี่ยงทางสุขภาพของคนงานในสถานประกอบการน้ำมันทางการหายใจในกรุงเทพมหานคร ประเทศไทย

<u>คำชี้แนะ</u> แบบสอบถามนี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาโท (สาธารณสุขศาสตร์มหาบัณฑิต) วิทยาลัยวิทยาศาสตร์สาธารณสุข จุฬาลงกรณ์มหาวิทยาลัย โดยผลที่ได้จะนำไปใช้เพื่อวัตถุประสงค์ทางการศึกษาเท่านั้น โปรดทำเครื่องหมาย X บน____ ซึ่งแบบสอบถามนี้ได้ผ่านความเห็นชอบจากผู้ทรงคุณวุฒิเป็นที่เรียบร้อยแล้ว จากกรรมการพิจารณาโครงร่างวิทยานิพนธ์เมื่อเดือนมกราคม 2554

ส่วนที่ 1 : ข้อมูลทั่วไป

1. เพศ __ชาย __หญิง
2. น้ำหนัก __________________ (กิโลกรัม) สูง __________________ (เซนติเมตร)
3. อายุ __________________________ปี
4. ระดับการศึกษา ____
5. รายได้________________________บาท/เดือน
6. ท่านสูบบุหรี่หรือไม่? __สูบ __ไม่สูบ จำนวน___________ มวน/วัน
7. สถานภาพของท่าน __แต่งงานแล้ว __โสด
8. ท่านมีโรคประจำตัวหรือไม่? ถ้ามี โปรดระบุ…
    8.1 โรคอะไร _____________________________________
    8.2 โรคอะไร _____________________________________
9. งานอดิเรกของท่าน…
    9.1 ____
    9.2____

10. เวลาว่างคุณทำอะไรเป็นประจำ____

11. ภายในสามเดือนที่ผ่านมาท่านมีปัญหาทางสุขภาพหรือไม่ ถ้ามีโปรดระบุ

11.1____

11.2____

12. ในสถานประกอบการน้ำมันแห่งนี้ท่านมีหน้าที่หรือตำแหน่งรับผิดชอบอะไรบ้าง...

12.1____

12.2____

ส่วนที่ 2 : ข้อมูลการใช้อุปกรณ์ป้องกันการรับสัมผัส

13. ท่านได้ใช้อุปกรณ์หน้ากากเพื่อป้องกันไอระเหยจากน้ำมันหรือไม่ (ชนิดใด)

__ใช้ (ผ้าธรรมดา)

__ใช้ (หน้ากากที่ได้รับมาตรฐานจาก EPA และมี serial number กำกับ)

__ไม่ใช้

ส่วนที่ 3 : ข้อมูลถานประกอบการน้ำมันเบื้องต้น

14. หัวจ่ายน้ำมันหลักของสถานีมีจำนวนทั้งหมด ___________________________________ หัว

15. หัวจ่ายน้ำมันสำหรับลูกค้ามีจำนวนทั้งหมด_________________ หัว

ส่วนที่ 4 : ข้อคิดเห็นเกี่ยวกับปัญหาทางสุขภาพในสถานประกอบการน้ำมัน

16. ท่านทราบหรือไม่ว่าไอระเหยน้ำมันมีอันตรายต่อสุขภาพ? __ทราบ __ไม่ทราบ

ถ้าทราบโปรดระบุ____

ท่านคิดว่าการรับสัมผัสทางใดที่สามารถรับสารพิษจากน้ำมันเข้าสู่ร่างกายคุณมากที่สุด ? :

__การหายใจ __การทาน/ดื่ม __ผิวหนัง

17. ท่านรู้สึกหรือมีอาการที่เกี่ยวกับสุขภาพภายหลังจากเข้ามาทำงานในสถานประกอบการน้ำมัน หรือไม่ ถ้ามี โปรดระบุ?

____

ส่วนที่ 5: ข้อมูลการรับสัมผัสทางการหายใจ

18. จำนวนครั้งในการเติมน้ำมันให้แก่ลูกค้า (โดยประมาณ)

______________________________________ ครั้ง/วัน

______________________________________ ครั้ง/อาทิตย์

______________________________________ ครั้ง/เดือน

19. การเติมน้ำมันแต่ละครั้งใช้เวลานานเท่าใด ____________________________นาที/ครั้ง

20. ท่านทำงานในสถานประกอบการน้ำมันแห่งนี้มานานเท่าใด? _______ เดือน หรือ คิดเป็น_______________วัน/ปี

21. ท่านทำงานในสถานประกอบการน้ำมันแห่งในแต่ละวันกี่ชั่วโมง_______________ชั่วโมง/วัน

ส่วนที่ 6: การใช้บริการระบบสุขภาพและผลกระทบต่อสุขภาพ

22. หากมีอาการเจ็บป่วย ท่านเข้ารับการรักษาที่ใด

22.1 โรงพยาบาลรัฐ (โปรดระบุ)……………………………………………………..

22.2 โรงพยาบาลเอกชน (โปรดระบุ)…………………………………………………

22.3 สถานีอนามัย (โปรดระบุ)...

22.4 คลินิกเอกชน (โปรดระบุ) ………………………………………………………

22.5 อื่นๆ (โปรดระบุ)...

23. ระบบประกันสุขภาพที่ท่านใช้บริการอยู่คือ

____

24. ท่านรับข้อมูลข่าวสารเกี่ยวกับระบบประกันสุขภาพจากแหล่งใด?

____

25. ท่านเคยมีอาการดังต่อไปนี้หรือไม่

อาการ	**ไม่เคย**	**เล็กน้อย**
ง่วงนอน		
เวียนศีรษะ		
ปวดศีรษะ		
ตาหรือผิวหนังเกิดการระคายเคือง		
ระคายเคืองทางเดินหายใจ (ไอ,มีเสมหะ)		
หมดสติ		
เหนื่อยล้า		
คลื่นไส้		
เจ็บคอ		
กล้ามเนื้อทำงานผิดปกติ		
สับสนง่าย		

ขอบคุณที่สละเวลาอันมีค่าและให้ความร่วมมือเป็นอย่างดี

ผู้วิจัยจะไม่เปิดเผยข้อมูลส่วนตัวใดๆของผู้ตอบแบบสอบถามนี้ทั้งในที่สาธารณะ การประชุมทางวิชาการต่างๆ หรือทางใดก็ตาม เพื่อพิทักษ์สิทธิของผู้มีส่วนร่วมในการวิจัย

APPENDIX D

COMPARISON OF CARBONYL COMPOUNDS

A. Comparison of carbonyl compounds in gasoline workers in urban station and suburb station

Chemical's name	T-test (degree of freedom = 22)	
	T	p-value
Formaldehyde**	-0.535	0.598
Acetaldehyde**	-2.52	0.020*
Acetone**	-0.223	0.826
Propionaldehyde**	-0.796	0.435
Crotonaldehyde	0.519	0.609
Butyraldehyde**	1.677	0.108
Benzaldehyde	1.817	0.083
Isovaleraldehyde	0.308	0.761
Valeraldehyde**	0.808	0.428
Hexanaldehyde**	-0.711	0.485

B. Comparison of among carbonyl concentration level of roadside in urban areas and carbonyl concentration level of roadside in suburb areas

Chemical's name	T-test (degree of freedom = 10)	
	T	p-value
Formaldehyde**	0.522	0.613
Acetaldehyde**	0.830	0.426
Acetone**	0.355	0.730
Propionaldehyde**	0.972	0.354
Crotonaldehyde	0.580	0.574
Butyraldehyde**	3.38	0.007*
Isovaleraldehyde	3.440	0.018*
Valeraldehyde**	-1.248	0.241
Hexanaldehyde**	0.966	0.357

* Statistically significant association at 0.05 Level.

**normal distribution curve

APPENDIX E

ASSOCIATION AMONG SYMPTOMS AND RISK FACTORS

A. Association between symptoms occurrence and study areas

Symptoms	Urban	Suburb	χ^2	P-value (Fisher's Exact test)
Drowsiness			0.297	0.618
Yes (%)	11(84.6)	6(75.0)		
No (%)	2(15.4)	2(25.0)		
Dizziness			0.151	1.000
Yes (%)	7(53.8)	5(62.5)		
No (%)	6(46.2)	3(37.5)		
Headaches			0.029	1.000
Yes (%)	7(53.8)	4(50.0)		
No (%)	6(46.2)	4(50.0)		
Eye Skin throat			0.101	0.100
irritation	9(69.2)	5(62.5)		
Yes (%)	4(30.8)	3(37.5)		
No (%)				
Respiratory tract			0.777	0.646
Yes (%)	9(69.2)	4(50.0)		
No (%)	4(30.8)	4(50.0)		
Unconsciousness			0.646	0.1000
Yes (%)	1(7.7)	0(0)		
No (%)	12(92.3)	8(100.0)		
Fatigue			0.505	0.631
Yes (%)	10(76.9)	5(62.5)		
No (%)	3(23.1)	3(37.5)		
Nausea			0.010	0.100
Yes (%)	3(23.1)	2(25.0)		
No (%)	10(76.9)	6(75.0)		
Sore throat			0.002	1.000
Yes (%)	5(38.5)	3(37.5)		
No (%)	8(61.5)	5(52.5)		
Lack of muscle			0.940	0.400
Yes (%)	6(46.2)	2(25.0)		
No (%)	7(53.8)	6(75.0)		
Confusion			1.147	0.387
Yes (%)	8(61.5)	3(37.5)		
No (%)	5(38.5)	5(62.5)		

B. Association between symptoms occurrence and education levels

Symptoms	Primary School	Secondary School	χ^2	P-value (Fisher's Exact test)
Drowsiness			0.103	1.000
Yes (%)	10 (83.3)	7 (77.8)		
No (%)	2 (16.7)	2 (22.2)		
Dizziness			1.037	0.396
Yes (%)	8 (66.7)	4 (44.4)		
No (%)	4 (33.3)	5 (55.6)		
Headaches			0.398	0.670
Yes (%)	7 (58.3)	4 (44.5)		
No (%)	5 (41.7)	5 (55.5)		
Eye Skin throat irritation			0.000	1.000
Yes (%)	8 (66.7)	6 (66.7)		
No (%)	4 (33.3)	3 (33.3)		
Respiratory tract irritation			0.269	0.673
Yes (%)	8 (66.7)	5 (55.6)		
No (%)	4 (33.3)	4 (44.4)		
Unconsciousness			0.788	1.000
Yes (%)	1 (8.3)	0 (0)		
No (%)	11 (91.7)	9 (100.0)		
Fatigue			2.353	0.178
Yes (%)	7 (58.3)	8 (88.9)		
No (%)	5 (41.7)	1 (11.1)		
Nausea			3.697	0.119
Yes (%)	1 (8.3)	4 (44.4)		
No (%)	11 (91.7)	5 (55.6)		
Sore throat			2.036	0.203
Yes (%)	3 (25.0)	5 (55.6)		
No (%)	9 (75.0)	4 (44.4)		
Lack of muscle			0.269	0.673
Yes (%)	4 (33.3)	4 (44.4)		
No (%)	8 (66.7)	5 (55.6)		
Confusion			1.289	0.387
Yes (%)	5 (41.7)	6 (66.7)		
No (%)	7 (58.3)	3 (33.3)		

C. Association between symptoms occurrence and gender

Symptoms	Male	Female	χ^2	P-value (Fisher's Exact test)
Drowsiness			3.041	0.131
Yes (%)	9 (69.2)	8 (100.0)		
No (%)	4 (30.8)	0 (0.0)		
Dizziness			1.683	0.367
Yes (%)	6 (46.2)	6 (75.0)		
No (%)	7 (53.8)	2 (25.0)		
Headaches			0.531	0.659
Yes (%)	6 (46.2)	5 (62.5)		
No (%)	7 (53.8)	3 (37.5)		
Eye Skin throat irritation			0.101	1.000
Yes (%)	9 (69.2)	5 (62.5)		
No (%)	4 (30.8)	3 (37.5)		
Respiratory tract irritation			0.002	1.000
Yes (%)	8 (61.5)	5 (62.5)		
No (%)	5 (38.5)	3 (37.5)		
Unconsciousness			0.646	1.000
Yes (%)	1 (7.7)	0 (0)		
No (%)	12 (92.3)	8 (100.0)		
Fatigue			0.505	0.631
Yes (%)	10 (76.9)	5 (62.5)		
No (%)	3 (23.1)	3 (37.5)		
Nausea			0.911	0.606
Yes (%)	4 (30.8)	1 (12.5)		
No (%)	9 (69.2)	7 (87.5)		
Sore throat			0.002	1.000
Yes (%)	5 (38.5)	3 (37.5)		
No (%)	8 (61.5)	5 (62.5)		
Lack of muscle			0.777	0.646
Yes (%)	4 (30.8)	4 (50.0)		
No (%)	9 (69.2)	4 (50.0)		
Confusion			0.029	1.000
Yes (%)	7 (53.8.5)	4 (50.5)		
No (%)	6 (46.2)	4 (50.5)		

D. Association between symptoms occurrence and gasoline workers' responsibility

Symptoms	**Only refueling responsibility**	**Multi responsibility**	χ^2	**P-value (Fisher's Exact test)**
Drowsiness			0.359	1.000
Yes (%)	7 (87.5)	10 (76.9)		
No (%)	1 (12.5)	3 (23.1)		
Dizziness			0.151	1.000
Yes (%)	5 (62.5)	7 (53.8)		
No (%)	3 (37.5)	6 (46.2)		
Headaches			0.029	1.000
Yes (%)	4 (50.0)	7 (53.8)		
No (%)	4 (50.0)	6 (46.2)		
Eye Skin throat irritation			0.101	1.000
Yes (%)	5 (62.5)	9 (69.2)		
No (%)	3 (37.5)	4 (30.8)		
Respiratory tract irritation			0.002	1.000
Yes (%)	5 (62.5)	8 (61.5)		
No (%)	3 (37.5)	5 (38.5)		
Unconsciousness			0.646	1.000
Yes (%)	0 (0.0)	1 (7.7)		
No (%)	8 (100.0)	12 (92.3)		
Fatigue			0.505	0.631
Yes (%)	5 (62.5)	10 (76.9)		
No (%)	3 (37.5)	3 (23.1)		
Nausea			0.010	1.000
Yes (%)	2 (25.0)	3 (23.1)		
No (%)	6 (75.0)	10 (76.9)		
Sore throat			0.777	0.646
Yes (%)	4 (50.0)	4 (30.8)		
No (%)	4 (50.0)	9 (69.2)		
Lack of muscle			0.002	1.000
Yes (%)	3 (37.5)	5 (38.5)		
No (%)	5 (62.5)	8 (61.5)		
Confusion			1.147	0.387
Yes (%)	3 (37.5)	8 (61.5)		
No (%)	5 (62.5)	5 (38.5)		

E. Association between symptoms occurrence and workers' awareness of VOCs

Symptoms	Don't Know	Know	χ^2	P-value (Fisher's Exact test)
Drowsiness			1.868	0.228
Yes (%)	3 (60.0)	14 (87.5)		
No (%)	2 (40.0)	2 (12.5)		
Dizziness			0.022	1.000
Yes (%)	3 (60.0)	9 (56.3)		
No (%)	2 (40.0)	7 (43.7)		
Headaches			0.403	0.635
Yes (%)	2 (40.0)	9 (56.3)		
No (%)	3 (60.0)	7 (43.7)		
Eye Skin throat irritation			0.131	1.000
Yes (%)	3 (60.0)	11 (68.8)		
No (%)	2 (40.0)	5 (31.2)		
Respiratory tract irritation			0.010	0.656
Yes (%)	3 (60.0)	10 (62.5)		
No (%)	2 (40.0)	6 (37.5)		
Unconsciousness			0.328	1.000
Yes (%)	0 (0.0)	1 (6.2)		
No (%)	5 (100.0)	15 (93.8)		
Fatigue			0.420	0.598
Yes (%)	3 (60.0)	12 (75.0)		
No (%)	2 (40.0)	4 (25.0)		
Nausea			0.948	0.553
Yes (%)	2 (40.0)	3 (18.8)		
No (%)	3 (60.0)	13 (81.2)		
Sore throat			0.010	1.000
Yes (%)	2 (40.0)	6 (37.5)		
No (%)	3 (60.0)	10 (62.5)		
Lack of muscle			0.911	0.606
Yes (%)	1 (20.0)	7 (43.8)		
No (%)	4 (80.0)	9 (56.2)		
Confusion			0.403	0.635
Yes (%)	2 (40.0)	9 (56.2)		
No (%)	3 (60.0)	7 (43.8)		

F. Association between symptoms occurrence and workers' symptom occurrence in the last three month

Symptoms	Never	Once	χ^2	P-value (Fisher's Exact test)
Drowsiness			0.618	0.574
Yes (%)	12 (85.7)	5 (71.4)		
No (%)	2 (14.3)	2 (28.6)		
Dizziness			0.875	0.397
Yes (%)	9 (64.3)	3 (42.8)		
No (%)	5 (35.7)	4 (57.2)		
Headaches			0.095	1.000
Yes (%)	7 (50.0)	4 (57.1)		
No (%)	7 (50.0)	3 (42.9)		
Eye Skin throat irritation			0.107	1.000
Yes (%)	9 (64.3)	5 (42.8)		
No (%)	5 (35.7)	2 (57.2)		
Respiratory tract irritation			6.462	0.018*
Yes (%)	6 (42.8)	7 (100.0)		
No (%)	8 (57.2)	0 (0.0)		
Unconsciousness			2.100	0.333
Yes (%)	0 (0)	1 (14.3)		
No (%)	14 (100.0)	6 (85.7)		
Fatigue			0.000	1.000
Yes (%)	10 (71.4)	5 (42.8)		
No (%)	4 (28.6)	2 (57.2)		
Nausea			0.525	0.624
Yes (%)	4 (28.6)	1 (14.3)		
No (%)	10 (71.4)	6 (85.7)		
Sore throat			2.524	0.174
Yes (%)	7 (50.0)	1 (14.3)		
No (%)	7 (80.0)	6 (85.7)		
Lack of muscle			0.101	1.000
Yes (%)	5 (35.7)	3 (42.9)		
No (%)	9 (64.3)	4 (57.1)		
Confusion			0.382	0.659
Yes (%)	8 (57.2)	3 (42.9)		
No (%)	6 (42.8)	4 (57.1)		

* Statistically significant association at 0.05 Level.

G. Association between symptoms occurrence and chronic disease

Symptoms	**Not have chronic disease**	**Have chronic disease**	χ^2	**P-value (Fisher's Exact test)**
Drowsiness			0.520	1.000
Yes (%)	15 (79.0)	2 (100.0)		
No (%)	4 (21.0)	0 (0.0)		
Dizziness			1.658	0.486
Yes (%)	10 (52.6)	2 (100.0)		
No (%)	9 (47.4)	0 (0.0)		
Headaches			2.010	0.476
Yes (%)	9 (47.4)	2 (100.0)		
No (%)	10 (52.6)	0 (0.0)		
Eye Skin throat irritation			0.276	1.000
Yes (%)	13 (68.4)	1 (50.0)		
No (%)	6 (31.6)	1 (50.0)		
Respiratory tract irritation			0.133	1.000
Yes (%)	12 (63.2)	1 (50.0)		
No (%)	7 (36.8)	1 (50.0)		
Unconsciousness			0.111	1.000
Yes (%)	1 (5.2)	0 (0)		
No (%)	18 (94.8)	2 (100.0)		
Fatigue			0.497	0.500
Yes (%)	14 (73.7)	1 (50.0)		
No (%)	5 (26.3)	1 (50.0)		
Nausea			0.691	1.000
Yes (%)	5 (26.3)	0 (0.0)		
No (%)	14 (73.7)	2 (100.0)		
Sore throat			1.360	0.505
Yes (%)	8 (42.1)	0 (0.0)		
No (%)	11 (57.9)	2 (100.0)		
Lack of muscle			1.360	0.505
Yes (%)	8 (42.1)	0 (0.0)		
No (%)	11 (57.9)	2 (100.0)		
Confusion			0.005	1.000
Yes (%)	10 (52.6)	1 (50.0)		
No (%)	9 (47.4)	1 (50.0)		

H. Association between symptoms occurrence and smoking behavior

Symptoms	Never smoke	Smoke	χ^2	P-value (Fisher's Exact test)
Drowsiness			0.114	1.000
Yes (%)	14 (82.4)	3 (75.0)		
No (%)	3 (17.6)	1 (25.0)		
Dizziness			3.706	0.104
Yes (%)	8 (47.1)	4 (100.0)		
No (%)	9 (52.9)	0 (50.0)		
Headaches			1.014	0.586
Yes (%)	8 (47.1)	3 (75.0)		
No (%)	9 (52.9)	1 (25.0)		
Eye Skin throat irritation			0.154	1.000
Yes (%)	11 (64.7)	3 (75.0)		
No (%)	6 (35.3)	1 (25.0)		
Respiratory tract irritation			0.359	1.000
Yes (%)	10 (58.8)	3 (75.0)		
No (%)	7 (51.2)	1 (25.0)		
Unconsciousness			4.462	0.190
Yes (%)	0 (0.0)	1 (25.0)		
No (%)	17 (100.0)	3 (75.0)		
Fatigue			1.112	0.544
Yes (%)	13 (76.5)	2 (50.0)		
No (%)	4 (23.5)	2 (50.0)		
Nausea			0.004	1.000
Yes (%)	4 (23.5)	1 (25.0)		
No (%)	13 (76.5)	3 (75.0)		
Sore throat			0.359	1.000
Yes (%)	7 (41.2)	1 (25.0)		
No (%)	10 (58.8)	3 (75.0)		
Lack of muscle			0.359	1.000
Yes (%)	7 (41.2)	1 (25.0)		
No (%)	10 (58.8)	3 (75.0)		
Confusion			1.485	0.311
Yes (%)	10 (58.8)	1 (25.0)		
No (%)	7 (41.2)	3 (75.0)		

I. Association between symptoms occurrence and marital status

Symptoms	**Single**	**Married**	χ^2	**P-value (Fisher's Exact test)**
Drowsiness			0.618	1.000
Yes (%)	12 (85.7)	5 (71.4)		
No (%)	2 (14.3)	2 (28.6)		
Dizziness			0.000	1.000
Yes (%)	8 (57.1)	4 (57.1)		
No (%)	10 (42.9)	3 (42.9)		
Headaches			0.095	1.000
Yes (%)	7 (50.0)	4 (57.1)		
No (%)	7 (50.0)	3 (42.9)		
Eye Skin throat irritation			0.107	1.000
Yes (%)	9 (64.3)	5 (71.4)		
No (%)	5 (35.7)	2 (28.6)		
Respiratory tract irritation			2.524	0.174
Yes (%)	7 (50.0)	6 (85.7)		
No (%)	7 (50.0)	1 (14.3)		
Unconsciousness			0.525	1.000
Yes (%)	1 (7.1)	0 (0)		
No (%)	13 (92.9)	7 (100.0)		
Fatigue			1.050	0.354
Yes (%)	11 (78.6)	4 (57.1)		
No (%)	3 (21.4)	3 (42.9)		
Nausea			3.281	0.123
Yes (%)	5 (35.7)	0 (0.0)		
No (%)	9 (64.3)	7 (100.0)		
Sore throat			2.524	0.174
Yes (%)	7 (50.0)	1 (14.3)		
No (%)	7 (50.0)	6 (85.7)		
Lack of muscle			2.524	0.174
Yes (%)	7 (50.0)	1 (14.3)		
No (%)	7 (50.0)	6 (85.7)		
Confusion			2.386	0.183
Yes (%)	9 (64.3)	2 (28.6)		
No (%)	5 (35.7)	5 (71.4)		

APPENDIX F

PATIENT/ PARTICIPANT INFORMATION SHEET

รูปแบบ

ข้อมูลสำหรับกลุ่มประชากรหรือผู้มีส่วนร่วมในการวิจัย

ชื่อโครงการวิจัย การประเมินความเสี่ยงทางสุขภาพของคนงานในสถานประกอบการน้ำมันทางการหายใจใน กรุงเทพมหานคร ประเทศไทย

ชื่อผู้วิจัย นายสุคท นพรัตนบัณฑิต ตำแหน่ง นิสิต

สถานที่ติดต่อผู้วิจัย (ที่ทำงาน) ชั้น 11 อาคารสถาบัน 3 วิทยาลัยวิทยาศาสตร์สาธารณสุข

(ที่บ้าน) 16/1 ถนนสุรวงศ์ แขวงสี่พระยา เขตบางรัก กรุงเทพมหานคร 10500

โทรศัพท์ (ที่ทำงาน) ……………......………ต่อ …...……….. โทรศัพท์ที่บ้าน ……………………….

โทรศัพท์มือถือ 0879221711 E-mail : Darkslide555@hotmail.com

ขอเรียนเชิญท่านเข้าร่วมในการวิจัย ก่อนที่ท่านจะตัดสินใจเข้าร่วมในการวิจัย มีความจำเป็นที่ท่านควรทำความเข้าใจว่างานวิจัยนี้ทำเพราะเหตุใด และเกี่ยวข้องกับอะไร กรุณาใช้เวลาในการอ่านข้อมูลต่อไปนี้อย่างละเอียดรอบคอบ และสอบถามข้อมูลเพิ่มเติมหรือข้อมูลที่ไม่ชัดเจนได้ตลอดเวลา

โครงการวิจัยนี้เกี่ยวข้องกับสารเคมีที่ล่องลอยในอากาศบริเวณปั๊มน้ำมันซึ่งสารเคมีเหล่านี้หากคนงานรับสัมผัสสารเข้าไป จะมีผลกระทบทางสุขภาพทั้งในระยะสั้น (เฉียบพลัน) เช่น เวียนศีรษะ ไอ จาม ง่วงนอน และระยะยาวหากรับสัมผัสมาก่อนเป็นเวลานาน (เรื้อรัง) เช่น มะเร็งเม็ดเลือดขาว ซึ่งผู้วิจัยเห็นความสำคัญของปัญหาด้านมลพิษอากาศในปั๊มน้ำมัน ซึ่งอาจมีผลกระทบทางสุขภาพต่อคนงานได้ ดังนั้นงานวิจัยนี้จึงถือกำเนิดขึ้นจากความสำคัญของปัญหาดังกล่าวเพื่อประเมินความเสี่ยงภาวะสุขภาพทั้งในปัจจุบันและอนาคต

วัตถุประสงค์ของงานวิจัยชิ้นนี้มีวัตถุประสงค์เพื่อประเมินความเสี่ยงทางสุขภาพจากการรับสัมผัสสารเคมีของคนงานที่ทำงานภายในปั๊มน้ำมัน (ซึ่งต่อไปนี้จะเรียกว่า ผู้มีส่วนร่วมการวิจัย) บริเวณใจกลางเมืองและบริเวณชานเมือง บริเวณใจกลางเมืองคือปั๊มน้ำมันที่ติดถนนสุขุมวิท ส่วนบริเวณชานเมืองคือปั๊มน้ำมันที่อยู่ติดถนนบางนาตราด ซึ่งสาเหตุของการเลือกสถานที่วิจัยทั้งสองสถานที่นั้น ผู้วิจัยคาดว่าความเสี่ยงทางสุขภาพของผู้มีส่วนร่วมการวิจัยผลลัพธ์ที่ออกมานั้นคาดว่ามีความแตกต่างกันพอสมควร ดังนั้นผู้วิจัยจึงเลือกสถานที่เหล่านี้ทำการวิจัย

ผู้มีส่วนร่วมในการวิจัยต้องเป็นคนที่ทำงานอยู่ในปั๊มน้ำมันนั้นๆ โดยต้องทำงานในช่วงเดือน เมษายน 2554 โดยไม่ลาออกจากงานในช่วงเวลาดังกล่าว เกณฑ์การคัดเข้า คือ ผู้มีส่วนร่วมการวิจัยต้องใช้เวลาในการทำงานส่วนมากอยู่บริเวณที่กลางแจ้ง หรือบริเวณที่เติมน้ำมัน, มีภาวะสุขภาพที่ดีขณะทำการวิจัย, ไม่มีอาการเจ็บป่วยช่วงเก็บข้อมูล และอายุต้องมากกว่าหรือเท่ากับ 18 ปี ส่วนเกณฑ์การคัดออกนั้นคือ ผู้มีส่วนร่วมการวิจัยที่ทำงานที่ใช้เวลาส่วนใหญ่ในที่ร่ม หรือในร้านค้าในปั๊มน้ำมัน, คนท้องหรือหญิงมีครรภ์

ปั๊มน้ำมันในการวิจัยนี้มีอยู่ 6 สถานี ในแต่ละสถานีนั้นมีผู้มีส่วนร่วมการวิจัยที่ต้องประเมินความเสี่ยงทางสุขภาพจากการรับสัมผัสสารเคมี สถานีละ 2 คน รวมเป็น 12 คน ตลอดการวิจัยเพื่อให้บรรลุถึงวัตถุประสงค์ของงานวิจัยนี้ แต่เนื่องจากงานวิจัยชิ้นนี้มีการใช้แบบสอบถามกับผู้มีส่วนร่วมการวิจัยทุกคนที่ทำงานหน้าลานเติมน้ำมัน

ในปั๊มน้ำมันเพื่อเป็นการเก็บข้อมูลทั่วไปของผู้มีส่วนร่วมการวิจัยในปั๊ม ซึ่งเป็นส่วนสำคัญของงานวิจัยนี้อีกส่วนหนึ่ง (แบบสอบถามนั้นผู้วิจัยจะเก็บข้อมูลส่วนตัวของผู้มีส่วนร่วมการวิจัยไว้เป็นความลับ ไม่มีการเผยแพร่) ด้วยเหตุนี้ จำนวนผู้มีส่วนร่วมในการวิจัย จึงมีมากกว่า 12 คน ขึ้นอยู่กับผู้มีส่วนร่วมการวิจัยในปั๊มน้ำมันแต่ละปั๊มว่ามีกี่คน ซึ่งทางผู้วิจัยได้กำหนดผู้ตอบแบบสอบถามอย่างน้อยปั๊มละ 4 คน หรืออาจมากกว่าหากเป็นไปได้

ผู้วิจัยได้ทำการติดต่อบริษัท ปตท. จำกัด มหาชน, บริษัท เชฟรอน ประเทศไทย, และ บริษัท เชลล์ แห่งประเทศไทย เพื่อขออนุญาตทำการวิจัยในปั๊มน้ำมัน ในเครือของบริษัททั้งสามนี้เป็นที่เรียบร้อย และได้มีการติดต่อประสานงานกับผู้จัดการปั๊มน้ำมันในแต่ละปั๊มเป็นที่เรียบร้อยเช่นกัน เหลือเพียงแค่การกำหนดวันที่ชัดเจนล่วงหน้าก่อนที่ผู้วิจัยจะลงพื้นที่จริงเท่านั้น

เหตุผลที่ได้รับเชิญเข้าร่วมโครงการวิจัย ปั๊มน้ำมันทั้ง 6 แห่งติดถนนใหญ่ ซึ่งมีการจราจรที่หนาแน่น และสภาพแวดล้อมที่แตกต่างกันทั้งในตัวเมืองและชานเมือง มีความแตกต่างกัน ซึ่งเหมาะสมต่องานวิจัยชิ้นนี้ รวมถึงสะดวกต่อการเข้าถึง

การแบ่งกลุ่มผู้มีส่วนร่วมในการวิจัยนี้มีสองกลุ่ม กลุ่มแรกคือ กลุ่มที่ต้องถูกประเมินการรับสัมผัสสารเคมีในปั๊มน้ำมัน มีจำนวน 12 คน (2 คน/สถานี) ส่วนอีกกลุ่มคือ กลุ่มผู้ตอบแบบสอบถาม (รวมถึงคนที่อยู่ในกลุ่มแรกด้วย)

ผู้ดำเนินการวิจัยนี้คือตัวผู้วิจัยเองในการติดต่อขออนุญาตจากบริษัททั้งสามบริษัท และการติดต่อกับผู้จัดการปั๊มโดยตรง รวมถึงการลงพื้นที่จริงทั้งหมด ซึ่งมีสองหน้าที่ หน้าที่แรกคือ ผู้วิจัยจะใช้แบบสอบถามกับผู้มีส่วนร่วมการวิจัยในปั๊มน้ำมันทุกคน หน้าที่ที่ สอง คือ การติดตั้งเครื่องเก็บตัวอย่างอากาศกับร่างกายของผู้มีส่วนร่วมการวิจัยโดยตรง รวมถึงการถอดเครื่องมือออกหากครบกำหนดเวลา

ผู้วิจัยจะนำเครื่องเก็บตัวอย่างอากาศซึ่งสามารถพกติดตัวไปกับผู้มีส่วนร่วมการวิจัยได้ ติดตั้งไปกับตัวผู้มีส่วนร่วมการวิจัย (เหน็บเอว) ตลอด 8 ชั่วโมงการทำงาน ซึ่งก่อนการติดตั้งจะบอกผู้มีส่วนร่วมการวิจัยเสมอว่าเครื่องมือนี้ไม่เป็นอันตรายแต่อย่างใด ซึ่งเครื่องมือนี้จะติดตั้งไว้ตลอดการทำงาน 8 ชั่วโมง ของวันนั้นๆ โดยผู้วิจัยจะทำการติดตั้งเครื่องมือชนิดนี้สามครั้ง (สามวัน) โดยแบ่งเป็นช่วงต้นเดือน กลางเดือน และปลายเดือน อย่างละ หนึ่งวัน เพื่อให้งานวิจัยนี้มีความเที่ยงตรงมากขึ้น โดยใช้เวลา 8 ชั่วโมงต่อครั้ง

ก่อนทำการวิจัยในวันนั้นๆ ผู้วิจัยจะติดต่อเจ้าของปั๊มน้ำมันหรือผู้ดูแลก่อน ว่าต้องใช้ผู้มีส่วนร่วมการวิจัยกี่คน มีความปลอดภัยไหม หลังจากนั้นจะทำการอธิบายให้ผู้มีส่วนร่วมการวิจัยในปั๊มน้ำมันรับทราบเกี่ยวกับเครื่องเก็บตัวอย่างอากาศที่ใช้ในงานวิจัยว่ามีความปลอดภัยไม่มีอันตรายใดๆ หากผู้มีส่วนร่วมการวิจัยในปั๊มน้ำมันไม่เชื่อถือบางสิ่งบางอย่างจากผู้วิจัย ผู้วิจัยจะติดต่อเจ้าของปั๊มให้มาช่วยอธิบายร่วมกับผู้วิจัยโดยตรง เพื่อความสบายใจของผู้ร่วมวิจัย

หากเกิดกรณีหรือเหตุสุดวิสัยเกี่ยวกับการมาทำงานของผู้มีส่วนร่วมการวิจัยในปั๊มน้ำมันซึ่งโดยปกติแล้ว เกณฑ์การคัดเข้าของผู้มีส่วนร่วมการวิจัยที่ต้องติดตั้งเครื่องเก็บตัวอย่างอากาศไว้กับตัว ควรจะเป็นคนๆเดียวกันตลอดงานวิจัย ซึ่งหากมีเหตุจำเป็น ผู้มีส่วนร่วมการวิจัยคนนั้นๆไม่สามารถมาทำงานในวันที่ผู้วิจัยจะเข้ามาเก็บตัวอย่าง ทางผู้วิจัยจะหาผู้มีส่วนร่วมการวิจัยคนอื่นที่ผ่านเกณฑ์การคัดเข้าจากทางผู้วิจัยอีกครั้งหนึ่งตามความเหมาะสม

งานวิจัยนี้ไม่มีอันตรายใดๆกับผู้มีส่วนร่วมการวิจัยในปั๊มน้ำมัน และทางผู้วิจัยได้เตรียมสิ่งตอบแทนสำหรับผู้มีส่วนร่วมในงานวิจัย คือค่าตอบแทนคนละ 200 บาท

งานวิจัยนี้จะเป็นประโยชน์ในการวางนโยบายการป้องกันการรับสัมผัสสารเคมีภายในบริเวณปั๊มน้ำมันในอนาคต เพื่อคุณภาพชีวิตที่ดีของคนงานในปั๊มน้ำมัน การเข้าร่วมเป็นกลุ่มประชากรหรือผู้มีส่วนร่วมในการวิจัยเป็นโดยสมัครใจ และสามารถปฏิเสธที่จะเข้าร่วมหรือถอนตัวจากการวิจัยได้ทุกขณะ โดยไม่ต้องให้เหตุผลและไม่สูญเสียประโยชน์ที่พึงได้รับ

หากท่านมีข้อสงสัยให้สอบถามเพิ่มเติมได้โดยสามารถติดต่อผู้วิจัยได้ตลอดเวลา และหากผู้วิจัยมีข้อมูลเพิ่มเติมที่เป็นประโยชน์หรือโทษเกี่ยวกับการวิจัย ผู้วิจัยจะแจ้งให้ท่านทราบอย่างรวดเร็ว เพื่อให้ผู้มีส่วนร่วมในการวิจัยทบทวนว่ายังสมัครใจจะอยู่ในงานวิจัยต่อไปหรือไม่

หากท่านไม่ได้รับการปฏิบัติตามข้อมูลดังกล่าวสามารถร้องเรียนได้ที่ คณะกรรมการพิจารณาจริยธรรมการวิจัยในคนกลุ่มสหสถาบัน ชุดที่ 1 จุฬาลงกรณ์มหาวิทยาลัย ชั้น 4 อาคารสถาบัน 2 ซอยจุฬาลงกรณ์ 62 ถนนพญาไท เขตปทุมวัน กรุงเทพฯ 10330 โทรศัพท์ 0-2218-8147 โทรสาร 0-2218-8147 E-mail: eccu@chula.ac.th

เลขที่โครงการวิจัย 027.2/54
วันที่รับรอง 0 2 พ.ค. 2554
วันหมดอายุ 0 1 พ.ค. 2555

APPENDIX G

INFORMED CONSENT FORM

หนังสือแสดงความยินยอมเข้าร่วมการวิจัย

คำแนะนำ: โปรดปรับข้อความให้สอดคล้องกับโครงการวิจัยของท่าน

ทำที่ ชั้น 11 อาคารสถาบัน 3 วิทยาลัยวิทยาศาสตร์
สาธารณสุข จุฬาลงกรณ์มหาวิทยาลัย
วันที่ 17 เดือน มกราคม พ.ศ. 2554

เลขที่ ประชากรตัวอย่างหรือผู้มีส่วนร่วมในการวิจัย…................……

ข้าพเจ้า ซึ่งได้ลงนามท้ายหนังสือนี้ ขอแสดงความยินยอมเข้าร่วมโครงการวิจัย

ชื่อโครงการวิจัย *การประเมินความเสี่ยงทางสุขภาพของคนงานในสถานประกอบการน้ำมันทางการหายใจในกรุงเทพมหานคร ประเทศไทย*

ชื่อผู้วิจัย นายสุคท นพรัตนบัณฑิต

ที่อยู่ที่ติดต่อ 16/1 ถนนสุรวงศ์ แขวงสี่พระยา เขตบางรัก กรุงเทพมหานคร 10500

โทรศัพท์ 022332353, 0879221711

เลขที่โครงการวิจัย 027.2/54
วันที่รับรอง 02 พ.ค. 2554
วันหมดอายุ 01 พ.ค. 2555

ข้าพเจ้า **ได้รับทราบ**รายละเอียดเกี่ยวกับที่มาและวัตถุประสงค์ในการทำวิจัย รายละเอียดขั้นตอนต่างๆ ที่จะต้องปฏิบัติหรือได้รับการปฏิบัติ ความเสี่ยง/อันตราย และประโยชน์ซึ่งจะเกิดขึ้นจากการวิจัยเรื่องนี้ โดยได้อ่านรายละเอียดในเอกสารชี้แจงผู้เข้าร่วมการวิจัยโดยตลอด และ**ได้รับคำอธิบาย**จากผู้วิจัย **จนเข้าใจเป็นอย่างดี**แล้ว

ข้าพเจ้าจึง**สมัครใจ**เข้าร่วมในโครงการวิจัยนี้ ตามที่ระบุไว้ในเอกสารชี้แจงผู้เข้าร่วมการวิจัย โดยข้าพเจ้ายินยอม....

1. *ข้าพเจ้ายินยอมตอบแบบสอบถามเพื่อประเมินความเสี่ยงทางสุขภาพของคนงานในสถานประกอบการน้ำมัน จำนวน 25 ข้อ*
2. *ติดเครื่องมือที่ทางผู้วิจัยได้จัดเตรียมไว้ให้เป็นเวลา 8 ชั่วโมงต่อครั้ง เป็นจำนวน สาม วัน (ช่วงต้นเดือน 1 วัน กลางเดือน 1 วัน และปลายเดือนอีก 1 วัน)*

ข้าพเจ้ามีสิทธิ**ถอนตัว**ออกจากการวิจัยเมื่อใดก็ได้ตามความประสงค์ **โดยไม่ต้องแจ้งเหตุผล** ซึ่งการถอนตัวออกจากการวิจัยนั้น จะไม่มีผลกระทบในทางใดๆ ต่อข้าพเจ้าทั้งสิ้น

ข้าพเจ้าได้รับคำรับรองว่า ผู้วิจัยจะปฏิบัติต่อข้าพเจ้าตามข้อมูลที่ระบุไว้ในเอกสารชี้แจงผู้เข้าร่วมการวิจัย และข้อมูลใดๆ ที่เกี่ยวข้องกับข้าพเจ้า ผู้วิจัยจะ**เก็บรักษาเป็นความลับ** โดยจะนำเสนอข้อมูลการวิจัยเป็นภาพรวมเท่านั้น ไม่มีข้อมูลใดในการรายงานที่จะนำไปสู่การระบุตัวข้าพเจ้า

หากข้าพเจ้าไม่ได้รับการปฏิบัติตรงตามที่ได้ระบุไว้ในเอกสารชี้แจงผู้เข้าร่วมการวิจัย ข้าพเจ้าสามารถร้องเรียนได้ที่คณะกรรมการพิจารณาจริยธรรมการวิจัยในคน กลุ่มสหสถาบัน ชุดที่ 1 จุฬาลงกรณ์มหาวิทยาลัย ชั้น 4 อาคารสถาบัน 2 ซอยจุฬาลงกรณ์ 62 ถนนพญาไท เขตปทุมวัน กรุงเทพฯ 10330 โทรศัพท์ 0-2218-8147 โทรสาร 0-2218-8147 **E-mail: eccu@chula.ac.th**

ข้าพเจ้าได้ลงลายมือชื่อไว้เป็นสำคัญต่อหน้าพยาน ทั้งนี้ข้าพเจ้าได้รับสำเนาเอกสารชี้แจงผู้เข้าร่วมการวิจัย และสำเนาหนังสือแสดงความยินยอมไว้แล้ว

ลงชื่อ.. ลงชื่อ..

(..) (..)

ผู้วิจัยหลัก ผู้มีส่วนร่วมในการวิจัย

ลงชื่อ..

(..)

พยาน

เลขที่โครงการวิจัย ....027.2/54....

วันที่รับรอง ....02 พ.ค. 2554....

วันหมดอายุ ....01 พ.ค. 2555....

BIOGRAPHY

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