UNIVERSITI PUTRA MALAYSIA

OCCURRENCE OF COMMONLY USED PESTICIDES IN PERSONAL AIR SAMPLES AND THEIR ASSOCIATED HEALTH RISK AMONG PADDY FARMERS IN TANJUNG KARANG, MALAYSIA

HAZWANEE BINTI MOHAMAD HAMSAN

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By

HAZWANEE BINTI MOHAMAD HAMSAN

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,
in Fulfilment of the Requirements for the Degree of
Master of Science

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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November 2017

Chair : Ho Yu Bin, PhD
Faculty : Medicine and Health Sciences

Introduction: Tanjung Karang, Selangor is widely known for its paddy cultivation activity and hosts the third largest paddy field in Malaysia. Pesticides contamination in agriculture fields has become an unavoidable problem and farmers are the major group of workers who are constantly handling pesticides. The occupational exposure to pesticides via inhalation could results in both acute and chronic health effects. **Objective:** This study aims to quantify the concentration of the commonly used pesticides (azoxystrobin, buprofezin, chlorantraniliprole, difenoconazole, fipronil, imidacloprid, isoprothiolane, pretilachlor, propiconazole, pymetrozine, tebuconazole, tricyclazole and trifloxystrobin) in personal air samples, assess their potential health risk to paddy farmers, determine the correlations between climatological conditions (wind speed and temperature) and the concentration of pesticides in personal air samples, determine the association between the proper usage of personal protective equipment (PPE) and self reported respiratory health symptoms among paddy farmers and determine the relationship between self reported respiratory health symptoms and pesticides exposure among paddy farmers. **Methodology:** A cross-sectional study was carried out at Tanjung Karang, Selangor and eighty-three farmers were involved in this study. A solid sorbent tube was attached to the farmer's breathing zone with a clip, and an air pump was fastened to the belt to collect personal air samples. Pesticides collected in the XAD-2 resin were extracted with acetone, centrifuged, concentrated via nitrogen blowdown and reconstituted with 1 mL of 3:1 ultrapure water:High-performance liquid chromatography (HPLC)-grade methanol solution. The extract was analyzed using ultra-high performance liquid chromatography tandem mass spectrometry (UHPLC-MS/MS). The health risk of pesticides due to inhalation exposure was calculated for non-carcinogenic (hazard quotients (HQ) and hazard index (HI)) and carcinogenic (lifetime cancer risk (LCR)) health risk. **Result:** The target compounds were detected with a maximum concentration reaching up to 462.50 ng m^{-3} (fipronil) and pretilachlor had the highest mean concentration (107.19 ng m^{-3}). The HQ was less than 1 for all the target compounds and the HI value was 3.86×10^{-3}, indicating that the risk of pesticides related diseases was not significant. The LCR for pymetrozine was at an acceptable level ($LCR<10^{-6}$) with 4.10×10^{-8}. The self-reported respiratory health symptoms by the paddy farmers reported in this study are as follows: breathing difficulty (16.9%),

chest pain (15.7%), cough (41.0%), phlegm (39.8%), and wheezing (18.1%). Spearman's correlation coefficient test stated that the concentrations of chlorantraniliprole, fipronil and pymetrozine were affected by windspeed and temperature. Simple logistic regressions analysis indicated that exposure to azoxystrobin, buprofezin, chlorantraniliprole, fipronil, isoprothiolane, pretilachlor, propiconazole, tricyclazole and trifloxystrobin were contributing factors that affect self-reported respiratory health symptoms in this study. **Conclusion:** There were no significant non-carcinogenic and carcinogenic health risks among farmers in the study area. The results reported in this study can be beneficial in terms of risk management within the agricultural community and contributed to the knowledge of pesticides exposure to farmers working on paddy fields in Malaysia.

(Keywords: Pesticides; Air; Inhalation; Malaysia; Ultra-high-performance liquid chromatography tandem mass spectrometry (UHPLC-MS/MS); Hazard Quotient (HQ); Hazard Index (HI); Lifetime cancer risk (LCR))

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains

KEHADIRAN RACUN PEROSAK YANG SELALU DIGUNAKAN DALAM SAMPEL UDARA PERIBADI DAN RISIKO KESIHATAN YANG BERKAITAN DI KALANGAN PESAWAH PADI DI TANJUNG KARANG, MALAYSIA

Oleh

HAZWANEE BINTI MOHAMAD HAMSAN

November 2017

Pengerusi : Ho Yu Bin, PhD
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Pengenalan: Tanjung Karang, Selangor adalah terkenal dengan aktiviti penanaman padi dan merupakan kawasan sawah padi ketiga terbesar di Malaysia. Pencemaran racun perosak di bidang pertanian merupakan masalah yang tidak dapat dielak dan pesawah padi adalah kumpulan pekerja utama yang kerap mengendalikan racun perosak. Pendedahan racun perosak di tempat kerja melalui penyedutan boleh menyebabkan kedua-dua kesan kesihatan akut dan kronik. **Objektif:** Kajian ini adalah bertujuan untuk menentukan kepekatan racun perosak yang selalu digunakan (azoxystrobin, buprofezin, chlorantraniliprole, difenoconazole, fipronil, imidacloprid, isoprothiolane, pretilachlor, propiconazole, pymetrozine, tebuconazole, tricyclazole and trifloxystrobin) dalam sampel udara peribadi, menilai risiko kesihatan yang berpotensi untuk pesawah padi, menentukan korelasi antara keadaan klimatologi (kelajuan angin dan suhu) dan kepekatan racun perosak dalam sampel udara peribadi, menentukan kaitan antara penggunaan alat perlindungan peribadi dengan betul dan simptom kesihatan pernafasan yang dilaporkan sendiri dalam kalangan pesawah padi dan menentukan hubungan antara simptom kesihatan pernafasan yang dilaporkan sendiri dan pendedahan kepada racun perosak dalam kalangan pesawah padi. **Methodologi:** Kajian keratan rentas telah dijalankan di Tanjung Karang, Selangor dan lapan puluh tiga responden telah terlibat dalam kajian ini. Penapis gentian kaca ditempatkan di zon pernafasan pesawah padi dengan klip, dan pam udara diletakkan pada tali pinggang untuk mengumpul sampel udara peribadi. Racun perosak terperangkap di resin XAD -2 telah diekstrak dengan aseton, disentrifugasi, dikeringkan menggunakan nitrogen dan di campurkan dengan 1 mL daripada 3:1; air ultrapure:Cecair kromatografi berprestasi tinggi (HPLC)-gred metanol. Ekstrak dianalisis menggunakan cecair kromatografi prestasi ultra-tinggi seiring spektrometri jisim (UHPLC-MS/MS). Kesan kesihatan racun perosak yang disebabkan oleh pendedahan udara telah dikira untuk bukan karsinogen (bahaya hasil bahagi (HQ) dan indeks bahaya (HI)) dan karsinogen (kesan kanser seumur hidup (LCR)). **Keputusan:** Kepekatan tertinggi mencecah sehingga 462.50 ng m^{-3} (fipronil) dan pretilachlor adalah kompaun yang mempunyai purata kepekatan tertinggi (107.19 ng m^{-3}). HQ adalah kurang dari 1 untuk semua kompaun yang dipilih dan nilai HI adalah 3.86×10^{-3}, menunjukkan bahawa risiko penyakit yang disebabkan oleh racun perosak adalah tidak ketara. LCR untuk pymetrozine adalah di

aras yang boleh diterima (LCR<10^{-6}) dengan 4.10 × 10^{-8}. Simptom kesihatan pernafasan yang dilaporkan sendiri oleh pesawah padi dalam kajian ini adalah seperti berikut: kesukaran bernafas (16.9%), sakit atau sesak dada (15.7%), batuk (41.0%), kahak (39.8%), and berdehit (18.1%). Ujian korelasi Spearman's menunjukkan bahawa kepekatan chlorantraniliprole, fipronil dan pymetrozine adalah terjejas oleh kelajuan angin dan suhu. Analisis logistik regresi mudah mendakwa bahawa pendedahan kepada azoxystrobin, buprofezin, chlorantraniliprole, fipronil, isoprothiolane, pretilachlor, propiconazole, tricyclazole dan trifloxystrobin merupakan faktor penyumbang yang menyebabkan simptom kesihatan pernafasan yang dilaporkan sendiri dalam kajian ini. **Kesimpulan:** Tidak ada risiko kesihatan bukan karsinogen dan karsinogen ketara di kalangan pesawah padi di kawasan kajian. Keputusan yang dilaporkan dalam kajian ini adalah berguna dalam pengurusan risiko dalam komuniti pertanian dan menyumbang kepada ilmu pendedahan kepada racun perosak kepada pesawah padi yang bekerja di sawah padi di Malaysia.

(Kata kunci: Racun perosak; Udara; Penyedutan; Malaysia; Cecair kromatografi prestasi ultra-tinggi seiring spektrometri jisim (UHPLC-MS/MS); Bahaya hasil bahagi (HQ); Indeks bahaya (HI); Risiko kanser seumur hidup (LCR))

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I would also like to dedicate my appreciation to all the farmers for their cooperation and participation in this study.

I certify that a Thesis Examination Committee has met on 8 November 2017 to conduct the final examination of Hazwanee binti Mohamad Hamsan on her thesis entitled "Occurrence of Commonly Used Pesticides in Personal Air Samples And their Associated Health Risk among Paddy Farmers in Tanjung Karang, Malaysia" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

Members of the Thesis Examination Committee were as follows:

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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Declaration by graduate student

I hereby confirm that:

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Declaration by Members of Supervisory Committee

This is to confirm that:

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Committee: _____

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

ADD	Average Daily Dose
AOEL	Acceptable Operator Exposure Levels
AT	Averaging Time
BW	Body Weight
CE	Collision Energy
CAS	Chemical Abstracts Service
CSF	Cancer Slope Factor
DOA	Department of Agriculture Malaysia
DOS	Department of Standards Malaysia
ED	Exposure Duration
EF	Exposure Frequency
ESI	Electrospray Ionization
EU	European Union
FAO	Food and Agriculture Organization
FFDCA	Federal Drugs, Food and Cosmetic Act
FIFRA	Federal Insecticides, Fungicides and Rodenticides Act
GHS	Globally Harmonized System
GPS	Global Positioning System
HBRV	Health Based Reference Values
HCL	Hydrochloric Acid
HI	Hazard Index
HQ	Hazard Quotients
HRA	Health Risk Assessment

IDL	Instrumental Detection Limit
IQL	Instrumental Quantification Limit
IS	Internal Standards
IUPAC	International Union of Pure and Applied Chemistry
JKEUPM	University Research Ethics Committee of Universiti Putra Malaysia
LADD	Lifetime Average Daily Dose
LCR	Lifetime Cancer Risk
LogP	Partition Coefficient
LT	Lifetime
MDL	Method Detection Limit
MQL	Method Quantification Limit
NA	Not Applicable
NAFP	National Agro-Food Policy
NCBI	National Center for Biotechnology Information
NIOSH	National Institute of Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
PELs	Permissible Exposure Limits
PPE	Personal Protective Equipment
PRIA	Pesticide Registration Improvement Extension Act
QC	Quality Control
RELs	Recommended Exposure Limits
RM	Malaysian Ringgit
RSC	Royal Society of Chemistry

RSD	Relative Standard Deviation
SD	Standard Deviations
SDS	Safety Data Sheet
TC	Testing and Certification
UHPLC-MS/MS	Ultra-High Performance Liquid Chromatography Tandem Mass Spectrometry
UK	United Kingdom
US	United States
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
WHO	World Health Organization

CHAPTER 1

INTRODUCTION

1.1 Background of study

In the last decades, high population growth combined with an increasing in rice demand has led to an intensification of rice production (USEPA, 2017). Rice production is done in paddy field and paddy field farming is widely practiced in Malaysia, Cambodia, Bangladesh, China, Taiwan, India, Indonesia, Japan, North Korea, South Korea, Myanmar, Nepal, Pakistan, the Philippines, Sri Lanka, Thailand, Vietnam and Laos as well as in the USA and Europe (USEPA, 2017). Increasing levels of rice yield are achieved by the introduction of high-yielding, short-duration varieties in association with a wider use of agrochemicals, particularly pesticides which are applied to prevent, mitigate or destroy pests (USEPA, 2017). The amount of pesticides used in paddy field area has increased dramatically and their toxic nature has raised concern about environmental impact and effects on human health.

Rice is the most economical and culturally important food crop among the Asian as rice is a staple food in many parts of Asia with Malaysians averagely consuming two and half plates of rice per day (Norimah et al., 2008). As a primary source of food in Malaysia, the paddy and rice industry has been given special attention by the government and is considered an important sector of the economy (Ramli, Shamsudin, Mohamed, and Radam, 2012). Paddy yields have been increasing since the 1960s, but since 1990s, the increase in rice production has been slower than population growth and it is anticipated that rice production will need to be increased by 30% by 2025 in order to cater for the world's growing population (Tarnanidis, Vlachopoulou, and Papathanasiou, 2017).

In an effort to increase rice production, the use of pesticides has become relatively prevalent. According to the Department of Agriculture (DOA), about 3000 pesticide products have been registered from April 2008 to March 2013 (DOA, 2013). Pesticides ranging from insecticide, fungicide, herbicide and rodenticide are littered in farms in Malaysia (DOA, 2013). While pesticides are widely used to control agricultural pests, a previous study conducted by Greene and Pohanish (2005), shown that less than 0.1% of applied pesticide actually reach the target pest, with the remaining spread into the environment, with consequent effects on farmers, consumers, air, soil and water. Pesticides act as a crucial tool to increase land productivity, minimize crop damage, and to ensure that the quantity and quality of agricultural products can be protected (Aktar et al., 2009).

Despite the numerous benefits that could come from the usage of pesticides, the risk of environmental contamination and effects to human health remains a major concern. According to Aktar et al. (2009), these chemical can enter the environment via various routes, such as spraying activities, soil seepage and water contamination. Moreover, the persistent nature and high toxicity of these pesticides can be detrimental to public health when exposed, either through consumption, dermal contact or inhalation (Kim et al., 2017).

Pesticides have been suggested to cause neurological, respiratory, gastrointestinal and dermatological problems, which could result in heart attacks, coma or even death (Arya, 2004). The acute effects of exposure to pesticides are skin and eye irritation, headaches, nausea and dizziness while chronic effects are asthma, diabetes, and cancer (Kim et al., 2017). Besides that, Van Maele-Fabry, Lantin, Hoet, and Lison (2010) suggested that diseases such as cancer, hormone disruption, asthma, allergies, and hypersensitivity have been linked with exposure to pesticides. For example, Lerro, Lubin, Ma, Zhang, and Freeman (2016) demonstrated an increased in the risk of lung cancer among users of herbicides and product mixtures compared to non-users. Meanwhile, Hernandez, Parron, and Alarcon (2011) and Amaral (2014) reported that the exposure of pesticide may contribute to the exacerbation of asthma through inflammation, irritation, immunosuppression, or endocrine disruption. The data collected from European Union (EU) showed that some pesticides are listed as suspected endocrine disrupting compounds, thus increasing the health concern regarding the endocrine-disrupting potential of pesticides (EU, 2016). Based on a study by Kjeldsen, Ghisari, and Bonefeld-Jorgensen (2013), the results showed that currently used pesticides in Denmark (terbuthylazine, bitertanol, propiconazole, prothioconazole, mancozeb, cypermethrin and malathion) had potential to disrupt the endocrine homeostasis by interfering with sex steroid hormone receptors and aromatase enzyme activity.

Farmers are the major group of workers who are constantly handling pesticides. According to Jaipieam, Visuthismajarn, Siriwong, Borjan, and Robson (2009), they are exposed to pesticide residues via direct and indirect inhalation during the preparation (mixing and loading) and application (spraying) of pesticides. Upon inhalation, pesticides are absorbed through the lung surface, and the harmful chemicals then penetrate into the blood stream and are circulated to the rest of the body (Jaipieam, Visuthismajarn, Siriwong, Borjan, and Robson , 2009).

1.2 Problem statement

The common routes for pesticide exposures are through dermal and inhalation. However, only inhalation exposure was investigated in this study. This is because a majority of the paddy farmers in the observation area used proper PPE against dermal exposure but went without proper protection for inhalation exposure. The safe handling of agricultural pesticides - Code of recommended practice (MS 479:2012) as developed by the Department of Standards Malaysia and SIRIM Berhad was referred to ensure the farmers had adequate dermal and inhalation protection (DOS, 2012).

Kampung Sawah Sempadan are located in the district of Tanjung Karang in the State of Selangor and have been selected as the study area on account of it being the third largest area of paddy field in Peninsular Malaysia and is also known as 'the rice bowl of Selangor'. It covers 14,848 acres of rice field with 2194 families of farmers and producing an average of 3.8 ton of rice per hectare per year (Fuad et al., 2012).

In order to determine the risk of inhalation exposure to pesticides, a quantitative measure of the risk could be generated via the health risk assessment (HRA) (Williams and Burson, 1985). Currently, no studies have reported the assessment of chronic carcinogenic and non-carcinogenic health risk based on occupational exposure of pesticides in personal air samples. Figure 1.1 shows that the farmers are at risk of inhalation exposure to pesticide during spraying activity. The risk of exposure further increases with the absences of personal protective equipment (PPE) and poor personal hygiene (Baharuddin, Sahid, Noor, Sulaiman, and Othman, 2011). Based on a review by Mamane et al. (2015), 12 out of 15 cross-sectional studies linked occupational pesticides exposure with respiratory diseases or symptoms such as chronic wheeze, cough, dyspnea, chest tightness and breathlessness. Besides that, frequent exposure of more than twice a month was shown to result in a higher prevalence of respiratory symptoms according to Faria, Facchini, Fassa, and Tomasi (2005). Figure 1.2 shows that the paddy farmer in the study area neglected usage of respirators as a proper PPE to reduce the inhalation exposure to pesticides during spraying activity.

To date, there have been many studies focusing on pesticide exposure in ambient air (Alegria, Bidleman, and Figueroa, 2006; Batterman, Chernyak, Gounden, Matooane, and Naidoo, 2008; Coscollà et al., 2010; Coscollà, Castillo, Pastor, and Yusà, 2011; Coscollà, Hart, Pastor, and Yusà, 2013; Coscollà, Yusà, Beser, and Pastor, 2009; Coscollà, Muñoz, et al., 2014; Coscollà, León, Pastor, and Yusà, 2014; Kallenborn, Oehme, Wynn-Williams, Schlabach, and Harris, 1998; Lin et al., 2015; López et al., 2017; López, Yusà, Millet, and Coscollà, 2016; Yang, Li, and Mu, 2008; V Yusà, Coscollà, Mellouki, Pastor, and de la Guardia, 2009; Vicent Yusà, Coscollà, and Millet, 2014; Zhao et al., 2015). However, there are not many studies on the concentration of pesticides in personal air samples. Among the few were reports on the concentrations of imidacloprid (Choi, Moon, and Kim, 2013), chlorpyrifos, dicrotophos, profenofos (Jaipieam, Visuthismajarn, Siriwong, Borjan, and Robson, 2009), 2,4-D, paraquat (Baharuddin, Sahid, Noor, Sulaiman, and Othman, 2011), atrazine (Lozier et al., 2013), penconazole (Tsakirakis et al., 2014) and amitraz (Aghasil, Hashim, Mehrabani, Omar, and Moin, 2010). These papers however, were specific case studies in Korea, Thailand, Honduras, Greece, Iran and there have been limited case studies in Malaysia regarding this issue. On top of that, 12 out of 13 target compounds investigated in this present study have never been reported in personal air samples before this.

This study aims to quantify the concentration of the commonly used pesticides in personal air samples and assess their potential health risk to the paddy farmers. The target compounds in this study were selected based on interviews with the farmers. The interview was conducted six months before the collection of personal air samples in order to identify the commonly used pesticides among the paddy farmers in the study area. The most applied pesticides were selected as the target compounds in this study.

The final list of target compounds contained a total of 13 compounds, which were azoxystrobin, buprofezin, chlorantraniliprole, difenoconazole, fipronil, imidacloprid, isoprothiolane, pretilachlor, propiconazole, pymetrozine, tebuconazole, tricyclazole and trifloxystrobin.

Figure 1.1: Spraying activities by the paddy farmers in *Kampung* Sawah Sempadan, Tanjung Karang, Selangor

Figure 1.2: One of the paddy farmers in the study area who used an old t-shirt to cover their breathing zone during spraying activity

1.3 Research justification

Tanjung Karang is a paddy growing town in Selangor, Malaysia. The paddy farmers in Tanjung Karang were using pesticides to control pests from invading the crops during agricultural activities with limited knowledge of its deleterious effects on health especially on respiratory health. Most of the paddy farmers in the study location did not wear proper PPE against exposure to pesticide via inhalation. Paddy farmers are enormously vulnerable as they are exposed to high level of pesticides due to the nature of their working environment (Rola and Pingali, 1993). The lack of awareness among farmers regarding safety protocol while handling pesticides, may lead to chronic health effects after long term exposure, such as cancer, neurobehavioral changes, liver abnormalities and kidney dysfunction (Kaplan, 2002).

Limited studies were found on the assessment of inhalation exposure to pesticides among paddy farmers. To the best of the author knowledge, there are no studies on the personal air samples and non-carcinogenic and carcinogenic health risk assessment of exposure to pesticides among paddy farmers. The occurrence data of pesticides in Malaysian paddy field and the health risk assessment farmers in this study is of great importance in awakening the public understanding and concerns on the hazardous health effects of occupational exposure of pesticide among paddy farmers in Malaysia.

Specifically, the significances of the study are listed below:

i. 12 out of 13 target compounds (azoxystrobin, buprofezin, chlorantraniliprole, difenoconazole, fipronil, isoprothiolane, pretilachlor, propiconazole, pymetrozine, tebuconazole, tricyclazole and trifloxystrobin) in this study were first time investigated in personal air samples.
ii. The non-carcinogenic and carcinogenic health risk assessment of inhalation exposure of pesticide among paddy farmers for all the target compounds were first time reported in this study.
iii. The information obtained in this study is useful for risk management in the agricultural community to significantly reduce the exposure to pesticide among paddy farmers and lower the risk of health hazards cause by inhalation of pesticides.

1.4 Conceptual framework

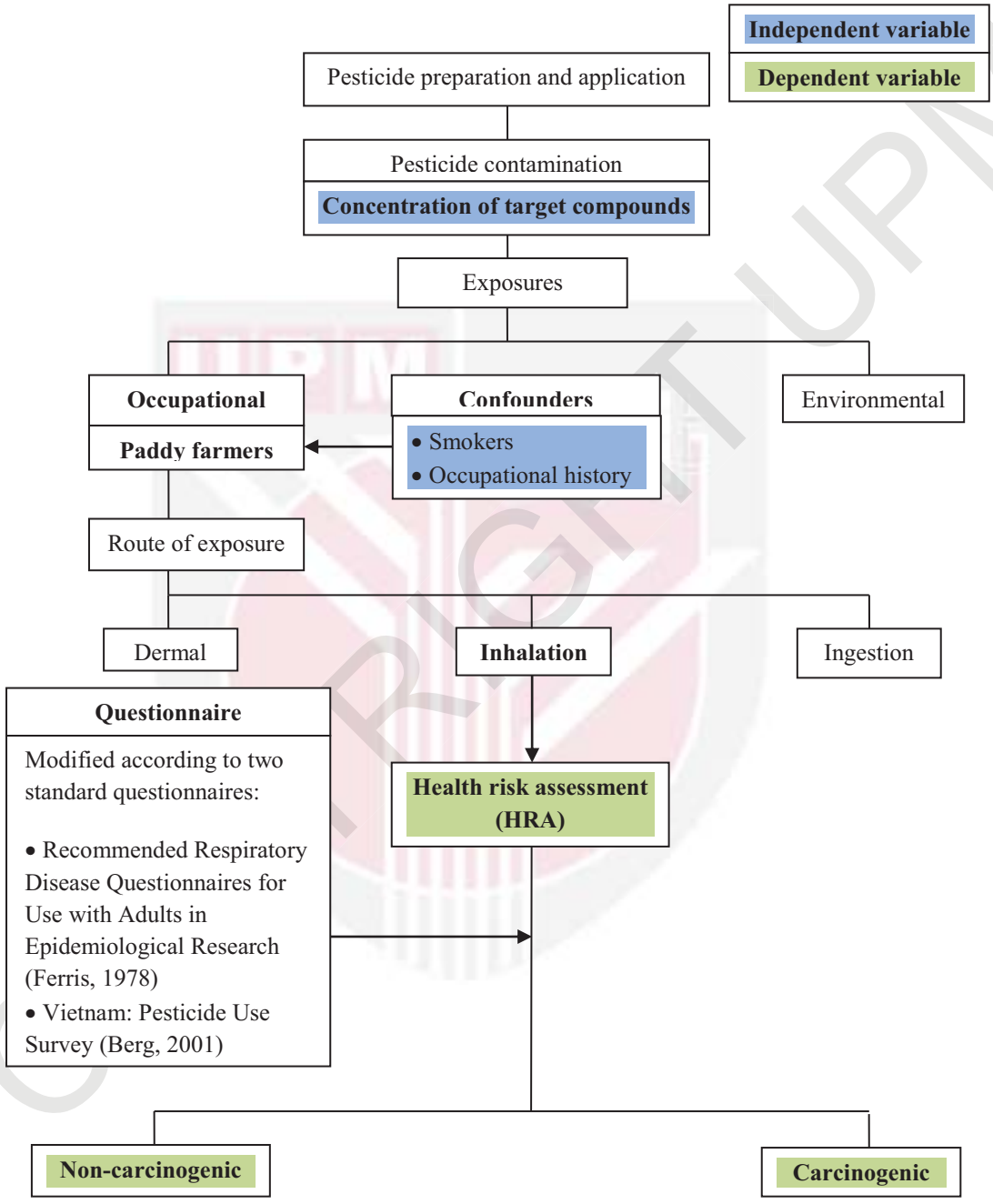

Figure 1.3: Conceptual framework

1.5 Research question

The present study is able to answer the following questions:

i) Do the personal air samples collected from paddy farmers in Tanjung Karang, Kuala Selangor contaminated with pesticides?
ii) Does spraying off pesticides cause any potential non-carcinogenic and carcinogenic health risk due to inhalation among the paddy farmers?
iii) Is there any correlation between the climatological conditions and the concentration of pesticides in personal air samples?
iv) Is there any association between the use of PPE and self-reported respiratory health symptoms among paddy farmers?

1.6 Objectives

1.6.1 General objective

This study aims to determine the concentrations of commonly used pesticides (azoxystrobin, buprofezin, chlorantraniliprole, difenoconazole, fipronil, imidacloprid, isoprothiolane, pretilachlor, propiconazole, pymetrozine, tebuconazole, tricyclazole, and trifloxystrobin) in personal air samples and their associated health risks among paddy farmers in Tanjung Karang, Kuala Selangor.

1.6.2 Specific objectives

i. To determine the concentration of commonly used pesticides in the personal air samples collected from paddy farmers at Tanjung Karang, Kuala Selangor paddy field.
ii. To assess the potential non-carcinogenic and carcinogenic health risk of paddy farmers at Tanjung Karang, Kuala Selangor due to inhalation of pesticides contaminated air during the spraying activity.
iii. To determine the correlations between climatological conditions (wind speed and temperature) and the concentration of pesticides in personal air samples.
iv. To determine the association between the proper usage of personal protective equipment (PPE) and self reported respiratory health symptoms among paddy farmers.

1.7 Hypothesis

i. There is significant correlations between climatological conditions (wind speed and temperature) and the concentration of pesticides in personal air samples.
ii. There is significant association between the proper usage of PPE and self reported respiratory health symptoms among the paddy farmers.

1.8 Ethical considerations

All respondents were briefed on the study and signed a written informed consent. The study was approved by the University Research Ethics Committee of Universiti Putra Malaysia, Selangor, Malaysia (JKEUPM) [Ref: FPSK (EXP15) P019].

The information obtained in this study is useful for risk management in the agricultural community to significantly reduce the exposure to pesticide among paddy farmers and lower the risk of health hazards cause by inhalation of pesticides. Besides that, this study also contributed to the knowledge of pesticides exposure to farmers working on paddy fields in Malaysia.

5.2 Recommendations

5.2.1 Authorities

Based on the results from this study where majority of the farmers were not properly educated on the benefits of using proper PPE, authorities (e.g. Malaysia Farmer' Organization Authority) should provide training on proper handling of pesticides and proper usage of PPE to farmers to reduce the risk of exposure to pesticides.

5.2.2 Farmers

Farmers who handled pesticides during preparation and application should wear proper PPE against pesticide exposure.

5.2.3 Future research

In this study, health based references values (HBRV) of isoprothiolane, pretilachlor, and tricyclazole for health risk assessment was not available on existing databases. Thus, there is a need to develop HBRV for inhalation route which currently is lacking from database. The personal air samples were collected from the paddy farmers during their spraying hours. Thus, the pesticide contaminated air inhaled by respondents outside of their working hours was not considered. Therefore, there is a need to consider the background concentration of pesticides in ambient air. Farmers and the residents living around the area may be exposed to pesticides. Further study may consider sampling the ambient air at the vicinity of farmers housing area to get the full exposure to pesticides of the farmers as well as the residents living around the paddy field.

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