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OCCURRENCE OF ISOPROTHIOLANE, TRICYCLAZOLE AND PROPICONAZOLE IN PERSONAL AIR SAMPLES AND THEIR REPORTED HEALTH SYMPTOMS AMONG PADDY FARMERS ANDNON-EXPOSED GROUP IN TANJUNG KARANG, SELANGOR

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BY

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Thesis submitted in fulfilment of the requirement for the degree of Bachelor Science (Environmental and Occupational Health) from the Faculty of Medicine and Health Sciences, Universiti Putra Malaysia.

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ABSTRACT

OCCURRENCE OF ISOPROTHIOLANE, TRICYCLAZOLE AND PROPICONAZOLE IN PERSONAL AIR SAMPLES AND THEIR REPORTED HEALTH SYMPTOMS AMONG PADDY FARMERS AND NON-EXPOSED GROUP IN TANJUNG KARANG, SELANGOR

NADHIRAH BINTI MOHD SIDEK

Introduction: Tanjung Karang, Selangor is the third largest paddy field in Peninsular Malaysia and widely known for its paddy cultivation activity. Pesticides contamination in agriculture fields has become an unavoidable problem among paddy farmers and can contribute to adverse environmental and health consequences. **Objectives:** This study aims to determine the occurrence of pesticides (isoprothiolane, tricyclazole and propiconazole) in personal air samples and their reported health symptoms among paddy farmers and non-exposed group in Tanjung Karang, Selangor. **Methodology:** A comparative cross-sectional study was carried out at Tanjung Karang, Selangor and eighty-five paddy farmers and eighty-five office workers from non-exposed group were involved in this study. A solid sorbent tube was attached to the farmer's and office worker's breathing zone with a clip and an air pump was fastened to their 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: methanol solution. The extract was analysed using ultra-high performance liquid chromatography tandem mass spectrometry (UHPLC-MS/MS). **Results and Discussion:** The maximum concentrations of isoprothiolane, tricyclazole and propiconazole found in personal air samples were 178.9 ng m^{-3}, 433.0 ng m^{-3} and 138.3 ng m^{-3} respectively. The concentrations of target compounds were significantly different among paddy farmers and non-exposed group. The reported health symptoms among paddy farmers were significantly different compared to non-exposed group. The percentage of reported health symptoms among paddy farmers was higher compared to non-exposed group. The sociodemographic background (age and level of education) was significantly associated with the reported health symptoms among paddy farmers compared to non-exposed group. The lifestyle (smoking behaviour, consumption of vegetables and fruits at least once a week and exercise once a week) was significantly associated with the reported health symptoms among paddy farmers compared to non-exposed group. There was significant association between concentrations of isoprothiolane and tricyclazole with reported health symptoms among paddy farmers compared to non-exposed group. **Conclusion:** The results reported in this study can be beneficial in terms of risk management within the agricultural community.

Keywords: Pesticides, air, inhalation, ultra-high performance liquid chromatography tandem mass spectrometry (UHPLC-MS/MS), health symptoms

ABSTRAK

KEJADIAN RACUN PEROSAK DI DALAM SAMPEL UDARA PERIBADI DAN GEJALA KESIHATAN DALAM KALANGAN PESAWAH PADI DAN KUMPULAN YANG TIDAK TERDEDAH DI TANJUNG KARANG, SELANGOR

NADHIRAH BINTI MOHD SIDEK

Pengenalan: Tanjung Karang, Selangor adalah ladang padi ketiga terbesar di Semenanjung Malaysia dan dikenali ramai kerana aktiviti penanaman padi. Pencemaran racun perosak dalam bidang pertanian telah menjadi masalah yang tidak dapat dielakkan di kalangan petani padi dan dapat menyumbang kepada akibat buruk terhadap alam sekitar dan kesihatan. **Objektif:** Kajian ini bertujuan untuk menentukan kejadian racun perosak (isoprothiolane, tricyclazole dan 2,4-D) dalam sampel udara peribadi dan gejala kesihatan mereka yang dilaporkan di kalangan petani padi dan kumpulan tidak terdedah di Tanjung Karang, Selangor. **Metodologi:** Kajian keratan rentas perbandingan telah dijalankan di Tanjung Karang, Selangor dan lapan puluh lima pesawah padi dan lapan puluh lima pekerja pejabat daripada kumpulan tidak terdedah telah terlibat dalam kajian ini. Penapis gentian kaca ditempatkan di zon pernafasan pesawah padi dan pekerja pejabat 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 methanol. Ekstrak dianalisis menggunakan cecair kromatografi prestasi ultra-tinggi seiring spektrometri jisim (UHPLC-MS/MS). **Keputusan dan Perbincangan:** Kepekatan maksimum isoprothiolane, tricyclazole dan propiconazole yang terdapat pada sampel udara peribadi adalah 178.9 ng m^{-3}, 433.0 ng m^{-3} dan 138.3 ng m^{-3} masing-masing. Kepekatan sebatian sasaran adalah jauh berbeza di kalangan petani padi dan kumpulan tidak terdedah. Gejala kesihatan yang dilaporkan di kalangan petani padi jauh berbeza berbanding kumpulan tidak terdedah. Peratusan simptom kesihatan yang dilaporkan di kalangan petani padi adalah lebih tinggi berbanding kumpulan tidak terdedah. Latar belakang sosiodemografi (umur dan tahap pendidikan) sangat dikaitkan dengan gejala kesihatan yang dilaporkan di kalangan petani padi berbanding kumpulan yang tidak terdedah. Gaya hidup (tindak-tanduk merokok, penggunaan sayur-sayuran dan buah-buahan sekurang-kurangnya sekali seminggu dan senaman seminggu sekali) adalah berkaitan dengan gejala kesihatan yang dilaporkan di kalangan petani padi berbanding kumpulan yang tidak terdedah. Terdapat hubungan yang ketara antara kepekatan isoprothiolane dan tricyclazole dengan gejala kesihatan yang dilaporkan di kalangan petani padi berbanding kumpulan yang tidak terdedah. **Kesimpulan:** Keputusan yang dilaporkan dalam kajian ini boleh memberi manfaat dari segi pengurusan risiko dalam komuniti pertanian.

Kata kunci: Racun perosak, udara, penyedutan, cecair kromatografi prestasi ultra-tinggi seiring spektrometri jisim (UHPLC-MS/MS), gejala kesihatan

TABLE OF CONTENTS

CHAPTER 5: DISCUSSION

CHAPTER 6: CONCLUSION AND RECOMMENDATION

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVATIONS

AOEL	Acceptable Operator Exposure Levels
BW	Body Weight
CAS	Chemical Abstracts Service
ESI	Electrospy Ionization
EU	European Union
FAO	Food Agriculture Organization
GPS	Global Positioning System
HCL	Hydrochloric Acid
IS	Internal Standard
IUPAC	International Union of Pure and Applied Chemistry
JKEUPM	University Research Ethics Committee of Universiti Putra Malaysia
MDL	Method Detection Limit
MQL	Method Quantification Limit
NA	Not Applicable
NCBI	National Centre for Biotechnology Information

NIOSH	National Institute of Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
PEL	Permissible Exposure Limit
PPE	Personal Protective Equipment
QC	Quality Control
RSD	Relative standard deviation
R^2	Regression coefficient
SD	Standard Deviation
S/N	Signal to-noise-ratio
UHPLC-MS/MS	Ultra-High Performance Liquid Chromatography Tandem Mass Spectrometry
USEPA	United States Environmental Protection Agency
WHO	World Health Organization

CHAPTER 1

INTRODUCTION

1.1 Background

Rice is a staple food for more than half of the world's population and is the second most broadly grown cereal crop. Rice industry has acknowledged a special consideration from the government due to its significance. Rice was recently set as the most critical food crop for guaranteeing the nation's food security as well as its social, economic and political importance such as poverty eradication. Rice grown on 673,745 ha of land, producing annually 2.6 million tons of paddy grain valued at RM 2 billon which is contribute with average growth rate of 3.7% of year, in the last five years. However, the current country's self-sufficiency level for rice production is about 71.4% and the balance imported from countries abroad (Siwar et al., 2014). The increased pressure to maintain high level of rice output for consumption has resulted in increased use of pesticides on rice fields in Malaysia (Jali et al., 2012).

Pesticides are one of the few toxic substances discharged intentionally into the environment to kill living organisms. For examples, rodents (rodenticides), fungus (fungicides), insects (insecticides) and weeds (herbicides). Agriculture is the major consumer which is about 85% of world production of pesticides to chemically control numerous pests. Besides, activities related to public health also used pesticides to control vector-borne diseases (malaria and dengue) and unwanted plants (grass and weeds) in ornamental landscaping, parks and gardens. They are also beneficial in destroying or avoiding the increase of insects, pests, bacteria, fungi and algae in electrical equipment, refrigerators, paint, carpets, paper, cardboard and food packaging materials (Gilden et al., 2010).

In any case, involuntary exposure to pesticides can be really harmful to people and other living organisms as they are intended to be poisonous (Sarwar, 2015). People may be exposed to pesticides through occupational use, eating foods or liquids containing pesticides residue, inhalation and contact with pesticides-contaminated air (Pimentel et al., 2013). Low levels of exposure to pesticides may have adverse health effects at early development (Damalas and Eleftherohorinos, 2011).

Some of the common pesticides used in Kampung Sawah Sempadan, Tanjung Karang, Selangor that focused in this study are isoprothiolane, tricyclazole and propiconazole. Interview with the farmers were conducted to identify the type of commonly used pesticides. There were 14 commonly used pesticides identified in this study. Among the 14 compounds, only three compounds were selected in this study which were isoprothiolane, tricyclazole and propiconazole.

1.2 Problem Statement

Pesticides are generally used in agricultural production to avoid and control pests, diseases, weeds and other plan pathogens. The use of pesticides have become relatively prevalent and act as a crucial tool to increase in land productivity, minimize crop damage and to ensure that the quantity and quality of agricultural products can be protected in an effort to increase rice production (Hamsan et al., 2017). Plough and harvester, pesticides, fertilizers and lime are examples of modern agricultural inputs that has been introduced by the Malaysian Government that act as a catalyst in improving the productivity.

Nevertheless, this agriculture input has given consequence towards the environment and living things mainly those which have been mixed from numerous chemical substance. Mamane et al. (2015) stated that 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. The pesticides that has been sprayed will transfer to the environment through water, wind and absorption process. It tend to be transferred thousands miles away and can be penetrated into meat, milk, human blood, animal and plants which can stay longer depends on the pesticides. Some can stay as residue within hours, week, month and year.

Tanjung Karang is the third largest area of paddy farmers in Peninsular Malaysia which known as the rice bowl of Selangor. Kampung Sawah Sempadan, which is one of the paddy farms cover an area of approximately 2,300 hectares of Tanjung Karang. Based on the previous study in Kampung Sawah Sempadan, the usage of personal protective equipment (PPE) was ignored by the farmers. Also, Hamsan et al. (2017) had reported only 8.4% of paddy farmers used proper PPE while 91.6% of them did not wear proper PPE.

This study aims to quantify the concentration of commonly used pesticides in personal air samples and assess their reported health symptoms among paddy farmers and non-exposed group. 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.

1.3 Research Justification

Agricultural activities have been arising along with the use of pesticides. During mixing and application of the pesticides, handlers of pesticides are at risk of exposure to pesticides residues through ingestion, inhalation and skin contact. There have been many studies focusing on pesticide exposure in ambient air (Batterman et al., 2008; Coscolla et al., 2014a, 2014b, 2013, 2011, 2010, 2009; Lin et al., 2015; Lopez et al., 2017, 2016; Yang et al., 2008; Yusa et al., 2014, 2009; Zhao et al., 2015). Nevertheless, there are not many studies on the concentration of pesticides in personal air samples.

One of the target compound has been reported in Kerian, Perak, no respondents were observed to have inhalation exposure readings that exceed the National Institute of Occupational Safety Health (NIOSH) permissible exposure limit (PEL) of 10 ppm for 2,4-D (Baharuddin et al., 2011). In Tanjung Karang, Selangor, the most frequently detected pesticides is tricyclazole and the least frequently detected pesticides is azoxystrobin and both came from the same agrochemical category, fungicides (Hamsan et al., 2017). The concentration of pesticides in personal air samples ranged from 462.5 ng/m^{-3} to 47.8 ng/m^{3} in Tanjung Karang, Selangor (Hamsan et al., 2017).

Currently, no studies have been reported the health symptoms among paddy farmers and non-exposed group based on occupational exposure of pesticides in personal air samples. Therefore, the aims of this study are to determine the occurrence of isoprothiolane, tricyclazole and propiconazole in air and their reported health symptoms among paddy farmers and non-exposed group in Tanjung Karang, Selangor through occupational exposure.

1.4 Conceptual Framework

Pesticides in agricultural activity were divided into five categories and all of the target compounds in this study belonged to fungicides category. The exposure of paddy farmers were through occupational setting. The pesticides was disperse through air and route of exposure was through inhalation. Personal air samples was used to collect the pesticides and the concentration of pesticides was determined by associated it with reported health symptoms among paddy farmers and non-exposed group.

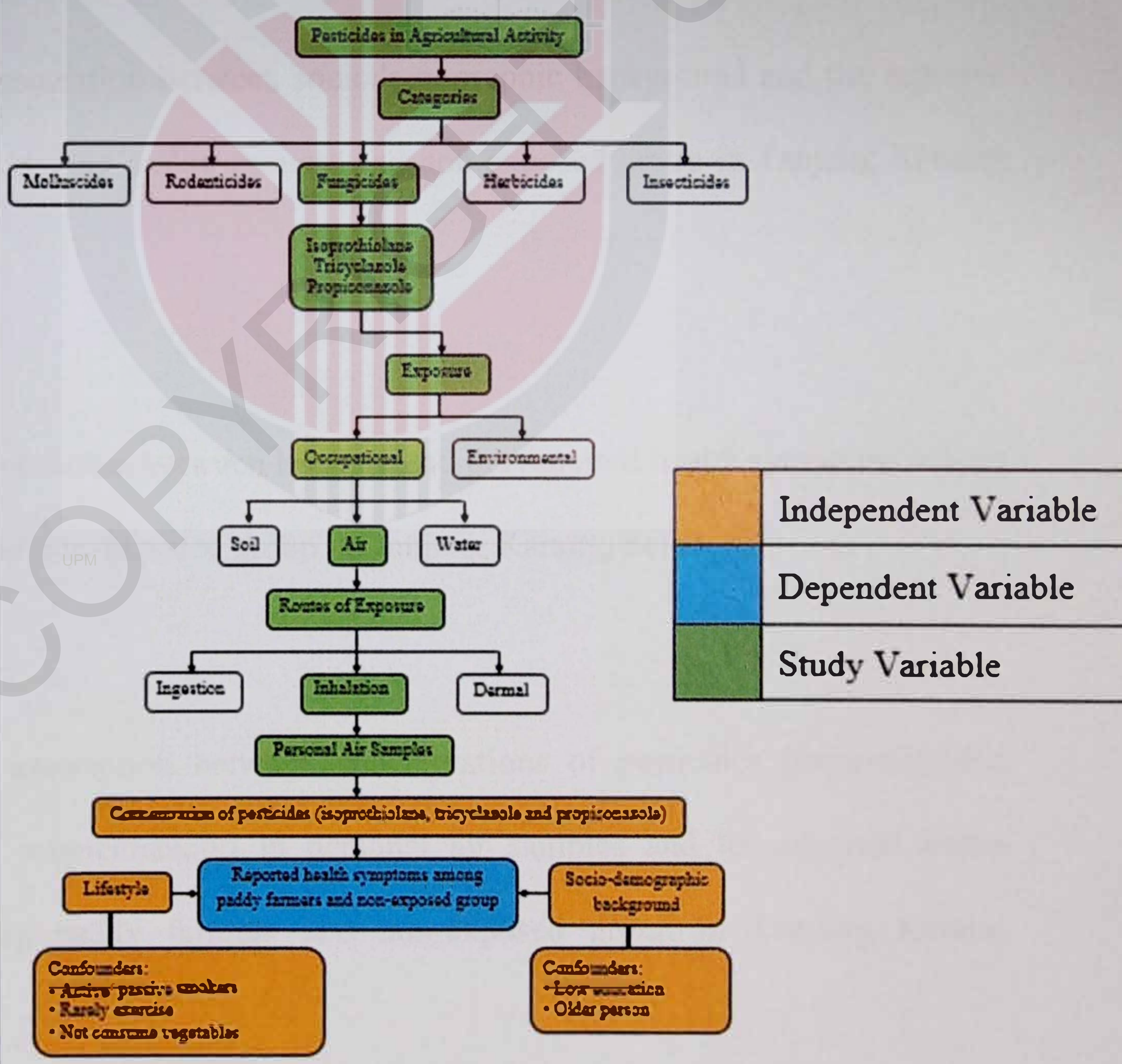


Figure 1.1: Conceptual Framework.

1.5 Research Question

1. What are the concentrations of pesticides (isoprothiolane, tricyclazole and propiconazole) in personal air samples collected among paddy farmers and non-exposed group in Tanjung Karang, Selangor?

2. Are the reported health symptoms of paddy farmers significantly different compared to non-exposed group in Tanjung Karang, Selangor?

3. Is there any association between sociodemographic background and the reported health symptoms among paddy farmers and non-exposed group in Tanjung Karang, Selangor?

4. Is there any association between lifestyle and the reported health symptoms among paddy farmers and non-exposed group in Tanjung Karang, Selangor?

5. Is there any association between concentrations of pesticides (isoprothiolane, tricyclazole and propiconazole) in personal air samples and the reported health symptoms among paddy farmers and non-exposed group in Tanjung Karang, Selangor?

1.6 Objectives

1.6.1 General Objective

To determine the occurrence of pesticides (isoprothiolane, tricyclazole and propiconazole) in personal air samples and their reported health symptoms among paddy farmers and non-exposed group in Tanjung Karang, Selangor.

1.6.2 Specific Objective

1. To determine the concentrations of pesticides (isoprothiolane, tricyclazole and propiconazole) in personal air samples collected among paddy farmers and non-exposed group in Tanjung Karang, Selangor.

2. To compare the concentrations of pesticides (isoprothiolane, tricyclazole and propiconazole) in personal air samples among paddy farmers and non-exposed group in Tanjung Karang, Selangor.

3. To compare the reported health symptoms among paddy farmers and non-exposed group in Tanjung Karang, Selangor.

4. To determine the association between sociodemographic background and reported health symptoms among paddy farmers and non-exposed group in Tanjung Karang, Selangor.

5. To determine the association between lifestyle and the reported health symptoms among paddy farmers and non-exposed group in Tanjung Karang, Selangor.

6. To determine the association between the concentrations of pesticides (isoprothiolane, tricyclazole and propiconazole) in personal air samples and reported health symptoms among paddy farmers and non-exposed group in Tanjung Karang, Selangor.

1.7 Hypothesis

1. The concentrations of pesticides (isoprothiolane, tricyclazole and propiconazole) in personal air samples collected among paddy farmers are significantly different compared to non-exposed group in Tanjung Karang, Selangor.

2. The reported health symptoms among paddy farmers are significantly different compared to non-exposed group in Tanjung Karang, Selangor.

3. The sociodemographic background is significantly associated with the reported health symptoms among paddy farmers and non-exposed group in Tanjung Karang, Selangor.

4. The lifestyle is significantly associated with the reported health symptoms among paddy farmers and non-exposed group in Tanjung Karang, Selangor.

5. The concentrations of pesticides (isoprothiolane, tricyclazole and propiconazole) in personal air samples is significantly associated with the reported health symptoms among paddy farmers and non-exposed group in Tanjung Karang, Selangor.

CHAPTER 2

LITERATURE REVIEW

2.1 Pesticides and Agricultural Development

According to the Environmental Protection Agency (EPA) (2007), the government body that regulates pesticides in the United States, a pesticides is any substance or mixture of substances intended for preventing, destroying, repelling or mitigating any pest. In developing country, the application of pesticides have been promoted among the agriculture farmers to raise their economic life and productivity (Ahmad et al., 2014). Health risks from occupational exposure and from residues in food and drinking water always been given a special attention even though pesticides had undergoes very strict regulation processes to function with reasonable certainty and minimal impact on human health and the environment. Stanley et al. (2005) stated that while chemical pesticides are widely used to control agricultural pests, studies have shown that less than 0.1% of applied pesticides actually reach the target pest, with the remainder spreading out into the environment, with consequent effects on workers, bystanders, consumers, wildlife, air, soil and water.

Occupational exposure to pesticides usually occurs to the workers that works in the pesticides industry which are the farmers. Exposure to general populations occurs primarily through eating of food and drinking water that have been contaminated with pesticides residues. Extensive exposure can occur in or around the home. Previous studies showed that pesticide exposure often induces acute and chronic neurological toxicity (Starks et al., 2012). One study found that farmers who used a greater amount of pesticides were more likely to suffer from headache, nausea, and skin problems (Qiao et al., 2012). 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., 2016). Based on a study by Mamane et al. (2015) which reviewed the available literature regarding the link between occupational exposure to pesticides and respiratory symptoms or diseases, they have suggested that occupational exposure to pesticides is associated with an increased risk of respiratory symptoms, asthma and chronic bronchitis. A study by Faria et al. (2005) on pesticides and respiratory symptoms shows that the prevalence of asthma symptoms was 12% and chronic respiratory disease symptoms was 22% among farmers and the study results provide evidence that farming exposure to pesticides is associated with higher prevalence of respiratory symptoms.

2.2 Target Pesticides

2.2.1 Isoprothiolane

ISO common name for isoprothilane is diisopropyl 1,3-dithiolan-2-ylidenemalonate (IUPAC). It is used as fungicides and plant growth regulator. Isoprothilane is used to control the fungi such as *Pyricularia oryzae*, *Helminthosporium sigmoideum* and *Fusarium nivale* (EFSA, 2012).

It was first introduced in China since 1981 as a protective and curative systemic fungicide and is still being utilized as a major chemical for rice blast control (Hu et al., 2014). Isoprothiolane can cause restrain of phospholipid synthesis in cells (Kaonga et al., 2017), where the mode of action of isoprothiolane is accepted to be obstruction with transmethation in the biosynthesis of phosphatidylcholine, a major layer lipid in eukaryotic cells, which essential part in signal transduction (Zhang et al., 2016). Isoprothiolane bring in severe acute toxicity prompting to sweating, cerebral pain, vomiting, giddiness, unconsciousness, eye irritation and serious eye damage (Selvi & Manonmani, 2013). Information of isoprothiolane is summarized in **Table 2.1.**

2.2.2 Tricyclazole

Tricyclazole or [(5-methyl-1, 2, 4 triazole 9, 3, 4-b) benzotiazole] is one of the common pesticides used in paddy rice planting. Tricyclazole is used to control blast disease in agriculture. The determination of pesticide residue in paddy rice attracts many research workers' interests internationally because it may pose a hazard to the health of human beings.

World Health Organization (WHO) (2017) has classified tricyclazole within pesticides with range of moderate damage. Some studies point to the effect of triazoles on male reproductive cells and increased abnormalities in them (Li et al., 2012; Goetz et al., 2009). According to histopathological studies, concentrations of tricyclazole in the liver could lead to necrosis, inflammatory cell infiltration, hyperplasia, watery degeneration of hepatocytes and severe hepatomegaly (Rowshanaie et al., 2015). Triazoles also increase Testosterone levels within the testes but reduce its metabolism in the liver (Goetz et al., 2007; Hester et al., 2012). Information of tricyclazole is summarized in **Table 2.2**.

2.2.3 Propiconazole

Fungicide propiconazole or its International Union of Pure and Applied Chemistry (IUPAC) name, 1-[[2-(2,4-dichlorophenyl)-4-propyl-1,3dioxolan-2-yl]methyl]-1,2,4-triazole has been developed in 1979 and marketed worldwide in a range of fungicide treatment products for preventive and control of plant diseases and fungi purposes. Propiconazole acts as an ergosterol biosynthesis inhibitor in which it was reported that fungal growth was significantly affected by the addition of propiconazole for doses more than 50 mg/kg (Fernandez-Calvino et al., 2017). Propiconazole's mode of action is particularly targets demethylation of C-14 in the midst of ergosterol biosynthesis. The biosynthesis of these ergosterol is essential to the development of cell divisions of living organisms. This nonappearance of ordinary sterol creation slows or stops the development of the growth, effectively avoiding further contamination as well as intrusion of host tissues. Consequently, propiconazole is believed to be fungistatic or growth repressing rather than fungicidal or killing.

Propiconazole is applied at the late growth stages in plant crops requiring the utilization of air and soil application procedures respectively and further causing a potential route of transport to adjacent aquatic environments by mean of drift as well as runoff (Edwards et al., 2016). The continuous use of propiconazole in cultivation activities may result in fungicides reaching the soil surface by drifting during application and subsequently, soil will act as sorbent carriers for these fungicides following significant rainy days. Rain washing propiconazole to the ground will reaching the aquatic environment and has potential to contaminate the groundwater. **Table 2.3** summarized the properties of propiconazole.

Table 2.1: Information of the targeted compounds.

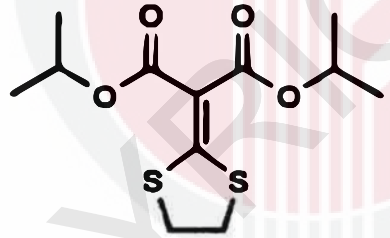
Common Name[a] / Pesticide Type[a] / IUPAC Name[a] / CAS Number[a]	Molecular Formula[a]	Molecular Structure[b]	Molecular Weight (g/mole)[a]	Log Kow[a]	Cancer Classification[d]
Isoprothiolane Fungicide Dipropan-2-yl 2-(1,3-dithiolan-2-ylidene)propanedioate 50512-35-1	$C_{12}H_{18}O_4S_2$		290.392	2.88	N/A

Table 2.2: Information of the targeted compounds.

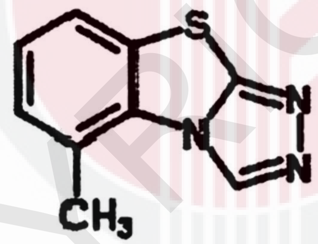
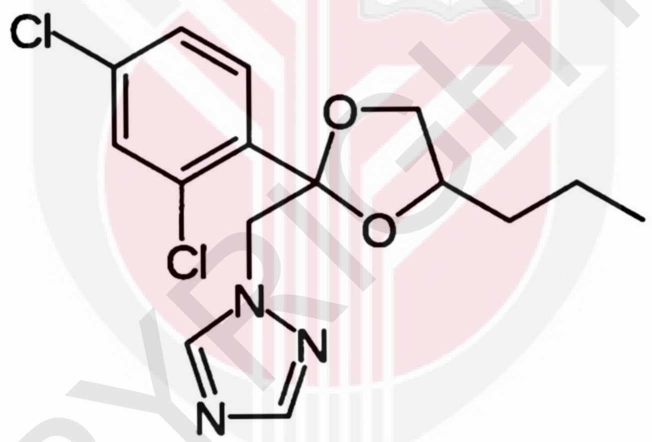
Common Name[a] Pesticide Type[a] IUPAC Name[a] CAS Number[a]	Molecular Formula[a]	Molecular Structure[b]	Molecular Weight (g/mole)[a]	Log Kow[a]	Cancer Classification[d]
Tricyclazole Fungicide 8-methyl-(1,2,4)triazolo(3,4-b)(1,3)benzothiazole 41814-78-2	$C_9H_7N_3S$		189.23	N/A	Not likely to be carcinogenic to humans

Table 2.3: Information of the targeted compounds.

Common Name[a] **Pesticide Type[a]** **IUPAC Name[a]** **CAS Number[a]**	**Molecular Formula[a]**	**Molecular Structure[b]**	**Molecular Weight (g/mole)[a]**	**Log Kow[a]**	**Cancer Classification[d]**
Propiconazole Fungicide 1-[[2-(2,4-dichlorophenyl)-4-propyl-1,3dioxolan-2-yl]methyl]-1,2,4-triazole 60207-90-1	$C_{15}H_{17}Cl_2N_3O_2$		342.22	3.72	Group C – Possible human carcinogen

[a]Pubchem, 2018. National Center for Biotechnology Information (NCBI). https://pubchem.ncbi.nlm.nih.gov/ (accessed October 2018)
[b]Chemspider, 2016. Royal Society of Chemistry. http://www.chemspider.com/ (accessed October 2018)
[c]USEPA (2016). Chemicals Evaluated for Carcinogenic Potential (Annual Cancer Report 2016). http://npic.orst.edu/chemicals_evaliated.pdf (accessed October 2018)
[d]Not available

2.3 Pesticides Contamination in Air

Not all pesticides reach the crop and up to 90% are emitted into the atmosphere depending on the spraying method and technology during spraying (Schummer et al., 2010). Pesticides sprayed to the crops or soil can also be re-emitted into the atmosphere by volatilization (Schummer et al., 2010). Volatilization is the process by which a compound evaporates to the atmosphere from another environmental compartment (Voutsas, Vavva, Magoulas & Tassios, 2005).

There are a few factors that affect the presence and concentration of pesticides in air. According to a study conducted by Baharuddin, Sahid, Noor, Sulaiman & Othman (2011), wind speed had the strongest impact on pesticide exposure via inhalation, while temperature and humidity also contribute to the exposure of pesticides in air.

Inhalation and dermal absorption are considered as the primary and most common routed of exposures to pesticides in occupational settings (Damalas & Eleftherohorinos, 2011). It is important to assess the exposure through inhalation as human have the least control over the inhalation pathway compared to others.

The acceptable operator exposure level (AOEL) for the target compounds in this study are as in **Table 2.4**.

Table 2.4: Acceptable operator exposure level (AOEL) for the target compounds.

Target compounds	AOEL (mg kg^{-1} bw day^{-1})
Isoprothiolane	N/A[b]
Tricyclazole	N/A[b]
Propiconazole	0.01[a]

[a]European Union (2017). EU Pesticides Database. http://eceuropa.eu/food/plant/pesticides/eu-pesticides-database/public/?event=activesubstance.selection&language=EN (accessed October 2018)

[d]Not available

2.4 Sampling and Analysis of Pesticides in Air

Personal air samplers are design to be small so that the process will not interfere with the normal daily work. Choi et al. (2013) stated that the personal air sampling as the common method for monitoring of inhalation exposure by attaching the glass tubes containing solid absorbents to battery-powered personal air sampling pumps.

The analysis of pesticides still remains challenge because of the different chemical classes are present at low concentrations in complex matrices (Farre, Pico & Barcelo, 2014). Therefore, it is necessary to continue developing multi-residual analytical methods with higher recoveries and lower limits of detection (Kuster, Lopez de Alda, Barcelo, 2006).

Most of the air sampling studies have used gas chromatography-mass spectrometry (GC-MS) for pesticides analysis but nowadays, Liquid Chromatography Mass Spectrometry (LC-MS) is preferred over Gas Chromatography (GC) and often employed for the analysis of pesticides due to their low detection (LOD) (Pareja et al., 2011; Li et al., 2012) and currently used pesticides are more polar, not easily vaporized (Farre, Pico & Barcelo, 2014). Armstrong, Dilld, Yu, Yost &Fenske (2014) in their study reported that in an inter-laboratory comparison, the limit of quantification (LOQ) for LC-MS/MS was 100 times lower than a typical GC-MS method.

2.5 Sociodemographic and Lifestyle

Understanding farmers' level of knowledge and practices regarding the safe use of pesticides is vital for providing sound educational and policy strategies that aim at limiting the health and environmental hazards caused by pesticides (Jallow et al., 2017). Even though farmers may know the hazards of pesticides very well, they may often adopt risky behaviours because of lack of education and poor knowledge and understanding of safe practices in pesticide use (Matthews, 2008). Educated farmers are more knowledgeable about pesticide safety, have better ability to read, understand and follow hazard warnings on labels, and conceptualized the consequences of poor pesticide usage practices (Karunamoorthi et al., 2012). Education status and training in pesticide use and safety are strong determinants of the appropriate use of PPE (Jallow et al., 2017). For example, the perception that PPE were useful to prevent exposure to pesticides was associated with at least a high school education among migrant farm workers in USA (Hwang et al., 2000), farmers in India (Weinberger et al., 2009) and in Mexico (Blanco-Muñoz et al., 2011). Lack of knowledge is likely to contribute to increased risk to the farmers (Jallow et al., 2017).

Low fruit and vegetable consumption increases the risk of obesity, coronary heart disease and stroke, type 2 diabetes, diverticulosis, hypertension and epithelial cancers such as cancer of the lung, oesophagus, mouth, stomach, colon and pancreases (Bes-Rastrollo et al., 2006). Although the disease burden that can be attributed to nutrition has not been quantified in many countries, the importance of fruit and vegetable consumption in the fight against diseases should not be underestimated (Justin et al., 2009). American College of Sports Medicine (2009) stated that systematic exercise is an integral component of current guidelines for health promotion and improvement of quality of life. There is strong evidence that people who participate regularly in exercise are less likely to develop diseases (Booth et al., 2008).

No significant association of acetylcholinesterase (AChE) activity with gender, education level, years of farm work, and area under rice cultivation was found (Sapbamrer et al., 2013). The study design did not control a number of confounding factors, such as gender, education level, exposure to previous organophosphates (Ops), carbamate poisoning, and underlying diseases (Sapbamrer et al., 2013). Farmers who were personally applying pesticides were more likely to be male and had more years of formal education compared to non-users (Silva et al., 2016). Regulatory norm 31 prohibits people under the age of 18 years or over the age of 60 years from doing work involving pesticides (Faria et al., 2009). The proportion of workers exposed to pesticides in these age groups is probably greater than what was found, because in addition to the selection of workers with greater exposure, more than half of workers began their occupational exposure to these products before the age of 18 years (Faria et al., 2009). However, there are limited study about the association between sociodemographic background and health symptoms while no previous study have been reported about the association between lifestyle and health symptoms. Hence, this study will aims to study the association between sociodemographic background and lifestyle with reported health symptoms among paddy farmers and non-exposed group.

2.6 Legislation and Regulation

In Malaysia, the Pesticides Act 1974 has been establish by the government to control the movement of pesticides in this country. This act regulates that the company or person who want to import or manufacture the pesticides must apply to the Board for registration of the pesticide and need to comply with all the guidelines provided. Under section 10, they must notify to the Board if there is any adverse effects from the pesticides on human beings, animals, plants, fruits or property within sixty days from such discovery.

Next, Occupational Safety and Health (Use and Standard of Exposure Chemical Hazardous to Health) Regulation 2000 is made to provide legal framework in order to control exposure of chemical hazardous such as pesticides to health at workplace. In my study, among the three type of pesticides, (isoprothiolane, tricyclazole and propiconazole) all of their permissible exposure limit (PEL) are not being stated. Under Section IV, it stated that an employer should made an assessment of the risks created by the chemicals exposed to the health of the employees.

Besides, there are also other laws in Malaysia that are related to pesticides such as Environmental Quality Act 1974. Based on Environmental Quality (Industrial Effluent) Regulations 2009, under Section 14, an owner or occupier of a premise shall adopt the best management practice for discharge of any industrial effluent or mixed effluent for any parameter as specified in the Ninth Schedule.

2.7 Personal Protective Equipment (PPE)

In handling pesticides, the risk is determined by the pesticide toxicity and whether there is an exposure to the pesticides and one way to reduce the risk of exposure is to use the personal protective equipment (PPE) (Hansen and Walker, 2017). According to Hansen and Walker (2017), PPE includes clothing and devices that protect the body from contact with chemicals such as pesticides and it is important to wear the right PPE. In general, the more toxic a pesticide is, the more PPE is needed to keep the pesticide handlers safe. According to Malaysian standard code of recommended practise (MS 479:2012) developed by The Department of Standards Malaysia and SIRIM Berhad (DOS, 2012), all farmers that involves in preparation (mixing and loading) and application (spraying) of pesticides should wear appropriate protective clothing/ devices as the container label prescribes.

CHAPTER 3

METHODOLOGY

3.1 Chemicals and Reagents

Reference standards of isoprothiolane (97.2%), tricyclazole (99.0%) and propiconazole (99.0%) were purchased from Dr. Ehrenstorfer (Germany). The internal standards (IS) diuron-d_6 (99.9%) and imidacloprid-d_4 (99.9%) were purchased from Sigma-Aldrich (Germany). Stock standard solutions (1000 mg L^{-1}) were prepared monthly by dissolving the standards in methanol. Working standard solutions (10 mg L^{-1}) were prepared from the stock standard solutions weekly. HPLC-grade methanol and HPLC-grade acetone were purchased from Fisher Scientific (UK).

3.2 Study Design

A comparative cross-sectional design was used for this study to assess the occurrence of pesticides in air and their reported health symptoms among paddy farmers and non-exposed group (office workers). This study involved laboratory analysis as to quantify the three compounds (isoprothiolane, tricyclazole and propiconazole).

3.3 Study Location

This study was carried out in a paddy field located in Tanjung Karang, Kuala Selangor. It is part of the Barat Laut Paddy Project within the north of Selangor state with Global Positioning System (GPS) coordinates of $3^{O}27'34.9''N$ $101^{O}12'48.5''E$. Tanjung Karang is generally known for its paddy cultivation activity which is the third largest paddy field in Peninsular Malaysia. Kampung Sawah Sempadan, Tanjung Karang comprises of 24 blocks of paddy field namely as Block A until Block X. The study location was illustrated in **Figure 3.1**. There were a few consideration that should be deal with when choosing the study location. Details of the study location were:

i. Agriculture area where paddy cultivation is the main activity.
ii. Study location must be in a short distance from the laboratory which preservation and analysis will be conducted.
iii. The residents who are willing to participate as respondents throughout this study.

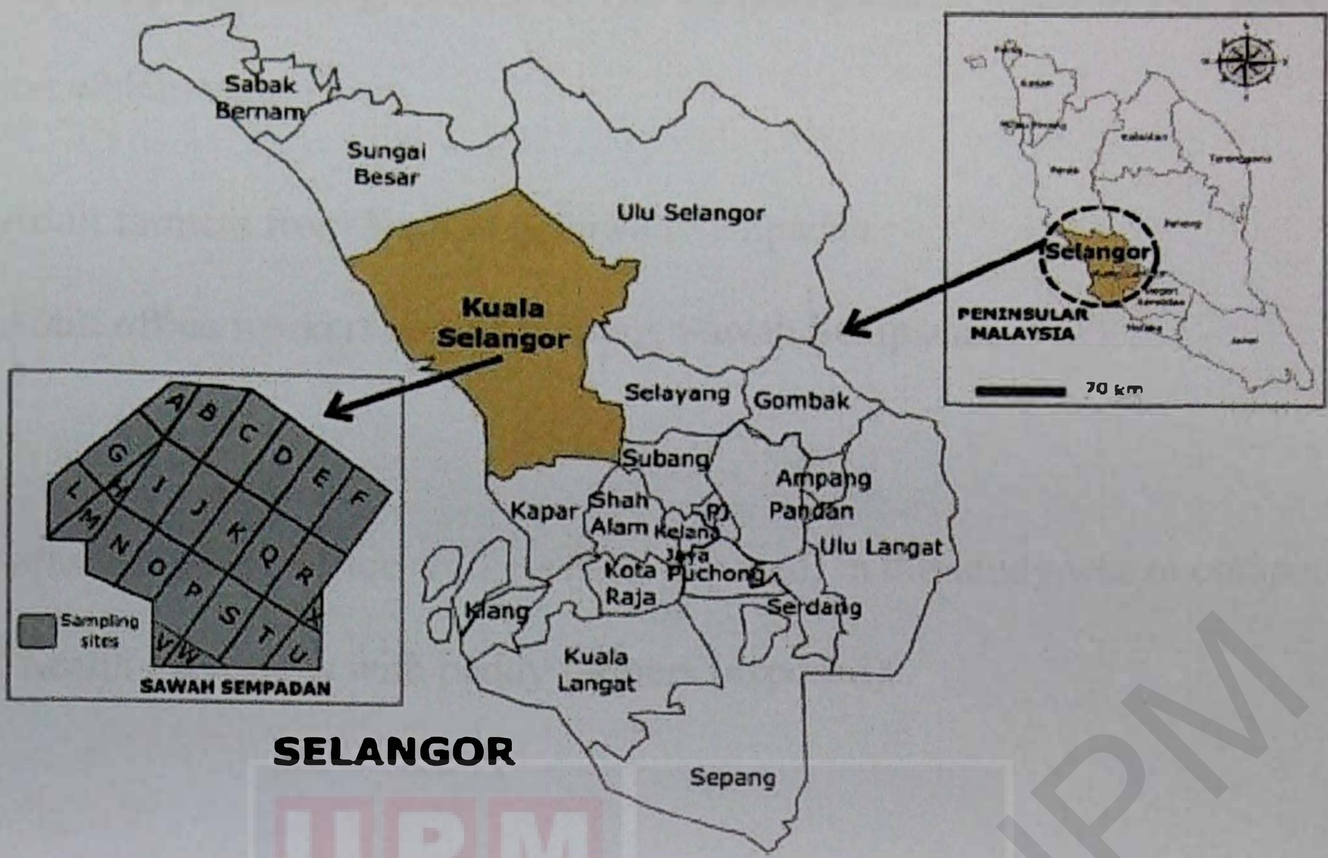


Figure 3.1: Map of Kampung Sawah Sempadan, Tanjung Karang, Kuala Selangor, Malaysia.

3.4 Sampling

3.4.1 Sampling population

The target population for this study were paddy farmers and office workers in Kampung Sawah Sempadan, Tanjung Karang, Selangor.

3.4.2 Sampling frame

The sampling frame in this study were the paddy farmers that was obtained from Farmers Organization Authority Office and office workers of Kampung Sawah

Sempadan, Tanjung Karang, Selangor. The sampling unit consists of two groups of population which were:

i. Adult farmers from Kampung Sawah Sempadan.
ii. Adult office workers from Kampung Sawah Sempadan.

The reasons having office workers (non-exposed) in this study was to compare the reported health symptoms with paddy farmers (exposed).

3.4.3 Sampling unit

Paddy farmers and office workers were selected as sampling unit. Inclusion criteria for paddy farmers were as follows:

i. Farmers who work in the paddy field and directly involved in preparation and application of pesticides.
ii. Age of the respondents between 18 to 59 years old.
iii. Farmers who have been working for at least 6 months.

The exclusion criteria for paddy farmers were as follows:

i. Paddy farmers who recruit foreign worker to work in preparation and application of pesticides.

Foreign workers do not have same immune system like local workers as they do not received same vaccines with local workers. Next, their lifestyle also different with local workers as they do many types of work which the exposure can affect their health symptoms.

The inclusion criteria for non-exposed group were as follows:

i. Age of the respondents between 18 to 59 years old.
ii. Office workers who were living at the same area with exposed group.

3.4.4 Confounders

The confounders for lifestyle were as follows:

i. Active/ passive smokers
ii. Person who rarely exercise
iii. Person who rarely eat vegetables and fruits

WHO (2015) stated that smoking was associated with an increases risk of getting health symptoms that lead to wide range of diseases. Next, Chen (2009) stated that individual's healthy lifestyle which emphasizes physical-related activities may reduce the chances of getting diseases. Moreover, intake of vegetables and fruits improves the antioxidants level in the blood which plays a crucial role in maintaining the overall health of a person (Rathinam et al., 2004).

The confounders for sociodemographic background were as follows:

i. People who were older

ii. Low education

Ahuwalia (2004) stated that immune function declines with age, leading to increase chances to get infection in aging individuals. Next, educated farmers are more knowledgeable about pesticides safety, having better ability to read, understand and follow hazard warning on labels and conceptualized the consequences of poor pesticides usage practices (Karunamoorthi et al., 2012).

The confounders were screen using questionnaire and the confounders was control through statistical analysis.

3.4.5 Sampling size

The total population of paddy farmers in Tanjung Karang as acquired by the district office of Tanjung Karang is approximately 7679 and the population of the paddy farmers in the study area (Kampung Sawah Sempadan) is 1147. A total 85 paddy farmers and 85 office workers were recruit in this study. Those who fulfil the inclusion and exclusion criteria were selected. The sample size for present study was ascertained by using formula adapted from Lameshow et al. (1990). Hence, the required sample size was calculated by using the following formula:

$$n = \frac{\{Z_{\frac{\alpha}{2}}\sqrt{2P(1-\overline{P})} + Z_{1-\beta}\sqrt{P_1(1-P_1) + P_2(1-P_2)}\}}{(P_1 - P_2)^2}$$

Equation 3.1

Where,

$\overline{P} = (P_1 + P_2)/2$

$P_1 = 0.564$

$P_2 = 0.333$

The sample size calculations was as follow:

$$n = \frac{\{1.96\sqrt{2(0.4485)(1-0.4485)} + 0.842\sqrt{0.564(1-0.564) + 0.333(1-0.333)}\}}{(0.564 - 0.333)^2}$$

$$n = \frac{(1.3786 + 0.5760)^2}{0.0534}$$

$$n = 71$$

The value for P_1 and P_2 were obtained from previous study by Hamid et al. (2016) using health symptoms of blurred vision. The study was about evaluate the risk of pesticides exposure to those applying the Class II pesticides in the paddy-growing areas of Kerian, Perak.

The minimum sample size for this study were 71 respondents for both groups. In order to achieve appropriate response rate, 20% of minimum sample size were added. The total sample size was 71 + 14 = 85 (exposed group) and 85 (non-exposed group).

3.5 Sampling technique

3.5.1 Personal air sampling

Personal air sampler was used to monitor the occupational exposure of pesticides among paddy farmers and non-exposed group from December 2018 until March 2019. Sampling and extraction method by Choi et al. (2013) was applied. Pesticide-contaminated air during spraying activity of farmer was collected using personal air monitor equipped with an air pump (Gilian GilAir-3, Sensidyne, Clearwater, FL) and a solid sorbent tube (SKC Sorbent Tube, XAD-2, 8x110mm size, 2-section, 200/400 mg sorbent, SKC, USA). The dual-layered solid sorbent tube consists of one larger bed of absorbent (400 mg) followed by a smaller back-up bed (200 mg) to trap any sample breakthrough. The beds contain separators of glass wool to secure the beds in place. XAD-2 resin was used to trap pesticides in air.

The personal air samples were collected with average of 2 hours/day for each group. For paddy farmers, we collected the samples during the spraying activity in the morning. Usually they sprayed around 6.00 am to 9.00 am. Meanwhile, for the office workers, they were approached at any time during their working hours. During personal air sampling, a glass fibre filter and an XAD-2 resin tube was attached to the breathing zone with a clip and the air pump was fastened to the belt. The air flow rate was set at 2 L min^{-1}. After mixing, loading or spraying, the XAD-2 resin and filter was removed from the glass tube and all resins was transferred to the 15 mL centrifuge tube and was spike with internal standard (imidacloprid-d_4 and diuron-d_6) for analysis of pesticides content.

3.5.2 Selection of target compounds

There were 13 compounds of regular used pesticides that have been distinguished upon interviewing the paddy farmers. Only three from these compounds was selected for this study. **Table 3.1** summarizes the frequency of the usage of pesticides active ingredients.

Table 3.1: List of pesticides active ingredients, frequency and percentage of usage by paddy farmers in Kampung Sawah Sempadan, Tanjung Karang.

	Pesticide active ingredients	Frequency	Percentage (%)	Remark
1.	Chlorantraniliprole	44	53.0	
2.	Difenoconazole	44	53.0	
3.	Pymetrozine	43	51.8	
4.	**Isoprothiolane**	41	34.9	Target compound
5.	**Propiconazole**	38	34.9	Target compound
6.	2,4-D	31	32.5	
7.	Tebuconazole	29	26.5	
8.	Trifloxystrobin	29	45.8	
9.	Azoxytrobin	27	20.5	
10.	Fipronil	22	15.7	
11.	**Tricyclazole**	21	2.4	Target compound
12.	Imidacloprid	17	12.0	
13.	Buprofezin	13	49.4	
14.	Pretilachlor	10	25.3	
15.	Paraquat dichloride	2	37.3	

N = 170 (Adapted from Hamsan et al., 2017).

3.5.3 Sample Extraction and Analysis

Pesticides trapped on the XAD-2 resin and filter was extracted with 10 mL of acetone, centrifuge at 40×100 rpm for 5 minutes and the supernatant was decanted into a centrifuge tube. After that, the extract was concentrated via a gentle stream of nitrogen blow down and reconstituted with 1 mL of injection solution (3:1 ultrapure water/HPLC-grade methanol). An aliquot (2 µL) of the extract was analysed using Ultra High-Performance Liquid Chromatography-tandem Mass Spectrometry (UHPLC-MS/MS).

3.6 Study Instruments

3.6.1 Questionnaire

A set of questionnaire was distributed among the paddy farmers and non-exposed group to obtain the demographic information and occupational exposure information. The questionnaire comprised of four sections namely Section A: personal information of the respondents, Section B: working background and experience, Section C: lifestyle and Section D: reported health symptoms. The questionnaire can be found in **Appendix A**. The questionnaire was developed based on questionnaire used in (i) Agriculture Health Study (AHS) by Alavanja, (1996); Hou et al. (2013); Andreotti et al. (2015), and (ii) Vietnam: Pesticide Use Survey (Berg, 2001).

3.6.2 Ultra High-Performance Liquid Chromatography-tandem Mass Spectrometry (UHPLC-MS/MS)

The UHPLC-MS/MS (Agilent, USA) method conditions were as follows: chromatographic separation was performed on an Eclipse Plus C18 column (2.1 mm × 50 mm I.D., 1.8 µ particle size). The mobile phase were; (a) a gradient of ultrapure water with 0.1% formic acid and 5 mM ammonium formate and, (b) methanol 0.1% formic acid and 5 mM ammonium formate. Then, the mobile phase was mixed as in **Table 3.2**.

Table 3.2: Gradient Condition.

	Time (minutes)	A%	B%	Flow rate (mL/min)
1	0	94.00	6.00	0.5
2	15.00	2.00	98.00	0.5
3	18.00	2.00	98.00	0.5
4	18.01	94.00	6.00	0.5
5	20.00	94.00	6.00	0.5

Mobile phase A (aqueous): 0.1% formic acid and 5mM ammonium formate in ultrapure water
Mobile phase B (solvent): 0.1% formic acid and 5mM ammonium formate in methanol

The flow rate was set at 0.5 mL min^{-1} and the total runtime was 20 minutes. The auto sampler and column temperature was set at $40^{O}C$ and 2.0 µL volume injection was used. All pesticides were detected using electrospray ionization (ESI) in positive ion mode. The optimised MS/MS conditions were summarized in **Table 3.3**. The optimize operating conditions were as follows: capillary voltage, 3500 V; gas temperature, 220°C; gas flow, 11 L min^{-1}, and nebulizer, 30 psi.

Table 3.3: Precursor ions, product ions, collision energy and fragmentation voltage for the 3 target compounds and 2 internal standards.

Target compounds	Precursor ion, m/z	Product, m/z (Collision energy, V)	Fragmentation, V
Isoprothiolane	291.10	231.00 (8), 188.80 (20)	380
Tricyclazole	190.00	163.10 (24), 136.20 (28)	380
Propiconazole	342.10	159.00 (32) 69.10 (16)	380
Internal Standard	**Precursor ion, m/z**	**Product, m/z (Collision energy, V)**	**Fragmentation, V**
Diuron-d_6	239.00	78.00 (25)	380
Imidacloprid-d_4	260.10	212.90 (21)	380

3.7 Quality Control

3.7.1 Questionnaire

Pre-test study was conducted among paddy farmers and office workers at Kampung Sungai Burung to assess the clarity of the questionnaire. Time taken for each respondent to answer the questions can be estimate through pre-testing. The number of respondents that involved in the pre-testing is 10% from the total sample size of this study. Cronbach's alpha was run to determine the validity, consistency and reliability of the questionnaire and the result obtained was 0.73.

3.7.2 Cleaning of Glassware

Before used, all glassware was washed with 5-10% hydrochloric acid wash to ensure they were free from any contaminants in light of EPA method 1699 (2007). All the glassware was soaked with 5-10% hydrochloric acid (HCL) overnight followed by washed with Decon 90. Then, all the glassware were rinsed immediately. First with methanol, then with hot tap water. After that, the glassware were rinsed with methanol again, followed by acetone and then dichloromethane. After washing, all of the glassware were dried at 60^{O}C and capped with solvent rinsed aluminium foil to prevent from accumulation of dust or other contaminants.

3.7.3 Calibration of UHPLC-MS/MS Performance

The instrument was calibrated with each analytes at a five-point calibration curve. Each calibration point was added the labelled internal standards (IS) corresponding to the analytes with a concentration of 50 ng mL to generate relative response factors (RRF). Calibration curve were going to be obtained by injecting the standards of isoprothiolane, tricyclazole and propiconazole that range from 0.1 ng/L to 500 ng/mL.

3.7.4 Preparation of blank

All the samples were spiked with IS mixtures prior to extraction. Internal standard (imidacloprid-d_4 and diuron-d_6) was spiked into one blank XAD-2 resin and ran through the entire sample preparation and extraction procedure for every batch of sample analysis to check for any possible background contamination in the sample.

3.7.5 Extraction Recovery

The extraction recovery was evaluated by spiking the samples with varied amounts of standards solutions of isoprothiolane, tricyclazole and propiconazole (Zhuang et al., 2009). The percent of recovery was calculated by comparing the concentrations of each compound spike before extraction (C_p) to its concentration spiked after extraction (C_a) in the similar matrix using **Equation 3.2** (Ho et al., 2012) where C_{qc} is the concentration of analytes in the blank sample.

$$Recovery\ (\%) = \frac{C_p - C_{qc}}{C_a - C_{qc}} \times 100$$

Equation 3.2

In order to keep away from any interference or contamination, a procedural blank (except no samples from the extraction until the instrumental analysis) was analysed for each batch of samples.

3.7.6 Method Validation

The mixtures of pesticides standard together with IS were spiked into the blank XAD-2 resin in decreasing amount to determine the MDL and MQL. XAD-2 resin was extracted and analysed using UHPLC-MS/MS. MDL and MQL were determined with a signal-to-noise ratio of >3 and >10 respectively (Choi et al., 2013).

3.8 Statistical Analysis

All the data were analysed using Statistical Package for the Social Sciences (SPSS) Version 22. In this study, descriptive analysis was used to present the percentage, mean and standard deviation to explain the concentration of pesticides, lifestyle, socio-demographic background and reported health symptoms among paddy farmers and non-exposed group. Next, Man Whitney-U test was used to compare the concentrations of pesticides in personal air samples among paddy farmers and non-exposed group. Besides that, Chi-square test was used to determine the differences between concentration of pesticides and reported health symptoms among paddy farmers and non-exposed group. Chi-square test also was used to determine the association of lifestyle, socio-demographic background and reported health symptoms among paddy farmers and non-exposed group.

3.9 Ethical Consideration

This study was obtained ethical approval from the Ethics Committee of Universiti Putra Malaysia (UPM), Selangor, Malaysia as this research involve human. Written consent was obtained from the respondents prior to the study and the instruction about questionnaire was explained to the respondents during filling up the questionnaire. All information obtained from the respondents were kept private and confidential and used for study purposes only.

CHAPTER 4

RESULTS

4.1 Quality Control

Calibration curves were obtained for all analytes to determine the concentration of pesticides (isoprothiolane, tricyclazole and propiconazole) in the personal air samples. Linear ranges, regression coefficients (R2), recovery, MDL and MQL (**Table 4.1**). Five-point calibration curves for all target compounds were derived in the range of 0.1–500 ng mL^{-1}. All calibration curves of the target compounds showed good linearity with regression coefficient (R2) ranges from 0.9995 to 0.9999. The MDL and MQL for all target compounds ranged from 0.1– 1.0 ng $sample^{-1}$ and 0.5–3.0 ng $sample^{-1}$ respectively. The values MDL and MQL were reported in the unit ng $sample^{-1}$ instead of ng m_{-3} because the blank XAD-2 resins were spiked with pesticides standards and IS directly without any volume of air passing through (Choi et al., 2013). The extraction recovery was examined for concentrations at 100 ng $sample^{-1}$ and ranged from 99 to 102%. All RSD values were less than 10%, which indicates reasonable extraction efficiencies.

Table 4.1: Information of linear range, R^2, percentage of recovery, MDL and MQL.

Target compound	Linear range (ng mL^{-1})	R^2	Recovery % (RSD %), n=1 100 ng $sample^{-1}$	MDL (ng $sample^{-1}$)	MQL (ng $sample^{-1}$)
Isoprothiolane	0.1-500	0.9996	101 (6.6)	0.1	0.5
Tricyclazole	0.1-500	0.9995	102 (4.1)	0.1	0.5
Propiconazole	0.5-500	0.9995	99 (3.8)	1.0	3.0

R^2: Coefficient of determination

Recovery %: Percentage of the concentration s of each analytes spiked before sample extraction compared to its concentration spiked after sample extraction in the XAD-2 resin

RSD: Relative standard deviation

MDL: Method detection limit

MQL: Method quantification limit

Internal stadards; ^{a}Diuron-d_6 and ^{b}Imidacloprid-d_4

4.2 Sociodemographic background of paddy farmers and non-exposed group.

The questionnaires were distributed among 85 paddy farmers and 85 office workers to obtain their sociodemographic background. **Table 4.2** shows the results for sociodemographic background of the respondents. From the table, it showed that 100% of the respondents (n=85) were male and Malay paddy farmers and 100% (n=85) were male and Malay office workers. The aged of the respondents for both groups were ranged from 18-59 years old. The mean age of exposed group was 41.65±11.06 years while the mean age for non-exposed group was 41.86±11.00 years. The mean weight of the respondents from exposed group and non-exposed were 72.03 ± 14.931 kg and 78.21 ± 16.521 kg respectively. The mean height of the respondents from exposed and non-exposed group were 166.41 ± 5.935 kg and 167.00 ± 6.690 m respectively. Meanwhile, the mean BMI of the respondents from exposed and non-exposed group were 26.67 ± 8.520 kg/m^2 and 28.00 ± 5.728 kg/m^2 respectively.

Table 4.2: Sociodemographic background of paddy farmers (n=85) and non-exposed group (n=85).

Variables	Expose Group			Non-exposed Group		
	Mean ± SD	**Minimum**	**Maximum**	**Mean ± SD**	**Minimum**	**Maximum**
Age (years)	41.65 ± 11.06	18	59	41.86 ± 11.00	19	59
Weight (kg)	72.03 ± 14.931	50	112	78.21 ± 16.521	50	137
Height (cm)	166.41 ± 5.935	153	180	167.00 ± 6.690	150	180
BMI (kg/m^2)	26.67 ± 8.520	18	89	28.00 ± 5.728	19	52
Variables	**Category**	**Frequency**	**Percentage (%)**	**Category**	**Frequency**	**Percentage (%)**
Gender	Male	85	100.0	Male	85	100.0
Race	Malay	85	100.0	Malay	85	100.0
Education level	No education	1	1.2	No education	0	0
	Primary	12	14.1	Primary	2	2.4
	Secondary	69	81.2	Secondary	35	41.2
	Tertiary	3	3.5	Tertiary	48	56.5
Smoking	Yes	47	55.3	Yes	33	38.8

4.3 Concentrations of pesticides in personal air samples collected among paddy farmers and non-exposed group.

Table 4.3 shows the mean concentrations of pesticides found in personal air samples collected among paddy farmers and non-exposed group. For paddy farmers, the most frequently detected pesticides in personal air samples in order of frequency were tricyclazole, isoprothiolane and propiconazole. Tricyclazole had the highest mean concentration (55.068 ng m^{-3}), followed by isoprothiolane (32.869 ng m^{-3}) while propiconazole had the lowest mean concentration (9.355 ng m^{-3}) among the target compounds.

For non-exposed group, the most frequently detected pesticides in personal air samples in order of frequency were tricyclazole, isoprothiolane and propiconazole. Tricyclazole had the highest mean concentration (0.876 ng m^{-3}) followed by isoprothiolane (0.461 ng m^{-3}) while propiconazole was less than MQL among the target compounds.

Table 4.3: Concentrations of pesticides in personal air samples collected among paddy farmers (n=85) and non-exposed group (n=85).

Group	Target compounds	Mean	Standard deviation	Minimum	Maximum	Frequency of detection in personal air samples
Exposed	Isoprothiolane[a]	32.869	48.7735	<MQL	178.9	47
	Tricyclazole[a]	55.068	80.9784	<MQL	433.0	69
	Propiconazole[b]	9.355	24.0405	<MQL	138.3	16

Group	Target compounds	Mean	Standard deviation	Minimum	Maximum	Frequency of detection in personal air samples
Non-exposed	Isoprothiolane[a]	0.461	1.6258	<MQL	8.8	7
	Tricyclazole[a]	0.876	2.4371	<MQL	9.8	11
	Propiconazole[b]	<MQL	-	<MQL	<MQL	0

MQL, method quantification limit.

[a] Diuron-d_6

[b] Imidacloprid-d_4

4.4 Comparison between concentrations of pesticides in personal air samples among paddy farmers and non-exposed group.

Table 4.4 shows the comparison between concentrations of pesticides in personal air samples among paddy farmers and non-exposed group. There were significant difference (p<0.05) between concentrations of tricyclazole (p=0.001), isoprothiolane (p=0.001) and propiconazole (p=0.001) in personal air samples among paddy farmers and non-exposed group.

4.5 Comparison of reported health symptoms among paddy farmers and non-exposed group.

Table 4.5 shows the most common health effects reported as a result of pesticide exposure among the paddy farmers and non-exposed group. Chi-square analysis showed a significant difference (p<0.05) between the exposed and non-exposed group for selected variables on health effects such as breathing difficulties (X^2=22.667, p=0.001), chest pain (X^2=7.441, p=0.006), nausea (X^2=22.694, P=0.001), vomiting (X^2=3.977, P=0.046) and runny nose (X^2=9.947, P=0.003). The results showed a higher percentage of occurrences for the exposed group than for the non-exposed group. However, no significant difference (p>0.05) was found for several health symptoms which were cough, phlegm, wheezing, sore throat and dizziness for exposed and non-exposed group.

Table 4.4: Comparison between concentrations of pesticides in personal air samples among paddy farmers (n=85) and non-exposed group (n=85).

Target compounds	Mean (STD)		[a]*z*	**p*
	Exposed	Non-exposed		
Isoprothiolane	32.87 (48.77)	0.46 (1.63)	-6.942	**0.001***
Tricyclazole	55.07 (80.98)	0.88 (2.44)	-9.424	**0.001***
Propiconazole	9.36 (24.04)	-	-4.183	**0.001***

**p*-value is significant at level 0.05

[a]*z* Obtained from Mann-Whitney U test

Table 4.5: Comparison of reported health symptoms among paddy farmers (n=85) and non-exposed group (n 85).

Health effects	Exposed group (n=85)		Non-exposed group (n=85)		X^2	*p*
	n (%)		n (%)			
Reported	Yes	No	Yes	No		
Breathing difficulties	20 (23.5)	65 (76.5)	0 (0.0)	85 (100.0)	22.667[a]	**0.001***
Chest pain	20 (23.5)	65 (76.5)	7 (8.2)	78 (91.8)	7.441[a]	**0.006***
Cough	34 (40.0)	51 (60.0)	28 (32.9)	57 (67.1)	0.914[a]	0.339
Phlegm	4 (4.7)	81 (95.3)	5 (5.9)	80 (94.1)	0.001[b]	1.000
Wheezing	3 (3.5)	82 (96.5)	0 (0.0)	85 (100.0)	1.357[b]	0.244
Sore throat	20 (23.5)	65 (76.5)	21 (24.7)	64 (75.3)	0.032[a]	0.858
Nausea	35 (41.2)	50 (58.8)	8 (9.4)	77 (90.6)	22.694[a]	**0.001***
Vomiting	13 (15.3)	72 (84.7)	5 (5.9)	80 (97.1)	3.977[a]	**0.046***
Dizziness	36 (42.4)	49 (57.6)	27 (31.8)	58 (68.2)	2.043[a]	0.153
Runny nose	15 (17.6)	70 (82.4)	3 (3.5)	82 (96.5)	9.947[a]	**0.003***

[a]Pearson Chi-Square
[b]Continuity Correction
**p* value is significant at 0.05 levels; ***p* value is significant at 0.001 levels

4.6 Association between sociodemographic background and reported health symptoms among paddy farmers and non-exposed group.

Table 4.6 shows the association between sociodemographic background (age) and reported health symptoms among paddy farmers and non-exposed group. There was no significant association between age 18-19 years old and 20-29 years old with the reported health symptoms among paddy farmers and non-exposed group. Meanwhile, this study showed that there was significant association between age 30-39 years old with breathing difficulties (X^2=7.566, p=0.006), chest pain (X^2=7.566, p=0.006) and nausea (X^2=8.400, p=0.004) among the exposed group. Next, it was found that there was a significant association between age 40-49 years old with nausea (X^2=6.857, p=0.009) among the exposed group. Lastly, there was also significant association between age 50-59 years old with nausea (X^2=6.788, p=0.009) among the exposed group.

Table 4.7 shows the association between sociodemographic background (level of education) and reported health symptoms among paddy farmers and non-exposed group. There was no significant association between no formal education level and primary education level with the reported health symptoms among paddy farmers and non-exposed group. Meanwhile, this study showed that there was significant association between secondary education level with breathing difficulties (X^2=11.041, p=0.010), chest pain (X^2=3.859, p=0.049) and nausea (X^2=5.182, p=0.023) among the exposed group. Next, it was found that there was a significant relationship between tertiary education level with nausea (X^2=19.489, p=0.001) among the exposed group.

Table 4.6: Association between sociodemographic background (age) and reported health symptoms among farmers (n=85) and non-exposed group (n=85).

Health symptoms	Age																			
	18-19				20-29				30-39				40-49				50-59			
	Exposed (%)	Non-exposed (%)	X^2	P	Exposed (%)	Non-exposed (%)	X^2	P	Exposed (%)	Non-exposed (%)	X^2	P	Exposed (%)	Non-exposed (%)	X^2	P	Exposed (%)	Non-exposed (%)	X^2	P
Breathing difficulties	-	-	-	-	4 (100)	0 (0)	2.625^{b}	0.105	8 (100)	0 (0)	7.566^{b}	0.006**	3 (100)	0 (0)	1.436^{b}	0.231	5 (100)	0 (0)	3.514^{b}	0.061
Chest pain	-	-	-	-	4 (80)	1 (20)	0.974^{b}	0.324	8 (100)	0 (0)	7.566^{b}	0.006**	3 (75)	1 (25)	0.276^{b}	0.599	5 (50)	5 (50)	0.000^{a}	1.000
Cough	1 (100)	0 (0)	0.000^{b}	1.000	4 (33.3)	8 (66.7)	2.333^{a}	0.127	7 (58.3)	5 (41.7)	0.467^{a}	0.495	11 (64.7)	6 (35.3)	2.471^{a}	0.116	11 (55)	9 (45)	0.311^{a}	0.577
Phlegm	-	-	-	-	-	-	-	-	1 (50)	1 (50)	0.000^{b}	1.000	1 (50)	1 (50)	0.000^{b}	1.000	2 (40)	3 (60)	0.000	1.000
wheezing	1 (100)	0 (0)	0.000^{b}	1.000	1 (100)	0 (0)	0.000^{b}	1.000	1 (100)	0 (0)	0.000^{b}	1.000	-	-	-	-	-	-	-	-
Sore throat	0 (0)	1 (100)	0.000^{b}	1.000	3 (37.5)	5 (62.5)	0.175^{b}	0.676	3 (42.9)	4 (57.1)	0.000^{b}	1.000	6 (66.7)	3 (33.3)	0.566^{b}	0.452	8 (50)	8 (50)	0.000^{a}	1.000
Nausea	1 (100)	0 (0)	0.000^{b}	1.000	4 (66.7)	2 (33.3)	0.212^{b}	0.645	9 (90)	1 (10)	8.400^{a}	0.004**	11 (78.6)	3 (21.4)	6.857^{a}	0.009**	10 (83.3)	2 (16.7)	6.788^{a}	0.009**
Vomiting	-	-	-	-	3 (100)	0 (0)	1.493^{b}	0.222	4 (57.1)	3 (42.9)	0.000^{b}	1.000	3 (100)	0 (0)	1.436	0.231	3 (60)	2 (40)	0.000^{b}	1.000
Dizziness	1 (100)	0 (0)	0.000^{b}	1.000	6 (46.2)	7 (53.8)	0.144^{a}	0.705	9 (52.9)	8 (47.1)	0.099^{a}	0.753	10 (66.7)	5 (33.3)	2.593^{a}	0.107	10 (58.8)	7 (41.2)	0.760^{a}	0.383
Runny nose	-	-	-	-	3 (75)	1 (25)	0.292^{b}	0.589	5 (83.3)	1 (16.)	1.750^{b}	0.186	5 (83.3)	1 (16.7)	1.750	0.186	2 (100)	0 (0)	0.519^{b}	0.471

[a]Pearson Chi Square

[b]Continuity correction

**p* value is significant at 0.05 levels; ***p* value is significant at 0.01 levels

Table 4.7: Association between sociodemographic background (level of education) and reported health symptoms among farmers (n–85) and non-exposed group (n=85).

	Level of Education															
	No formal				Primary				Secondary				Tertiary			
Health Symptoms	**Exposed (%)**	**Non-exposed (%)**	**X^2**	***p***	**Exposed (%)**	**Non-exposed (%)**	**X^2**	***p***	**Exposed (%)**	**Non-exposed (%)**	**X^2**	***p***	**Exposed (%)**	**Non-exposed (%)**	**X^2**	***p***
Breathing Difficulties	0 (0.0)	0 (0.0)	-	-	1 (100.0)	0 (0.0)	0.000[b]	1.000	18 (100.0)	0 (0.0)	11.041[a]	**0.01****	1 (100.0)	0 (0.0)	3.586[b]	0.058
Chest pain	0 (0.0)	0 (0.0)	-	-	3 (100.0)	0 (0.0)	0.000[b]	1.000	17 (85.0)	3 (15.0)	3.859[a]	**0.049***	0 (0.0)	4 (100.0)	0.000[b]	1.000
Cough	1 (100.0)	0 (0.0)	-		4 (66.7)	2 (33.3)	0.984[b]	0.321	27 (73.0)	10 (27.0)	1.130[a]	0.288	2 (11.1)	16 (88.9)	0.302[b]	0.583
Phlegm	0 (0.0)	0 (0.0)	-	-	1 (100.0)	0 (0.0)	0.000[b]	1.000	3 (75.0)	1 (25.0)	0.000[b]	1.000	0 (0.0)	4 (100.0)	0.000[b]	1.000
Wheezing	0 (0.0)	0 (0.0)	-	-	0 (0.0)	0 (0.0)	0.000[b]	1.000	3 (100.0)	0 (0.0)	0.399[b]	0.527	0 (0.0)	0 (0.0)		
Sore throat	1 (100.0)	0 (0.0)	-	-	2 (100.0)	0 (0.0)	0.000[b]	1.000	16 (66.7)	8 (33.3)	0.001[a]	0.970	1 (7.1)	13 (92.9)	0.000[b]	1.000
Nausea	1 (100.0)	0 (0.0)	-	-	4 (100.0)	0 (0.0)	0.015[b]	0.904	27 (81.8)	6 (18.2)	5.182[a]	**0.023***	3 (60.0)	2 (40.0)	19.489[b]	**0.001****
Vomit	0 (0.0)	0 (0.0)	-	-	2 (100.0)	0 (0.0)	0.000[b]	1.000	10 (90.9)	1 (9.1)	2.208[b]	0.137	1 (20.0)	4 (40.0)	0.170[b]	0.680
Dizzy	0 (0.0)	0 (0.0)	-	-	7 (77.8)	2 (22.2)	0.117[b]	0.733	26 (72.2)	10 (27.8)	0.851[a]	0.356	3 (16.7)	15 (83.3)	3.221[b]	0.073
Runny nose	0 (0.0)	0 (0.0)	-	-	1 (100.0)	0 (0.0)	0.000[b]	1.000	14 (87.5)	2 (12.5)	3.790[a]	0.052	0 (0.0)	1 (100.0)	0.000[b]	1.000

[a]Pearson Chi-Square
[b]Continuity Correction
* *p* value is significant at 0.05 levels; ***p* value is significant at 0.01 level

4.7 Association between lifestyle and the reported health symptoms among paddy farmers and non-exposed group.

Table 4.8 shows the association between lifestyle (smoking behavior, consumption of vegetable at least once per week, consumption of fruit at least once per week, exercise at least once per week and supplement intake) with reported health symptoms among paddy farmers and non-exposed group. There was significant association between smoking behaviour with breathing difficulties (X^2=8.011, p=0.005), chest pain (X^2=4.285, P=0.038), nausea (X^2=15.276, p=0.001), dizzy (X^2=4.981, p=0.026) and runny nose (X^2=4.493, p=0.034) among the exposed group. Next, this study showed that there was significant association between consumption of vegetable at least once per week with breathing difficulties (X^2=22.995, p=0.001), chest pain (X^2=7.654, p=0.006), nausea (X^2=21.922, p=0.001), vomit (X^2=4.093, p=0.043) and runny nose (X^2=9.129, p=0.003) among the exposed group. Besides that, based on the results, it was found that there was also a significant association between consumption of fruit at least once per week with breathing difficulties (X^2=22.418, p=0.001), chest pain (X^2=7.268, p=0.007), nausea (X^2=22.313, p=0.001), vomit (X^2=3.874, p=0.049) and runny nose (X^2=8.796, p=0.003) among the exposed group. Moreover, there was significant association between exercise at least once per week with breathing difficulties (X^2=10.409, p=0.001), chest pain (X^2=3.958, p=0.047), nausea (X^2=14.137, p=0.001) and runny nose (X^2=3.958, p=0.047) among the exposed group. Lastly, there was no significant association between supplement intakes with health symptoms among the two groups.

Table 4.8: Association between lifestyle and the reported health symptoms among paddy farmers (n=85) and non-exposed group (n=85).

Health Symptoms	Smoker				Vegetable/ week				Fruit/ week				Exercise/week				Supplement/ month			
	Exposed	Non-exposed	X^2	*p*	Exposed	Non-exposed	X^2	*p*	Exposed	Non-exposed	X^2	*p*	Exposed	Non-exposed	X^2	*p*	Exposed	Non-exposed	X^2	*p*
Breathing difficulties	12 (100.0)	0 (0.0)	8.011[b]	0.005*	20 (100.0)	0 (0.0)	22.995[a]	0.001*	20 (100.0)	0 (0.0)	22.418[a]	0.001*	7 (100.0)	0 (0.0)	10.409[b]	0.001*	3 (100.0)	0 (0.0)	2.999[b]	0.083
Chest pain	11 (84.6)	2 (15.4)	4.285[a]	0.038*	20 (74.1)	7 (25.9)	7.654[a]	0.006*	20 (74.1)	7 (25.9)	7.268[a]	0.007*	7 (70.0)	3 (30.0)	3.958[b]	0.047*	1 (33.3)	2 (66.7)	0.001[b]	1.000
Cough	20 (71.4)	8 (28.6)	2.857[a]	0.091	32 (53.3)	28 (46.7)	0.494[a]	0.482	34 (54.8)	28 (45.2)	0.808[a]	0.369	13 (39.4)	20 (60.6)	0.205[a]	0.650	4 (33.3)	8 (66.7)	0.001[b]	1.000
Phlegm	2 (100.0)	0 (0.0)	0.224[b]	0.636	4 (44.4)	5 (55.6)	0.001[b]	1.000	4 (44.4)	5 (55.6)	0.001[b]	0.985	1 (16.7)	5 (83.3)	0.351[b]	0.554	2 (40.0)	3 (60.0)	0.001[b]	1.000
Wheezing	2 (100.0)	0 (0.0)	0.224[b]	0.636	3 (100.0)	0 (0.0)	1.382[b]	0.240	3 (100.0)	0 (0.0)	1.333[b]	0.248	1 (100.0)	0 (0.0)	0.082[b]	0.774	-	-	-	-
Sore throat	10 (76.9)	3 (23.1)	2.115[a]	0.146	20 (48.8)	21 (51.2)	0.018[a]	0.892	20 (48.8)	21 (51.2)	0.050[a]	0.824	11 (37.9)	18 (62.1)	0.048[a]	0.826	3 (33.3)	6 (66.7)	0.001[b]	1.000
Nausea	24 (88.9)	3 (11.1)	15.276[a]	0.001*	34 (81.0)	8 (19.0)	21.922[a]	0.001*	35 (81.4)	8 (18.6)	22.313[a]	0.001*	15 (71.4)	6 (28.6)	14.137[a]	0.001*	2 (100.0)	0 (0.0)	1.302[b]	0.254
Vomit	7 (77.8)	2 (22.2)	0.759[b]	0.383	13 (72.2)	5 (27.8)	4.093[a]	0.043*	13 (72.2)	5 (27.8)	3.874[a]	0.049*	5 (55.6)	4 (44.4)	0.804[b]	0.370	0 (0.0)	1 (100.0)	0.001[b]	1.000
Dizzy	23 (74.2)	8 (25.8)	4.981[a]	0.026*	35 (56.5)	27 (43.5)	1.798[a]	0.180	36 (57.1)	27 (42.9)	1.884[a]	0.170	15 (42.9)	20 (57.1)	0.999[a]	0.318	4 (40.0)	6 (60.0)	0.001[b]	1.000
Runny nose	8 (100.0)	0 (0.0)	4.493	0.034*	15 (83.3)	3 (16.7)	9.129[a]	0.003*	15 (83.3)	3 (16.7)	8.796[a]	0.003*	7 (70.0)	3 (30.0)	3.958[b]	0.047*	2 (100.0)	0 (0.0)	1.302[b]	0.254

[a]Pearson Chi-Square
[b]Continuity Correction
* *p* value is significant at 0.05 levels; ***p* value is significant at 0.01 level

4.8 Association between concentrations of pesticides and reported health symptoms among paddy farmers and non-exposed group.

Table 4.9 shows the association between concentrations of pesticides (isoprothiolane, tricyclazole and propiconazole) and reported health symptoms among paddy farmers and non-exposed group. There was significant association between concentrations of isoprothiolane with chest pain (X^2=11.551, p=0.001) among the exposed group. Next, there was significant association between concentrations of tricyclazole with breathing difficulties (X^2=9.511, p=0.002), nausea (X^2=11.291, p=0.001) and runny nose (X^2=10.278, p=0.001) among the exposed group.

Table 4.9: Association between concentrations of pesticides and reported health symptoms among paddy farmers (n=85) and non-exposed group (n=85).

Health symptoms	Target compounds											
	Isoprothiolane				Tricyclazole				Propiconazole			
	Exposed	Non-exposed	X^2	*p*	Exposed	Non-exposed	X^2	*p*	Exposed	Non-exposed	X^2	*p*
Breathing difficulties	13 (65.0)	7 (8.2)	2.381[a]	0.123	16 (80.0)	12 (14.1)	9.511[a]	**0.002***	2 (10.0)	-	0.000[b]	1.000
Chest pain	10 (50.0)	2 (28.6)	11.551[a]	**0.001***	15 (75.0)	1 (14.3)	1.735[a]	0.188	2 (10.0)	-	0.001[b]	0.976
Cough	17 (50.0)	2 (7.1)	0.056[a]	0.812	25 (73.5)	5 (17.9)	0.021[a]	0.884	8 (23.5)	-	1.395[a]	0.238
Phlegm	2 (50.0)	1 (20.0)	0.000[b]	1.000	4 (100.0)	-	0.000[b]	1.000	1 (25.0)	-	0.000[b]	1.000
Wheezing	2 (66.7)	7 (8.2)	0.469[b]	0.494	2 (66.7)	12 (14.1)	0.007[b]	0.934	1 (33.3)	-	0.189[b]	0.664
Sore throat	10 (50.0)	3 (14.3)	0.000[a]	0.993	17 (85.0)	4 (19.0)	0.276[a]	0.599	3 (15.0)	-	0.049[b]	0.826
Nausea	16 (45.7)	1 (12.5)	1.603[a]	0.205	28 (80.0)	2 (25.0)	11.291[a]	**0.001***	9 (25.7)	-	7.240[b]	**0.007***
Vomiting	7 (53.8)	-	0.471[a]	0.492	10 (76.9)	-	0.505[a]	0.477	2 (15.4)	-	0.000[b]	1.000
Dizzy	19 (52.8)	3 (11.1)	0.460[a]	0.498	30 (83.3)	4 (14.8)	1.603[a]	0.205	6 (16.7)	-	0.001[a]	0.969
Runny nose	6 (40.0)	-	0.023[a]	0.880	13 (86.7)	2 (66.7)	10.278[a]	**0.001***	2 (13.3)	-	0.000[b]	1.000

[a]Pearson Chi-Square
[b]Continuity Correction
**p* value is significant at 0.05 levels, ***p* value is significant at 0.01 level

CHAPTER 5

DISCUSSION

5.1 Sociodemographic background of paddy farmers and non-exposed group.

In this study, the sociodemographic background of paddy farmers and non-exposed group were determined. All of paddy farmers and non-exposed group involved in this study were Malay as majority of the residents in Kampung Sawah Sempadan and Tanjung Karang were Malay. In term of gender, the paddy farmers were all male which suggest that the female residents were not engaged in paddy cultivation activities like male residents. For the non-exposed group, all the respondents also were all male because we need to match the gender in order to control bias. The mean age of paddy farmers was 42 years old. This indicate that paddy cultivation activities were usually carried out by the middle-age group. For the non-exposed group, the mean age also was 42 years old. The mean weight of paddy farmers was 72 kg while the mean weight for non-exposed group was 78 kg. The mean height for paddy farmers was 166 cm while for non-exposed group was 167 cm. The mean BMI for paddy farmers was 27 kg/m^2 while for non-exposed group was 28 kg/m^2.

5.2 Concentrations of pesticides in personal air samples collected among paddy farmers and non-exposed group.

Based on the **Table 4.3**, tricyclazole was the most frequently detected pesticides among paddy farmers followed by isoprothiolane and propiconazole. All of the pesticides come from the same agrochemical category which was fungicides. Fungicides were used for reproductive and ripening phases of paddy to minimize crop damage and protect the quantity of agricultural products. The farmers in the sampling area preferred to use tricyclazole because they claimed that tricyclazole was cheap and more effective compared to other compound. Similar findings was reported by Hamsan et al., (2017).

The mean concentrations of tricyclazole, isoprothiolane and propiconazole in exposed group were 55.068 ng m^{-3}, 32.869 ng m^{-3} and 9.355 ng m^{-3}. The results showed comparable mean concentration of tricyclazole, isoprothiolane and propiconazole with a study by Hamsan et al. (2017), which reported the mean concentrations of tricyclazole, isoprothiolane and propiconazole were 65.03 ng m^{-3}, 57.42 ng m^{-3} and 49.70 ng m^{-3} respectively. The mean concentration of pesticides in this study were lower compared to other studies possibly because the wind speed were low and all personal air samples were collected in the morning (Baharuddin et al., 2011).

For non-exposed group, based on the result, the mean concentrations for all target compound were lower compared to exposed group because the personal air samples were collected during their working hours and in indoor area. Moreover, their working distance also far away from the paddy field area, thus making the mean concentrations of pesticides in personal air samples collected among non-exposed group were lower. General population or non-exposed group can exposed to pesticide in or around workplace that nearby the paddy field area (Damalas and Eleftherohorinos, 2011).

5.3 Comparison between concentrations of pesticides in personal air samples among paddy farmers and non-exposed group.

Based on the table, the concentrations of pesticides in personal air samples among paddy farmers were higher compared to non-exposed group. This is because the paddy farmers were directly exposed with pesticides during spraying activity. Jaipieam et al. (2009) also stated that paddy farmers are at greater risk to expose to pesticides residue via direct and indirect inhalation during preparation (mixing and loading) and application (spraying). For the non-exposed group, the personal air samples was collected during office hours and in indoor area. Moreover, their working distance also far away from the paddy field area, thus making the mean concentrations of pesticides in personal air samples collected among non-exposed group were lower.

5.4 Comparison of reported health symptoms among paddy farmers and non-exposed group.

In **Table 4.5**, the comparison of reported health symptoms among paddy farmers and non-exposed group was observed. The result shows that several health symptoms like breathing difficulties, chest pain, nausea, vomiting and runny nose were significant among the paddy farmers as compared to non-exposed group. Chi-square test was run in order to determine which health symptoms show the significant difference among paddy farmers and non-exposed group.

Similar findings have been reported by Baharuddin et al. (2011) which stated that there was a significant difference ($p<0.05$) between exposed and non-exposed group for selected variables on health effects such as nausea. A study involving 185 farmworkers in the Gaza Strip found that the most common symptoms related to pesticides exposure included breathing difficulties and chest pain (Yassin et al., 2012). A survey of Thai farmers reported that the health symptoms related to pesticide exposure included vomiting (Sapbamrer, 2011). A study among Philippine farmers exposure to pesticides also reported increasing occurrences of respiratory tract effects compared with the controls (Pingali, 1995). Sapbamrer et al. (2013) indicate that breathing difficulties and chest pain were related with exposure to pesticides for exposed group.

5.5 Association between sociodemographic background (age) and reported health symptoms among farmers and non-exposed group.

Chi-square test was used to determine the association between sociodemographic background (age) and reported health symptoms among paddy farmers and non-exposed group. There was significant association between age 30-39 years old with breathing difficulties, chest pain and nausea among the exposed group. The result shows that 100% of the paddy farmers who age between 30-39 years old had breathing difficulties and chest pain while none of the respondents from non-exposed group having that health symptoms. Ninety percent of the paddy farmer reported that they had nausea from pesticide exposure compared to non-exposed group which was 10%.

Next, it was found that there was a significant association between age 40-49 years old with nausea among the exposed group. Up to 78.6% of paddy farmers reported that they had nausea compared to 21.4% respondents from non-exposed group. Besides that, there was significant association between age 50-59 years old with nausea among the exposed group. The result showed that 83.3% of paddy farmers reported that they had nausea compared to 16.7% respondents from non-exposed group.

The percentage of the respondents who experienced the health symptoms were higher in exposed group because all the paddy farmers were directly exposed to pesticides compared to non-exposed group. Besides that, the health symptoms was significant in adults 30-59 years old compared to the adults 18-29 years old for both exposed and non-exposed group. This is because immune function declines with age, leading to increase chances to get infection in aged individuals. Aging is usually associated with increase in chronic disease as well as infections and associated morbidity (Ahluwalia, 2004).

5.6 Association between sociodemographic background (level of education) and reported health symptoms among farmers and non-exposed group.

Table 4.7 showed the association between sociodemographic background (level of education) and reported health symptoms among paddy farmers and non-exposed group. There was significant association between secondary education level with breathing difficulties, chest pain, nausea and runny nose among the exposed population. Hundred percent of the paddy farmers had breathing difficulties while none of the respondents from non-exposed group experienced breathing difficulties. Next, 85% paddy farmers had chest pain compared to non-exposed group which was 15%. Besides that, 81.8% paddy farmers had nausea compared to 18.2% respondents from non-exposed group. Also, 87.5% paddy farmers reported they had runny nose compared to 12.5% respondents from non-exposed group. The result showed that there was a significant relationship between tertiary education level with nausea among the exposed group. Up to 60% of paddy farmers reported nausea compared to 40% respondents from non-exposed group.

Understanding farmers' education level is vital for providing sound educational that aim at limiting the health and environmental hazards caused by pesticides. Majority of the farmers in this study having secondary education level compared to tertiary education level making higher significant association of secondary education level with health symptoms compared to tertiary education level. Farmers who had low education level is likely to contribute to increased risk of getting health symptoms to the farmers as they did not aware about hazard from pesticides. Educated farmers are more knowledgeable about pesticides safety, having better ability to read, understand and follow hazard warning on labels and conceptualized the consequences of poor pesticides usage practices (Karunamoorthi et al., 2012).

5.7 Association between lifestyle and the reported health symptoms among paddy farmers and non-exposed group.

The association between lifestyle and the reported health symptoms among paddy farmers and non-exposed group was statistically analysed using the Chi-square test (**Table 4.8**). The results showed that smoking behaviour were significantly associated with breathing difficulties, chest pain, nausea, dizzy and runny nose for exposed group. This finding shows that although pesticide exposure by inhalation among paddy farmers was related to reported health symptoms, the smoking behaviour significantly increase the chance of getting health symptoms. These results are in line with those of other studies, such as Manyilizu et al. (2017), who stated that smoking was associated with an increased incidence of chest pain compared to non-exposed group.

The percentage of consume vegetables and fruits at least once a week were higher among the exposed group as compared to non-exposed group. The results showed that consumption of vegetables and fruits at least once a week were significantly associated with breathing difficulties, chest pain, nausea, vomiting and runny nose for exposed group. Intake of fruits and vegetables improves the antioxidants level in the blood which plays a crucial role in maintaining the overall health of a person (Rathinam et al., 2004). However, in this case, the exposed group who directly exposed to pesticides was more prominent to reported health symptoms even though they consume vegetables and fruits at least once per week.

The frequency of exercise has significant association with breathing difficulties, chest pain, nausea and runny nose for exposed group. Exercise are essential components for reducing the severity of health risk factor (Vanhees et al., 2011). Furthermore, an individual's healthy lifestyle which emphasizes physical health-related activities may reduce the chances of getting disease (Chen, 2009). However, in this study, the exposed group was more prominent to reported health symptoms even though they exercise at least once per week.

5.8 Association between concentrations of pesticides and reported health symptoms among paddy farmers and non-exposed group.

Chi-square test was used to determine the association between concentrations of pesticides (isoprothiolane, tricyclazole and propiconazole) and reported health symptoms among paddy farmers and non-exposed group. There was significant association between concentrations of isoprothiolane with chest pain among the exposed group. Similar findings have also been reported by Hamsan et al., (2018), who reported that concentration of isoprothiolane was a significant contributing factor of chest pain symptoms. Next, there was significant association between concentrations of tricyclazole with breathing difficulties, nausea and runny nose among the exposed group. The percentage of the respondents who experienced the health symptoms were higher in exposed group as compared to non-exposed group. LeVan et al. (2005) also reported increase health symptoms happened among farmers that applied pesticides. In this study, the concentrations of isoprothiolane and tricyclazole in personal air samples were contributing factors that affected the reported health symptoms. Tricyclazole was the most frequently detected pesticide in this study and it was also the contributing factor for most of the reported health symptoms in this study.

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

The mean concentration of isoprothiolane (min=<Method Quantification Limit (MQL), max=178.9 ng m^{-3}), tricyclazole (min=<MQL, max=433.0 ng m^{-3}) and propiconazole (min=<MQL, max=138.3 ng m^{-3}) were higher in personal air samples of paddy farmers compared to non-exposed group. The concentrations of target compounds were significantly different among paddy farmers and non-exposed group. The reported health symptoms among paddy farmers were significantly different compared to non-exposed group. Higher percentage of reported health symptoms among paddy farmers compared to non-exposed group.

The sociodemographic background (age and level of education) was significantly associated with the reported health symptoms among paddy farmers as compared to non-exposed group. The lifestyle (smoking behaviour, consumption of vegetables and fruits at least once a week and exercise once a week) was significantly associated with the reported health symptoms among paddy farmers as compared to non-exposed group.

There was significant association between concentrations of isoprothiolane and tricyclazole with reported health symptoms among paddy farmers compared to non-exposed group. Throughout this study, the farmers should be provided with training on proper handling of pesticides and the importance of usage of personal protective equipment during spraying the pesticides. We also need to educate the farmers by giving awareness about the danger and health symptoms from pesticides exposure.

6.2 Limitation

There were some limitations encounter while conducting this study. Firstly, during sampling, it is difficult to obtain local paddy farmers as most of the paddy farmers were foreign workers who are being recruited by the local paddy farmers. Next, most of the respondents do not give accurate information about lifestyle as they cannot remember it.

6.2 Recommendation

Throughout this study, the authorities should educate and provide training on proper handling of pesticides and proper usage of personal protective equipment (PPE) to farmers in order to reduce the risk of exposure to pesticides. Farmers who handled pesticides during preparation and application of pesticides should wear proper PPE. The results obtained from this study also could help those agricultural community particularly paddy farmers as they will be more aware in relation to pesticides ingredients used by them.

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APPENDIX A:

Questionnaire

JABATAN KESIHATAN PERSEKITARAN & PEKERJAAN

FAKULTI PERUBATAN DAN SAINS KESIHATAN

UNIVERSITI PUTRA MALAYSIA

KEJADIAN RACUN PEROSAK DI DALAM SAMPEL UDARA PERIBADI DAN GEJALA KESIHATAN DALAM KALANGAN PETANI DAN KUMPULAN YANG TIDAK TERDEDAH DI TANJUNG KARANG, SELANGOR

ARAHAN SOALAN:

1. Borang soal selidik ini mengandungi **Empat (4)** bahagian iaitu:

   Bahagian A: Maklumat Diri

   Bahagian B: Latar Belakang Pekerjaan

   Bahagian C: Gaya Hidup

   Bahagian D: Maklumat Gejala/Tanda Kesihatan

2. Anda diminta menjawab semua soalan di dalam buku soalan ini
3. Buku soalan ini hendaklah dikembalikan kepada pengkaji setelah selesai menjawab.

KEJADIAN RACUN PEROSAK DI DALAM SAMPEL UDARA PERIBADI DAN GEJALA KESIHATAN DALAM KALANGAN PETANI DAN KUMPULAN YANG TIDAK TERDEDAH DI TANJUNG KARANG, SELANGOR

BAHAGIAN A: MAKLUMAT DIRI

1. Jantina:
   - ☐ Lelaki
   - ☐ Perempuan

2. Umur:
   - ☐ tahun

3. Bangsa:
   - ☐ Melayu
   - ☐ Cina
   - ☐ India
   - ☐ Lain-lain (sila nyatakan) ………………

4. Tahap pendidikan:
   - ☐ Tiada pendidikan formal
   - ☐ Pendidikan primer (sekolah rendah)
   - ☐ Pendidikan sekunder (sekolah menengah)
   - ☐ Pendidikan tertinggi (peringkat university/ kolej)

BAHAGIAN B: LATAR BELAKANG PEKERJAAN

5. Pekerjaan sekarang: ………………..

6. Tempoh bekerja di tempat sekarang: ……………….. bulan/ tahun

7. Jumlah hari bekerja dalam seminggu: ……………….. hari/ seminggu

8. Jumlah masa bekerja dalam seminggu: ……………….. jam/ sehari

9. Pekerjaan terdahulu: ………………..

10. Tempoh bekerja di tempat dahulu: ……………….. bulan/ tahun

KEJADIAN RACUN PEROSAK DI DALAM SAMPEL UDARA PERIBADI DAN GEJALA KESIHATAN DALAM KALANGAN PETANI DAN KUMPULAN YANG TIDAK TERDEDAH DI TANJUNG KARANG, SELANGOR

BAHAGIAN C: GAYA HIDUP

11. Adakah anda merokok sekarang?
☐ Ya ☐ Tidak
Jika "Ya", sila jawab soalan 12 - 14. Jika "Tidak", sila terus ke soalan 15.

12. Secara purata, berapakah kekerapan anda merokok setiap hari?
☐ 10 batang atau kurang ☐ 11 - 20 batang
☐ 21 - 40 batang ☐ Lebih dari 40 batang

13. Berapakah jumlah tahun anda menghisap rokok?
☐ tahun

14. Apakah jenis rokok yang anda hisap?
☐ Batang ☐ Daun
☐ Paip ☐ Vape (elektronik)

15. Adakah anda pernah merokok dalam tempoh 2 tahun yang lepas?
☐ Ya ☐ Tidak

16. Adakah mana-mana ahli keluarga yang merokok di rumah anda?
☐ Ya ☐ Tidak
Jika "Ya", sila jawab soalan 17 & 18. Jika "Tidak", sila terus ke soalan 19.

17. Berapa orangkah yang merokok di rumah anda? (tidak termasuk diri anda)
☐ orang

18. Adakah anda makan sayur-sayuran?
☐ Ya ☐ Tidak

19. Jika "Ya", berapa kerap anda makan sayur-sayuran dalam seminggu?
kali/ minggu

20. Adakah anda makan buah-buahan?
☐ Ya ☐ Tidak

21. Jika "Ya", berapa kerap anda makan buah-buahan dalam seminggu?
☐ kali/ minggu

22. Adakah anda melakukan aktiviti senaman?
☐ Ya ☐ Tidak

23. Jika "Ya", berapa kerap anda melakukan aktiviti senaman dalam seminggu?
☐ kali/ seminggu

24. Di manakah anda melakukan aktiviti senaman?
☐ Di tempat terbuka
☐ Di ruang tertutup
☐ Kedua-duanya

25. Adakah anda mengambil sebarang makanan tambahan?
☐ Ya ☐ Tidak

26. Jika "Ya", berapa lamakah anda telah mengambil makanan tambahan terebut?
☐ bulan/ tahun

BAHAGIAN D: GEJALA/ TANDA KESIHATAN

27. Apakah jenis-jenis gejala/ tanda yang anda alami dalam tempoh masa 12 bulan yang lepas? (Sila tandakan (/) pada mana yang berkaitan)

No.	Gejala/ tanda kesihatan	Ya	Tidak
1.	Kesukaran bernafas		
2.	Sakit dada		
3.	Batuk		
4.	Kahak		
5.	Berdehit		
6.	Sakit tekak		
7.	Loya		
8.	Muntah		
9.	Pening		
10.	Hidung berair		

KEJADIAN RACUN PEROSAK DI DALAM SAMPEL UDARA PERIBADI DAN GEJALA KESIHATAN DALAM KALANGAN PETANI DAN KUMPULAN YANG TIDAK TERDEDAH DI TANJUNG KARANG, SELANGOR

28. Pada bulan berapakah anda kerap mengalami gejala/ tanda kesihatan di atas?

	Setiap bulan		
	Januari		Julai
	Februari		Ogos
	Mac		September
	April		Oktober
	Mei		November
	Jun		Disember

29. Adakah anda berjumpa dengan doctor apabila menagalami gejala/ tanda kesihatan di atas?

☐ Ya ☐ Tidak

30. Maklumat komposisi badan.

Parameter komposisi badan	**Keputusan**
Tinggi	m
Berat	kg
Indeks jisim badan	kg/m^2

~ Borang soal selidik tamat ~

Terima kasih atas kerjasama yang telah anda berikan.

Adakah anda ingin mengetahui keputusan kajian ini? Jika "Ya", sila isikan maklumat berikut untuk makluman tentang keputusan kajian.

☐ Ya ☐ Tidak

Nama: ……………………………………………………………………………

Alamat surat menyurat: ……………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

No. telefon: ……………………………………………………………………

APPENDIX B:

Consent Form

JAWATANKUASA ETIKA UNIVERSITI UNTUK PENYELIDIKAN MELIBATKAN MANUSIA (JKEUPM)
UNIVERSITI PUTRA MALAYSIA, 43400 UPM SERDANG, SELANGOR, MALAYSIA

BORANG 2.4: PENERANGAN DAN PERSETUJUAN RESPONDEN

Sila baca maklumat berikut dengan teliti. Sekiranya anda mempunyai sebarang pertanyaan, sila kemukakan kepada penyelidik.

1.TAJUK KAJIAN

Kejadian Racun Perosak Di Dalam Sampel Udara Peribadi Dan Gejala Kesihatan Dalam Kalangan Pesawah Padi Dan Kumpulan Yang Tidak Terdedah Di Tanjung Karang, Selangor.

2. PENGENALAN

Malaysia merupakan sebuah negara yang banyak bergantung kepada hasil pertanian. Oleh sebab itu, pengenalan pelbagai jenis racun perosak dalam aktiviti pertanian seperti penanaman padi semakin meluas. Kawasan sawah padi Kampung Sawah Sempadan, Tanjung Karang, Kuala Selangor merupakan kawasan kajian yang menjadi pilihan dalam kajian ini. Kajian ini akan dijalankan dari bulan Disember 2018 hingga bulan Jun 2019 yang melibatkan seramai 85 orang pesawah padi dan 85 orang daripada kumpulan yang tidak terdedah. Penduduk di kawasan ini kebanyakan merupakan petani yang mengusahakan tanaman padi di sekitar Kampung Sawah Sempadan yang telah menjadi identiti penduduk setempat. Kawasan ini telah dipilih untuk menjadi kawasan kajian kerana pemerhatian mendapati bahawa hampir semua pesawah padi yang mengusahakan tanaman padi di kawasan ini tidak menggunakan kelengkapan pelindung diri semasa menjalankan aktiviti di sawah padi seperti ketika menyembur racun perosak kepada tanaman. Racun perosak boleh tersebar di udara melalui proses seperti aliran semburan dari kawasan asal penyemburan racun perosak ke kawasan bukan semburan. Kajian terdahulu telah menyatakan bahawa udara yang dicemari dengan racun perosak ini adalah berbahaya kepada kesihatan dan boleh menyebabkan pelbagai penyakit pernafasan atau gejala kesihatan seperti batuk, sesak dada, sesak nafas, loya, muntah dan pening. Penemuan kehadiran racun perosak dalam udara telah banyak dilaporkan. Walau bagaimanapun, tidak banyak kajian mengenai kepekatan racun perosak dalam sampel udara peribadi dilaporkan.Sehingga kini, di Malaysia, tiada kajian yang telah melaporkan gejala kesihatan dalam kalangan petani padi dan kumpulan tidak terdedah berdasarkan pendedahan pekerjaan kepada racun perosak dalam sampel udara peribadi. Oleh itu, kajian ini dilakukan untuk mengkaji kejadian racun perosak di dalam sampel udara peribadi dan gejala kesihatan dalam kalangan pesawah padi dan kumpulan yang tidak terdedah di Tanjung Karang, Selangor.

3. APAKAH YANG PERLU ANDA LAKUKAN?

Responden dikehendaki untuk menjawab semua soalan yang terdapat di dalam borang kaji selidik yang dibekalkan oleh penyelidik untuk tujuan mendapatkan informasi mengenai maklumat diri, latar belakang pekerjaan, gaya hidup dan maklumat gejala/ tanda kesihatan.

4. SIAPA YANG TIDAK BOLEH MENYERTAI KAJIAN INI?

Kanak-kanak yang berusia 18 tahun ke bawah dan orang yang berumur lebih dari 59 tahun tidak dibenarkan menyertai kajian ini. Penyertaan adalah sukarela dan peserta boleh menarik diri dari kajian pada bila-bila masa tanpa kehilangan sebarang manfaat.

5. APAKAH FAEDAH MENYERTAI KAJIAN INI?

a) KEPADA ANDA SEBAGAI PESERTA?
Responden yang menyertai kajian ini dapat mengetahui maklumat risiko pendedahan peribadi masing-masing kepada racun perosak dan kesan pendedahan ini kepada kesihatan, sama ada membawa masalah kesihatan seperti gejala kesihatan.

b) KEPADA PENYELIDIK?
Penyelidik akan dapat mengumpul maklumat mengenai kehadiran racun perosak dalam udara di kawasan sawah padi Kampung Sawah Sempadan dan seterusnya mengkaji kesan kehadiran racun perosak dalam udara ini kepada kesihatan pesawah padi yang terdedah kepada udara yang dicemari dengan racun perosak ini.

6. ADAKAH IA BERISIKO?

Tidak, responden hanya perlu mengisi borang kaji selidik mengenai maklumat diri, latar belakang pekerjaan, gaya hidup dan maklumat gejala/ tanda kesihatan yang dibekalkan oleh penyelidik.

7. ADAKAH MAKLUMAT DAN IDENTITI SAYA KEKAL RAHSIA?

Ya, segala maklumat dan identiti responden adalah sulit dan akan kekal rahsia dan hanya akan digunakan untuk tujuan kajian sahaja.

8. SIAPA YANG SAYA PERLU HUBUNGI SEKIRANYA SAYA MEMPUNYAI SOALAN TAMBAHAN SEMASA MENGIKUTI PENYELIDIKAN INI?

Responden boleh menghubungi penyelidik kajian ini:

017-5353958
NADHIRAH BINTI MOHD SIDEK
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FAKULTI PERUBATAN DAN SAINS KESIHATAN,
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43400 UPM SERDANG,
SELANGOR, MALAYSIA.
yubin@upm.edu.my

Sila tandatangan di sini sekiranya anda telah membaca dan memahami kandungan halaman ini _______

9. PERSETUJUAN

Saya.. No Kad Pengenalan. .... beralamat.. ....dengan ini bersetuju untuk mengambil bahagian secara sukarela dalam penyelidikan yang tersebut di atas *(kajian klinikal/percubaan ubat-ubatan/rakaman video/kumpulan sasaran/temuduga/ soal selidik).

Saya telah diberi penjelasan secara menyeluruh mengenai penyelidikan ini dari segi metodologi, risiko dan komplikasi (seperti tertulis pada Helaian Penerangan Responden). Saya memahami bahawa saya berhak menarik diri dari penyelidikan ini pada bila-bila masa tanpa memberi sebarang alasan.Saya juga memahami bahawa sebarang maklumat yang berkaitan identiti saya akan dirahsiakan.

Saya* berminat / tidak berminat untuk mengetahui keputusan kajian yang melibatkan saya.

I setuju/tidak bersetuju untuk imei/gambar/rakaman video/ rakaman suara digunakan dalam apa jua bentuk penerbitan atau pembentangan. (sekiranya berkaitan).

*potong yang tidak berkenaan

Tandatangan .... (*Responden*)

Tandatangan .... (*Saksi*)

Tarikh :..

Nama :..

No. K/P: ....

Saya mengesahkan bahawa saya telah menerangkan kepada responden ini sifat dan tujuan penyelidikan yang tersebut di atas.

Tarikh ....

Tandatangan .... (*Penyelidik*)

APPENDIX C:

Ethical Approval

APPENDIX D:

Original Data

Table S1: Concentrations of target compounds detected in the personal air samples among the paddy farmers, ng m^{-3} (n=85).

Personal air samples	Isoprothiolane	Propiconazole	Tricyclazole
1	15.6	ND	125.7
2	ND	ND	75.9
3	16.6	ND	98.1
4	5	ND	243
5	50.7	ND	92.2
6	74.4	ND	71.7
7	ND	ND	22.4
8	ND	ND	14.3
9	ND	ND	55.2
10	ND	ND	9.8
11	ND	ND	23.1
12	ND	28.2	16.3
13	ND	19.5	23.9
14	ND	ND	19.8
15	ND	64.4	21.8
16	11.1	ND	5.8
17	ND	ND	17.2
18	ND	ND	12.1
19	26.9	ND	70
20	ND	ND	28.2
21	ND	ND	44.4
22	ND	99.9	6.9
23	ND	19.1	ND
24	ND	ND	5.3
25	4.2	40.7	4.1
26	ND	ND	8.6
27	ND	ND	ND
28	22.8	18.2	30.6
29	30.6	86.9	38.6
30	17	ND	ND
31	28.4	37.7	9.6
32	4.3	ND	7
33	ND	48.3	17.3
34	ND	ND	1.8
35	ND	138.3	ND
36	25.3	36.7	8.8
37	ND	45.1	28
38	ND	ND	31.7
39	13.5	ND	96.8
40	ND	ND	39.4
41	118.3	47.6	41.8
42	18.2	23.2	77.9

43	7.2	ND	ND
44	ND	ND	27.7
45	ND	41.4	ND
46	ND	ND	23.2
47	37.9	ND	ND
48	48	ND	55.9
49	60.7	ND	43.8
50	73.1	ND	24
51	59.8	ND	35.7
52	65.6	ND	18.9
53	126.9	ND	151.8
54	178.9	ND	19
55	116.8	ND	ND
56	117.9	ND	ND
57	102.9	ND	101.5
58	ND	ND	40.2
59	ND	ND	283.1
60	80.7	ND	ND
61	82.2	ND	224.8
62	ND	ND	20.6
63	107.9	ND	50
64	19.3	ND	23.6
65	30	ND	65.5
66	151.6	ND	68.7
67	ND	ND	ND
68	ND	ND	74.7
69	154	ND	113.8
70	ND	ND	55.9
71	56.1	ND	ND
72	ND	ND	ND
73	176.9	ND	ND
74	ND	ND	ND
75	142.5	ND	169.4
76	3.7	ND	180.5
77	8.8	ND	26.7
78	40.5	ND	117
79	ND	ND	411.7
80	6	ND	37.5
81	12.2	ND	43.6
82	32.8	ND	433
83	154	ND	138
84	ND	ND	55.9
85	56.1	ND	ND

ND – Not detected

Table S2: Concentrations of target compounds detected in the personal air samples among the non-exposed group, ng m^{-3} (n=85).

Personal air samples	Isoprothiolane	Propiconazole	Tricyclazole
1	ND	ND	ND
2	ND	ND	9.8
3	ND	ND	ND
4	ND	ND	ND
5	ND	ND	ND
6	ND	ND	ND
7	ND	ND	ND
8	ND	ND	5.8
9	ND	ND	ND
10	ND	ND	ND
11	ND	ND	ND
12	5	ND	ND
13	ND	ND	ND
14	ND	ND	ND
15	ND	ND	ND
16	ND	ND	ND
17	ND	ND	ND
18	ND	ND	ND
19	ND	ND	ND
20	ND	ND	ND
21	ND	ND	ND
22	ND	ND	6.9
23	ND	ND	ND
24	ND	ND	5.3
25	4.2	ND	4.1
26	ND	ND	8.6
27	ND	ND	ND
28	ND	ND	ND
29	ND	ND	ND
30	ND	ND	ND
31	ND	ND	9.6
32	4.3	ND	7
33	ND	ND	ND
34	ND	ND	1.8
35	ND	ND	ND
36	ND	ND	8.8
37	ND	ND	ND
38	ND	ND	ND
39	ND	ND	6.8
40	ND	ND	ND
41	ND	ND	ND
42	ND	ND	ND

43	7.2	ND	ND
44	ND	ND	ND
45	ND	ND	ND
46	ND	ND	ND
47	ND	ND	ND
48	ND	ND	ND
49	ND	ND	ND
50	ND	ND	ND
51	ND	ND	ND
52	ND	ND	ND
53	ND	ND	ND
54	ND	ND	ND
55	ND	ND	ND
56	ND	ND	ND
57	ND	ND	ND
58	ND	ND	ND
59	ND	ND	ND
60	ND	ND	ND
61	ND	ND	ND
62	ND	ND	ND
63	ND	ND	ND
64	ND	ND	ND
65	ND	ND	ND
66	ND	ND	ND
67	ND	ND	ND
68	ND	ND	ND
69	6	ND	ND
70	ND	ND	ND
71	ND	ND	ND
72	ND	ND	ND
73	ND	ND	ND
74	ND	ND	ND
75	ND	ND	ND
76	3.7	ND	ND
77	8.8	ND	ND
78	ND	ND	ND
79	ND	ND	ND
80	ND	ND	ND
81	ND	ND	ND
82	ND	ND	ND
83	ND	ND	ND
84	ND	ND	ND
85	ND	ND	ND

ND – Not detected