HUMAN HEALTH RISK ASSESSMENT RELATED TO DERMAL EXPOSURE OF CHLORPYRIFOS IN RICE-GROWING FARMERS AT NAKHON NAYOK PROVINCE, THAILAND

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การประเมินความเสี่ยงด้านสุขภาพจากการรับสัมผัสสารคลอไพริฟอส ผ่านทางผิวหนังของชาวนาในจังหวัดนครนายก ประเทศไทย

นางสาวสัตตมาส ลรรพรัตน์

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
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Thesis Title	HUMAN HEALTH RISK ASSESSMENT RELATED TO DERMAL EXPOSURE OF CHLORPYRIFOS IN RICE-GROWING FARMERS AT NAKHON NAYOK PROVINCE, THAILAND
By	Miss Sattamat Lappharat
Field of Study	Environmental Management
Thesis Advisor	Assistant Professor Wattasit Siriwong, Ph.D.

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Accepted by the Graduate School, Chulalongkorn University in Partial Fulfillment of the Requirements for the Master's Degree

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สัตตมาส ลรรพรัตน์ : การประเมินความเสี่ยงด้านสุขภาพจากการรับสัมผัสสารคลอไพริฟอสผ่านทางผิวหนังของชาวนาในจังหวัดนครนายก ประเทศไทย (HUMAN HEALTH RISK ASSESSMENT RELATED TO DERMAL EXPOSURE OF CHLORPYRIFOS IN RICE-GROWING AT NAKHON NAYOK PROVINCE, THAILAND) อ. ที่ปรึกษาวิทยานิพนธ์หลัก : ผศ.ดร.วัฒน์สิทธิ์ ศิริวงศ์, 124 หน้า.

การประเมินความเสี่ยงด้านสุขภาพจากการรับสัมผัสสารคลอไพริฟอสผ่านทางผิวหนังได้ทำการศึกษาจากกลุ่มชาวนาในตำบลศีรษะกระบือ อำเภอองครักษ์ จังหวัดนครนายก ประเทศไทย การศึกษาครั้งนี้มีจำนวนผู้เข้าร่วมทั้งหมด 35 คน โดยส่วนใหญ่เป็นเพศชายและเกี่ยวข้องกับการใช้สารกำจัดศัตรูพืช ในการศึกษาครั้งนี้เลือกใช้สารเรืองแสงเพื่อแสดงบริเวณที่ปนเปื้อนสารกำจัดศัตรูพืชบนผิวหนัง ผลการทดลองพบว่าบริเวณขาช่วงล่าง (97.14%) และต้นขา (97.14%) เป็นบริเวณที่พบสารเรืองแสงมากที่สุด ส่วนอกภายในเสื้อ คือ บริเวณที่พบสารเรืองแสงน้อยที่สุด (45.71%) อีกทั้งเปอร์เซนต์การให้คะแนนสารเรืองแสงพบว่าบริเวณขาช่วงล่าง (72.38%) และต้นขา (62.86%) เป็นบริเวณที่มีค่าการเรืองแสงสูงสุดและบริเวณอกภายในเสื้อ (19.05%) คือ บริเวณที่มีค่าการเรืองแสงน้อยสุด ซึ่งสอดคล้องกับคะแนนความถี่ที่พบสารเรืองแสงบนร่างกายชาวนา ในการหาปริมาณความเข้มข้นของสารคลอไพริฟอสบนร่างกาย ชาวนาจะถูกติดแผ่นผ้าก๊อซบนร่างกายทั้งหมด 7 จุด บริเวณขาช่วงล่างของชาวนาทั้งชายและหญิงเป็นบริเวณที่พบการปนเปื้อนสารคลอไพริฟอสสูงสุด (261.64 และ164.64 มก./กกแผ่นผ้าก๊อซ, ตามลำดับ) ค่าการเปรียบเทียบความเข้มข้นของคลอไพริ-ฟอสที่ตกค้างบนร่างกายระหว่างชายและหญิงพบว่าไม่แตกต่างอย่างมีนัยสำคัญ (Mann-Whitney U test;$p>0.05$)นอกจากนี้ยังทำการศึกษาความสัมพันธ์ระหว่างความเข้มของคลอไพริฟอสที่ตกค้างบนร่างกายและค่าการเรืองแสงของสารเรืองแสงบนร่างกายพบว่ามีความสัมพันธ์กันอย่างมีนัยสำคัญที่บริเวณหน้าอกภายนอกและภายในเสื้อ, ขาช่วงบน, ขาช่วงล่าง,และ ทั้งร่างกาย (Spearman's rho ; $p<0.05$) จากการคำนวณค่าเฉลี่ยของค่ารับการรับสัมผัสสารต่อวันบนร่างกาย 7 จุดของชาวนาเพศชายและหญิงมีค่าดังนี้ 31.72×10^{-4},193.32×10^{-4},5.38×10^{-4},190.48×10^{-4},170.47×10^{-4},465.91×10^{-4},และ 43.04×10^{-4}มก./กก./วัน ตามลำดับ ดัชนีชี้บ่งอันตราย (Hazard Quotient , HQ) ที่ค่าเฉลี่ยและระดับ 95 เปอร์เซนต์ไทล์บนร่างกาย 7 จุดของชายและหญิงมีค่าสูงกว่าค่าที่ยอมรับได้ นั่นคือ 1 (HQ>1) จากค่าดังกล่าวสามารถแปลความหมายได้ว่า ชาวนาในพื้นที่ได้รับความเสี่ยงด้านสุขภาพจากการรับสัมผัสสารคลอไพริฟอสผ่านทางผิวหนัง จากการศึกษาข้างต้นนี้ทำให้ทราบว่าความปลอดภัยในการจัดการความเสี่ยงด้านพฤติกรรมการใช้สารกำจัดศัตรูพืชควรนำไปเสนอแนะและนำไปปฏิบัติในพื้นที่ศีรษะกระบือเพื่อลดความเสี่ยงอันตรายที่เกิดจากการใช้สารคลอไพริฟอสผ่านทางผิวหนัง

สาขาวิชา การจัดการสิ่งแวดล้อม ลายมือชื่อนิสิต………………………………….....................

ปีการศึกษา 2555 ลายมือชื่อ อ.ที่ปรึกษาวิทยานิพนธ์หลัก…..…………………..

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SATTAMAT LAPPHARAT : HUMAN HEALTH RISK ASSESSMENT RELATED TO DERMAL EXPOSURE OF CHLORPYRIFOS IN RICE-GROWING AT NAKHON NAYOK PROVINCE, THAILAND ADVISOR : ASST.PROF. WATTASIT SIRIWONG, Ph.D., 124 pp.

Rice-growing farmers in Sisa Krabue sub-district, Ongkharak district, Nakhon Nayok province, Thailand was studied health risk assessment of chlorpyrifos exposure through dermal route. This study had 35 participants who related with pesticide application and most of them were male. In this study used fluorescent tracer to reveal pesticide contaminated on body skin. The result showed the frequency of fluorescent tracer was largely found on lower (97.14%) and upper legs (97.14%)of farmers and rarely found on their chest under clothes (45.71%) and the greatest number of percent fluorescent scoring was lower (72.38%) and upper legs (62.86%) and the smallest percent of fluorescent scoring was chest under clothes (19.05%) that was same as percent frequency of pesticide residues on seven parts of farmers' body. The farmers were patched with cotton gauze on seven points of farmers' body. Both of male and female lower leg were the part of body where was the highest concentration of chlorpyrifos (261.64 and 164.64 mg/kg of gauze, orderly). The comparison of chlorpyrifos concentration on seven parts of body between male and female, There was not a statistical difference (Mann-Whitney U test; $p>0.05$). Moreover, There was significantly correlation between chlorpyrifos residues concentration and fluorescent scoring on chest on clothes, chest under clothes, upper leg, lower leg, and whole body (Spearman's rho; $p<0.05$). ADD on seven parts of male and female farmers were 31.72×10^{-4}, 193.32×10^{-4}, 5.38×10^{-4}, 190.48×10^{-4}, 170.47×10^{-4}, 465.91×10^{-4}, and 43.04×10^{-4}mg/kg-day, orderly. Hazard Quotient (HQ) at mean and 95^{th} percentile level on seven parts of body of both male and female was greater than acceptable level (HQ >1). This can be interpreted that rice-growing farmers in this area received adverse health risk from skin exposure to chlorpyrifos. In conclusion, safety risk management in term of pesticide use and practices should be conducted in Sisa Krabue area to minimize exposure from chlorpyrifos usage via dermal route.

Field of Study: Environmental Management Student's Signature: ……………………….

Academic Year: 2012 Advisor's Signature: ……………………..

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LIST OF ABBREVIATIONS

AchE	Acetylcholinesterase Enzyme
ABS	Absorption factor
ADD	Average Daily Dose
AOAC	The Scientific Association Dedicated to Analytical Excellence®
AT	Average Time
BW	Body Weight
C	Pesticide Concentration
ED	Exposure Duration
EF	Exposure Frequency
GC-FPD	Gas Chromatography with Flame Photometric Detector
HQ	Hazard Quotient
HI	Hazard Index
IRIS	US EPA's Integrated Risk Information System
LOD	Limit of Detections
LOQ	Limit of Quantifications
LOAEL	Lowest Observed Adverse Effect Level
NOAEL	No Observed Adverse Effect Level
OPs	Organophosphate Pesticides
R_fD	Reference Dose
RME	Reasonable Maximum Exposure
US EPA	United State Environment Protection Agency

CHAPTER I
INTRODUCTION

1.1 Theoretical background

The present and the past, Thailand is one of the largest agricultural products exporters in the world due to the appropriate geography and weather. In rural area, most of people in the country are in agricultural sector and their main incomes are earned from agricultural goods (Office of Agricultural Economics, 2010). The pesticides are essential substances that widely used in most area of agricultural products to reduce crops damage and to increase agricultural goods. Therefore, the farmers decide to use a variety of pesticides in high amount to protect their crops and to control plant disease (Jaipieam, 2008).

Nakhon Nayok is a province, which located in central of Thailand. In 2010, there are 61,874 households in this province. According to the total households data, there are 26,656 agricultural households and most of them are rice farmers. Nowadays, the farming area approximately 1.33 million rais, almost 50% (612,504 rais) of the area is rice farming (Nakhon Nayok Agricultural Extension Office, 2010).

Ongkharak is one district of Nakhon Nayok province. There are 11 sub-districts, which are subdivided into 116 villages. The number of total household is 17,890 in this district and 6,447 (36%) of them are agricultural households.

Sisa Krabue is sub-district that located in Ongkharak district. In this sub-district, there are a large number of fields for farming and the highest number of rice-growing farmers. There are 1,940 households and 13 villages. The number of total population in this area is 6,732 (Nakhon Nayok Agricultural Extension Office, 2010).

When water is enough for growing rice, weed and grass will be removed at the beginning of each rice cropping. After that, pesticides are required in the paddy field cycle. Pesticides will be applied 3-4 times when the rice plants are blooming, which are around 20 days old. If there is high number of insects, pesticide will be applied more than usual. Many farmers believe that using high amount concentration of pesticide (more than indicated on the label) and mixing variety of pesticides together will help them killing insects rapidly (Grandstaff *et al.*, 2004).

The pesticide application in Thailand has significantly increased over time. The large numbers of imported pesticides were chlorpyrifos, fenobucarb, cartap, hydrochloride, cypermethin, and methomyl. The imported pesticides approximately accounted for 75% of the total imported herbicides, pesticides, and fungicides (Office of Agricultural Regulation, 2011).

Organophosphate pesticides is the most widely applied in agriculture instead of organochlorine pesticides due to its effectiveness, low cost, less persistent in environment. However, organophosphate pesticides have many adverse effects on human health. They are efficiently absorbed by dermal contract, inhalation, and ingestion. When they enter to the body, they will inhibit acetylcholinesterase enzyme (AChE) activity in nervous system and cause many symptoms such as pulmonary edema, muscle weakness, blurred vision, respiratory difficulty, and death due to respiratory failure. The severity of their toxics depends on the exposure dose, frequency, and duration (Ooraikul, 2010).

In general, the risk of dermal exposure with pesticides was high during mixing, loading, spraying, and transporting pesticide. Moreover, spillage and leakage of pesticides onto the farmers' back during spraying the pesticides are one important factor of health risk also (Grandstaff and Srisupan, 2004).

Method for dermal exposure analysis was patch technique and fluorescent tracer. Patch technique is commonly used to analyze pesticide residues leftover on skin and beneficial for quantitative assessment. Fluorescent tracer is nontoxic chemical that uses to reveal pesticides scatter on the skin of rice-growing farmers. Both of two techniques would leave awareness and stimulate them to minimize risk from pesticide exposure (Galvin and Lee, 2007).

This research aimed to (1) examine chlorpyrifos residues on farmers' body, (2) assess health risk of farmers who use and contact with pesticide, and (3) safety manage pesticide application for rice farmers

1.2 Hypotheses

1) There are different concentrations of pesticide residues found on rice farmers' body.
2) Farmers in Nakhon Nayok province, Thailand are at risk of chlorpyrifos pesticide exposure from dermal contact.

1.3 Objectives

1) To measure chlorpyrifos residues on the rice farmers' body using patch technique
2) To evaluate the part of rice farmers' body where there is high concentration of chlorpyrifos residues from patch technique and fluorescent tracer
3) To assess the health risk of rice-growing farmers from the health information, pesticide application, exposure data, and work practices on pesticides
4) To provide suggestions on health risk and safety guidelines to reduce the risk from pesticide exposure for rice farmers

1.4 Scopes of the study

1) Patch samples were collected from rice-growing in Sisa Krabue sub-district, Ongkharak district, Nakhon Nayok province, Thailand, and pesticide residues in samples extracted by liquid-liquid method.
2) Face-to-face interviews rice-growing farmers and questionnaire observations were administered in this area.
3) Pesticide exposure and health risk assessment were assessed for rice farmers who apply pesticide.
4) Information of protected equipment and safety manual related to pesticide exposure and risk assessment were provided to rice farmers.

CHAPTER II
LITERATURE REVIEW

2.1 Current management of pesticide application in Thailand

Thailand is a main agricultural exporter and agricultural goods are an essential part of Thai economy. Enlargement of agricultural export is the cause of high demand for using chemical pesticide. The extension of pesticide application has an affect on insect resistance and changes of environmental condition. The Royal Thai Government (RTG) has issued and enacted a primary legal instrument, Hazardous Substance Act, to manage and control pesticide application and minimize pesticide exposure to human, plants, animals and environment. Under this act, the Hazardous Substance Committee (HSC) was set up three Thai ministries, the Ministry of Industry (MOI), the Ministry of Public Health (MoPH), and the Ministry of Agriculture and Cooperatives (MoAC). According to the ministry divided regulation functions make Thai pesticide regulation shattered and impractical. The deficiency of uniform system designed pesticide management is the main reason of effective pesticide regulation in Thailand. According to this fact has resulted in various problems that related to environment contamination and human health risk (Panuwet *et al.,* 2012).

2.2 Organophosphate pesticide

Nowadays, the most widely used to control agriculture products belong to the organophosphate group. Most organophosphate pesticides (OPs) are ester or thiol derivatives of phosphoric acid. General structure themselves is shown in Figure 2.1 R_1 and R_2 are alkyl groups, which are able to directly attach phosphorous atom or via an oxygen atom, or a sulfur atom. In some cases, R_1 is directly bonded with phosphorous atom and R_2 bonds with an oxygen or sulfur atom. The X group can be various and may belong to a wide range of aliphatic, aromatic or heterocyclic groups. The X group, which is known as a leaving group due to hydrolysis of the ester bond reaction, it will be moved out from phosphorous (Singh and Walker, 2006). Almost all of OPPs are slightly dissolved in water, have high oil to water partition coefficient, and low vapor pressure (Ooraikul, 2010).

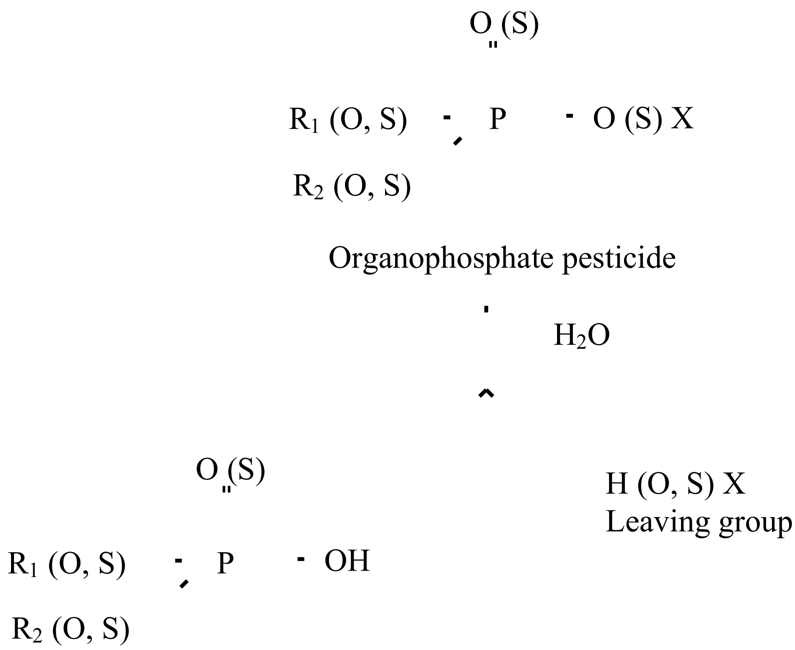


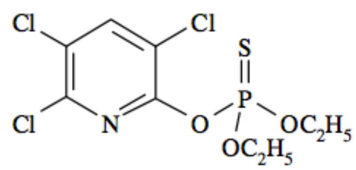
Figure 2.1 The general of organophosphate pesticide form and hydrolysis pathway.
Source: Singh and Walker, 2006

2.3 Chlorpyrifos

Chlorpyrifos is chlorinated organophosphate pesticide. In the past, chlorpyrifos was used for control mosquitoes, crop pest, and household pest such as termite, ant, and cockroach (Howard, 1991). Nowadays, chlorpyrifos is the most of worldwide used to against pest for the important crops (ie, rice, maize, sugarcane, cotton, vegetables, and fruits) because it is low cost and effective to eliminate pest. Moreover, chlorpyrifos is classified as moderately toxic compound for acute oral; LD_{50} 135-163 mg/kg for rat and 500 mg/kg for guinea pig (Racke, 1993).

2.3.1 Chemical and physical properties of chlorpyrifos

The IUPAC name of chlorpyrifos is *O,O*-diethyl *O*-3,5,6-trichloro-2-pyridyl phosphorothioate, molecular weight of chlorpyrifos is 350.6, and chemical structure of chlorpyrifos is shown in Figure 2.2. The form of chlorpyrifos is a white crystal solid with a strong odor and the melting point of chlorpyrifos is 41.5-42.5^{o}C. Chlorpyrifos is able to dissolve small amount in water (2 mg/l at 25^{o}C) but is easily solvable in organic solvents (ie, acetone,benzene, hexane, and xylene).In neutral and acidic condition, chlorpyrifos can tolerate, but its stability decrease when increase pH. The vapor pressure of chlorpyrifos is 1.87x10^{-5} mmHg at 20^{o}C (Extoxnet, 2013).



Empirical Formula:	$C_9H_{11}Cl_3NO_3PS$
Molecular Weight:	350.6
CAS Registry No.:	2921-88-2
Chemical No.:	059101

Figure 2.2 Structure of chlorpyrifos (EPA, 2000)

Environmental fate of chlorpyrifos:

The half-life of chlorpyrifos in soil is range 10-120 days that depends on different environmental factors, which are temperature, moisture content, soil pH, soil type, and organic carbon content (Singh and Walker, 2006). Under low temperature and low pH condition, chlorpyrifos is persistent and its half-life in this condition is 92-341 days. Naturally, photolysis, chemical hydrolysis or soil microorganisms are able to degrade chlorpyrifos (Racke, 1993).

2.3.2 Toxicokinetics of chlorpyrifos

Absorption of chlorpyrifos happens through skin, respiratory tract, and gastrointestinal tract. Occupational exposure to chlorpyrifos is able happen during handling, loading, mixing, and application activities. Therefore, dermal absorption is an initial route of chlorpyrifos exposure for occupational exposure. This exposure can be detected primary in blood and urine (Falicia and Paul, 2005).

Dermal absorption was evaluated 3 percent based on the ratio of the oral LOAEL (0.3 mg/kg/day) from the rat developmental neurotoxicity (DNT) that studied to dermal LOAEL (10 mg/kg/day) from the 21 days rat dermal study. This absorption factor is similar to the dermal absorption in human data of 1-3% (EPA, 2000).

When chlorpyrifos gets into animal body via dermal or oral route, it will distribute and rapidly absorb to all organs of the animal body. Moreover, chlorpyrifos is particularly metabolized in the liver but a large amount of chlorpyrifos is hardly to metabolize. In rats fed chlorpyrifos, after 3 days 75% of chlorpyrifos was excreted in urine and 8% in feces, 7% was eliminate by exhalation, and 4% was leftover on organs. The main urinary metabolites were 3,5,6-TCP, glucuronide and sulfate conjugate of TCP (Cattani, 2004).

In human (adult males), 70% of chlorpyrifos was excreted in the urine as TCP within 5 days after acute oral exposure. The least of dermal absorption was 1-3% of acute exposure and the mean pharmacokinetic half-life for 3,5,6-TCP in the urine was 27 hours after dermal and oral exposure (EPA, 2000).

2.4 Toxicological effects of organophosphate pesticide

The main action of organophosphate pesticide exposure concerns with nervous system. Acetylcholine is a neurotransmitter that exists in the peripheral automatic nervous system, in some parts of the central nervous system, and in the somatic motor nervous system. When acetylcholine releases to nerve synapse or neuromuscular junction, the acetylcholine is rapidly broken down by acetylcholinesterase (AChE). Muscular, nerve fibers, and gland that called neurons are inhibited or stimulated the signals across the electrical twitching called synapses. This is continuous reaction occurs speedily with the acetylcholine causing stimulation and acetylcholinesterase closing the signal. When organophosphate pesticide enters in the system, it inhibits cholinesterase. Hence, cholinesterase disables hydrolysis acetylcholine resulting in symptoms of neurotoxicity. Normal function of acetylcholinesterase is presented in Figure 2.3. If acetylcholinesterase cannot remove acetylcholine (Figure 2.4), the muscles will overstimulation (Falicia and Paul, 2005).

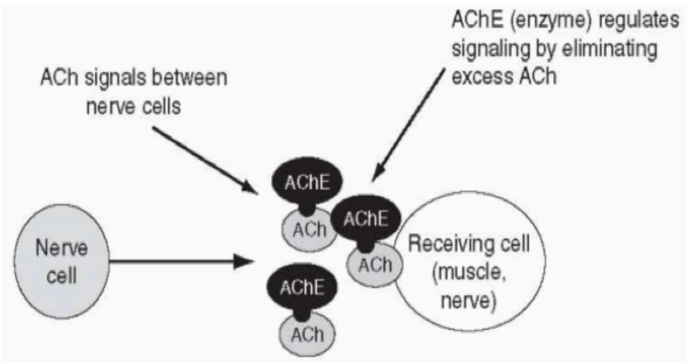


Figure 2.3 Normal nerve signals (Falicia and Paul, 2005)

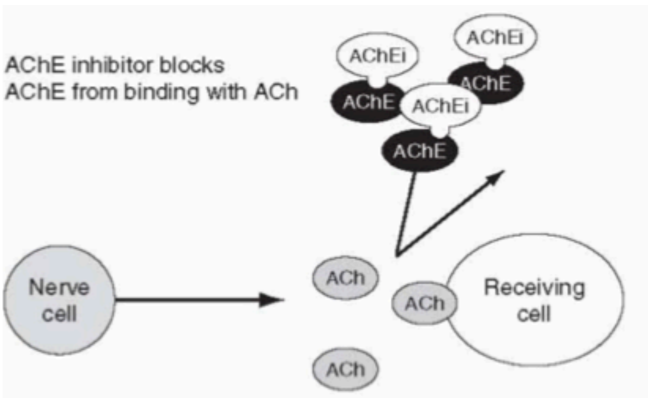


Figure 2.4 Acetylcholinesterase inhibition (Falicia and Paul, 2005)

Toxicity mechanisms of organophosphate pesticide:

OPs will inhibit an esterase, in particular acetylcholinesterase (AChE). This process that concerns with phosphorylation of a serine hydroxyl group causes the accumulation of the neurotransmitter, which is acetylcholine. Acetylcholine is necessary for the transmission of nerve impulses in the brain, skeletal muscles, and other areas. However, after the transmission of the impulses, the acetylcholine has to be hydrolyzed to prevent overstimulation in the nervous system. The regeneration of phosphorylated acetylcholine esterase is very slow, result in accumulation of acetylcholine at synapses. Then, nerve are overstimulated and jammed. This inhibition contributes to spasm, paralysis, and finally death (Marrs, 1993).

2.5 Acute and chronic effect of chlorpyrifos

Acute effects depend on dose intake and route of exposure. The signs and symptoms include blurred vision, eye pain, nausea, vomiting, cough, chest tightness, headache, and respiratory failure until death. Following dermal, inhalation, and oral exposure, chlorpyrifos is moderately toxic to human. The male rabbits dermal absorption LD_{50} values of chlorpyrifos were 1265 mg/kg and the female rabbits dermal absorption LD_{50} values were 930 mg/kg (Cattani, 2004).

An acute dermal pharmacokinetic study in human, males dermally exposed to 0.05 mg/kg chlorpyrifos presented peak of 27-45% of plasma cholinesterase inhibition on day 3 and mean red blood cell cholinesterase inhibition was 8.6% on day 4 (EPA, 2000).

For chronic effects can occur when intake chlorpyrifos at low concentration for long times, which can conclude chronic effects depend on duration of times. Signs and symptom include arm and leg weakness that lead to paralysis in future (Ooraikul, 2010).

Chlorpyrifos was chronic effect to rats, mice, and dogs. The inhibition of plasma, red blood cell and brain cholinesterase happened in the range of 0.03-3 mg/kg/day in all animal species. Since, chlorpyrifos is non persistent in the human body, there is not a complete association between biological effect markers such as dose and cholinesterase level. In human, chronic effect does not create adverse effect in central or peripheral nervous system and clinical neurotoxicity effects are unlikely (Cattani, 2004).

2.6 Environmental health risk assessment

Risk is described as exposure and hazard. There are four steps of risk assessment, which compose of (1) Hazard identification (2) Dose-response assessment (3) Exposure assessment and (4) Risk characterization (Robson *et al.,* 2007).

2.6.1 Hazard identification

The first step of risk assessment is an important process of deciding when exposure of chemical contributes to increasing adverse effects in human health. This step used to evaluate harmful of substances that based on data collection, which includes chemical, behavior of chemical, and physical of substances, exposure route and toxicity of substances (IRIS, 2008). OPs are classified as non-carcinogens substance and the critical effect of chlorpyrifos is human cholinesterase inhibition in 20 days after absorption (EPA, 2009).

2.6.2 Dose-response assessment

Relationship of dose and response describes the possible and severity of adverse health effects that are concerned with amount and condition of exposure route. In generally, as the dose increases, the measurement of response will increase also and there may be no response at low doses. There are two steps of dose-response assessment. Firstly, all data collection or experimental data is assessed in order to find range of observed doses. Secondly, adverse health effects are estimated under the lower range of available observed data for make implications about critical regions where the dose levels begin to trigger the risk in human population.

A No-Observed-Adverse-Effect Level (NOAEL) is the highest exposure level that has not statistically or biologically increases. In cases that NOAEL has not shown in experiment, the term of lowest-observed-adverse-effect level (LOAEL) is used, which is the lowest testing. Reference dose (R_fD) is an estimation of a daily route exposure to human population who is likely to be without a considerable risk of harmful effect during a lifetime (IRIS, 2008).

2.6.3 Exposure assessment

Exposure assessment is the quantitative and qualitative estimate of chemicals contact, which includes intensity of chemicals, frequency and duration time of contact, intake rates, resulting dose, and the route of exposure (EPA, 1992). There are two ways that chemicals get into human body. First step is contact or exposure and second step is cross the boundary. And there are two route for cross the boundary that are intake and uptake. Intake means chemical get into body through mouth or nose but if chemical cross from outside to inside body by tissue or skin absorbing, it called uptake (Taneepanichskul, 2009).

Dermal exposure is an interactive between a source and a worker, means the mass of chemical contacting the body barrier (skin) and available absorption per unit time. The internal dose or absorbed dose is determined as the mass moving through body skin into systemic circulation and the metabolites of chemical or concentration of chemical can be detected in urine, blood, breath, fluids or tissues. Normally, dermal exposure happens by one of three these pathways: immersion, deposition, or surface contact. Immersion arises when a worker's skin reaches with liquid, solid or gas phase of chemical, for example this pathway is hand dipping in solvent. Deposition can occur when aerosol (pesticide application, chemical spraying) or vapor of chemical touches the skin. When skin contacts with contaminated surface that causes chemical residues transfer to skin, is defined as surface contact. Therefore, dermal route is a primary route exposure in occupational workers; most of farmers in the paddy field have to focuses on pesticide residues, which deposit on skin and absorb to their body. There are three categories for estimate dermal contact that are surrogate skin techniques, chemical removal techniques, and fluorescent tracer techniques (Fenske, 1993).

2.6.3.1 Surrogate skin techniques

There are two methods for surrogate skin techniques. First is gauze patch technique. It is a cost-effective method for hazard evaluation, useful for quantitative exposure estimation and common analyzing chemical residue on skin, which involves placing gauze patch sample on the body. The necessary consideration for patch technique is composition and size of patch used in dermal exposure, and it should based on characteristic of pesticides. Secondly, it is body garments. Whole body garments have been suggested as a standard for pesticide measurement. In generally, whole body garments contain of long underwear garments or coverall worn next to the skin without protective layer. The advantage of this method when compared with patch techniques is no extrapolation to total surface area is required for the body. However, there is the limitation of body garments that cannot measure pesticide residues on top of body such as head, neck and face, hands, and feet (Galvin, 2007).

2.6.3.2 Chemical removal techniques

Washing and wiping are method that can remove chemical deposit and concentration of chemicals can be measured. In mainly, wash technique used to only assess hand exposure while wipe techniques can be applied to other skin surfaces. Hand wash sampling should be collected when workers usually clean their hands at break or at the end of the working. The major disadvantage of wash technique is that it cannot remove total of chemical residues, which deposit on the skin. The result requires appropriate removal efficiency. For wipe technique has developed to assess pesticide that exposure to the hands, face, and neck. Some study reported that hand wiping has relatively high efficiency of pesticide removal. Skin wiping seems to be easy and convenience technique but it is not acceptable as a quantitative exposure assessment method (Fenske *et al*., 2005).

2.6.3.3 Fluorescent tracers techniques

This is a visualization of skin exposure patterns with fluorescent tracers application. Fluorescent tracers are nontoxic chemical that can mark areas where pesticides get on skin and clothes. They have special properties that are able to glow in the dark area under UV-A light (black light) condition. Qualitative studies with fluorescent tracer can give crucial information about pesticide residues deposit on skin patterns, personal protective equipment, and work practices. However, this method has some limitations. First, it requires introduction of a tracer compound in agricultural spray mix. Secondly, there have to be shown a correspondence between pesticide deposition and fluorescent compound deposition. Thirdly, it need exactly of tracer measurement (Galvin and Lee, 2007).

2.6.3.4 Reasonable Maximum Exposure (RME)

The highest exposure that is reasonably supposed to happen at a site is defined as reasonable maximum exposure (RME). The RME was used to determine the potential risk assessment in this site and estimated the worst-case scenario for individual pathways. The main purpose of the RME is to approximate a conservative exposure case that remains within the range of possible exposures. Hence, the upper confidence (95^{th} percentile) on the arithmetic of concentration averages were used to determine the RME because the uncertainty related to any approximate of concentration exposure might occur in this study (Taneepanichskul, 2012).

2.6.4 Risk characterization

The last step of human health risk assessment is risk characterization. It concludes qualitative and quantitative data, which is a tool to link with the risk manager or decision makers. The risk characterization is a process that combines and uses the appropriate method to analyze the necessary information from the hazard identification, dose-response assessment, and exposure assessment to make risk estimates for the exposure of interest (IRIS, 2008).

2.7 Determining sample size for the mean

The appropriate sample size is an important factor for a good estimate of representable population in case study and provides the number needed for the data analysis. There are two procedures to consider sample size for variable that are continuous. First method is combination of responses into two categories then uses sample size base on proportion. Second method is formula for the sample size for the mean usage. The equation calculates sample size for the mean, shown as below (Israle, 1992).

$$n_0 = \frac{Z^2\sigma^2}{e^2} \qquad \textit{eq. 2-5}$$

where:

n_0	= sample size
Z	= abscissa of the normal curve that cuts off an area α at the tails
e	= desired level of precision
σ^2	= variance of an attribute in the population

2.8 Related articles

Geno *et al.* (1996) reported hand wiping and analysis procedure for dermal exposure assessment was improved for dermal contact pesticide measurement. Cellulose dressing sponges wetted with 2-propanol was used in this study. The removal efficiency of experiments presented that dry residues of the pesticides chlorpyrifos and pyrethrin I were quantitatively removed from hands immediately after contact, which was better efficiency than previously reported for hand rinsed. For the concentration range investigated, wipe removal efficiencies was greater than 80% could be expected with this method with a standard deviation of up to 20% for chlorpyrifos and up to 30% for pyrethrin. The results were based on 12 hand wiping obtained from 2 human subjects.

Moreover, the recovery studied for 29 additional organochlorine, organophosphorus insecticides and phenoxy-acid herbicides were shown good extraction efficiency for acids and neutrals from a single extraction. This study indicated that this procedure might be readily test in young children. However, they needed to investigate the stability of target pesticides in the isopropanol matrix, and a cleanup procedure could be added to remove fats and oils from the wipe extract. In addition, they believed hand wiping from farm workers following mixing, loading or activities application, adults, and children in a non occupational would provide an accurate and direct measurement of the dermal contact to pesticides.

Grandstaff and Srisupan (2004) examined agropesticide usage in Thailand that has been increasing trend. A large number of rice farmers in rural area in central Thailand did not apply pesticides by themselves but they hired others. Most of sprayers have contacted with pesticide more than five years, they had acute pesticide poisoning experience and most of them have knocked out by pesticide incident. Therefore, they tried to prevent and take care themselves from pesticides anyway there were some limitations that were lack of knowledge to use pesticide correctly and lack of awareness.

Taneepanichskul (2009) studied dermal exposure in chili-growing farmer during growing season to assess risk of chlorpyrifos in chili farmers at Hua Rua sub-district, Ubon Rachatani province, Thailand that found chlorpyrifos residues on 35 chili-growing farmers' hands after spraying by using hand-wiping technique to collect samples. The average daily dose (ADD) of farmers was 2.51×10^{-9} mg.kg^{-1}·day^{-1}. The ADD of male farmers was higher than female farmers. Both Hazard Quotient (HQ) of male and female farmers was lower than acceptable level. The summary was not at risk with non-carcinogenic effects from dermal exposure however the researcher recommended that inhalation and oral exposure routes should be estimated risk assessment due to the farmers had mentioned on acute and back and forth or prolonged effects of OPPs after their application.

Pan (2009) studied dermal exposure of OPPs that was chlorpyrifos and profenofos to assess health risk in rice farmers at the Rangsit Agriculture Area, Prathumthani province, Thailand. The 29 of rice farmers were interviewed to access work practices and pesticide usage. Some of participants have neurological signs and symptoms that may be concerned with OPPs. The rice farmers at this site applied more than one type of pesticide and overdose using. The 14 rice farmers were assessed health risk of chlorpyrifos and profenofos exposure. Hazard Index (HI) assumes the effects of the different compounds and effects that are additive. HI of chlorpyrifos and profenofos are higher than unity (HI > 1). Theses rice farmer may be got risk and chronic adverse health effects.

Ooraikul (2010) researched risk assessment of OPPs from chili consumer at Hua Rua sub-district, Ubon Rachatani province, Thailand. The 110 consumers (45 males and 65 females) were interviewed. The result showed the average chili intake rate of this area was 0.018 kg/day, which was higher than the average of general Thais. Thirty-three chili samples were extracted using QuEChERS method and analyzed by GC-FPD that found chlorpyrifos (0.010 - 1.303 mg/kg) and profenofos (0.520 - 6.290 mg/kg). Both of chlorpyrifos and profenofos contaminated samples were higher than the MRLs. The ADD of chlorpyrifos from chili consumption was 1.07×10^{-4} mg/kg-day and ADD of profenofos was 8.00×10^{-4} mg/kg-day, which means profenofos exposure is higher than chlorpyrifos for chili consumers. Hazard quotient (HQ) of chlorpyrifos was lower than the acceptable level (HQ<1) and HQ of profenofos was greater than the acceptable level (HQ>1). The researcher suggested that correctly pesticide usage should be trained in Hua Rua area to minimize the risk for chili consumers.

Panuwet *et al.* (2012) reported that Thailand is an agricultural country and one of the world's leading food exporters. People in this country believe that use large amount of pesticide, it can prevent their crops and increases yields. There are rising number of pesticide application from the past that challenge for the Royal Thai Government to manage and control pesticide use found on the current policy and legal infrastructure. They have studied various keys component for agricultural pesticide management in Thailand. One of the main problems for effective pesticide regulation in this country is ununiformed system to design specifically for pesticide management that causes overuse or misuse of pesticide, increases environmental contaminant and human health risk.

Taneepanichskul *et al.* (2012) investigated usual pesticide application and health symptoms that concerned with pesticide exposure among chili-growing farmers comprising of an association between personal protective equipment (PPE) using and health symptoms. The main group of participants was men (65%) that have elementary education level. Their handling and practicing of pesticide usage were doubtful. Storing pesticide at home without mixing them in their house is 20% and using overdose of pesticide requirement is 95%. They usually used PPE such as glove, nose mark, boot, and coverall during pesticide usage. Some of health symptoms reports were throat irritation (40%), excessive salivation (65%), blurred-vision (35%), and memory problem (70%). This study investigated that some PPE usage related to adverse health problems for example skin problem vs. wearing gloves ($R=-0.612^{**}$) and headache vs. nose mask ($R=-0.745^{**}$).

CHAPTER III
METHODOLOGY

3.1 Research design

This study is a descriptive cross-sectional survey, which composes of laboratory study and observational questionnaire as shown in Figure 3.1. The experimental in laboratory is one important part for measure the amount of chlorpyrifos residues on gauze patch samples and the observational questionnaire is the essential way to collect the local information about their work practices and health data. All samples were conducted from October 2012 to January 2013.

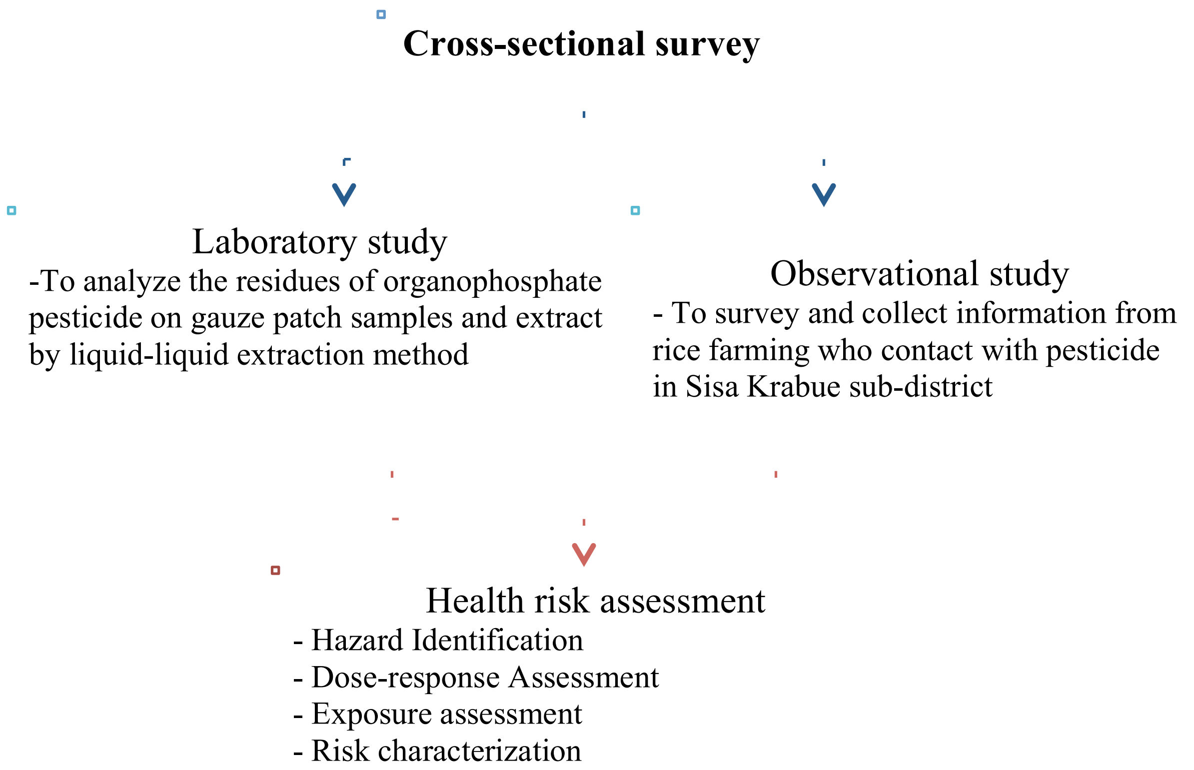


Figure 3.1 Flow chart of research process

3.2 The study area:

The study area is located in the Sisa Krabue sub-district, Ongkharak district, Nakhon Nayok province. Most of cultivation is paddy field. Figure 3.2 shows the study site and paddy field at this study area.

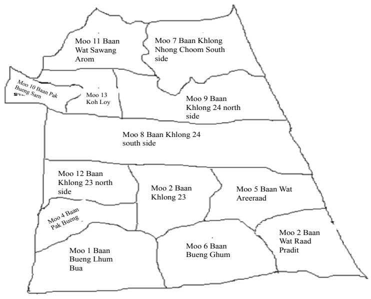


Figure 3.2 The study area at Sisa Krabue sub-district, Ongkharak district, Nakhon Nayok province, Thailand

3.3 Study populations

The target population of this study was the rice-growing farmers who were men or women , the age between 18-59 years old, and have stayed at least 2 years in Sisa Krabue sub-district where has a large area of rice farming located in Ongkharak district, Nakhon Nayok province, central Thailand. Moreover, this target samples have used and contacted with organophosphate pesticide directly on paddy fields for 1 year at least. This project selected populations by simple random sampling from list of name at Sisa Krabue sub-district public health center. This random sampling was done by choosing 1 person from 1 household and the sample was collected from 35 rice farmers in this area. Number of samples was calculated by sample size for the mean equation (*eq. 3-1*).

$$n_0 = \frac{Z^2\sigma^2}{e^2} \qquad \textit{eq.3-1}$$

For normal distribution assumes Z value = 1.960 and e = ± 5% (0.050). Variance value that referred to Pan research, studied in paddy fields and target sample was rice-growing farmers as same as this study. Variance of sample was equal 0.022 (Pan, 2009).

Therefore: $n_0 = \frac{(1.960)^2\ (0.022)}{(0.050)^2}$

$= 33.81$ farmers.

So, sample size was 34 farmers from the calculation, but this study collected 35 farmers for drop out and sample pre-test extraction. There is one group of sample that behaved and worked as their usual practices. The Ethics Review Committee for Research Involving Human Research Subjects, Health Science Group, Chulalongkorn University, Thailand approved this study and the certified code No. 009/2013. The target populations were willing to attend this project by leaflet that the owner project offered them. Before putting gauze patch on farmers' skin, the main researcher would ask them "Did they have an allergy from gauze patch". If subjects were allergic, we would cut them out and if they had an allergy during doing research, the main researcher would find some medicine for them. This target population would be attached patch (cotton gauze) on seven positions of farmers' body for dermal exposure estimation, these patches were collected after they finished spraying pesticide that took time for 1-2 hours, which depended on size of paddy field. After that they would be face-to-face interview using questionnaire by the main researcher or co-researcher. For interview, it would take 15-20 minutes. During farmers were mixing, loading, spraying, and transporting pesticide; the owner of this project would take them pictures.

3.4 Observational study

Most of the participants in this case study were local people who have lived in Sisa Krabue sub-district, Ongkharak district, Nakhon Nayok province. This research was focused on local people who use and contact with organophosphate pesticides at Sisa Krabue area. This observational study consists of questionnaire observation and face-to-face interview the people in this area. For face-to-face interview, they will be interviewed by open-ended questions. For the questionnaire interview, it contains of three parts as follows:

Part 1: the general information and personal history of the rice farmers who always apply and contact with pesticides, were given, namely, ages (years), gender, body weight (kilograms), height (centimeters), education level, pesticide application practices, and duration of rice farming.

Part 2: the information on health problems were obtained to assess any health problems that concern with exposure to organophosphate pesticides, involving signs and symptoms that happened throughout the local's history of health, and their general health status.

Part 3: the information on pesticide application, exposure information, and work practices on pesticides, namely, type of pesticides that they used, area cultivated (rais), loading and mixing pesticides (milliliters per liters of water), duration of application (hours), frequency of pesticides application, use or not use personal protective equipment when they apply pesticides.

The structure of the questionnaire is based on questions, which were established by Ooraikul (2010), Pan (2009), Taneepanichskul (2009), and Siriwong (2006).

3.5 Hazard identification

Chlorpyrifos is moderately toxic for acute dermal, inhalation, and oral exposures. Moreover, chlorpyrifos is grouped in category II toxicity for all exposure routes and it is a non-carcinogenic substance (EPA, 2000).

3.6 Exposure assessment

3.6.1 Surrogate skin techniques

Surrogate skin techniques or body skin sampling is the method for study the pesticide residues absorbed on skin. This technique is used to estimate dermal exposure by 10x10 cm cotton gauze swabs, put into seven places on the rice farmers' inside and outside clothes, which shown in Figure 3.3. At first place, is on hat that close to the top of the farmers' heads. Second place, is over sternum that is on outside of normal clothes. Third place is on sternum that is on inside of normal clothes. Fourth place is upper surface of right forearm, midway between elbow and wrist, on outside of normal clothes. Fifth place is on front of left leg, mid-thigh on outside of normal clothes. Sixth place is on front of left leg, above ankle, on outside of normal clothes. Seventh place is on the back between shoulder blades, on outside of normal clothes. At the end of the sampling period, the seven patch samples were removed from the clothes, covered them by aluminum foil, then kept them in zip-lock plastic bag and stored in ice box that filled ice and salt. After that samples were kept in frozen in laboratory at -20 ^{o}C until analyzed with GC-FPD (Jaipieam, 2008).

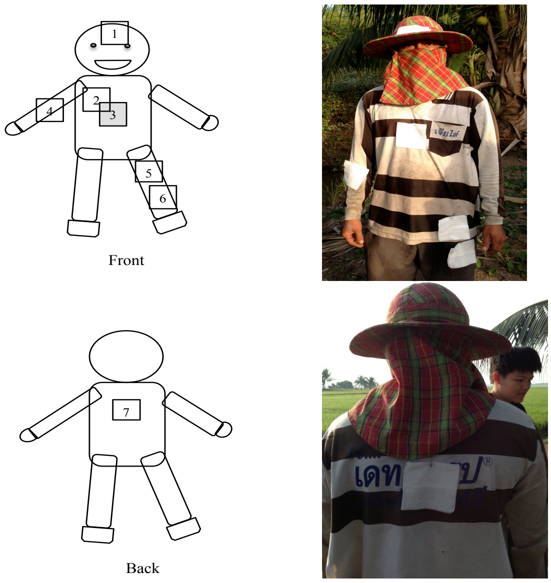


Figure 3.3 Seven places of patch techniques according to WHO sampling protocol

3.6.2 Visualization of skin exposure with fluorescent tracers

Before start of workdays, the fluorescent tracer Tinopal CBS-X® was added into the tank of mixing pesticide (260 milligrams per one liter of water) by one tank. Then, the farmers will be poured the pesticide in that tank (Figure 3.4). There is not any adverse health affects data of Tinopal CBS-X® (Houghton *et al.*, 1999). Then, the farmers applied the pesticide as usual of their work practices. After finishing the pesticide application, the gauze samples that had fluorescent tracer mixed with pesticide residues were collected and taken picture in dark room under UV-A condition (Aurora *et al.,* 2004).

3.6.3 Laboratory study

3.6.3.1 Extraction of gauze patch samples

Method for pesticide residues extraction is liquid-liquid extraction (LLE) method. It is simple, effective, quick, low cost, and safe method for the pesticide residues consideration. This method involves pesticide residues extraction from sample by mechanical shaking mixing with ethyl acetate.

After collecting the samples, samples were stored at -20^{o}C. Samples were extracted by liquid-liquid extraction method. First, the patch samples were placed in 250 milliliters flask and added 20 milliliters of ethyl acetate. After that agitated them on a mechanical shaker at high speed for 10 minutes. Then, the gauze patch was taken into another 250 milliliters flask, added 20 milliliters of ethyl acetate and agitated them again for 5 minutes. After that combined solvent from two flask together and evaporated solvent with air pump until solvent was less than one milliliter, then used acetone to adjust volume to one milliliters. Finally, the solvent was taken and injected to Gas Chromatography with Flame Photometric Detector (GC-FPD) (Adapted from Farahat (2010)). A schematic of the extraction procedure was shown in Figure 3.4

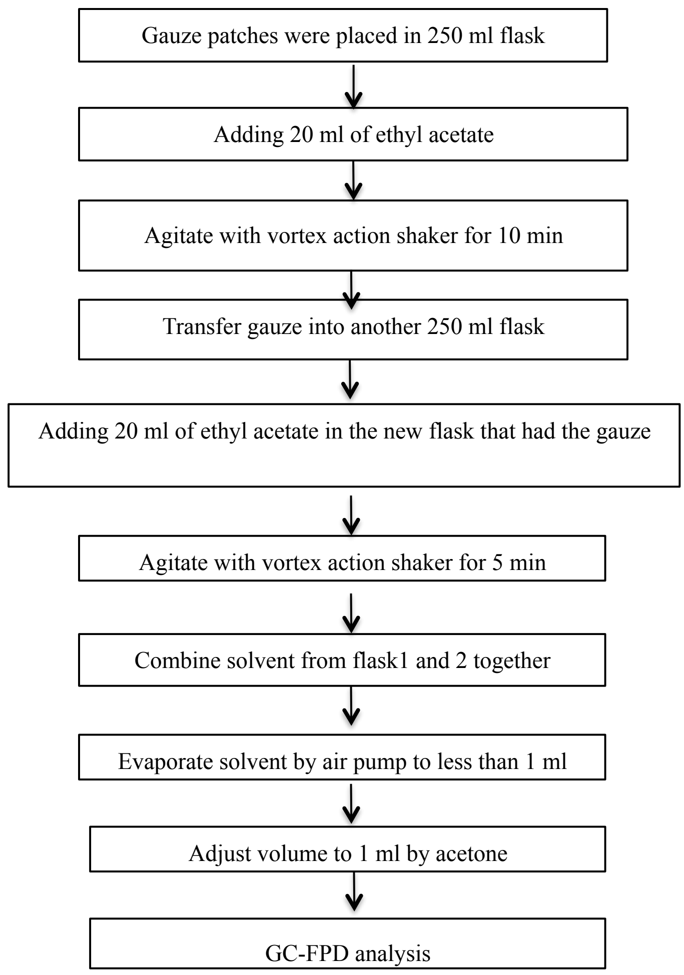


Figure 3.4 Flow chart of the liquid-liquid extraction method

3.6.3.2 Calculation of chlorpyrifos residues concentration on cotton gauze

Known concentration of chlorpyrifos was spiked on cotton gauze and extracted chlorpyrifos concentration from gauze. Then, the solvent of chlorpyrifos from extraction was injected and analyzed by GC-FPD. After, we knew the concentration of gauze from extraction. Then, we could calculate concentration of chlorpyrifos in term of liquid phase (solvent) to solid phase (on gauze).

Spiking chlorpyrifos concentration 100 ppm, volume 10 µl (1×10^{-5} l)
Assume the specific gravity of gauze = 1 g/l
For this study, weight of one gauze = 2 g (0.002 kg)

Then, using

$$C_1V_1 = C_2V_2$$

$$(100 \text{ ppm})(1 \times 10^{-5} \text{ l}) = C_2 (0.002 \text{ kg})$$

$$C_2 = \frac{(100 \text{ ppm})(1 \times 10^{-5} \text{ l})}{(0.002 \text{ kg})}$$

$$= 0.5 \text{ mg/kg}$$

Therefore, concentration of chlorpyrifos on gauze pad was 0.5 mg/kg

3.6.3.3 Gas Chromatography analysis

In this research, Agilent 7890 equipment with Flame Photometric Detector (FPD) was used for quantification. Substances were separated by HP-5 (30.00 meters length, 250 micrometers diameter, 0.25 micrometers film thickness) coated with 5% Phenyl Methyl Siloxan. Samples quantification was performed using multiple external standards. The optimum condition could be provided as shown in Table 3.1.

Table 3.1 The analysis condition of chlorpyrifos by GC-FPD

Capillary Column	HP-5 (30.00 m length, 250 µm i.d., 0.25 µm film thickness) coated with 5% Phenyl Methyl Siloxan			
Carrier Gas	Nitrogen at 2 ml/min flow rate			
Make up gas	Nitrogen at 45 ml/min flow rate			
Detector gas	Air at 100 ml/min flow rate Hydrogen at 75 ml/min flow rate			
Type of Injection	Spiltless			
Injection volume	1 µL			
Injection temperature	230 °C			
Detector	Flame Photometric Detector (FPD)			
Detector Temperature	250 °C			
Oven Ramp	Flow rate °C/min	Next °C	Hold (min)	Run Time (min)
Initial		100	0.00	0.00
Ramp 1	10.00	220	0.00	12.00
Ramp 2	20.00	260	1.00	15.00
Ramp 3	20.00	280	5.00	21.00
Post run		300	3.00	24.00

3.6.4 Dermal exposure assessment

Average Daily Dose (ADD) Calculation

The average daily dose (ADD) is used to exposure non-carcinogenic chemicals as a daily dose on a per-unit-body-weight basis. ADD is a measurement that uses to evaluate the exposure of non-carcinogenic effects. The route-specific mathematical algorithms is used for calculate ADD. For dermal contact with chemicals in soil or water, dermal absorbed average daily dose can be evaluated by the equation below (EPA, 1997)

$$ADD_{dermal} = \frac{DA_{event} \times EV \times ED \times EF \times SA}{BW \times AT} \qquad eq.3\text{-}2$$

where:

ADD	=	average daily dose (mg/kg-day)
DA_{event}	=	absorbed dose per event (mg/cm^2-event) (from DA_{event} calculation)
EV	=	event frequency (events/day) (from questionnaire)
ED	=	exposure duration (years) (from questionnaire)
EF	=	exposure frequency (days/years) (from questionnaire)
SA	=	skin surface area available for part of body (cm^2) (from skin surface area calculation)
BW	=	body weight (kg) (from questionnaire)
AT	=	average time (days) for non-carcinogenic effects (from ED x 365 days)

DA_{event} stands for absorbed dose per event (mg/cm^2-h) that can be determined by using dermal absorption fraction (US EPA, 1997; Jaipieam, 2008), where Cs was equal mg/kg of gauze that was approximate one part of body.

ABS = Dermal absorption fraction (unit less), the value of this factor was specific with chemical. For chlorpyrifos was 0.03 (EPA, 1999).

Therefore;

$$\frac{\text{Cs mg of pesticide}}{\text{Kg weight of gauze}} \times \frac{10^{-3}\text{ kg}}{1\text{ g sample}} \times \frac{\text{Weight (kg)}}{1\text{ gauze}} \times \frac{10^{3}\text{ g}}{1\text{ kg}} \times \frac{1\text{ gauze}}{\text{SA (cm}^2\text{-event)}} \times \text{ABS}$$

Simplified to,

$$DA_{event} = \frac{\text{Cs mg of pesticide}}{\text{SA (cm}^2\text{-event)}} \times \text{ABS}$$

The average weight of one gauze before extraction was 2 grams. So, the gauze was equal 0.002 kilograms because we assumed the specific gravity of gauze equal the specific gravity of water that was 1g/L.

The surface area of skin exposed to contaminant can be considered by estimation techniques. The contact rate for the pollutant is calculated by the estimation of the surface area for specific of body part. The data of total surface area of the particular body that shown in Table 3.2 (EPA, 1997).

Table 3.2 Surface area of body part for adult (m^2)

Surface area of body part (m^2)	**Men**	**Women**
Head	0.20	0.11
Trunk (includes neck)	0.60	0.54
Upper extremities	0.32	0.28
Arms (include upper arms and forearms)	0.23	0.21
Hands	0.08	0.08
Lower extremities	0.64	0.63
Legs	0.51	0.49
Thighs	0.20	0.26
Lower legs	0.21	0.19
Feet	0.11	0.10

Source: EPA (1997)

According to EPA handbook, total body surface area can be estimated from body weight and body height, which calculated by the equation below (EPA, 1997):

$$SA = a_0 H^{a1} W^{a2} \qquad \textit{eq. 3-3}$$

where:

SA = surface area (m^2)

H = height (cm)

W = weight (kg)

a_0, a_1, a_2 = constant value from US EPA (1997)

3.7 Risk assessment

Chlorpyrifos is organized as non-carcinogenic pesticide. The criterion, that is the one used in non-carcinogen risk characterization, is the reference dose (R_fD). The individual risks evaluation of non-carcinogenic toxicity is calculated using the hazard quotient (HQ) that indicates the degree of exposure, greater or less than the R_fD. If the exposure is more than the R_fD, the exposure population may be in danger. The reference dose was specific for chlorpyrifos through dermal contact was 0.0015 (IRIS, 2008).

$$\text{Hazard Quotient (HQ)} = \frac{\text{Exposure}}{R_fD} \qquad \textit{eq. 3-4}$$

where:

Exposure = chemical exposure level or ADD (mg/kg-day)

RfD = reference dose (mg/kg-day)

HQ > 1 means adverse non-carcinogenic effect of concern (Risk)

HQ ≤ 1 means acceptable level (No concern)

Combining the hazard quotients form the Hazard Index (HI), which estimates the effects of the different compounds and effects are additives. HI method is recommended for groups of toxicologically similar chemicals that have dose response data. When the hazard index exceeds unity (HI > 1), the exposure population may be at risk, on the other hand HI is less than or equal to 1 should be taken as the acceptable reference or standard (US EPA, 1992)

Hazard Index (HI) = Σ (HQ) *eq. 3-5*

where:

HI > 1 Adverse non-carcinogenic effects of concern (Risk)

HI $\leq$ 1 Acceptable level (No concern)

For non-carcinogenic toxicity of an individual risk estimation was evaluated by calculating the Hazard Quotient (HQ) and Hazard Index (HI) (*equation 3-4 and 3-5*), respectively. The interpretation of HQ and HI value are the same that the results are greater than 1 (> 1 exposure exceeds the R_fD, probable risk), the exposed populations may be at risk, whereas HQ and HI are less than or equal to 1 should be taken as the acceptable reference or standard (US EPA, 1992)

3.8 Quality control

In this study, all of samples were analyzed by Agilent 7890 equipment with Flame Photometric Detector (FPD); HP-5 (30.00 meters length, 250 micrometers diameter, 0.25 micrometers film thickness). For the calibration curve of chlorpyrifos, there were five levels of concentration that were 0.01, 0.10, 1.00, 10.00, and 100.00 µg/ml, which shown in Appendix F and the calibration standard was run every 10 samples and all measurements were performed in the ranges of linearity. In Appendix F, validation data was presented essentially quantitative recovery at 100 ppm in the range of 100 – 120 % and the average precision of the matrices was 3.01% Relative standard deviation (RSD). The average limit of detections (LOD) in this study was 0.01 µg/ml and limit of quantifications (LOQ) was 0.02 µg/ml. Refer to the Scientific Association Dedicated to

Excellence in Analytical Method (AOAC), all quality control values presented this qualitative study was in the recommended standard level (AOAC, 1993).

3.9 Data analysis

3.9.1 Statistical analysis

SPSS version 17.0 for Window was used to analyze data. The general information of all participants was described by mean, standard deviation and percentage. In addition, 95^{th} percentile level was used to over protection of all rice-growing farmers. Moreover, correlation and comparison were used SPSS to evaluate data.

3.10 Ethic consideration

The Ethics Review Committee for Research Involving Human Research Subjects, Health Science Group, Chulalongkorn University, Thailand, has approved in accordance with the International Conference on Harmonization-Good Clinical Practice (ICH-GCP) and/or Code of Conduct in Animal Use of NRCT version 2000. The certified code No. 009/2013. All participants signed a consent form prior to participation in this study

CHAPTER IV
RESULTS AND DISCUSSIONS

Quantitative and qualitative information on pesticide exposure were collected from rice-growing farmers who have lived in Sisa Krabue sub-district. All of participants felt pleasant to be in a part of this research. Face-to-face interview and fluorescent tracer could explain qualitative data. Moreover, there was a quantitative fact from gauze patch technique. This technique presented the amount of pesticide concentration on rice-growing farmers' body. According to both of quantitative and qualitative data that could assess health risk and account surface area and average daily dose from pesticide application of the study population in this area.

4.1 General information and health effects related to pesticide exposure

4.1.1 Rice-growing farmers characteristics

In this research, there were 35 participants that consisted of 21 men (60%) and 14 women (40%). Most age of them was 32 to 38 years old while an average age (±SD) of all was 38.66 (± 9.15) years old. Elementary school completion was 57.15%, which was higher than those who had finished junior high school accounted 25.71% and high school counted 11.43%, respectively. The average weight (±SD) and height (±SD) of these participants were 58.17 (± 7.33) kilograms and 164.37 (± 8.01) centimeters tall, orderly. The number of smoker and non-smokers were quite the same that were 51.43% of smokers and 48.57 of non-smokers (Table 4.1).

Table 4.1 General characteristics of rice-growing farmers in Sisa Krabue sub-district, Ongkharak district, Nakhon Nayok province, Thailand

Characteristics	**Rice-growing Farmers**	
	Number (n = 35)	**Percentage (%)**
Gender		
Male	21	60
Female	14	40
Age groups		
18-24	2	5.71
25-31	6	17.15
32-38	10	28.57
39-45	9	25.71
46-52	6	17.15
53-59	2	5.71
Mean age ± SD	38.66 (± 9.15)	
Weight (kg) (mean ± SD)	58.17 (± 7.33)	
Height (cm) (mean ± SD)	164.37 (± 8.01)	
Education	**Number (n=35)**	**Percentage**
(%)		
Uneducated	2	5.71
Elementary School	20	57.15
Junior High School (M.1-3)	9	25.71
High School (M.4-6)	4	11.43
Smoking Status		
Non-Smokers	17	48.57

Similar to the previous study (Pan, 2009), most of rice-growing farmers in Rangsit cultural area were male and the average age of the participants was 46.1 years old that was quite different from this study. The average age of the participants in this study was 38.7 years old that meant people in this site might have more chances to get risk from pesticide application than Rangsit cultural area due to long exposure duration.

However, both researches had similar that there are some female involving pesticide exposures because men did an agricultural motion in developing countries normally.

Some of participants lacked of education, thus, they would be a susceptible group because it was difficult to protect them from pesticide misusing although the container of pesticide had instruction. And the greatest number of rice-growing farmers in this area finished elementary school, which was same as in the previous study (Taneepanichskul, 2012). Therefore, they were able to read and understand how to use pesticide in the right way; they might be lesser to get risk from pesticide exposure. Even though, they had a high education but most of them still usually used over amount of pesticide instruction. Moreover, they mixed a variety kind of pesticides together in one time. The first reason of this behavior was they believed that if they used a high amount and a different kind of pesticides, it would help to kill pest in short time. Pump and sprayers hire were high cost, so this was the second reason that they used many kind of pesticides such as abamectin, carbamate, and fungicide in one time, this would help them to save time and money.

4.1.2 Rice-growing farmers information concern with pesticide exposure

The highest number of pesticide application was ranged 10 to 19 years that calculated 51.43%. The average working hours of pesticide usage for one person was two hours each time. At this area, mostly they worked in a team that had 4-5 persons in their team. The hours of pesticide application and number of sprayers depended on size of cultivation area. The average of area cultivated in the past was 208.91 rai (Table 4.2).

Table 4.2 Agricultural works and farming characteristics (n = 35)

Area cultivated (rai[a]) (Range)	30-1,000
Duration of application/time[b] (Hours) (mean ± SD)	2.29 (± 0.52)
Years of using pesticides (mean ± SD)	14.23 (± 7.59)
	n (%)
0 – 9	10 (28.57%)
10 -19	18 (51.43%)
20 or more	7 (20%)

[a]*Change Unit: 1 rai = 0.4 acre*

[b]*Duration of application including mixing and loading*

All of rice-growing farmers in this site applied many kinds of pesticides such as abamectin and carbamate, and used the needed amounts of pesticides accounted 71.43%. The number of farmers who smoked when they worked at cultivation site was 51.43% that was higher than non-smokers and most of them did not take a meal to the site counted 71.43%. After their work practices, they washed their clothes immediately was 100% and separated their working clothes from family clothes was 82.86% (Table 4.3).

Table 4.3 Handling and practicing of pesticide use in rice-growing farmers (n = 35)

	Rice-growing Farmers: n (%)	
	YES	**NO**
1. Mixing more than 2 pesticides and overdose	25(71.43%)	10 (28.57%)
2.Washing working clothes after work	35 (100%)	-
Washing working clothes with the family clothes	6 (17.14%)	29 (82.86%)
3. Smoking while applying pesticides	18 (51.43%)	17 (48.57%)
4. Having a meal at farm area	10(28.57%)	25(71.43%)

Table 4.4 Use of personal protective equipment (PPE) in rice-growing farmers (n = 35)

	Rice-growing Farmers: n (%)	
	Use	**Not use**
Gloves	-	35 (100%)
Inappropriate fabric face masks	22 (62.86%)	13(37.14%)
Boots	1 (2.86%)	34(97.14%)
Hats	29(82.86%)	6 (17.14%)
Long sleeved shirts	35 (100%)	-
Long legged pants	28 (80%)	7 (20%)

Using of personal protective equipment (PPE) during pesticide usage in paddy field was shown in Table 4.4. At this study area, most of them rarely wore PPE (gloves, inappropriate fabric facemasks, boots, hats, long sleeved shirts, and long legged pants). Wearing long legged pants calculated 80% that was higher than wearing short-legged pants. The 100% of participants wore long sleeved shirts. The 100% and 97.14% of all participants did not wear gloves and boots, orderly. Moreover, the number of participants who wore facemasks and hats accounted 62.86% and 82.86 %, respectively.

According to data observation, rice-growing farmers in this site normally mixed or applied pesticide without any personal protective equipment (PPE) to prevent themselves from pesticide. They only used inappropriate hat or fabric facemask (made from their t-shirt) to protect them from sunlight. In addition, almost of them did not wear rubber boots, glasses, or gloves and most of them wore socks or had bare feet to apply pesticide. The main PPE was long sleeved shirt and long pants. These behaviors were same as (Pan, 2009). The cause of this problem was PPE had high price, so PPE was not widely used in this area or they lacked of consciousness in adverse health effects from pesticide usage.

In accordance with Jaipieam (2008), at Bang Rieng sub-district, Songkhla province, vegetable growers in this area mostly used portable pump to spray pesticide. Refer to Pan (2009), rice-growing farmers at Rangsit agricultural area totally used backpack sprayer and mist blower. In this study, there was one type of sprayer, which use to spray pesticide was sprayer connected with motor tank. The various sprayers caused different route of exposure. For, the sprayer connected with motor tank might cause risk through dermal and inhalation route but this research focused on skin exposure.

According to fluorescent tracer tracking data, the area that found pesticide residues were upper leg, lower leg, chest, arm, back, and head but the lower leg was the highest of pesticide-contaminated area.

Most of rice-growing farmers in this research usually sprayed pesticide at dawn and dusk of day due to slightly of sunlight. All of them often misapplied pesticide because they thought it would be rapidly protect their crops away from pest, which was similar to Panuwet *et al* (2008), which reported the huge risk of pesticide toxicant was Thai farmers on account of improper pesticide handling, incorrect personal protective equipment usage owing to deficient toxicity of pesticide knowledge.

Fourteen percent of rice farmers got blurred vision and dizziness during apply pesticide. A few number of them had arms or legs weakness and headache. In conversely, there were forty percent of them that had headache after applied pesticide for twenty-four hours (Table 4.5).

Table 4.5 Signs and symptoms concern with pesticide exposure in rice-growing farmers (n = 35)

Symptoms	**Rice-growing Farmers: n (%)**		
	Never (after and during apply pesticide)	**Somewhat**	
		During pesticide application	**After pesticide application 24 hours**
Headache	17 (48.57)	3 (8.57)	15 (42.86)
Nausea/Vomiting	32 (91.43)	0	3 (8.57)
Abdomen cramp	34 (97.14)	0	1 (2.86)
Blurred vision	14 (40.00)	5 (14.29)	16 (45.71)
Tearing	33 (94.29)	0	2 (5.71)
Dizziness	18 (51.43)	5 (14.29)	12 (34.29)
Numbness or pins and needles in your hands and feet	31 (88.57)	0	4 (11.43)
Arms and legs weakness	22 (62.86)	1 (2.86)	12 (34.29)
Involuntary twitches or jerks in your arms or legs	33 (94.29)	0	2 (5.71)
Chest tightness	35 (100.00)	0	0
Difficult breathing	34 (97.14)	0	1 (2.86)

4.1.3 Body surface area calculation

Body surface area (SA) of study population was calculated, which was specific for people in this area. The value of SA was a part of factor to account average daily dose (ADD). The model of DuBois and DuBois (1916) (cited in US EPA, 2011) surface area calculation was used in this study (*equation 4-1*). The gender, personal weight and height were factor for this calculation (Table 4.6).

$$SA = a_0 H^{a1} W^{a2} \qquad \textit{eq. 4-1}$$

where:

SA = surface area (m^2)

H = height (cm)

W = weight (kg)

a_0, a_1, a_2 = constant values (US EPA, 1997)

The a_0, a_1, and a_2 in this equation were referred to the US EPA's defaults values that were shown in the Appendix C.

Table 4.6 Average weight (kg) and height (cm) of rice-growing farmers (divided by gender)

Gender	Male	Female	Male & Female
Weight ± SD	60.90 ± 7.43	54.07 ± 5.03	58.17 ± 7.33
Height ± SD	165.62 ± 8.23	162.50 ± 7.56	164.37 ± 8.01

Body surface areas were calculated separately into seven parts of body; head, chest, arm, upper leg, lower leg, back, and whole body that were shown in Table 4.7. The value of chest surface area was equal the value of back surface area because both of these parts was upper extremities part of body. Weight and Height information of each personal were gotten from face-to-face interview. In addition, the specific defaults value of calculation was provided under the Table 4.6.

Table 4.7 Average surface area (m^2) of rice-growing farmers in the study area

Average surface area (m^2)	Gender		
	Male	Female	Male & Female
Head	0.12^a	0.11^b	0.12
Chest	0.32^c	0.27^d	0.30
Arm	0.24^e	0.22^f	0.23
Upper leg	0.32^g	0.30^g	0.31
Lower leg	0.22^h	0.21^h	0.22
Back	0.32^c	0.27^d	0.30
Total (Whole body)	1.54	1.38	1.79

Defaults value of SA calculation
[a]a_0 = 0.0492, a_1 = 0.339, a_2 = -0.0950 (US EPA, 1985 cited in US EPA, 1997)
[b]a_0 = 0.0256, a_1 = 0.124, a_2 = 0.189 (US EPA, 1985 cited in US EPA, 1997)
[c]a_0 = 0.00329, a_1 = 0.466,a_2 = 0.524 (US EPA, 1985 cited in US EPA, 1997)
[d]a_0 = 0.0288, a_1 = 0.341, a_2 = 0.175 (US EPA, 1985 cited in US EPA, 1997)
[e]a_0 = 0.00111, a_1 = 0.616, a_2 = 0.561 (US EPA, 1985 cited in US EPA, 1997)
[f]a_0 = 0.00223, a_1 = 0.201, a_2 = 0.748 (US EPA, 1985 cited in US EPA, 1997)
[g]a_0 = 0.00352, a_1 = 0.629, a_2 = 0.379 (US EPA, 1985 cited in US EPA, 1997)
[h]a_0 = 0.000276, a_1 = 0.416, a_2 = 0.973 (US EPA, 1985 cited in US EPA, 1997)

Comparing the different value of body surface area between specific participants calculation (both male and female), which showed in Figure 5.1 and defaults values from US EPA (US EPA, 2011). Rice-growing farmers in this study had head, chest, and back surface area quite same as defaults values. Moreover, arm and lower leg surface area was slightly divergent from defaults values. Whereas, upper leg surface area of participants from calculation were higher than defaults values. The reason that the values were dissimilar because factors were weight and height that used to calculate depended on participants who concerned with this research. Male would get more risk than female, as the dissimilar of body surface area had mainly an effect on pesticide exposure through skin pathway, which meant who had more surface area will get more chance to contact with pesticide. According to the underneath figure that showed male had higher body surface area than female, so they will get more an amount of pesticide.

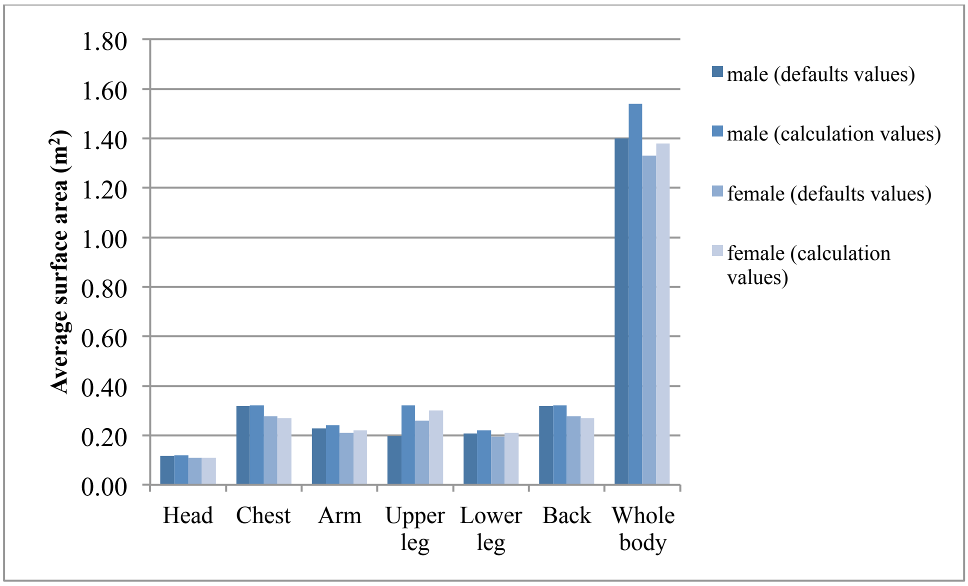


Figure 4.1 The comparative relation between defaults values and calculated body surface area

4.2 Pesticide exposure concentration via dermal pathway of rice farmers

In the study site, most of rice-growing farmers usually did not wear personal protective equipment, especially gloves. Loading, mixing, and spraying process of pesticide application in the paddy field became a significant part to get chemical into the farmers' body. Fluorescent tracer was added to track the pesticide residues on farmers' body. In addition, gauze patch technique was used to evaluate the pesticide concentration on their body. The cotton gauze were attached on seven positions on farmers' body such as head, chest on clothes, chest under clothes, arm, upper leg, lower leg, and back.

4.2.1 Fluorescent tracer tracking skin exposure

Fluorescent tracer technique was useful to reveal pesticide contamination on the skin of rice-growing farmers. All of participants could see the expanse of pesticide contamination on their body. This would leave consciousness and motivate them to protect themselves from pesticide exposure. Upper leg and lower leg area were the highest frequency of fluorescent tracer find. The lowest frequency of fluorescent tracer finding was chest under clothes area (Table 4.8) and percent frequency of pesticide residues on seven parts of farmers' body was shown in Figure 4.2.

Table 4.8 Frequency of fluorescent tracer on seven positions of farmers' body (n = 35)

	Rice-growing Farmers: n (%)	
	YES	**NO**
Head	28 (80.00%)	7 (20.00%)
Chest on clothes	32 (91.43%)	3(8.57%)
Chest under clothes	15 (45.71%)	20(54.29%)
Arm	29(85.71%)	6(14.29%)
Upper leg	34(97.14%)	1(2.86%)
Lower leg	34(97.14%)	1(2.86%)
Back	29(82.86%)	6(17.14%)

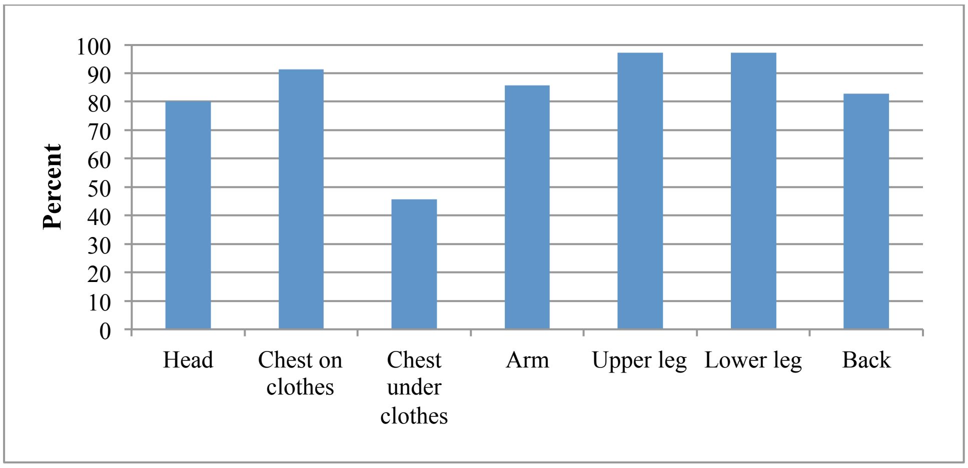


Figure 4.2 Percent frequency of pesticide residues on seven parts of farmers' body

Fluorescent tracer photographs of pesticide exposure on seven parts of rice farmers' body was used to evaluate by scoring. Figure 4.3 was shown scoring pattern for fluorescent images. The greatest number of fluorescent scoring was lower leg and the smallest number of fluorescent scoring was chest under clothes (Figure 4.4). Figure 4.5 was shown percent fluorescent score on seven parts of farmers' body that was same as percent frequency of pesticide residues on seven parts of farmers' body

Score 0	= without any fluorescent	Score 2	= moderate fluorescent
Score 1	= less fluorescent	Score 3	= high amount of fluorescent

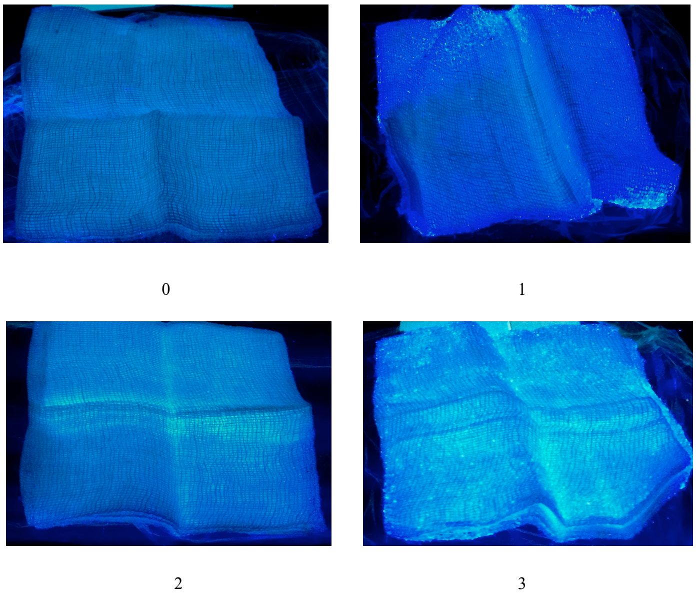


Figure 4.3 Fluorescent images scoring pattern

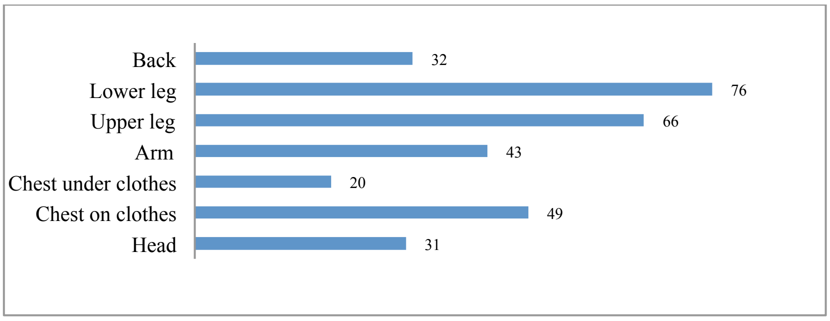


Figure 4.4 Total fluorescent images scoring on seven parts of rice farmers' body (n = 35)

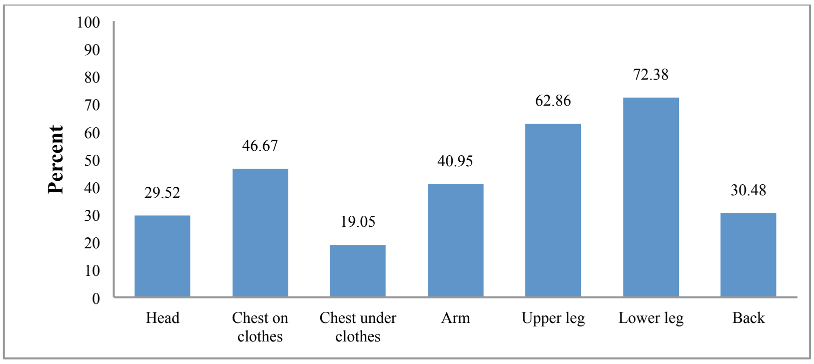


Figure 4.5 Percent fluorescent score on seven parts of farmers' body

Most of agricultural workers in developing countries have a serious problem concern with pesticide exposure. The large number of agricultural pesticide toxicant occurs via dermal exposure and absorption when workers apply pesticide (mixing, loading, spraying). This technique can display pesticide residues that contaminate on workers body. Fluorescent tracer will compel agricultural workers to conscious learning how to apply and manage pesticide in the correct and safety way (Galvin and Lee, 2007).

Aragón (2004) studied visual scoring system of fluorescent tracer deposits on skin of farmers in Nicaragua. They mixed fluorescent tracer with pesticide and recorded video in dark room under UV-A condition after farmers finished their work. Then, they used this video to transform qualitative monitoring of fluorescent tracer into quantitative by means of computer program. For video imaging technique to assess exposure (VITAE) had some limitation for temperature, dark room and low intensity of fluorescent that made it hard to read the result and score. Conversely, this study focused on qualitative data from fluorescent tracer. The highest frequency of fluorescent tracer finding was lower leg and upper leg. When rice-growing farmers sprayed pesticide, they used sprayer connected with motor tank that did not cause much pesticide spreading but it dropped on the top of rice and ground while they were spraying, they usually walked pass this pesticide contaminated area, so, this might be reasonable to answer this result. And the lowest frequency of fluorescent tracer finding was chest under clothes because most of farmers wore long sleeved shirt, which covered this part of body, hence, a few amount of pesticide could deposit on this area. Moreover, we used fluorescent images to evaluate pesticide exposure on seven part of rice-growing farmers' body found that lower leg was the largest of fluorescent score and chest under clothes was the smallest of fluorescent score, which was similar to fluorescent frequency.

4.2.2 Concentration of chlorpyrifos on seven positions of rice farmers from gauze patch technique

Refer to patch samples observation that was beneficial to estimate pesticide residues deposited on rice-growing farmers' body. This technique was set on seven parts of body (on head, chest on clothes, chest under clothes, arm, upper leg, lower leg, and back). Table 4.9 and 4.10 were shown mean, minimum, maximum and 95th percentile of chlorpyrifos concentration on seven positions of both male and female participants. The reasonable maximum exposure (RME) at 95th percentile was estimated to prevention and protect of high dermal exposure rice farmers. Figure 4.6 and 4.7 was shown the different an average and 95th percentile level of chlorpyrifos concentration on seven parts between male and female rice-growing farmers.

Table 4.9 Chlorpyrifos concentration on seven positions of male farmers' body (n = 21)

Part of body	Concentration (mg/kg of gauze, ppm)			
	Mean ± SD	Minimum	Maximum	95th percentile
Head	14.01±8.76	1.87	33.05	32.81
Chest on clothes	32.29±43.91	0.94	175.40	168.15
Chest under clothes	1.73±1.78	0.01	4.72	4.69
Arm	56.63±119.70	2.03	545.94	510.53
Upper leg	138.14±139.40	2.02	469.90	461.10
Lower leg	261.64±307.75	1.67	1,088.13	1,061.90
Back	21.90±50.04	0.88	236.66	216.67
Whole body	526.34±478.84	11.82	1,716.37	1,651.15

Table 4.10 Chlorpyrifos concentration on seven positions of female farmers' body (n = 14)

Part of body	Concentration (mg/kg of gauze, ppm)			
	Mean ± SD	**Minimum**	**Maximum**	**95th percentile**
Head	15.01±10.93	1.83	44.04	44.04
Chest on clothes	144.59±288.11	1.55	936.52	936.52
Chest under clothes	3.19±3.58	0.01	12.37	12.37
Arm	59.09±80.26	2.29	248.52	248.52
Upper leg	96.75±116.46	1.74	352.56	352.56
Lower leg	164.64±200.53	2.03	677.47	677.47
Back	17.47±15.51	1.21	63.04	63.04
Whole body	500.75±595.15	13.14	1,635.78	1,635.78

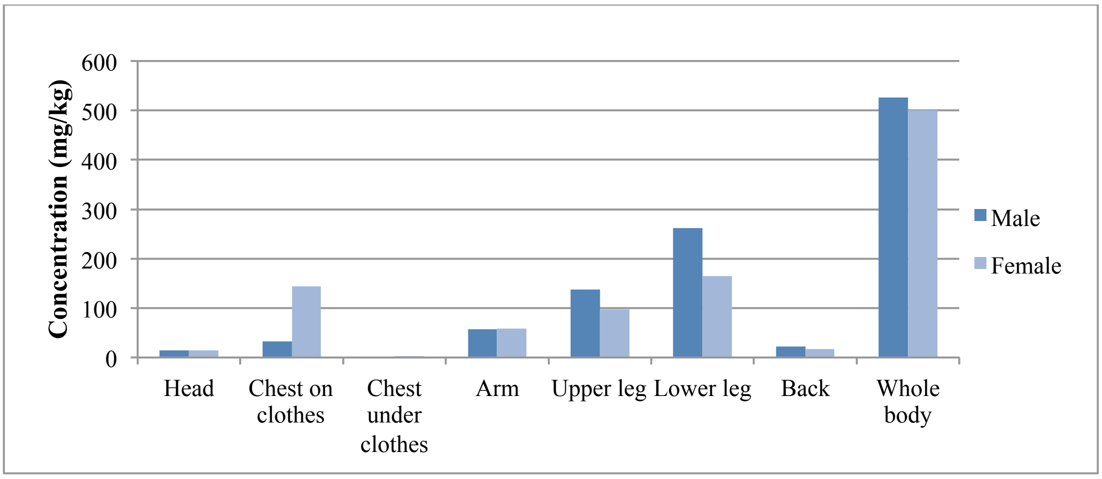


Figure 4.6 An average of chlorpyrifos concentration on seven parts of male and female rice-growing farmers' body

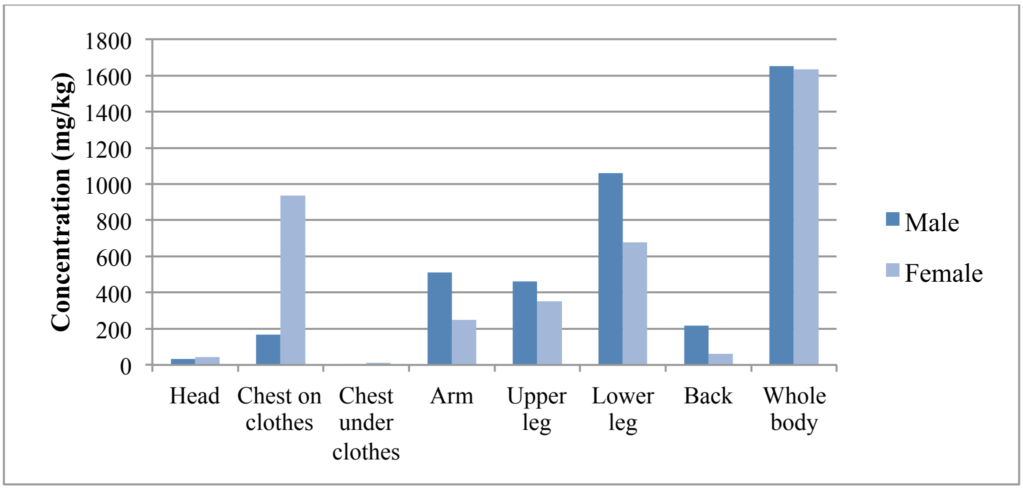


Figure 4.7 The 95th percentile level of chlorpyrifos concentration on seven parts of male and female rice-growing farmers' body

Gauze patch technique was used to evaluate skin exposure that related to pesticide residues leftover on rice-growing farmers who applied pesticide. Gauze patch was set in seven parts on rice-growing farmers' inside and outside of body (Jaipieam, 2008). The 35 participants were collected gauze patch samples totally seven positions for each participants after their work practices. The average residues of chlorpyrifos concentration on seven positions of male (head, chest on clothes, chest under clothes, arm, upper leg, lower leg, and back) were 14.01, 32.29, 1.73, 56.63, 138.14, 261.64, and 21.90 mg/kg, respectively. And the average residues of chlorpyrifos concentration on seven positions of female were 15.01, 144.59, 3.19, 59.09, 96.75, 164.64, and 17.47 mg/kg, orderly. The average residue of chlorpyrifos concentration on whole body of male and female was 513.56 mg/kg. For male, upper leg and lower leg were the highest part of chlorpyrifos residues contamination. Chest on clothes and lower leg were the largest area of chlorpyrifos residues remaining on female body.

4.2.3 Comparison of an average chlorpyrifos concentration on seven parts between male and female rice-growing farmers' body

Data of this study was non parametric, so Mann-Whitney U test was used to evaluate differentiation of data. Table 4.11 was shown the difference of chlorpyrifos concentration on seven parts between male and female rice-growing farmers' body. There was not a statistical different of chlorpyrifos concentration on seven parts between male and female rice-growing farmers' body (Mann-Whitney U test; $p>0.05$) that meant their work practices (mixing, loading, and spraying pesticide) between male and female were the same.

Table 4.11 The difference of chlorpyrifos concentration on seven parts between male and female rice-growing farmers' body.

Part of body	P-values*
Head	0.840
Chest on clothes	0.590
Chest under clothes	0.233
Arm	0.662
Upper leg	0.419
Lower leg	0.459
Back	0.213
Whole body	0.686

*Mann-Whitney U test

4.2.4 Correlation between concentration of chlorpyrifos residues and fluorescent score on seven parts of rice-growing farmers' body

Spearman rho's correlation was used to examine association between concentration of pesticide residues and fluorescent score on seven parts of farmers' body. There was significant correlation between chlorpyrifos residues concentration and fluorescent score on chest under clothes, chest on clothes, upper leg, lower leg, back, and whole body (Table 4.12). Chest on clothes and whole body were the parts of body where had moderate correlation with the relevant of r_s at 0.648 and 0.672, orderly. Head, arm, and back were the parts where had association between chlorpyrifos residues concentration and fluorescent score but they were not significant. The reason of this result might be an error from fluorescent tracer scoring.

Table 4.12 Spearman correlation coefficient (r_s) between concentration of pesticide residues and fluorescent score on seven parts of farmers' body

Part of body	Correlation coefficient (r_s)
Head	0.091
Chest on clothes	0.648**
Chest under clothes	0.393*
Arm	0.306
Upper leg	0.533**
Lower leg	0.542**
Back	-0.018
Whole body	0.672**

**Correlation is significant at the 0.05 level (2-tailed)*

*** Correlation is significant at the 0.01 level (2-tailed)*

4.3 Estimation of average daily dose

The average daily dose was used to evaluate the exposure for non-carcinogenic exposure. Dermal exposure was the main pathway to get adverse risk for rice-growing farmers. The exposure of body skin contact was calculated by the equation 3-2, which presented in Chapter 3. The values of each factor of 35 rice-growing farmers were shown in Table 4.13-4.15.

Table 4.13 Value of concentration and surface area on seven parts of each person for absorbed dose per event calculation

No. farmers	Head		Chest on clothes		Chest under clothes		Arm		Upper leg		Lower leg		Back		Whole body	
	Cs (mg/kg)	SA (cm^2)	Cs (mg/kg)	SA (cm^2)	Cs (mg/kg)	SA (cm^2)	Cs (mg/kg)	SA (cm^2)	Cs (mg/kg)	SA (cm^2)	Cs (mg/kg)	SA (cm^2)	Cs (mg/kg)	SA (cm^2)	Cs (mg/kg)	SA (cm^2)
1	7.51	1.24×10^3	6.39	3.42×10^3	0.01	3.42×10^3	2.64	2.61×10^3	10.62	3.42×10^3	14.54	2.35×10^3	11.22	3.42×10^3	52.94	16.45×10^3
2	4.21	1.20×10^3	0.99	3.22×10^3	0.01	3.22×10^3	2.15	2.41×10^3	3.422	3.17×10^3	4.68	2.21×10^3	2.17	3.22×10^3	17.63	15.43×10^3
3	13.76	1.16×10^3	6.33	3.04×10^3	0.25	3.04×10^3	11.33	2.25×10^3	276.87	2.96×10^3	163.28	2.07×10^3	7.29	3.04×10^3	479.11	14.52×10^3
4	11.23	1.18×10^3	1.03	3.01×10^3	0.01	3.01×10^3	66.90	2.24×10^3	111.95	2.98×10^3	93.93	2.00×10^3	5.73	3.01×10^3	290.77	14.42×10^3
5	1.87	1.25×10^3	1.40	3.30×10^3	0.01	3.30×10^3	10.54	2.51×10^3	45.34	3.34×10^3	34.33	2.20×10^3	0.88	3.30×10^3	94.37	15.90×10^3
6	6.86	1.28×10^3	5.30	3.59×10^3	0.01	3.59×10^3	3.37	2.78×10^3	7.67	3.64×10^3	5.41	2.47×10^3	2.57	3.59×10^3	31.18	17.35×10^3
7	19.88	1.30×10^3	25.91	3.53×10^3	3.70	3.53×10^3	22.73	2.75×10^3	112.56	3.65×10^3	825.82	2.36×10^3	16.36	3.53×10^3	1,026.96	17.14×10^3
8	30.69	1.21×10^3	10.27	3.27×10^3	3.34	3.27×10^3	35.57	2.47×10^3	178.80	3.24×10^3	797.99	2.24×10^3	7.49	3.27×10^3	1,064.14	15.70×10^3
9	14.43	1.19×10^3	11.63	3.26×10^3	1.10	3.26×10^3	25.52	2.45×10^3	469.90	3.20×10^3	345.18	2.26×10^3	9.73	3.26×10^3	877.49	15.62×10^3
10	16.52	1.21×10^3	27.53	2.97×10^3	0.92	2.97×10^3	545.94	2.21×10^3	105.83	29752.0666	177.24	1.92×10^3	13.90	2.97×10^3	887.88	14.25×10^3
11	28.08	1.15×10^3	37.91	2.81×10^3	3.80	2.81×10^3	50.34	2.05×10^3	233.01	2.75×10^3	496.55	1.84×10^3	36.73	2.81×10^3	886.42	13.43×10^3
12	44.04	1.12×10^3	28.88	2.77×10^3	2.60	2.77×10^3	47.23	2.41×10^3	138.16	3.06×10^3	117.48	2.25×10^3	29.70	2.77×10^3	408.08	14.37×10^3

Table 4.13 Value of concentration and surface area on seven parts of each person for absorbed dose per event calculation (Continued)

No. farmers	Head		Chest on clothes		Chest under clothes		Arm		Upper leg		Lower leg		Back		Whole body	
	Cs (mg/kg)	SA (cm^2)	Cs (mg/kg)	SA (cm^2)	Cs (mg/kg)	SA (cm^2)	Cs (mg/kg)	SA (cm^2)	Cs (mg/kg)	SA (cm^2)	Cs (mg/kg)	SA (cm^2)	Cs (mg/kg)	SA (cm^2)	Cs (mg/kg)	SA (cm^2)
13	33.05	1.28×10^3	87.90	3.51×10^3	0.01	3.51×10^3	45.10	2.71×10^3	225.52	3.57×10^3	1088.13	2.39×10^3	236.66	3.51×10^3	1,716.37	16.97×10^3
14	10.65	1.24×10^3	102.88	3.39×10^3	4.42	3.39×10^3	24.28	2.59×10^3	295.32	3.41×10^3	302.26	2.32×10^3	9.69	3.39×10^3	749.49	16.35×10^3
15	23.05	1.09×10^3	57.35	2.66×10^3	1.54	2.66×10^3	54.92	2.18×10^3	352.56	2.82×10^3	299.65	1.96×10^3	15.38	2.66×10^3	804.45	13.36×10^3
16	19.93	1.08×10^3	642.53	2.64×10^3	4.43	2.64×10^3	248.52	2.19×10^3	351.15	2.80×10^3	355.82	1.97×10^3	13.38	2.64×10^3	1,635.78	13.33×10^3
17	12.70	1.23×10^3	73.62	3.21×10^3	3.96	3.21×10^3	191.82	2.42×10^3	381.97	3.22×10^3	374.69	2.13×10^3	6.43	3.21×10^3	1045.20	15.42×10^3
18	12.48	1.18×10^3	175.40	3.04×10^3	1.50	3.04×10^3	72.97	2.26×10^3	276.29	3.00×10^3	256.93	2.04×10^3	13.61	3.04×10^3	809.20	14.56×10^3
19	3.67	1.20×10^3	1.96	3.10×10^3	0.01	3.10×10^3	2.03	2.32×10^3	2.02	3.08×10^3	3.41	2.06×10^3	2.48	3.10×10^3	15.59	14.86×10^3
20	16.26	1.10×10^3	936.52	2.76×10^3	12.37	2.76×10^3	196.35	2.26×10^3	98.92	3.02×10^3	338.11	2.09×10^3	17.60	2.76×10^3	1,616.13	14.00×10^3
21	3.38	1.11×10^3	1.547	2.81×10^3	0.01	2.81×10^3	3.22	2.25×10^3	1.74	3.13×10^3	2.03	2.10×10^3	1.21	2.81×10^3	13.14	14.22×10^3
22	23.07	1.08×10^3	15.35	2.64×10^3	2.69	2.64×10^3	22.12	2.18×10^3	30.36	2.80×10^3	286.20	2.00×10^3	12.88	2.64×10^3	392.68	13.30×10^3
23	2.17	1.32×10^3	0.94	3.75×10^3	0.01	3.75×10^3	2.30	2.95×10^3	2.79	3.86×10^3	2.19	2.57×10^3	1.42	3.75×10^3	11.82	18.20×10^3
24	3.77	1.12×10^3	3.20	2.87×10^3	0.01	2.87×10^3	2.44	2.30×10^3	3.39	3.25×10^3	2.81	2.17×10^3	3.08	2.87×10^3	18.71	14.56×10^3
25	16.34	1.10×10^3	7.69	2.75×10^3	1.01	2.75×10^3	28.11	2.22×10^3	38.25	3.00×10^3	15.45	2.04×10^3	17.92	2.75×10^3	124.77	13.85×10^3
26	11.76	1.20×10^3	21.71	3.30×10^3	2.91	3.30×10^3	20.51	2.48×10^3	51.78	3.23×10^3	224.27	2.31×10^3	22.27	3.30×10^3	355.21	15.80×10^3

Table 4.13 Value of concentration and surface area on seven parts of each person for absorbed dose per event calculation (Continued)

No. farmers	Head		Chest on clothes		Chest under clothes		Arm		Upper leg		Lower leg		Back		Whole body	
	Cs (mg/kg)	SA (cm^2)	Cs (mg/kg)	SA (cm^2)	Cs (mg/kg)	SA (cm^2)	Cs (mg/kg)	SA (cm^2)	Cs (mg/kg)	SA (cm^2)	Cs (mg/kg)	SA (cm^2)	Cs (mg/kg)	SA (cm^2)	Cs (mg/kg)	SA (cm^2)
27	17.50	1.20 x 10^3	31.34	3.11 x 10^3	2.40	3.11 x 10^3	19.73	2.33 x 10^3	38.98	3.08 x 10^3	200.40	2.10 x 10^3	15.73	3.11 x 10^3	326.08	14.92 x 10^3
28	19.24	1.20 x 10^3	14.96	3.22 x 10^3	3.31	3.22 x 10^3	15.55	2.41 x 10^3	30.92	3.17 x 10^3	1.67	2.21 x 10^3	9.29	3.22 x 10^3	94.94	15.43 x 10^3
29	16.04	1.15 x 10^3	32.68	3.06 x 10^3	4.72	3.06 x 10^3	17.83	2.26 x 10^3	39.41	3.00 x 10^3	81.58	2.11 x 10^3	28.19	3.06 x 10^3	220.45	14.60 x 10^3
30	11.62	1.12 x 10^3	13.56	2.89 x 10^3	5.33	2.89 x 10^3	16.81	2.34 x 10^3	68.68	3.30 x 10^3	117.72	2.22 x 10^3	16.65	2.89 x 10^3	250.37	14.77 x 10^3
31	15.88	1.10 x 10^3	11.56	2.76 x 10^3	2.05	2.76 x 10^3	20.41	2.21 x 10^3	59.30	3.02 x 10^3	37.26	2.03 x 10^3	26.54	2.76 x 10^3	173.00	13.87 x 10^3
32	1.83	1.06 x 10^3	5.31	2.53 x 10^3	0.27	2.53 x 10^3	2.29	2.01 x 10^3	2.33	2.56 x 10^3	2.98	1.74 x 10^3	1.814	2.53 x 10^3	16.83	12.43 x 10^3
33	5.27	1.11 x 10^3	3.07	2.74 x 10^3	0.79	2.74 x 10^3	21.10	2.35 x 10^3	11.59	3.00 x 10^3	24.78	2.17 x 10^3	15.48	2.74 x 10^3	82.07	14.10 x 10^3
34	12.35	1.10 x 10^3	276.88	2.75 x 10^3	8.82	2.75 x 10^3	156.80	2.24 x 10^3	115.00	3.01 x 10^3	677.47	2.06 x 10^3	63.04	2.75 x 10^3	1310.33	13.92 x 10^3
35	13.41	1.09 x 10^3	20.86	2.72 x 10^3	2.77	2.72 x 10^3	7.01	2.19 x 10^3	83.09	2.95 x 10^3	27.19	2.00 x 10^3	9.87	2.72 x 10^3	164.20	13.68 x 10^3

Table 4.14 Value of absorbed dose per event on seven parts of each person for average daily dose (ADD) equation (body contact)

No. farmer	Absorbed dose per event (mg/cm^2-event)							
	Head	Chest on clothes	Chest under clothes	Arm	Upper leg	Lower leg	Back	Whole body
1	1,813.93 x 10^{-7}	561.72 x 10^{-7}	0.88 x 10^{-7}	304.21 x 10^{-7}	931.28 x 10^{-7}	1,859.56 x 10^{-7}	985.37 x 10^{-7}	965.59 x 10^{-7}
2	1,055.60 x 10^{-7}	92.32 x 10^{-7}	0.93 x 10^{-7}	266.68 x 10^{-7}	323.66 x 10^{-7}	634.44 x 10^{-7}	202.40 x 10^{-7}	342.68 x 10^{-7}
3	3,548.54 x 10^{-7}	624.79 x 10^{-7}	24.41 x 10^{-7}	1,512.85 x 10^{-7}	28,045.52 x 10^{-7}	23,672.51 x 10^{-7}	719.63 x 10^{-7}	9,900.28 x 10^{-7}
4	2,844.59 x 10^{-7}	102.72 x 10^{-7}	1.00 x 10^{-7}	8,978.53 x 10^{-7}	11,289.69 x 10^{-7}	14,073.25 x 10^{-7}	570.98 x 10^{-7}	6,049.25 x 10^{-7}
5	448.57 x 10^{-7}	127.21 x 10^{-7}	0.91 x 10^{-7}	1,258.62 x 10^{-7}	4,077.21 x 10^{-7}	4,682.71 x 10^{-7}	79.72 x 10^{-7}	1,780.96 x 10^{-7}
6	1,609.87 x 10^{-7}	442.403 x 10^{-7}	0.84 x 10^{-7}	363.31 x 10^{-7}	632.08 x 10^{-7}	656.00 x 10^{-7}	214.73 x 10^{-7}	538.99 x 10^{-7}
7	4,575.25 x 10^{-7}	2,196.48 x 10^{-7}	313.64 x 10^{-7}	2,479.53 x 10^{-7}	9,264.22 x 10^{-7}	104,822.80 x 10^{-7}	1,386.61 x 10^{-7}	17,975.36 x 10^{-7}
8	7,606.87 x 10^{-7}	942.43 x 10^{-7}	306.26 x 10^{-7}	4,327.63 x 10^{-7}	16,562.99 x 10^{-7}	106,726.83 x 10^{-7}	686.94 x 10^{-7}	20,336.76 x 10^{-7}
9	3,626.69 x 10^{-7}	1,071.17 x 10^{-7}	101.05 x 10^{-7}	3,129.55 x 10^{-7}	44,077.38 x 10^{-7}	45,774.21 x 10^{-7}	895.83 x 10^{-7}	16,855.96 x 10^{-7}
10	4,111.27 x 10^{-7}	2,781.88 x 10^{-7}	92.94 x 10^{-7}	74,098.29 x 10^{-7}	10,670.74 x 10^{-7}	27,712.29 x 10^{-7}	1,404.38 x 10^{-7}	18,694.84 x 10^{-7}
11	7,317.50 x 10^{-7}	4,042.96 x 10^{-7}	405.00 x 10^{-7}	7,351.03 x 10^{-7}	25,384.53 x 10^{-7}	80,921.69 x 10^{-7}	3,917.15 x 10^{-7}	19,806.05 x 10^{-7}
12	11,821.29 x 10^{-7}	3,130.94 x 10^{-7}	281.93 x 10^{-7}	5,881.50 x 10^{-7}	13,540.66 x 10^{-7}	15,648.95 x 10^{-7}	3,219.98 x 10^{-7}	8,517.08 x 10^{-7}
13	7,774.68 x 10^{-7}	7,504.52 x 10^{-7}	0.85 x 10^{-7}	4,990.31 x 10^{-7}	18,960.83 x 10^{-7}	136,491.72 x 10^{-7}	20,206.19 x 10^{-7}	30,335.66 x 10^{-7}
14	2,570.00 x 10^{-7}	9,092.07 x 10^{-7}	390.27 x 10^{-7}	2,812.33 x 10^{-7}	26,013.75 x 10^{-7}	39,101.93 x 10^{-7}	856.16 x 10^{-7}	13,754.28 x 10^{-7}
15	6,373.02 x 10^{-7}	6,474.46 x 10^{-7}	173.92 x 10^{-7}	7,557.14 x 10^{-7}	37,479.50 x 10^{-7}	45,860.73 x 10^{-7}	1,736.70 x 10^{-7}	18,060.90 x 10^{-7}
16	5,511.92 x 10^{-7}	72,879.11 x 10^{-7}	503.04 x 10^{-7}	34,019.72 x 10^{-7}	37,629.97 x 10^{-7}	54,257.89 x 10^{-7}	1,517.88 x 10^{-7}	36,805.12 x 10^{-7}
17	3,094.24 x 10^{-7}	6,888.56 x 10^{-7}	370.61 x 10^{-7}	23,746.39 x 10^{-7}	35,551.89 x 10^{-7}	52,758.46 x 10^{-7}	601.86 x 10^{-7}	20,333.23 x 10^{-7}

Table 4.14 Value of absorbed dose per event on seven parts of each person for average daily dose (ADD) equation (body contact) (Continued)

No. farmer	Absorbed dose per event (mg/cm^2-event)							
	Head	Chest on clothes	Chest under clothes	Arm	Upper leg	Lower leg	Back	Whole body
18	3,169.09 x 10^{-7}	17,297.76 x 10^{-7}	147.78 x 10^{-7}	9,690.87 x 10^{-7}	27,663.17 x 10^{-7}	37,795.12 x 10^{-7}	1,342.51 x 10^{-7}	16,672.34 x 10^{-7}
19	914.89 x 10^{-7}	189.84 x 10^{-7}	0.97 x 10^{-7}	263.01 x 10^{-7}	196.75 x 10^{-7}	496.72 x 10^{-7}	240.33 x 10^{-7}	314.72 x 10^{-7}
20	4,421.25 x 10^{-7}	10,190.29 x 10^{-7}	1,346.32 x 10^{-7}	26,021.36 x 10^{-7}	9,811.96 x 10^{-7}	48,555.11 x 10^{-7}	1,914.52 x 10^{-7}	34,644.59 x 10^{-7}
21	915.22 x 10^{-7}	165.03 x 10^{-7}	1.07 x 10^{-7}	429.24 x 10^{-7}	166.28 x 10^{-7}	290.08 x 10^{-7}	129.12 x 10^{-7}	277.22 x 10^{-7}
22	6,385.84 x 10^{-7}	1,743.24 x 10^{-7}	305.34 x 10^{-7}	3,041.86 x 10^{-7}	3,261.38 x 10^{-7}	43,905.97 x 10^{-7}	1,462.85 x 10^{-7}	8,858.86 x 10^{-7}
23	492.92 x 10^{-7}	75.32 x 10^{-7}	0.80 x 10^{-7}	234.54 x 10^{-7}	216.48 x 10^{-7}	255.25 x 10^{-7}	113.90 x 10^{-7}	194.84 x 10^{-7}
24	1,011.12 x 10^{-7}	334.81 x 10^{-7}	1.05 x 10^{-7}	319.12 x 10^{-7}	313.43 x 10^{-7}	388.97 x 10^{-7}	322.85 x 10^{-7}	385.37 x 10^{-7}
25	4,464.04 x 10^{-7}	840.03 x 10^{-7}	110.71 x 10^{-7}	3,795.32 x 10^{-7}	3,829.87 x 10^{-7}	2,271.97 x 10^{-7}	1,958.19 x 10^{-7}	2,703.26 x 10^{-7}
26	2,961.64 x 10^{-7}	1,974.78 x 10^{-7}	264.89 x 10^{-7}	2,482.97 x 10^{-7}	4,815.36 x 10^{-7}	29,089.78 x 10^{-7}	2,026.14 x 10^{-7}	6,743.27 x 10^{-7}
27	4,395.16 x 10^{-7}	3,019.67 x 10^{-7}	231.13 x 10^{-7}	2,545.52 x 10^{-7}	3,798.37 x 10^{-7}	28,695.53 x 10^{-7}	1,515.38 x 10^{-7}	6,556.30 x 10^{-7}
28	4,825.29 x 10^{-7}	1,393.99 x 10^{-7}	308.60 x 10^{-7}	1,932.45 x 10^{-7}	2,925.76 x 10^{-7}	226.83 x 10^{-7}	865.43 x 10^{-7}	1,845.81 x 10^{-7}
29	4,173.47 x 10^{-7}	3,204.57 x 10^{-7}	463.30 x 10^{-7}	2,369.26 x 10^{-7}	3,994.41 x 10^{-7}	11,580.69 x 10^{-7}	2,764.11 x 10^{-7}	4,529.12 x 10^{-7}
30	3,103.40 x 10^{-7}	1,407.22 x 10^{-7}	553.53 x 10^{-7}	2,157.86 x 10^{-7}	6,239.96 x 10^{-7}	15,882.37 x 10^{-7}	1,728.12 x 10^{-7}	5,086.32 x 10^{-7}
31	4,337.94 x 10^{-7}	1,258.23 x 10^{-7}	223.26 x 10^{-7}	2,771.49 x 10^{-7}	5,898.27 x 10^{-7}	5,506.59 x 10^{-7}	2,889.11 x 10^{-7}	3,743.04 x 10^{-7}
32	518.89 x 10^{-7}	630.47 x 10^{-7}	32.20 x 10^{-7}	341.54 x 10^{-7}	272.75 x 10^{-7}	514.13 x 10^{-7}	215.22 x 10^{-7}	406.19 x 10^{-7}
33	1,426.07 x 10^{-7}	336.18 x 10^{-7}	86.33 x 10^{-7}	2,692.99 x 10^{-7}	1,162.19 x 10^{-7}	3,419.47 x 10^{-7}	1,697.56 x 10^{-7}	0.000174657
34	3,365.70 x 10^{-7}	30,191.95 x 10^{-7}	961.91 x 10^{-7}	20,971.17 x 10^{-7}	11,458.56 x 10^{-7}	98,457.86 x 10^{-7}	6,873.66 x 10^{-7}	0.002823838
35	3,680.42 x 10^{-7}	2,299.25 x 10^{-7}	305.61 x 10^{-7}	958.85 x 10^{-7}	8,455.98 x 10^{-7}	4,079.77 x 10^{-7}	1,087.82 x 10^{-7}	3,601.58 x 10^{-7}

Table 4.15 Value of factors of each person for average daily dose (ADD) equation (body contact)

No. farmer	Event frequency (EV) (events/day)	Exposure duration (ED) (years)	Exposure frequency (EF) (days/year)	Body weight (BW) (kg)	Averaging time (AT) (days)
1	3	7	56	65	2,555
2	3	6	112	58	2,190
3	2	9	24	53	3,285
4	4	8	70	55	2,920
5	3	12	56	65	4,380
6	3	16	42	71	5,840
7	4	18	16	74	6,570
8	3	12	100	60	4,380
9	2	10	84	58	3,650
10	3	20	36	57	7,300
11	4	6	56	50	2,190
12	3	9	70	53	3,285
13	1	10	12	70	3,650
14	2	10	32	65	3,650
15	1	7	42	50	2,555
16	4	11	56	49	4,015
17	2	19	60	62	6,935

Table 4.15 Value of factors of each person for average daily dose (ADD) equation (body contact) (Continued)

No. farmer	Event frequency (EV) (events/day)	Exposure duration (ED) (years)	Exposure frequency (EF) (days/year)	Body weight (BW) (kg)	Averaging time (AT) (days)
18	3	17	112	55	6,205
19	2	25	24	58	9,125
20	2	30	56	55	10,950
21	3	33	24	59	12,045
22	2	14	96	49	5,110
23	4	10	18	78	3,650
24	3	35	12	62	12,775
25	1	20	30	55	7,300
26	2	4	56	58	1,460
27	2	20	24	57	7,300
28	4	15	80	58	5,475
29	4	10	24	52	3,650
30	3	10	168	63	3,650
31	2	16	112	56	5,840
32	3	8	96	45	2,920
33	4	18	18	52	6,570
34	4	15	12	55	5,475
35	3	8	16	54	2,920

The average daily dose (ADD) of 35 rice-growing farmers was calculated from the equation 3-2, which presented in Chapter 3. The values of ADD on seven parts and whole body of each person were shown in Table 4.16 and bar chart of ADD values of whole body was shown in Figure 4.8.

Table 4.16 The average daily dose (ADD) on seven parts of 35 rice-growing farmers at Sisa Krabue sub-district, Ongkharak district, Nakhon Nayok Province was calculated from the ADD equation

No. farmer	ADD (mg/kg-day)							
	Head	Chest on clothes	Chest under clothes	Arm	Upper leg	Lower leg	Back	Whole body
1	159.55 x 10^{-5}	135.85 x 10^{-5}	0.21 x 10^{-5}	56.17 x 10^{-5}	225.59 x 10^{-5}	308.86 x 10^{-5}	238.31 x 10^{-5}	1,124.53 x 10^{-5}
2	200.44 x 10^{-5}	47.17 x 10^{-5}	0.48 x 10^{-5}	102.21 x 10^{-5}	162.85 x 10^{-5}	222.71 x 10^{-5}	103.40 x 10^{-5}	839.25 x 10^{-5}
3	102.46 x 10^{-5}	47.11 x 10^{-5}	1.84 x 10^{-5}	84.32 x 10^{-5}	2,060.98 x 10^{-5}	1,215.45 x 10^{-5}	54.26 x 10^{-5}	3,566.42 x 10^{-5}
4	469.74 x 10^{-5}	43.15 x 10^{-5}	0.42 x 10^{-5}	2798.94 x 10^{-5}	4,684.48 x 10^{-5}	3,930.13 x 10^{-5}	239.87 x 10^{-5}	12,166.74 x 10^{-5}
5	39.70 x 10^{-5}	29.72 x 10^{-5}	0.21 x 10^{-5}	223.93 x 10^{-5}	963.20 x 10^{-5}	729.33 x 10^{-5}	18.62 x 10^{-5}	2,004.71 x 10^{-5}
6	100.01 x 10^{-5}	77.25 x 10^{-5}	0.15 x 10^{-5}	49.11 x 10^{-5}	111.86 x 10^{-5}	78.93 x 10^{-5}	37.49 x 10^{-5}	454.79 x 10^{-5}
7	141.35 x 10^{-5}	184.17 x 10^{-5}	26.30 x 10^{-5}	161.56 x 10^{-5}	800.16 x 10^{-5}	5,870.35 x 10^{-5}	116.26 x 10^{-5}	7,300.15 x 10^{-5}
8	1,261.10 x 10^{-5}	422.18 x 10^{-5}	137.20 x 10^{-5}	1,461.75 x 10^{-5}	7,347.77 x 10^{-5}	32,794.24 x 10^{-5}	307.73 x 10^{-5}	43,731.96 x 10^{-5}
9	343.57 x 10^{-5}	276.98 x 10^{-5}	26.13 x 10^{-5}	607.59 x 10^{-5}	11,186.94 x 10^{-5}	8,217.86 x 10^{-5}	231.64 x 10^{-5}	20,890.71 x 10^{-5}
10	257.20 x 10^{-5}	428.79 x 10^{-5}	14.33 x 10^{-5}	8,502.04 x 10^{-5}	1,648.04 x 10^{-5}	2,760.24 x 10^{-5}	216.47 x 10^{-5}	13,827.09 x 10^{-5}
11	1,034.03 x 10^{-5}	1,395.96 x 10^{-5}	139.84 x 10^{-5}	1,853.57 x 10^{-5}	8,580.01 x 10^{-5}	18,283.84 x 10^{-5}	1,352.52 x 10^{-5}	32,639.77 x 10^{-5}
12	1,434.21 x 10^{-5}	940.52 x 10^{-5}	84.69 x 10^{-5}	1,538.04 x 10^{-5}	4,499.36 x 10^{-5}	3,825.81 x 10^{-5}	967.27 x 10^{-5}	13,289.90 x 10^{-5}
13	46.56 x 10^{-5}	123.85 x 10^{-5}	0.01 x 10^{-5}	63.55 x 10^{-5}	317.76 x 10^{-5}	1,533.18 x 10^{-5}	333.46 x 10^{-5}	2,418.37 x 10^{-5}
14	86.21 x 10^{-5}	832.54 x 10^{-5}	35.74 x 10^{-5}	196.52 x 10^{-5}	2,389.91 x 10^{-5}	2,446.13 x 10^{-5}	78.40 x 10^{-5}	6,065.44 x 10^{-5}
15	159.16 x 10^{-5}	395.96 x 10^{-5}	10.64 x 10^{-5}	379.16 x 10^{-5}	2,434.09 x 10^{-5}	2,068.79 x 10^{-5}	106.21 x 10^{-5}	5,554.01 x 10^{-5}
16	749.01 x 10^{-5}	24,142.19 x 10^{-5}	166.64 x 10^{-5}	9,337.73 x 10^{-5}	13,193.96 x 10^{-5}	13,369.36 x 10^{-5}	502.82 x 10^{-5}	61,461.70 x 10^{-5}
17	202.07 x 10^{-5}	1,171.14 x 10^{-5}	63.01 x 10^{-5}	3,051.51 x 10^{-5}	6,076.39 x 10^{-5}	5,960.63 x 10^{-5}	102.32 x 10^{-5}	16,627.07 x 10^{-5}

Table 4.16 The average daily dose (ADD) on seven parts of 35 rice-growing farmers at Sisa Krabue sub-district, Ongkharak district, Nakhon Nayok Province was calculated from the ADD equation (Continued)

No. farmers	ADD (mg/kg-day)							
	Head	Chest on clothes	Chest under clothes	Arm	Upper leg	Lower leg	Back	Whole body
18	626.87 x 10^{-5}	8,807.19 x 10^{-5}	75.24 x 10^{-5}	3,663.91 x 10^{-5}	13,873.24 x 10^{-5}	12,901.14 x 10^{-5}	683.54 x 10^{-5}	40,631.13 x 10^{-5}
19	24.99 x 10^{-5}	133.34 x 10^{-5}	0.07 x 10^{-5}	13.82 x 10^{-5}	13.75 x 10^{-5}	23.20 x 10^{-5}	16.88 x 10^{-5}	106.05 x 10^{-5}
20	272.12 x 10^{-5}	15,674.83 x 10^{-5}	20.71 x 10^{-5}	3,286.35 x 10^{-5}	1,655.67 x 10^{-5}	5,659.01 x 10^{-5}	294.49 x 10^{-5}	27,049.57 x 10^{-5}
21	33.89 x 10^{-5}	15.51 x 10^{-5}	0.10 x 10^{-5}	32.35 x 10^{-5}	17.41 x 10^{-5}	20.37 x 10^{-5}	12.14 x 10^{-5}	131.77 x 10^{-5}
22	742.92 x 10^{-5}	494.44 x 10^{-5}	86.60 x 10^{-5}	712.35 x 10^{-5}	977.86 x 10^{-5}	9,217.40 x 10^{-5}	414.91 x 10^{-5}	12,646.48 x 10^{-5}
23	16.44 x 10^{-5}	7.15 x 10^{-5}	0.08 x 10^{-5}	17.47 x 10^{-5}	21.14 x 10^{-5}	16.61 x 10^{-5}	10.81 x 10^{-5}	89.70 x 10^{-5}
24	17.97 x 10^{-5}	15.26 x 10^{-5}	0.05 x 10^{-5}	11.66 x 10^{-5}	16.19 x 10^{-5}	13.43 x 10^{-5}	14.72 x 10^{-5}	89.28 x 10^{-5}
25	73.25 x 10^{-5}	34.46 x 10^{-5}	4.54 x 10^{-5}	126.04 x 10^{-5}	171.49 x 10^{-5}	69.24 x 10^{-5}	80.33 x 10^{-5}	559.37 x 10^{-5}
26	186.64 x 10^{-5}	344.50 x 10^{-5}	46.21 x 10^{-5}	325.50 x 10^{-5}	821.82 x 10^{-5}	3,559.52 x 10^{-5}	353.46 x 10^{-5}	5,637.64 x 10^{-5}
27	121.16 x 10^{-5}	216.90 x 10^{-5}	16.60 x 10^{-5}	136.56 x 10^{-5}	269.81 x 10^{-5}	1,387.07 x 10^{-5}	108.85 x 10^{-5}	2,256.95 x 10^{-5}
28	872.62 x 10^{-5}	678.26 x 10^{-5}	150.15 x 10^{-5}	705.37 x 10^{-5}	1,402.00 x 10^{-5}	75.83 x 10^{-5}	421.08 x 10^{-5}	4,305.32 x 10^{-5}
29	243.37 x 10^{-5}	495.85 x 10^{-5}	71.69 x 10^{-5}	270.55 x 10^{-5}	597.97 x 10^{-5}	1,237.95 x 10^{-5}	427.70 x 10^{-5}	3,345.08 x 10^{-5}
30	764.01 x 10^{-5}	891.64 x 10^{-5}	350.72 x 10^{-5}	1,105.28 x 10^{-5}	4,515.79 x 10^{-5}	7,740.32 x 10^{-5}	1,094.96 x 10^{-5}	16,462.71 x 10^{-5}
31	521.93 x 10^{-5}	380.03 x 10^{-5}	67.43 x 10^{-5}	671.07 x 10^{-5}	1,949.55 x 10^{-5}	1,224.89 x 10^{-5}	872.61 x 10^{-5}	5,687.52 x 10^{-5}
32	96.02 x 10^{-5}	279.57 x 10^{-5}	14.28 x 10^{-5}	120.58 x 10^{-5}	122.63 x 10^{-5}	156.77 x 10^{-5}	95.43 x 10^{-5}	885.29 x 10^{-5}
33	60.00 x 10^{-5}	34.89 x 10^{-5}	8.96 x 10^{-5}	240.04 x 10^{-5}	131.93 x 10^{-5}	281.99 x 10^{-5}	176.17 x 10^{-5}	933.98 x 10^{-5}
34	88.57 x 10^{-5}	1,986.09 x 10^{-5}	63.28 x 10^{-5}	1,124.72 x 10^{-5}	824.81 x 10^{-5}	4,859.53 x 10^{-5}	452.16 x 10^{-5}	9,399.15 x 10^{-5}
35	97.96 x 10^{-5}	152.42 x 10^{-5}	20.26 x 10^{-5}	51.22 x 10^{-5}	607.06 x 10^{-5}	198.64 x 10^{-5}	72.11 x 10^{-5}	1,199.67 x 10^{-5}

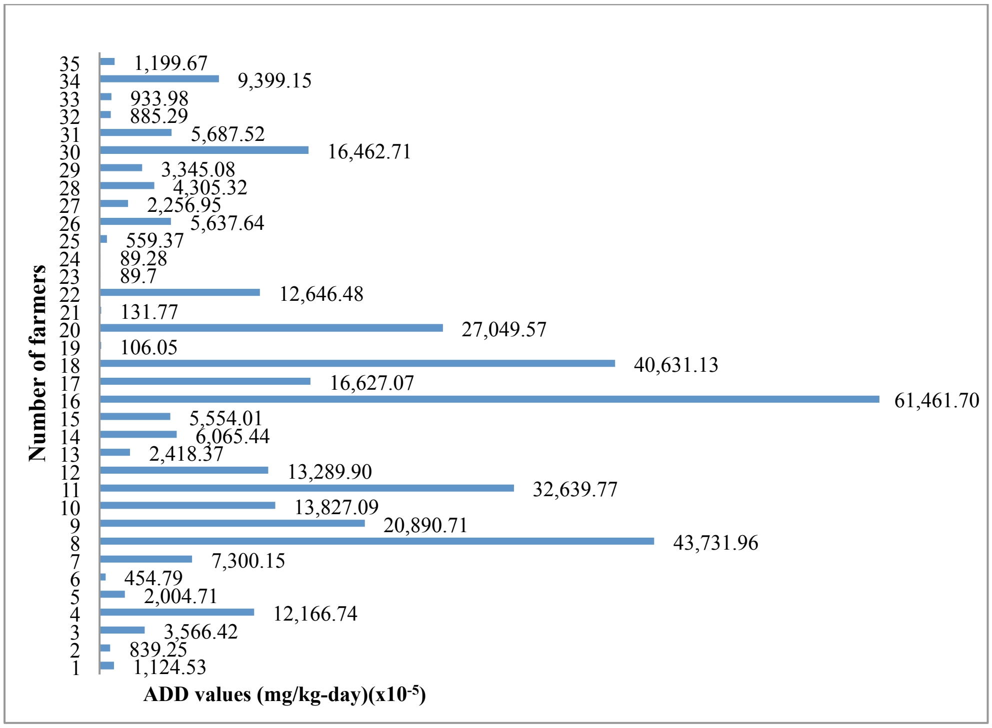


Figure 4.8 The bar chart of ADD of whole body of each person

4.4 Risk characterization

For non-carcinogenic risk characterization, Hazard Quotient (HQ), and Hazard Index (HI) were used to estimate the risk level. Both of them were calculated by the equation 3-4 in Chapter 3.

Hazard Quotient (HQ) value of seven parts and whole body (HI) of 35 rice-growing farmers was shown in Table 4.17. Most of HQ and HI values were greater than acceptable level (higher than 1) that meant rice-growing farmers in this area got risk from pesticide exposure via dermal pathway. Figure 4.9 was shown bar chart of HI values for 35 rice-growing farmers. The reason for this result might be using high amount of pesticide and their poor behavior such as using inappropriate of fabric facemask that made from their shirt, using sock or bare foot or bare hand.

Table 4.17 Hazard Quotient (HQ) on seven parts of 35 rice-growing farmers at Sisa Krabue sub-district, Ongkharak district, Nakhon Nayok Province

No. farmer	HQ							
	Head	Chest on clothes	Chest under clothes	Arm	Upper leg	Lower leg	Back	Whole body (HI)
1	1.06	0.91	0.00	0.37	1.50	2.06	1.59	7.50
2	1.34	0.31	0.00	0.68	1.09	1.48	0.69	5.60
3	0.68	0.31	0.01	0.56	13.74	8.10	0.36	23.78
4	3.13	0.29	0.00	18.66	31.23	26.20	1.60	81.11
5	0.26	0.20	0.00	1.49	6.42	4.86	0.12	13.36
6	0.67	0.51	0.00	0.33	0.75	0.53	0.25	3.03
7	0.94	1.23	0.18	1.08	5.33	39.14	0.78	48.67
8	8.41	2.81	0.91	9.75	48.99	218.63	2.05	291.55
9	2.29	1.85	0.17	4.05	74.58	54.79	1.54	139.27
10	1.71	2.86	0.10	56.68	10.99	18.40	1.44	92.18
11	6.89	9.31	0.93	12.36	57.20	121.89	9.02	217.60
12	9.56	6.27	0.56	10.25	30.00	25.51	6.45	88.60
13	0.31	0.83	0.00	0.42	2.12	10.22	2.22	16.12
14	0.57	5.55	0.24	1.31	15.93	16.31	0.52	40.44
15	1.06	2.64	0.07	2.53	16.23	13.80	0.71	37.03
16	5.00	160.95	1.11	62.25	87.96	89.13	3.35	409.74
17	1.35	7.81	0.42	20.34	40.51	39.74	0.68	110.85
18	4.18	58.718	0.50	24.43	92.49	86.01	4.56	270.87
19	0.17	0.09	0.00	0.09	0.09	0.15	0.11	0.71
20	1.81	104.50	1.38	21.91	11.04	37.73	1.96	180.33
21	0.23	0.10	0.00	0.22	0.12	0.14	0.08	0.88
22	4.95	3.30	0.58	4.75	6.52	61.45	2.77	84.31
23	0.11	0.05	0.00	0.12	0.14	0.11	0.07	0.60
24	0.12	0.10	0.00	0.08	0.11	0.09	0.10	0.60
25	0.49	0.23	0.03	0.84	1.14	0.46	0.54	3.73

Table 4.17 Hazard Quotient (HQ) on seven parts of 35 rice-growing farmers at Sisa Krabue sub-district, Ongkharak district, Nakhon Nayok Province (Continued)

No. farmer	HQ						
	Head	Chest on clothes	Chest under clothes	Arm	Upper leg	Lower leg	Back	Whole body (HI)
26	1.24	2.30	0.31	2.17	5.48	23.73	2.36	37.58
27	0.81	1.45	0.11	0.91	1.80	9.25	0.73	15.05
28	5.82	4.52	1.00	4.70	9.35	0.51	2.81	28.70
29	1.62	3.31	0.48	1.80	4.00	8.25	2.85	22.30
30	5.09	5.94	2.34	7.37	30.11	51.60	7.30	109.75
31	3.48	2.53	0.45	4.47	13.00	8.17	5.82	37.92
32	0.64	1.86	0.10	0.80	0.82	1.05	0.64	5.90
33	0.40	0.23	0.06	1.60	0.88	1.88	1.17	6.23
34	0.59	13.24	0.42	7.50	5.50	32.40	3.01	62.66
35	0.65	1.02	0.14	0.34	4.05	1.32	0.48	8.00

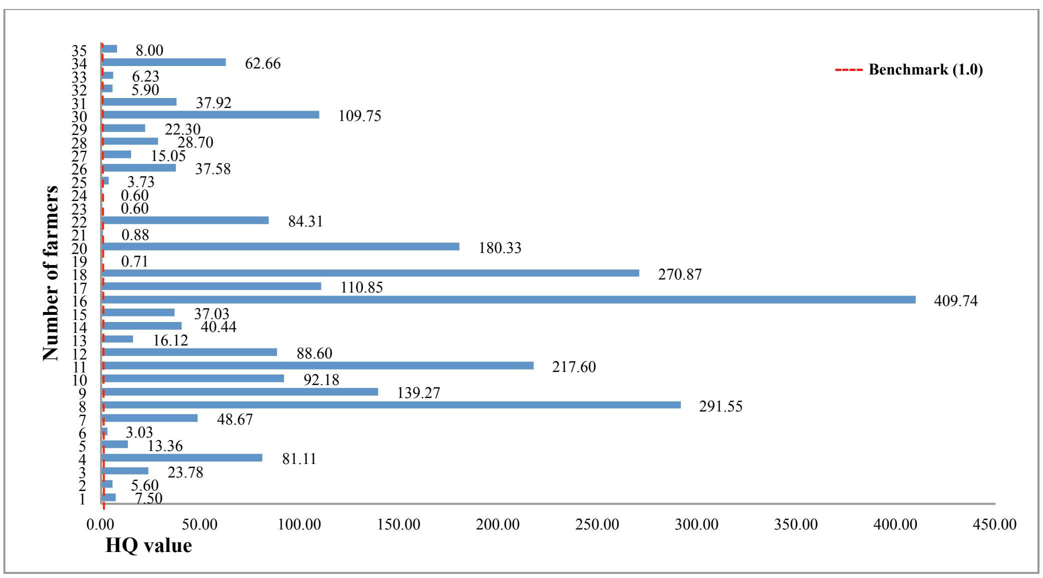


Figure 4.9 Hazard Quotient (HQ) of chlorpyrifos for 35 rice-growing farmers

The value of each factors at mean and 95th percentile level both of male and female for average daily dose (ADD) calculation were shown in Table 4.18-4.20.

Table 4.18 Value of factors in average daily dose (ADD) equation (body skin contact) for male rice-growing farmers at Sisa Krabue sub-district, Ongkharak district, Nakhon Nayok Province

Part of body	Absorbed dose per event (mg/cm^2-event)		Surface area (cm^2)	Event frequency (EV) (events/day)	Exposure duration (ED) (years)	Exposure frequency (EF) (days/year)	Body weight (BW) (kg)	Averaging time (AT) (days)
	mean	95^{th} percentile						
Head	35.03×10^{-5}	82.03×10^{-5}	1.20×10^{3}	2.86	12.57	52.10	60.90	4,588.57
Chest on clothes	30.27×10^{-5}	157.64×10^{-5}	3.20×10^{3}	2.86	12.57	52.10	60.90	4,588.57
Chest under clothes	1.62×10^{-5}	4.40×10^{-5}	3.20×10^{3}	2.86	12.57	52.10	60.90	4,588.57
Arm	70.79×10^{-5}	638.16×10^{-5}	2.40×10^{3}	2.86	12.57	52.10	60.90	4,588.57
Upper leg	129.51×10^{-5}	432.28×10^{-5}	3.20×10^{3}	2.86	12.57	52.10	60.90	4,588.57
Lower leg	356.78×10^{-5}	$1,448.05 \times 10^{-5}$	2.20×10^{3}	2.86	12.57	52.10	60.90	4,588.57
Back	20.53×10^{-5}	203.13×10^{-5}	3.20×10^{3}	2.86	12.57	52.10	60.90	4,588.57
Whole body	102.53×10^{-5}	478.41×10^{-5}	15.40×10^{3}	2.86	12.57	52.10	60.90	4,588.57

Table 4.19 Value of factors in average daily dose (ADD) equation (body skin contact) for female rice-growing farmers at Sisa Krabue sub-district, Ongkharak district, Nakhon Nayok Province

Part of body	Absorbed dose per event (mg/cm^2-event)		Surface area (cm^2)	Event frequency (EV) (events/day)	Exposure duration (ED) (years)	Exposure frequency (EF) (days/year)	Body weight (BW) (kg)	Averaging time (AT) (days)
	mean	95^{th} percentile						
Head	40.94×10^{-5}	120.11×10^{-5}	1.10×10^{3}	2.71	16.71	57.71	54.07	6,100.71
Chest on clothes	160.66×10^{-5}	$1,040.58 \times 10^{-5}$	2.70×10^{3}	2.71	16.71	57.71	54.07	6,100.71
Chest under clothes	3.54×10^{-5}	13.74×10^{-5}	2.70×10^{3}	2.71	16.71	57.71	54.07	6,100.71
Arm	80.58×10^{-5}	338.89×10^{-5}	2.20×10^{3}	2.71	16.71	57.71	54.07	6,100.71
Upper leg	96.75×10^{-5}	352.56×10^{-5}	3.00×10^{3}	2.71	16.71	57.71	54.07	6,100.71
Lower leg	235.20×10^{-5}	967.81×10^{-5}	2.10×10^{3}	2.71	16.71	57.71	54.07	6,100.71
Back	19.41×10^{-5}	70.04×10^{-5}	2.70×10^{3}	2.71	16.71	57.71	54.07	6,100.71
Whole body	108.86×10^{-5}	507.50×10^{-5}	13.80×10^{3}	2.71	16.71	57.71	54.07	6,100.71

Table 4.20 Value of factors in average daily dose (ADD) equation (body skin contact) for male and female rice-growing farmers at Sisa Krabue sub-district, Ongkharak district, Nakhon Nayok Province

Part of body	Absorbed dose per event (mg/cm^2-event)		Surface area (cm^2)	Event frequency (EV) (events/day)	Exposure duration (ED) (years)	Exposure frequency (EF) (days/year)	Body weight (BW) (kg)	Averaging time (AT) (days)
	mean	95^{th} percentile						
Head	36.28×10^{-5}	96.06×10^{-5}	1.20×10^{3}	2.79	14.64	54.91	57.49	5,344.64
Chest on clothes	88.44×10^{-5}	552.34×10^{-5}	3.00×10^{3}	2.79	14.64	54.91	57.49	5,344.64
Chest under clothes	2.46×10^{-5}	8.53×10^{-5}	3.00×10^{3}	2.79	14.64	54.91	57.49	5,344.64
Arm	75.47×10^{-5}	495.03×10^{-5}	2.30×10^{3}	2.79	14.64	54.91	57.49	5,344.64
Upper leg	113.66×10^{-5}	393.71×10^{-5}	3.10×10^{3}	2.79	14.64	54.91	57.49	5,344.64
Lower leg	290.65×10^{-5}	$1,185.93 \times 10^{-5}$	2.20×10^{3}	2.79	14.64	54.91	57.49	5,344.64
Back	19.69×10^{-5}	139.86×10^{-5}	3.00×10^{3}	2.79	14.64	54.91	57.49	5,344.64
Whole body	86.07×10^{-5}	391.26×10^{-5}	17.90×10^{3}	2.79	14.64	54.91	57.49	5,344.64

The average daily dose (ADD) at mean and 95th percentile level was calculated from ADD equation that shown in the equation 3-2 in Chapter 3. At mean and 95th percentile level, men's average daily dose (ADD) on lower leg was higher than female whereas ADD on chest on clothes of female was higher than male (Table 4.21 and Figure 4.10-4.11). For whole body, ADD value of female was higher than male because pesticide exposure duration of female was greater than male.

Table 4.21 The average daily dose (ADD) on seven parts of male and female rice-growing farmers at Sisa Krabue sub-district, Ongkharak district, Nakhon Nayok Province

Part of body	ADD (mg/kg-day)					
	Male		Female		Total male and female	
	mean	95th percentile	mean	95th percentile	mean	95th percentile
Head	28.18 x 10^{-4}	65.98 x 10^{-4}	35.68 x 10^{-4}	104.67 x 10^{-4}	31.72 x 10^{-4}	83.99 x 10^{-4}
Chest on clothes	64.92 x 10^{-4}	338.11 x 10^{-4}	343.66 x 10^{-4}	2,225.87 x 10^{-4}	193.32 x 10^{-4}	1,207.35 x 10^{-4}
Chest under clothes	3.48 x 10^{-4}	9.44 x 10^{-4}	7.57 x 10^{-4}	29.39 x 10^{-4}	5.38 x 10^{-4}	18.65 x 10^{-4}
Arm	113.87 x 10^{-4}	1,026.56 x 10^{-4}	140.45 x 10^{-4}	590.67 x 10^{-4}	190.48 x 10^{-4}	829.59 x 10^{-4}
Upper leg	277.78 x 10^{-4}	927.17 x 10^{-4}	229.95 x 10^{-4}	837.94 x 10^{-4}	170.47 x 10^{-4}	889.29 x 10^{-4}
Lower leg	526.10 x 10^{-4}	2,135.26 x 10^{-4}	391.31 x 10^{-4}	1,610.16 x 10^{-4}	465.91 x 10^{-4}	1,901.02 x 10^{-4}
Back	44.03 x 10^{-4}	435.68 x 10^{-4}	41.52 x 10^{-4}	149.82 x 10^{-4}	43.04 x 10^{-4}	305.72 x 10^{-4}
Whole body	1,058.36 x 10^{-4}	4,938.16 x 10^{-4}	1,190.14 x 10^{-4}	5,548.52 x 10^{-4}	1,122.56 x 10^{-4}	5,102.98 x 10^{-4}

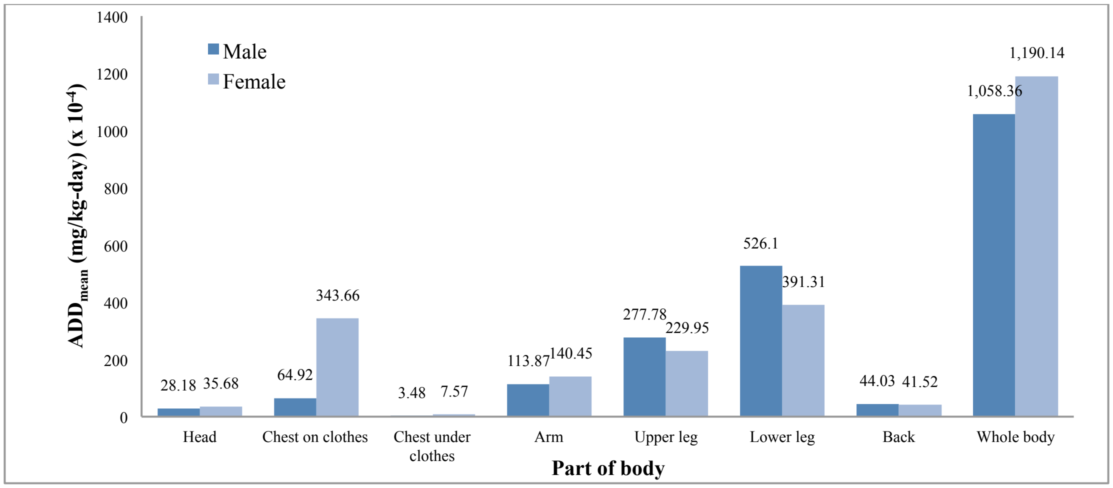


Figure 4.10 Average daily dose (ADD) at mean of male and female rice farmers

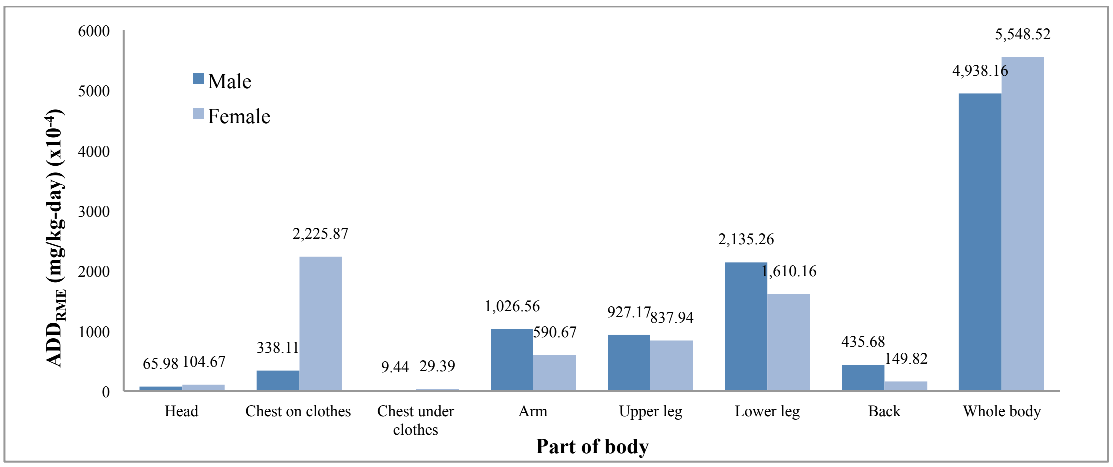


Figure 4.11 Average daily dose (ADD) at RME of male and female rice farmers

Hazard Quotient (HQ) of chlorpyrifos on seven positions of both male and female rice-growing farmers' body at mean was over the acceptable level (higher than 1) except chest under clothes area where was HQ value less than acceptable level. Therefore, rice farmers in this area got risk from pesticide exposure through dermal pathway. However, HQ value at mean on upper body of female was higher than male because the different size of body between male and female (Table 4.22 and Figure 4.12).

HQ at RME level was higher than the mean level. Moreover, HQ value at RME was also greater than the acceptable level (Table 4.22 and Figure 4.13). This can be interpreted that rice farmers in this area received risk from dermal exposure to chlorpyrifos. The reason for this situation was their deficient behavior for example mixing more than one pesticide and using overdose, washing working clothes with family clothes, having meal at farm area, and smoking during applying pesticide.

Table 4.22 Hazard Quotient (HQ) on seven parts of of male and female rice-growing farmers at Sisa Krabue sub-district, Ongkharak district, Nakhon Nayok Province

Part of body	HQ					
	Male		Female		Total male and female	
	mean	95th percentile	mean	95th percentile	mean	95th percentile
Head	1.88	4.40	2.38	6.98	2.11	5.60
Chest on clothes	4.33	22.54	22.91	148.39	12.89	80.49
Chest under clothes	0.23	0.63	0.50	1.96	0.36	1.24
Arm	7.59	68.44	9.36	39.38	12.70	55.31
Upper leg	18.52	61.81	15.33	55.86	11.36	59.29
Lower leg	35.07	142.35	26.09	107.34	31.06	126.73
Back	2.94	29.05	2.77	9.99	2.87	20.38
Whole body	70.56	329.22	79.34	369.90	74.84	340.20

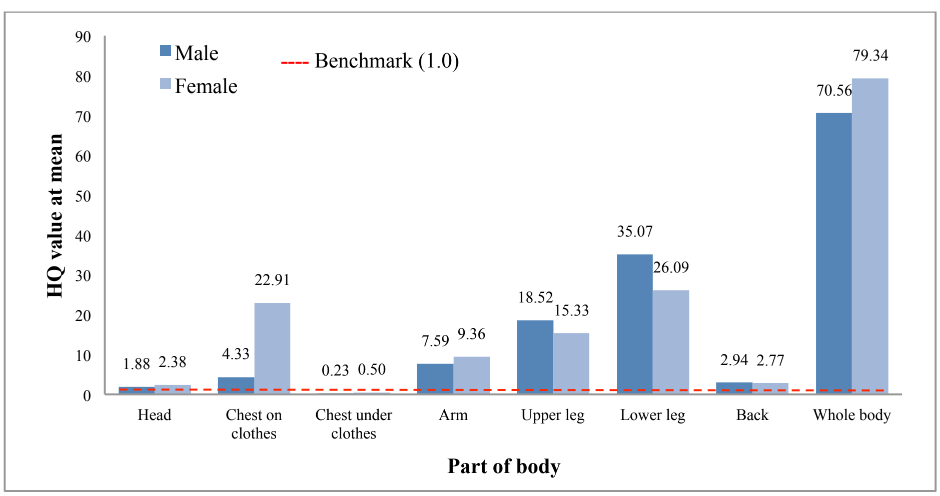


Figure 4.12 Hazard Quotient (HQ) at mean of male and female rice farmers

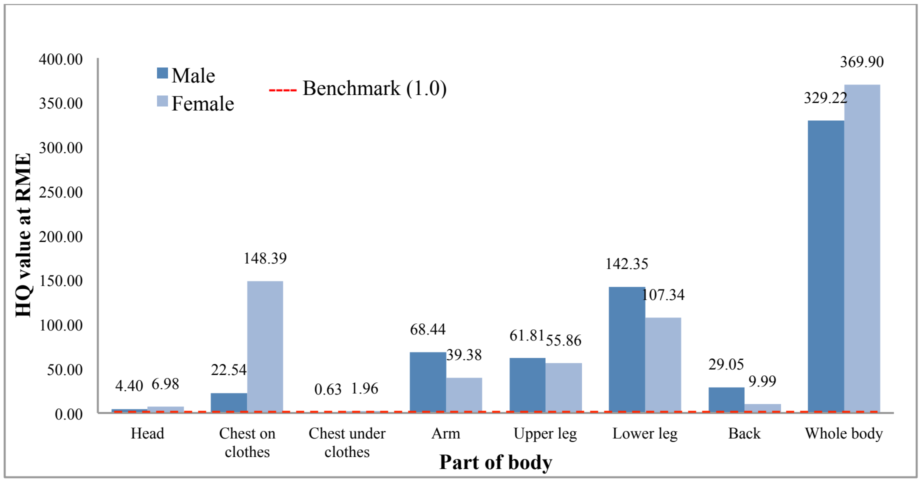


Figure 4.13 Hazard Quotient (HQ) at RME of male and female rice farmers

4.5 Safety management of organophosphate pesticide

The mainly purpose of risk management is to minimize or to prevent risks that concern with social, cultural, ethical, political, and legal considerations in order to improve community's health (Charnley, 1998; US EPA, 1997). Refer to the fluorescent tracer and gauze patch results that clearly revealed pesticide residues contaminated on rice-growing body although it did not make harm to their health through dermal contact.

However, this result can impel the participants to concern about the negative effect from pesticide application, hence, the appropriate safety management of pesticide application can reduce pesticide exposure to them.

4.5.1 Personal awareness

Working clothes for pesticide operators must be comfortable and safety protection them from pesticide such as long-sleeved upper garment and long- legged pants. According to the result showed that lower leg and chest on clothes were the highest surface area of pesticide contamination, therefore, they should pay attention to protect these areas by using PVC long apron. The long PVC apron was effective to prevent operators from pesticide during spraying and suitable for tropical zone like Thailand. The long PVC apron covered the front of body up to the neck and down to the lower legs, so it could cut down the risk to operators. Moreover, pesticide operators should not smoke, drink, or eat at the field site. When they finished work, they should clean their body and wash their clothes separately from other clothing.

4.5.2 Community consciousness

The local government should teach and provide the safety management of pesticide usage information to villager or create some activities such as women or household in village set a team to made pesticide from local herbs and motivate them to use it in their field. This would make them save cost and cut down risk from chemical pesticide.

4.5.3 Government agencies concern

The government should cut down to import the pesticide from foreign country and create some policy to protect agricultural workers from chemical pesticide or support them to use natural way to eliminate pest or weed. In addition, government should pay attention to the price of personal protective equipment for agricultural worker and examine or ban some kind of pesticides, which cause severely adverse health affect to agricultural workers.

CHAPTER V
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Dermal exposure to chlorpyrifos of rice-growing farmers in Sisa Krabue sub-district, Ongkharak district, Nakhon Nayok province, Thailand was studied in this research. This study selected patch technique and fluorescent tracer to measure and determine chlorpyrifos residues leftover on rice-growing farmers. The results were concluded as following.

1) All participants were rice-growing farmers who always used chemical pesticide that depended on symptoms of rice. They sprayed chlorpyrifos four or five times for one crop by using sprayer connected with motor tank. Moreover, they always used large amount of pesticide (exceed pesticide label) and mixed a different kind of pesticides together. All of them never have tested pesticide residues contaminated on their body before. In addition, they did not wear personal protective equipment such as rubber gloves or boots to protect them from chemical pesticide.

2) Fluorescent tracer was used to track pesticide residues on seven positions of rice-growing farmers body. Head, chest on clothes, arm, upper leg, lower leg, and back surface areas were mostly found fluorescent on these areas and chest under clothes was rarely found fluorescent on this area. According to percent frequency of fluorescent tracer, lower leg (97.14%) and upper leg (97.14%) were the highest part of chlorpyrifos contamination, whereas chest under clothes (45.71%) was the lowest part of chlorpyrifos leftover. Moreover, the largest number of fluorescent scoring was lower leg (72.38%) and the smallest number of fluorescent scoring was chest under clothes (19.05%) that was similar to percent frequency of fluorescent tracer.

3) Body surface areas of rice-growing farmers in this study was calculated separately into seven parts of body; head, chest, arm, upper leg, lower leg, and back. Some part of body surface areas like head, chest, and back were close to US EPA default

values. The values of seven parts body surface area of male were 0.12, 0.32, 0.24, 0.32, 0.22, and 0.32 m^2 and female were 0.11, 0.27, 0.22, 0.30, 0.21,and 0.27 m^2, respectively.

4) The concentration of chlorpyrifos on seven parts of body between male and female farmers' body was not significantly difference (Mann-Whitney U test; $p > 0.05$).

5) The association between concentration of chlorpyrifos residues and fluorescent tracer scoring on seven parts of rice farmers' body was correlated because correlation coefficient was close to 1 (Spearman rho).

6) The average daily dose (ADD) at mean level of male and female rice-growing farmers (on head, chest on clothes, chest under clothes, arm, upper leg, lower leg, back, and whole body) were 31.72×10^{-4}, 193.32×10^{-4}, 5.38×10^{-4}, 190.48×10^{-4}, 170.47×10^{-4}, 465.91×10^{-4}, 43.04×10^{-4}, $1{,}122.56 \times 10^{-4}$ mg/kg-day, respectively.

7) Hazard Quotient (HQ) at mean and RME on seven positions and whole body of both male and female rice-growing farmers in this area were exceed than the acceptable level 1.0. This could be concluded that they got adverse health effect from chlorpyrifos exposure to dermal pathway.

8) The suitable of safety risk management should be provided in this area to protect rice-growing farmers to get risk from pesticide through dermal exposure for example wearing PVC long apron that could cover upper body and lower body, using appropriate facemask, wearing gloves and boots, using the amount of pesticide following the instruction.

5.2 Recommendations

1) This study focused on chlorpyrifos. It was mostly used in the group of organophosphate pesticide. Therefore, this research studied only chlorpyrifos. The further study should study more on other groups of pesticides or another types of pesticides in organophosphate group.

2) This research investigated organophosphate pesticide through skin exposure by patch technique after they finished their work practices in the field. The further study should look into other routes of exposure such as inhalation route and oral route.

Moreover, the next study should find different way to determine pesticide residues deposit on skin except patch technique for example body garment or pesticide removal.

3 This study mainly paid attention to rice-growing farmers who sprayed pesticide in the field but we did not concentrate on local people who lived near the field. The further investigation should survey susceptible group or people who had house near the field.

4. This study largely attended to spray pesticide but we did not focus on loading and mixing pesticide. Moreover, we mainly studied pesticide application in the field. The next study should research other behaviors of pesticide using and change the study site such as household.

5. Inhalation exposure should be assessed because the participants reported on signs and symptoms (headache, blurred vision) that concerned with pesticide exposure.

5.3 Research outcomes

1) The concentrations of chlorpyrifos residues on farmers' body were evaluated.

2) Major route of farmer exposure, dermal route in rice farmers would be assessed.

3) Harmful human health risks of local people who applied pesticides, was minimized.

4) This information was the good agricultural practices for rice farmers to manage utilizing and prevent themselves from organophosphate pesticide application.

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APPENDICES

Appendix A
Questionnaire (English)

Pesticides exposure via dermal route of rice-growing farmers questionnaire

Interviewer name ______________________________ **Number __________**

Date _____/______/_____

Center of Excellence for

Environmental and Hazardous Waste Management

Chulalongkorn University

Questionnaire the pesticide application of rice-growing farmers at Sisa Krabue sub-district, Ongkharak district, Nakhon Nayok province, Thailand

Please answer the question and/or mark ✓ in the blank

PART 1: GENERAL INFORMATION

1.Code of participant _______________

2. Age_______________years

3.Gender ( ) Male ( ) Female

4. Status ( ) Single ( ) Marriage ( ) Widow ( ) Divorce

5. The highest education level

( ) Iliteracy ( ) Elementary School ( ) Junior Highschool

( ) High School ( ) Diploma ( ) Bachelor's Degree

6. How many years do you apply pesticide in your paddy field______________ years

7. How many times do you apply pesticide for one day ________________times/day

8. How long do you work in paddy field for one day ______________hours/day

9. In one week, how many days do you work in paddy field ______________ days/week

10. How many members in your family are farmers (including the interviewee)__________person (s)

11. Nowadays, what methods do you use to kill pest in field (choose more than one choices)

( ) Apply pesticide by yourself ( ) Hire someone to apply pesticide ( ) Invite relative to help

12. In last year, how many farm areas do you apply pesticide (including you or not) ___________rais

13. Do you do organic culture (not use pesticide)

( ) Yes ( ) No

14. Do you grow other crops except rice

( ) No ( ) Yes____

And do you apply pesticide with them

( ) Yes ( ) No

PART 2: GENERAL HEALTH INFORMATION

1. Weight_________________kilograms

2. Height______________________centimeters

3. In last year, do you have any signs or symptoms follow this table

Signs and symptoms	Never	Almost never	During pesticide exposure	Shortly affter pesticide application	When not apply pesticide
Headache					
Nausea/Vomitting					
Abdomen cramp					
Blurred vision					
Tearing					
Dizziness					
Numbness or pins and needles in your hands and feet					
Arms and legs weakness					
Involuntary twitches or jerks in your arms or legs					
Chest tightness					
Difficult breathing					

4. Do you know what causes of these following symptoms ( ) Yes ( ) No

5. Do you feel abnormal after inhale or touch pesticide

( ) Yes ( ) No

6. When you feel abnormal after inhale or touch pesticide, do you know the name of pesticide

( ) Yes ( ) No

PART 3: PESTICIDE APPLICATION AND WORK PRACTICES

1. In generally, how do you mix pesticide (Please choose one choice)

( ) Follow the bottle label

( ) Mix more than instruction

( ) Follow the neighbourhoods' suggestion

( ) Mix more than one type of pesticide

2. What method do you spray pesticide (Choose more than one choice)

( ) Not spray pesticide

( ) Sprayer with tractor

( ) Hand spray gun

( ) Backpack sprayer

( ) Mist blower

Or other sprayer equipments ____

When you spray ( ) spray in furrow ( ) banded

3. Nowadays, how do you apply pesticide (Please choose one choice)

( ) Spray by yourself (one person)

( ) Make a team to spray (4-5 persons)

( ) Hire someone to spray

4. Who would you listen to when you decide to purchase pesticide (Choose more than one choices)

( ) Neighbourhood ( ) Advertisment

( ) Agricultural officer ( ) Sales representative

( ) Shopkeeper's advice

5. How do you mix pesticide (Choose more than one choices)

( ) Wearing rubber gloves and using stirring stick

( ) Wearing fabric gloves and using stirring stick

( ) Using hand and using stirring stick

( ) Using hand only

6. When do you spray pesticide

( ) Early morning

( ) At noon

( ) Evening

( ) Up to sprayer ____

7. Which personal protective equipments do you usually use when you mix pesticide (Choose more than one choices)

( ) None ( ) Chemical gloves

( ) Chemical protective mask ( ) Goggle or glasses

( ) Dust protective mask ( ) Fabric gloves

( ) Normal face mask ( ) Rubber boots

( ) Hat ( ) Apron ( ) fabric ( ) plastic

( ) Clothes coverall ( ) Other please describe briefly____________________

8. Mostly, which part of your body contact pesticide when you mix and spray pesticide (Choose more than one choices)

( ) None ( ) Face

( ) Hands and arms ( ) Body

9. What kind of outfit do you wear when you apply pesticide (Please choose one choice)

( ) Short sleeved t-shirt and short pants ( ) Vest and long pants

( ) Long sleeved t-shirt and long pants ( ) Vest and short pants

( ) Long sleeved shirt and short pants ( ) Long sleeved shirt and long pants

10. If you spill some pesticide on your clothes and body in early morning, when do you change clothes and clean your body (Please choose one choice)

( ) Take a bath and change clothes immediately

( ) Take a bath and change clothes after finish work

( ) Take a bath and change clothes at noon

( ) Take a bath and change clothes the end of day

11. After you mix and spray pesticide, how do you clean your body (Please choose one choice)

( ) Wash hands and arms immediately ( ) Wash hands and arms before lunch

( ) Take a bath immediately ( ) Take a bath at noon

( ) Wash hands and arms in evening ( ) Take a bath after finish work

( ) Other please describe briefly ____

12. Which products do you use to clean body after touching and mixing pesticide (Choose more than one choices)

( ) Only water ( ) Detergent

( ) Soap ( ) Dishwashing

13. How do you do with your clothes after you apply pesticide (Please choose one choice)

( ) Change new clothes immediately

( ) Change new clothes before lunch

( ) Change new clothes after the end of day

14. How often do you clean your clothes after that clothes contact with pesticide (Please choose one choice)

( ) Wash it immediately ( ) Keep it and wear it again whole week

( ) Keep it and wear it again whole month ( ) Keep it and wear it again on next day

15. What is the method in disposing pesticide container (Choose more than one choices)

( ) Disposing on the ground

( ) Keep to dispose in your landfill

( ) Disposing in the hole

( ) Disposing in nature water source

( ) Disposing in garbage

( ) Incinerating

16. Where is the source of water used

( ) Water from paddy field channel

( ) Deep well

( ) Tap water

( ) Water from cannel

17. Do you have lunch in paddy field

( ) Mostly ( ) Sometime

( ) Often ( ) Never

18. Do you smoke cigarette or tobacco

( ) Yes ____________________cigarettes/day

( ) Never

( ) Stop smoking

19. Do you smoke cigarette or tobacco during pesticide application

( ) Mostly

( ) Sometime

( ) Often

( ) Never

20. Mostly, which pesticide do you use in your field (Can choose more than one choices)

Type of pesticide	Duration (year)	An average of pesticide application in one year
( ) Abamectin (Ammet)		
( ) Chlopyrifos (predator, chlopyrifos 40%, merchaindise)		
( ) Profenofos		
( ) Carbamet		
( ) Other please describe briefly ______________________________		

And what reason do you choose that pesticide (Can choose more than one choices)

( ) Cheap

( ) Easy to purchase

( ) Neighbours' advice

( ) Short time to kill pest

Adapt from : Japieam ,2008 and Un Mei Pan, 2009.

Appendix B
Questionnaire (Thai)

แบบสอบถามเรื่องการสัมผัสสารกำจัดศัตรูพืชทางผ่านผิวหนังของเกษตรกร

ชื่อผู้สัมภาษณ์ ______________________________ **แบบสอบถามเลขที่**__________

วันที่ ______/_______/_____

ศูนย์ความเป็นเลิศแห่งชาติด้านการจัดการ
สิ่งแวดล้อมและของเสียอันตราย

แบบสอบถามสำหรับการประเมินความเสี่ยงสุขภาพของเกษตรกร ที่ใช้สารกำจัดศัตรูพืช
ต.ศีรษะกระบือ อ.องครักษ์ จังหวัดนครนายก ประเทศไทย
กรุณาตอบคำถามและทำเครื่องหมาย ✓ ใน ( ) และเติมลงในช่องว่าง

ส่วนที่ 1: ข้อมูลทั่วไปเกี่ยวกับผู้ตอบแบบสอบถาม

1.รหัสผู้เข้าร่วมวิจัย____

2. อายุ_______________ปี

3.เพศ ( ) ชาย ( ) หญิง

4. สถานภาพ ( ) โสด( ) แต่งงาน ( ) หม้าย ( ) หย่าร้าง

5. วุฒิการศึกษาสูงสุด

( ) ไม่ได้เรียนหนังสือ ( ) ประถมศึกษา ( ) มัธยมศึกษาตอนต้น หรือ ปวช.

( ) มัธยมศึกษาตอนปลาย หรือ ปวส. ( ) อนุปริญญา ( ) ปริญญาตรีหรือสูงกว่า

6. ท่านใช้สารกำจัดศัตรูพืชในการทำนามากี่ปี_______________ปี

7. ส่วนใหญ่ท่านใช้สารกำจัดศัตรูพืชกี่ครั้งใน 1 วัน ________________ครั้ง/วัน

8. ส่วนใหญ่ท่านทำงานในนากี่ชั่วโมงต่อวัน ______________ชั่วโมง/วัน

9. โดยส่วนใหญ่ท่านทำงานในนากี่วันต่อสัปดาห์ ______________วัน/สัปดาห์

10. สมาชิกในครอบครัวของท่านที่เป็นชาวนาหรือทำงานเกี่ยวกับการใช้สารกำจัดศัตรูพืช (รวมท่านด้วย)_______คน

11. ปัจจุบันท่านกำจัดศัตรูพืชอย่างไร (เลือกได้มากกว่า 1 ข้อ)

( ) ฉีดสารกำจัดศัตรูพืชด้วยตัวเอง

( ) จ้างคนฉีดสารกำจัดศัตรูพืช

( ) เรียกญาติพี่น้องมาช่วยฉีดสารกำจัดศัตรูพืช

12. เมื่อปีที่ผ่านมาท่านฉีดสารกำจัดศัตรูพืชกี่ไร่โดยประมาณ (ไม่ว่าจะเป็นท่านเองหรือไม่) ________ไร่

13. ท่านมีการทำการเกษตรแบบอินทรีย์หรือไม่ (ไม่ใช้สารกำจัดศัตรูพืช)

( ) มี ( ) ไม่มี

14. ท่านได้ปลูกผลผลิตอื่นนอกจากข้าวหรือไม่

( ) ไม่มี ( ) มี คือ______________________________

และได้ใช้สารกำจัดศัตรูพืชกับผลผลิตอื่นนี้ด้วยหรือไม่

( ) ใช้ ( ) ไม่ใช้

ส่วนที่ 2 : ข้อมูลด้านสุขภาพ

1. น้ำหนัก________________กิโลกรัม

2. ส่วนสูง____________________เซนติเมตร

3. ในปีที่ผ่านมาท่านมีอาการดังต่อไปนี้หรือไม่

ลักษณะอาการ	ไม่เคย	เหมือนจะไม่เคย	เคยขณะฉีดพ่นหรือสัมผัสสารกำจัดศัตรูพืช	เล็กน้อยหลังจากฉีดพ่นหรือสัมผัสสารกำจัดศัตรูพืชภายในเวลา 24 ชั่วโมง	เคยเมื่อไม่ได้ฉีดพ่นหรือสัมผัสสารกำจัดศัตรูพืช
วิงเวียนศีรษะ					
คลื่นไส้/อาเจียน					
มีอาการเกร็งบริเวณช่องท้อง					
มีอาการมองเห็นแบบพร่ามัว					
มีน้ำตาคลอหรือไหล					
มีอาการมึนงง					
มีความรู้สึกเหมือนมีเข็มมาทิ่มแทงบริเวณมือและเท้า					
แขนขาอ่อนแรง					
แขนขากระตุก					
เจ็บบริเวณหน้าอก					
แน่นหน้าอกจนหายใจลำบาก					

4. ท่านทราบสาเหตุของอาการต่างๆข้างต้นหรือไม่ ( ) ทราบ ( ) ไม่ทราบ

5. ท่านรู้สึกว่ามีอาการผิดปกติหลักจากได้กลิ่นหรือสัมผัสสารกำจัดศัตรูพืชหรือไม่

( ) รู้สึก ( ) ไม่รู้สึก

6. เมื่อท่านรู้สึกถึงความผิดปกติของร่างกายหลังจากการสูดดมหรือสัมผัสสารกำจัดศัตรูพืช ท่านทราบชื่อสารกำจัดศัตรูพืชหรือไม่

( ) ทราบ ( ) ไม่ทราบ

ส่วนที่ 3 : ข้อมูลการใช้สารกำจัดศัตรูพืช การได้รับสัมผัส และการปฏิบัติตน

1. โดยปกติท่านผสมสารกำจัดศัตรูพืชอย่างไร (โปรดเลือกเพียง 1 ข้อ)

( ) ตามคำแนะนำข้างฉลาก ( ) มากกว่าคำแนะนำข้างฉลาก

( ) ตามคำแนะนำของเพื่อนบ้าน ( ) ผสมสารกำจัดศัตรูพืชหลายชนิดเข้าด้วยกัน

2. ในการฉีดพ่นสารกำจัดศัตรูพืชท่านใช้วิธีใดต่อไปนี้ (เลือกได้มากกว่า 1 ข้อ)

( ) ไม่ฉีดพ่นสารกำจัดศัตรูพืช ( ) ฉีดพ่นด้วยรถแทรกเตอร์

( ) ฉีดพ่นด้วยเครื่องฉีดพ่นแบบมือ ( ) ฉีดพ่นด้วยเครื่องฉีดพ่นแบบสะพายหลัง

( ) ฉีดพ่นด้วยเครื่องฉีดพ่นแบบควัน หรือ ฉีดพ่นด้วยเครื่องมือชนิดอื่น ________________________________

เมื่อท่านฉีดพ่น ( ) ท่านฉีดพ่นลงในร่องนา ( ) ฉีดพ่นเป็นแนว

3. ปัจจุบันท่านฉีดพ่นสารกำจัดศัตรูพืชอย่างไร (โปรดเลือกเพียง 1 ข้อ)

( ) ฉีดพ่นโดยตัวท่านเองเพียงคนเดียว

( ) รวมกลุ่มคนประมาณ 4-5 คนในการฉีดพ่น

( ) จ้างคนฉีดพ่น

4. สาเหตุที่ท่านตัดสินใจเลือกซื้อสารกำจัดศัตรูพืช โดยคำแนะนำจากใคร (เลือกได้มากกว่า 1 ข้อ)

( ) เพื่อนบ้าน ( ) เกษตรกรอำเภอ หรือ ตำบล

( ) ผู้จำหน่ายแนะนำ ( ) โฆษณา ( ) ตัวแทนจำหน่าย

5. ท่านปฏิบัติตนอย่างไรในขณะผสมสารกำจัดศัตรูพืช (เลือกได้มากกว่า 1 ข้อ)

( ) สวมถุงมือยางและใช้ไม้คนสาร

( ) สวมถุงมือผ้าและใช้ไม้คนสาร

( ) ใช้มือเปล่าและใช้ไม้คนสาร

( ) ใช้มือเปล่าเพียงอย่างเดียว

6. เวลาใดที่ท่านทำการฉีดพ่นสารกำจัดศัตรูพืช

( ) เช้าตรู่

( ) เที่ยงวัน

( ) ตอนเย็น

( ) ไม่แน่นอนตามความสะดวก คือ ____

7. ท่านใช้อุปกรณ์ป้องกันตัวเองในขณะฉีดพ่นหรือสัมผัสสารกำจัดศัตรูพืชชนิดใดบ้าง (เลือกได้มากกว่า 1 ข้อ)

( ) ไม่ใช้เลย ( ) หน้ากากแบบมีตัวกรอง

( ) หน้ากากกันฝุ่น ( ) ผ้าปิดหน้า

( ) หมวก ( ) แว่นตา

( ) ถุงมือทนสารเคมี ( ) ถุงมือผ้าหรือหนัง

( ) ผ้ากันเปื้อน ( ) ผ้า ( ) พลาสติก

( ) รองเท้าบูธ

( ) ใส่เสื้อผ้าปกคลุมทั้งตัว

( ) อื่นๆโปรดระบุ ____

8. โดยส่วนใหญ่ที่ท่านผสมหรือฉีดพ่นสารกำจัดศัตรูพืช ร่างกายส่วนใดของท่านสัมผัสกับสารกำจัดศัตรูพืชบ่อย ครั้ง (เลือกได้ มากกว่า 1 ข้อ)

( ) ไม่มีส่วนใดในร่างกาย ( ) มือและแขน

( ) หน้า ( ) ลำตัว

9. ลักษณะเสื้อและกางเกงส่วนใหญ่ที่ท่านสวมใส่ในขณะฉีดพ่นสารกำจัดศัตรูพืช (โปรดเลือกเพียง 1 ข้อ)

( ) เสื้อยืดแขนสั้นและกางเกงขาสั้น ( ) เสื้อยืดแขนสั้นและกางเกงขายาว

( ) เสื้อยืดไม่มีแขนและกางกางขาสั้น ( ) เสื้อยืดไม่มีแขนและกางเกงขายาว

( ) เสื้อเชิ้ตแขนยาวและกางเกงขาสั้น ( ) เสื้อเชิ้ตแขนยาวและกางเกงขายาว

10. ถ้ามีสารกำจัดศัตรูพืชหกรดบนเสื้อและตัวของท่านในตอนเช้า เมื่อใดที่ท่านจะเปลี่ยนเสื้อและล้างตัว (โปรดเลือกเพียง 1 ข้อ)

( ) ล้างและเปลี่ยนเสื้อผ้าทันที ( ) เปลี่ยนเสื้อผ้าและล้างตัวหลังจากฉีดพ่นสารกำจัดศัตรูพืชเสร็จ

( ) เปลี่ยนเสื้อผ้าและล้างตัวตอนเที่ยง ( ) เปลี่ยนเสื้อผ้าและล้างตัวตอนเย็นเมื่อเสร็จสิ้นงาน

11. ถ้าท่านผสมหรือฉีดพ่นสารกำจัดศัตรูพืชในตอนเช้า หลังจากการผสมหรือฉีดพ่นสารท่านทำความสะอาดร่างกายของท่านอย่างไร (โปรดเลือกเพียง 1 ข้อ)

( ) ล้างมือและแขนโดยทันที ( ) อาบน้ำโดยทันที

( ) อาบน้ำตอนพักเที่ยง ( ) ล้างมือและแขนก่อนพักเที่ยง

( ) ล้างมือและแขนในตอนเย็น ( ) อาบน้ำตอนเย็นเมื่อเสร็จสิ้นงาน

( ) อื่นๆ โปรดระบุ ____

12. ท่านใช้ผลิตภัณฑ์ชนิดใดในการชำระล้างร่างกายของท่านหลังจากผสมหรือสัมผัสสารกำจัดศัตรูพืช (เลือกได้มากกว่า 1 ข้อ)

( ) น้ำสะอาดเพียงอย่างเดียว ( ) สบู่

( ) ผงซักฟอก ( ) น้ำยาล้างจาน

13. หลังจากที่ท่านผสมหรือฉีดพ่นสารกำจัดศัตรูพืช ส่วนใหญ่ท่านทำอย่างไรกับเสื้อผ้าชุดนั้น (โปรดเลือกเพียง 1 ข้อ)

( ) เปลี่ยนเสื้อตัวใหม่โดยทันที

( ) เปลี่ยนเสื้อก่อนพักเที่ยง

( ) เปลี่ยนเสื้อตอนเย็นหลังเสร็จงาน

14. บ่อยครั้งแค่ไหนที่ท่านทำความสะอาดเสื้อผ้า หลังการผสมและฉีดพ่นสารกำจัดศัตรูพืช (โปรดเลือกเพียง 1 ข้อ)

( ) ซักทันที

( ) เก็บเสื้อตัวนั้นไว้แล้วนำมาใส่ใหม่ในวันถัดไป

( ) เก็บเสื้อตัวนั้นไว้แล้วนำมาใส่ใหม่ทั้งสัปดาห์

( ) เก็บเสื้อตัวนั้นไว้แล้วนำมาใส่ใหม่ทั้งเดือน

15. ท่านทำอย่างไรกับขวดสารกำจัดศัตรูที่ใช้หมดแล้ว (เลือกได้ มากกว่า 1 ข้อ)

( ) ทิ้งบนพื้น ( ) เก็บและทิ้งในพื้นที่ทิ้งขยะส่วนตัวของท่าน

( ) ขุดหลุมแล้วทิ้ง ( ) ทิ้งลงแหล่งน้ำ

( ) ทิ้งในถังขยะ ( ) เผา

16. ท่านใช้แหล่งน้ำใดในการผสมกับสารกำจัดศัตรูพืช

( ) น้ำจากร่องคูคันนา ( ) น้ำจากบ่อ

( ) น้ำประปา ( ) น้ำจากลำคลอง

17. ท่านกินอาหารมื้อกลางวันในนาช่วงฉีดพ่นสารกำจัดศัตรูพืชหรือไม่

( ) กินเป็นประจำ ( ) กินบางครั้ง

( ) กินบ้าง ( ) ไม่กินเลย

18. ท่านสูบบุหรี่หรือใบยาสูบหรือไม่

( ) สูบ __________________มวนต่อวัน

( ) ไม่เคยสูบ

( ) เลิกสูบแล้ว

19. ท่านสูบบุหรี่หรือใบยาสูบในขณะฉีดพ่นสารหรือไม่

( ) สูบเป็นประจำ ( ) สูบบางครั้ง

( ) สูบบ้าง ( ) ไม่สูบเลย

20. โดยส่วนใหญ่ท่านใช้สารกำจัดศัตรูพืชชนิดใดในนาของท่าน (เลือกได้มากกว่า 1 ข้อ)

ชนิดสารกำจัดศัตรูพืช	ระยะเวลาที่ใช้ (ปี)	ใน 1 ปีท่านใช้สารชนิดนี้กี่วัน โดยเฉลี่ย
( ) อะบาเมกติน (เอมเม็ท)		
( ) คลอไพรีฟอส (พรีเดเตอร์, คลอร์ไพริฟอส40%, เมอร์เชนไดส์)		
( ) โพรฟีโนฟอส		
( ) คาร์บาเมต		
( ) อื่นๆโปรดระบุ ______________________________		

และสาเหตุใดที่ท่านเลือกใช้สารกำจัดศัตรูพืชชนิดนั้น (เลือกได้มากกว่า 1 ข้อ)

( ) ราคาถูก

( ) หาซื้อง่าย

( ) เพื่อนบ้านแนะนำ

( ) สามารถกำจัดศัตรูพืชได้ดีในเวลาสั้น

Adapt from : Japieam ,2008 and Pan, 2009.

Appendix C
Body surface area

Table C-1 Equation parameters for calculating adult body surface area

Body Part	N	Equation for surface areas (m^2) a_o	W^{a1}	H^{a2}	P	R^2	S.E.
Head							
Female	57	0.0256	0.124	0.189	0.01	0.302	0.00678
Male	32	0.0492	0.339	-0.0950	0.01	0.222	0.0202
Trunk							
Female	57	0.188	0.647	-0.304	0.001	0.877	0.00567
Male	32	0.0240	0.808	-0.0131	0.001	0.894	0.0118
Upper Extremities							
Female	57	0.0288	0.341	0.175	0.001	0.526	0.00833
Male	48	0.00329	0.466	0.524	0.001	0.821	0.0101
Arms							
Female	13	0.00223	0.201	0.748	0.01	0.731	0.00996
Male	32	0.00111	0.616	0.561	0.001	0.892	0.0177
Upper Arms							
Male	6	8.70	0.741	-1.40	0.25	0.576	0.0387
Forearms							
Male	6	0.326	0.858	-0.895	0.05	0.897	0.0207
Hands							
Female	12[b]	0.0131	0.412	0.0274	0.1	0.447	0.0172
Male	32	0.0257	0.573	-0.218	0.001	0.575	0.0187
Lower Extremities[c]	105	0.00286	0.458	0.696	0.001	0.802	0.00633
Legs	45	0.00240	0.542	0.626	0.001	0.780	0.0130
Thighs	45	0.00352	0.629	0.379	0.001	0.739	0.0149
Lower legs	45	0.000276	0.416	0.973	0.001	0.727	0.0149
Feet	45	0.000618	0.372	0.725	0.001	0.651	0.0147

[a] $SA = a_o W^{a1} H^{a2}$
W = Weight in kilograms; H = Height in centimeters; P = Level of significance; R^2 = Coefficient of determination;
SA = Surface Area; S.E. = Standard error; N = Number of observations
[b] One observation for a female whose body weight exceeded the 95 percentile was not used.
[c] Although two separate regressions were marginally indicated by the F test, pooling was done for consistency with individual components of lower extremities.
Source: U.S. EPA, 1985.

Adapted from: US EPA, 1997

Table C-2 Comparative relation of default values and body surface area calculation

Average surface area (m^2)	Gender					
	Male calculation[a]	**Default values**[b]	**Female calculation**[a]	**Default values**[b]	**Male & Female calculation**[c]	**Default values**[d]
Head	0.12	0.12	0.11	0.11	0.12	0.12
Chest	0.32	0.32	0.27	0.28	0.30	0.30
Arm	0.24	0.23	0.22	0.21	0.23	0.22
Upper leg	0.32	0.20	0.30	0.26	0.31	0.23
Lower leg	0.22	0.21	0.21	0.19	0.22	0.20
Back	0.32	0.32	0.27	0.28	0.30	0.30
Whole body	1.54	1.40	1.38	1.33	1.79	1.37

[a] specific value of participants' body surface area calculation

[b] default value of body surface area (US EPA, 1997)

[c] average value of male and female participants' body surface area calculation

[d] average body surface area default values

Appendix D
Average Daily Dose (ADD) Calculation of Rice farmers

Example ADD calculation on seven parts and whole body of farmer number 1

Head

ADD $= \dfrac{1{,}813.93 \times 10^{-7}\ \text{mg/cm}^2\text{-event} \times 3\ \text{events/day} \times 7\ \text{years} \times 56\ \text{days/year} \times 1.24 \times 10^3\ \text{cm}^2}{65\ \text{kg} \times 2{,}555\ \text{days}}$

$= 159.55 \times 10^{-5}$ mg/kg-day

Chest on clothes

ADD $= \dfrac{561.72 \times 10^{-7}\ \text{mg/cm}^2\text{-event} \times 3\ \text{events/day} \times 7\ \text{years} \times 56\ \text{days/year} \times 3.42 \times 10^3\ \text{cm}^2}{65\ \text{kg} \times 2{,}555\ \text{days}}$

$= 135.85 \times 10^{-5}$ mg/kg-day

Chest under clothes

ADD $= \dfrac{0.88 \times 10^{-7}\ \text{mg/cm}^2\text{-event} \times 3\ \text{events/day} \times 7\ \text{years} \times 56\ \text{days/year} \times 3.42 \times 10^3\ \text{cm}^2}{65\ \text{kg} \times 2{,}555\ \text{days}}$

$= 0.21 \times 10^{-5}$ mg/kg-day

Arm

ADD $= \dfrac{304.21 \times 10^{-7}\ \text{mg/cm}^2\text{-event} \times 3\ \text{events/day} \times 7\ \text{years} \times 56\ \text{days/year} \times 2.61 \times 10^3\ \text{cm}^2}{65\ \text{kg} \times 2{,}555\ \text{days}}$

$= 56.17 \times 10^{-5}$ mg/kg-day

Upper leg

ADD $= \dfrac{931.28 \times 10^{-7}\ \text{mg/cm}^2\text{-event} \times 3\ \text{events/day} \times 7\ \text{years} \times 56\ \text{days/year} \times 3.42 \times 10^3\ \text{cm}^2}{65\ \text{kg} \times 2{,}555\ \text{days}}$

$= 225.59 \times 10^{-5}$ mg/kg-day

Lower leg

ADD $= \dfrac{1{,}859.56 \times 10^{-7}\ \text{mg/cm}^2\text{-event} \times 3\ \text{events/day} \times 7\ \text{years} \times 56\ \text{days/year} \times 2.35 \times 10^3\ \text{cm}^2}{65\ \text{kg} \times 2{,}555\ \text{days}}$

$= 308.86 \times 10^{-5}$ mg/kg-day

Back

ADD $= \dfrac{985.37 \times 10^{-7}\ \text{mg/cm}^2\text{-event} \times 3\ \text{events/day} \times 7\ \text{years} \times 56\ \text{days/year} \times 3.42 \times 10^3\ \text{cm}^2}{65\ \text{kg} \times 2{,}555\ \text{days}}$

$= 238.31 \times 10^{-5}$ mg/kg-day

Whole body

ADD $= \dfrac{965.59 \times 10^{-7}\ \text{mg/cm}^2\text{-event} \times 3\ \text{events/day} \times 7\ \text{years} \times 56\ \text{days/year} \times 16.45 \times 10^3\ \text{cm}^2}{65\ \text{kg} \times 2{,}555\ \text{days}}$

$= 1{,}124.53 \times 10^{-5}$ mg/kg-day

Body contact **(Male)**

Head

$ADD_{mean} = \dfrac{35.03 \times 10^{-5}\ \text{mg/cm}^2\text{-event} \times 2.86\ \text{events/day} \times 12.57\ \text{years} \times 52.10\ \text{days/year} \times 1.20 \times 10^3\ \text{cm}^2}{60.90\ \text{kg} \times 4{,}588.57\ \text{days}}$

$= 28.18 \times 10^{-4}\ \text{mg/kg-day}$

$ADD_{RME} = \dfrac{82.03 \times 10^{-5}\ \text{mg/cm}^2\text{-event} \times 2.86\ \text{events/day} \times 12.57\ \text{years} \times 52.10\ \text{days/year} \times 1.20 \times 10^3\ \text{cm}^2}{60.90\ \text{kg} \times 4{,}588.57\ \text{days}}$

$= 65.98 \times 10^{-4}\ \text{mg/kg-day}$

Chest on clothes

$ADD_{mean} = \dfrac{30.27 \times 10^{-5}\ \text{mg/cm}^2\text{-event} \times 2.86\ \text{events/day} \times 12.57\ \text{years} \times 52.10\ \text{days/year} \times 3.20 \times 10^3\ \text{cm}^2}{60.90\ \text{kg} \times 4{,}588.57\ \text{days}}$

$= 64.92 \times 10^{-4}\ \text{mg/kg-day}$

$ADD_{RME} = \dfrac{157.64 \times 10^{-5}\ \text{mg/cm}^2\text{-event} \times 2.86\ \text{events/day} \times 12.57\ \text{years} \times 52.10\ \text{days/year} \times 3.20 \times 10^3\ \text{cm}^2}{60.90\ \text{kg} \times 4{,}588.57\ \text{days}}$

$= 338.11 \times 10^{-4}\ \text{mg/kg-day}$

Chest under clothes

$ADD_{mean} = \dfrac{1.62 \times 10^{-5}\ \text{mg/cm}^2\text{-event} \times 2.86\ \text{events/day} \times 12.57\ \text{years} \times 52.10\ \text{days/year} \times 3.20 \times 10^3\ \text{cm}^2}{60.90\ \text{kg} \times 4{,}588.57\ \text{days}}$

$= 3.48 \times 10^{-4}\ \text{mg/kg-day}$

$ADD_{RME} = \dfrac{4.40 \times 10^{-5}\ \text{mg/cm}^2\text{-event} \times 2.86\ \text{events/day} \times 12.57\ \text{years} \times 52.10\ \text{days/year} \times 3.20 \times 10^3\ \text{cm}^2}{60.90\ \text{kg} \times 4{,}588.57\ \text{days}}$

$= 9.44 \times 10^{-4}\ \text{mg/kg-day}$

Arm

$ADD_{mean} = \dfrac{70.79 \times 10^{-5}\ \text{mg/cm}^2\text{-event} \times 2.86\ \text{events/day} \times 12.57\ \text{years} \times 52.10\ \text{days/year} \times 2.40 \times 10^3\ \text{cm}^2}{60.90\ \text{kg} \times 4{,}588.57\ \text{days}}$

$= 113.87 \times 10^{-4}\ \text{mg/kg-day}$

$ADD_{RME} = \dfrac{638.16 \times 10^{-5}\ \text{mg/cm}^2\text{-event} \times 2.86\ \text{events/day} \times 12.57\ \text{years} \times 52.10\ \text{days/year} \times 2.40 \times 10^3\ \text{cm}^2}{60.90\ \text{kg} \times 4{,}588.57\ \text{days}}$

$= 1{,}026.56 \times 10^{-4}\ \text{mg/kg-day}$

Upper leg

$ADD_{mean} = \dfrac{129.51 \times 10^{-5}\ \text{mg/cm}^2\text{-event} \times 2.86\ \text{events/day} \times 12.57\ \text{years} \times 52.10\ \text{days/year} \times 3.20 \times 10^3\ \text{cm}^2}{60.90\ \text{kg} \times 4{,}588.57\ \text{days}}$

$= 277.78 \times 10^{-4}\ \text{mg/kg-day}$

$ADD_{RME} = \dfrac{432.28 \times 10^{-5}\ \text{mg/cm}^2\text{-event} \times 2.86\ \text{events/day} \times 12.57\ \text{years} \times 52.10\ \text{days/year} \times 3.20 \times 10^3\ \text{cm}^2}{60.90\ \text{kg} \times 4{,}588.57\ \text{days}}$

$= 927.17 \times 10^{-4}\ \text{mg/kg-day}$

Lower leg

$$ADD_{mean} = \frac{356.78 \times 10^{-5}\ mg/cm^2\text{-event} \times 2.86\ events/day \times 12.57\ years \times 52.10\ days/year \times 2.20 \times 10^3\ cm^2}{60.90\ kg \times 4{,}588.57\ days}$$

$$= 526.10 \times 10^{-4}\ mg/kg\text{-day}$$

$$ADD_{RME} = \frac{1{,}448.05 \times 10^{-5}\ mg/cm^2\text{-event} \times 2.86\ events/day \times 12.57\ years \times 52.10\ days/year \times 2.20 \times 10^3\ cm^2}{60.90\ kg \times 4{,}588.57\ days}$$

$$= 2{,}135.26 \times 10^{-4}\ mg/kg\text{-day}$$

Back

$$ADD_{mean} = \frac{20.53 \times 10^{-5}\ mg/cm^2\text{-event} \times 2.86\ events/day \times 12.57\ years \times 52.10\ days/year \times 3.20 \times 10^3\ cm^2}{60.90\ kg \times 4{,}588.57\ days}$$

$$= 44.03 \times 10^{-4}\ mg/kg\text{-day}$$

$$ADD_{RME} = \frac{203.13 \times 10^{-5}\ mg/cm^2\text{-event} \times 2.86\ events/day \times 12.57\ years \times 52.10\ days/year \times 3.20 \times 10^3\ cm^2}{60.90\ kg \times 4{,}588.57\ days}$$

$$= 435.68 \times 10^{-4}\ mg/kg\text{-day}$$

Whole body

$$ADD_{mean} = \frac{102.53 \times 10^{-5}\ mg/cm^2\text{-event} \times 2.86\ events/day \times 12.57\ years \times 52.10\ days/year \times 15.40 \times 10^3\ cm^2}{60.90\ kg \times 4{,}588.57\ days}$$

$$= 1{,}058.36 \times 10^{-4}\ mg/kg\text{-day}$$

$$ADD_{RME} = \frac{478.71 \times 10^{-5}\ mg/cm^2\text{-event} \times 2.86\ events/day \times 12.57\ years \times 52.10\ days/year \times 15.40 \times 10^3\ cm^2}{60.90\ kg \times 4{,}588.57\ days}$$

$$= 4{,}938.16 \times 10^{-4}\ mg/kg\text{-day}$$

Body contact **(Female)**

Head

$$ADD_{mean} = \frac{40.94 \times 10^{-5}\ \text{mg/cm}^2\text{-event} \times 2.71\ \text{events/day} \times 16.71\ \text{years} \times 57.71\ \text{days/year} \times 1.10 \times 10^3\ \text{cm}^2}{54.07\ \text{kg} \times 6{,}100.71\ \text{days}}$$

$$= 35.68 \times 10^{-4}\ \text{mg/kg-day}$$

$$ADD_{RME} = \frac{120.11 \times 10^{-5}\ \text{mg/cm}^2\text{-event} \times 2.71\ \text{events/day} \times 16.71\ \text{years} \times 57.71\ \text{days/year} \times 1.10 \times 10^3\ \text{cm}^2}{54.07\ \text{kg} \times 6{,}100.71\ \text{days}}$$

$$= 104.67 \times 10^{-4}\ \text{mg/kg-day}$$

Chest on clothes

$$ADD_{mean} = \frac{160.66 \times 10^{-5}\ \text{mg/cm}^2\text{-event} \times 2.71\ \text{events/day} \times 16.71\ \text{years} \times 57.71\ \text{days/year} \times 2.70 \times 10^3\ \text{cm}^2}{54.07\ \text{kg} \times 6{,}100.71\ \text{days}}$$

$$= 343.66 \times 10^{-4}\ \text{mg/kg-day}$$

$$ADD_{RME} = \frac{1{,}040.58 \times 10^{-5}\ \text{mg/cm}^2\text{-event} \times 2.71\ \text{events/day} \times 16.71\ \text{years} \times 57.71\ \text{days/year} \times 2.70 \times 10^3\ \text{cm}^2}{54.07\ \text{kg} \times 6{,}100.71\ \text{days}}$$

$$= 2{,}225.87 \times 10^{-4}\ \text{mg/kg-day}$$

Chest under clothes

$$ADD_{mean} = \frac{3.54 \times 10^{-5}\ \text{mg/cm}^2\text{-event} \times 2.71\ \text{events/day} \times 16.71\ \text{years} \times 57.71\ \text{days/year} \times 2.70 \times 10^3\ \text{cm}^2}{54.07\ \text{kg} \times 6{,}100.71\ \text{days}}$$

$$= 7.57 \times 10^{-4}\ \text{mg/kg-day}$$

$$ADD_{RME} = \frac{13.74 \times 10^{-5}\ \text{mg/cm}^2\text{-event} \times 2.71\ \text{events/day} \times 16.71\ \text{years} \times 57.71\ \text{days/year} \times 2.70 \times 10^3\ \text{cm}^2}{54.07\ \text{kg} \times 6{,}100.71\ \text{days}}$$

$$= 29.39 \times 10^{-4}\ \text{mg/kg-day}$$

Arm

$$ADD_{mean} = \frac{80.58 \times 10^{-5}\ \text{mg/cm}^2\text{-event} \times 2.71\ \text{events/day} \times 16.71\ \text{years} \times 57.71\ \text{days/year} \times 2.20 \times 10^3\ \text{cm}^2}{54.07\ \text{kg} \times 6{,}100.71\ \text{days}}$$

$$= 140.45 \times 10^{-4}\ \text{mg/kg-day}$$

$$ADD_{RME} = \frac{338.89 \times 10^{-5}\ \text{mg/cm}^2\text{-event} \times 2.71\ \text{events/day} \times 16.71\ \text{years} \times 57.71\ \text{days/year} \times 2.20 \times 10^3\ \text{cm}^2}{54.07\ \text{kg} \times 6{,}100.71\ \text{days}}$$

$$= 590.67 \times 10^{-4}\ \text{mg/kg-day}$$

Upper leg

$$ADD_{mean} = \frac{96.75 \times 10^{-5}\ \text{mg/cm}^2\text{-event} \times 2.71\ \text{events/day} \times 16.71\ \text{years} \times 57.71\ \text{days/year} \times 3.00 \times 10^3\ \text{cm}^2}{54.07\ \text{kg} \times 6{,}100.71\ \text{days}}$$

$$= 229.95 \times 10^{-4}\ \text{mg/kg-day}$$

$$ADD_{RME} = \frac{352.56 \times 10^{-5}\ \text{mg/cm}^2\text{-event} \times 2.71\ \text{events/day} \times 16.71\ \text{years} \times 57.71\ \text{days/year} \times 3.00 \times 10^3\ \text{cm}^2}{54.07\ \text{kg} \times 6{,}100.71\ \text{days}}$$

$$= 837.94 \times 10^{-4}\ \text{mg/kg-day}$$

Lower leg

$ADD_{mean} = \dfrac{235.20 \times 10^{-5} \text{ mg/cm}^2\text{-event} \times 2.71 \text{ events/day} \times 16.71 \text{ years} \times 57.71 \text{ days/year} \times 2.10 \times 10^3 \text{ cm}^2}{54.07 \text{ kg} \times 6{,}100.71 \text{ days}}$

$= 391.31 \times 10^{-4} \text{ mg/kg-day}$

$ADD_{RME} = \dfrac{967.81 \times 10^{-5} \text{ mg/cm}^2\text{-event} \times 2.71 \text{ events/day} \times 16.71 \text{ years} \times 57.71 \text{ days/year} \times 2.10 \times 10^3 \text{ cm}^2}{54.07 \text{ kg} \times 6{,}100.71 \text{ days}}$

$= 1{,}610.16 \times 10^{-4} \text{ mg/kg-day}$

Back

$ADD_{mean} = \dfrac{19.14 \times 10^{-5} \text{ mg/cm}^2\text{-event} \times 2.71 \text{ events/day} \times 16.71 \text{ years} \times 57.71 \text{ days/year} \times 2.70 \times 10^3 \text{ cm}^2}{54.07 \text{ kg} \times 6{,}100.71 \text{ days}}$

$= 41.52 \times 10^{-4} \text{ mg/kg-day}$

$ADD_{RME} = \dfrac{70.04 \times 10^{-5} \text{ mg/cm}^2\text{-event} \times 2.71 \text{ events/day} \times 16.71 \text{ years} \times 57.71 \text{ days/year} \times 2.70 \times 10^3 \text{ cm}^2}{54.07 \text{ kg} \times 6{,}100.71 \text{ days}}$

$= 149.82 \times 10^{-4} \text{ mg/kg-day}$

Whole body

$ADD_{mean} = \dfrac{108.86 \times 10^{-5} \text{ mg/cm}^2\text{-event} \times 2.71 \text{ events/day} \times 16.71 \text{ years} \times 57.71 \text{ days/year} \times 13.80 \times 10^3 \text{ cm}^2}{54.07 \text{ kg} \times 6{,}100.71 \text{ days}}$

$= 1{,}190.14 \times 10^{-4} \text{ mg/kg-day}$

$ADD_{RME} = \dfrac{507.50 \times 10^{-5} \text{ mg/cm}^2\text{-event} \times 2.71 \text{ events/day} \times 16.71 \text{ years} \times 57.71 \text{ days/year} \times 13.80 \times 10^3 \text{ cm}^2}{54.07 \text{ kg} \times 6{,}100.71 \text{ days}}$

$= 5{,}548.52 \times 10^{-4} \text{ mg/kg-day}$

Body contact (Male and Female)

Head

$$ADD_{mean} = \frac{36.28 \times 10^{-5}\ mg/cm^2\text{-event} \times 2.79\ events/day \times 14.64\ years \times 54.91\ days/year \times 1.20 \times 10^3\ cm^2}{57.49\ kg \times 5{,}344.64\ days}$$

$$= 31.72 \times 10^{-4}\ mg/kg\text{-day}$$

$$ADD_{RME} = \frac{96.06 \times 10^{-5}\ mg/cm^2\text{-event} \times 2.79\ events/day \times 14.64\ years \times 54.91\ days/year \times 1.20 \times 10^3\ cm^2}{57.49\ kg \times 5{,}344.64\ days}$$

$$= 83.99 \times 10^{-4}\ mg/kg\text{-day}$$

Chest on clothes

$$ADD_{mean} = \frac{88.44 \times 10^{-5}\ mg/cm^2\text{-event} \times 2.79\ events/day \times 14.64\ years \times 54.91\ days/year \times 3.00 \times 10^3\ cm^2}{57.49\ kg \times 5{,}344.64\ days}$$

$$= 193.32 \times 10^{-4}\ mg/kg\text{-day}$$

$$ADD_{RME} = \frac{552.34 \times 10^{-5}\ mg/cm^2\text{-event} \times 2.79\ events/day \times 14.64\ years \times 54.91\ days/year \times 3.00 \times 10^3\ cm^2}{57.49\ kg \times 5{,}344.64\ days}$$

$$= 1{,}207.35 \times 10^{-4}\ mg/kg\text{-day}$$

Chest under clothes

$$ADD_{mean} = \frac{2.46 \times 10^{-5}\ mg/cm^2\text{-event} \times 2.79\ events/day \times 14.64\ years \times 54.91\ days/year \times 3.00 \times 10^3\ cm^2}{57.49\ kg \times 5{,}344.64\ days}$$

$$= 5.38 \times 10^{-4}\ mg/kg\text{-day}$$

$$ADD_{RME} = \frac{8.53 \times 10^{-5}\ mg/cm^2\text{-event} \times 2.79\ events/day \times 14.64\ years \times 54.91\ days/year \times 3.00 \times 10^3\ cm^2}{57.49\ kg \times 5{,}344.64\ days}$$

$$= 18.65 \times 10^{-4}\ mg/kg\text{-day}$$

Arm

$$ADD_{mean} = \frac{75.47 \times 10^{-5}\ mg/cm^2\text{-event} \times 2.79\ events/day \times 14.64\ years \times 54.91\ days/year \times 2.30 \times 10^3\ cm^2}{57.49\ kg \times 5{,}344.64\ days}$$

$$= 190.48 \times 10^{-4}\ mg/kg\text{-day}$$

$$ADD_{RME} = \frac{495.03 \times 10^{-5}\ mg/cm^2\text{-event} \times 2.79\ events/day \times 14.64\ years \times 54.91\ days/year \times 2.30 \times 10^3\ cm^2}{57.49\ kg \times 5{,}344.64\ days}$$

$$= 829.59 \times 10^{-4}\ mg/kg\text{-day}$$

Upper leg

$$ADD_{mean} = \frac{113.66 \times 10^{-5}\ mg/cm^2\text{-event} \times 2.79\ events/day \times 14.64\ years \times 54.91\ days/year \times 3.10 \times 10^3\ cm^2}{57.49\ kg \times 5{,}344.64\ days}$$

$$= 170.47 \times 10^{-4}\ mg/kg\text{-day}$$

$$ADD_{RME} = \frac{393.71 \times 10^{-5}\ mg/cm^2\text{-event} \times 2.79\ events/day \times 14.64\ years \times 54.91\ days/year \times 3.10 \times 10^3\ cm^2}{57.49\ kg \times 5{,}344.64\ days}$$

$$= 889.29 \times 10^{-4}\ mg/kg\text{-day}$$

Lower leg

$$ADD_{mean} = \frac{290.65 \times 10^{-5}\ mg/cm^2\text{-event} \times 2.79\ events/day \times 14.64\ years \times 54.91\ days/year \times 2.20 \times 10^3\ cm^2}{57.49\ kg \times 5{,}344.64\ days}$$

$$= 465.91 \times 10^{-4}\ mg/kg\text{-day}$$

$$ADD_{RME} = \frac{1{,}185.93 \times 10^{-5}\ mg/cm^2\text{-event} \times 2.79\ events/day \times 14.64\ years \times 54.91\ days/year \times 2.20 \times 10^3\ cm^2}{57.49\ kg \times 5{,}344.64\ days}$$

$$= 1{,}901.02 \times 10^{-4}\ mg/kg\text{-day}$$

Back

$$ADD_{mean} = \frac{19.69 \times 10^{-5}\ mg/cm^2\text{-event} \times 2.79\ events/day \times 14.64\ years \times 54.91\ days/year \times 3.00 \times 10^3\ cm^2}{57.49\ kg \times 5{,}344.64\ days}$$

$$= 43.04 \times 10^{-4}\ mg/kg\text{-day}$$

$$ADD_{RME} = \frac{139.86 \times 10^{-5}\ mg/cm^2\text{-event} \times 2.79\ events/day \times 14.64\ years \times 54.91\ days/year \times 3.00 \times 10^3\ cm^2}{57.49\ kg \times 5{,}344.64\ days}$$

$$= 305.72 \times 10^{-4}\ mg/kg\text{-day}$$

Whole body

$$ADD_{mean} = \frac{86.07 \times 10^{-5}\ mg/cm^2\text{-event} \times 2.79\ events/day \times 14.64\ years \times 54.91\ days/year \times 17.90 \times 10^3\ cm^2}{57.49\ kg \times 5{,}344.64\ days}$$

$$= 1{,}122.56 \times 10^{-4}\ mg/kg\text{-day}$$

$$ADD_{RME} = \frac{391.26 \times 10^{-5}\ mg/cm^2\text{-event} \times 2.79\ events/day \times 14.64\ years \times 54.91\ days/year \times 17.90 \times 10^3\ cm^2}{57.49\ kg \times 5{,}344.64\ days}$$

$$= 5{,}102.98 \times 10^{-4}\ mg/kg\text{-day}$$

Appendix E
Scoring Fluorescent tracer

Table E-1 Scoring fluorescent tracer

No. farmers	Head	Chest on clothes	Chest under clothes	Arm	Upper leg	Lower leg	Back
1	3	3	0	1	3	1	2
2	1	0	0	2	1	2	0
3	1	1	0	1	3	3	1
4	1	1	0	2	3	3	1
5	1	1	0	1	2	3	0
6	1	1	0	1	1	2	1
7	1	0	2	2	2	3	1
8	1	1	1	1	2	3	1
9	0	1	1	1	3	3	1
10	1	1	0	2	1	2	1
11	1	1	0	0	2	3	1
12	1	1	1	1	1	1	1
13	1	3	2	3	2	1	1
14	0	3	1	0	3	3	2
15	1	3	2	1	3	3	1
16	2	3	1	3	3	3	1
17	1	3	1	2	3	3	1
18	1	3	1	3	3	3	1
19	1	1	1	1	1	0	0
20	1	3	2	1	1	2	1
21	1	0	0	2	2	2	2
22	1	1	0	1	2	3	1
23	1	1	0	1	1	1	1
24	1	1	0	1	1	1	1
25	1	1	0	1	2	3	1
26	1	1	0	0	3	3	1
27	1	1	0	0	1	2	1
28	1	1	1	1	2	1	1
29	0	1	0	1	0	1	0
30	0	1	1	1	3	3	0

No. farmers	Head	Chest on clothes	Chest under clothes	Arm	Upper leg	Lower leg	Back
31	0	1	1	0	1	3	1
32	1	1	0	1	1	1	1
33	0	1	0	1	2	2	0
34	1	2	0	2	1	2	1
35	0	1	1	1	1	1	1
Total	31	49	20	43	66	76	32

Appendix F
Calibration Curve and Quality Control

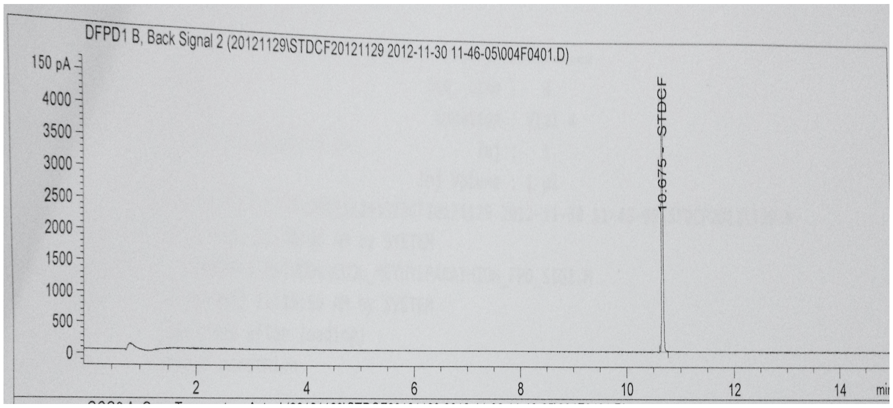

Figure F-1 Chromatogram of standard chlorpyrifos at 1 ppm

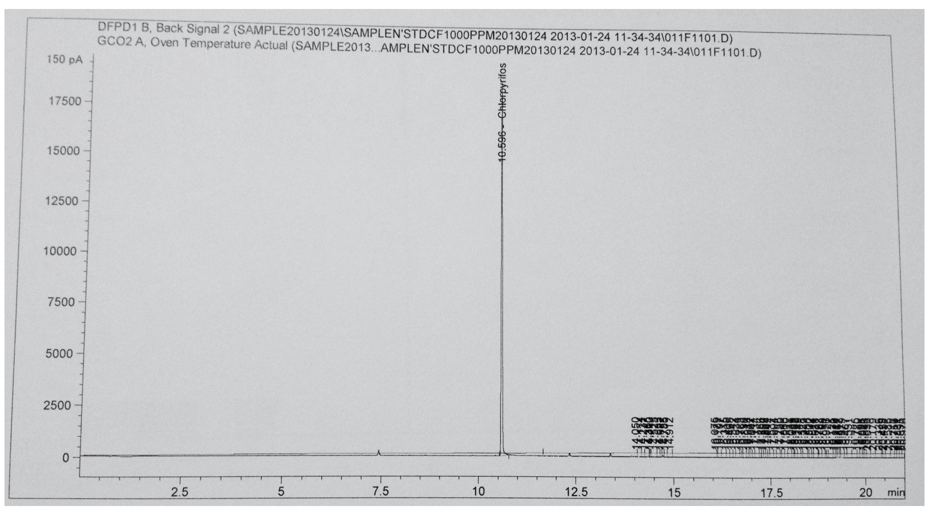

Figure F-2 Chromatogram of gauze sample

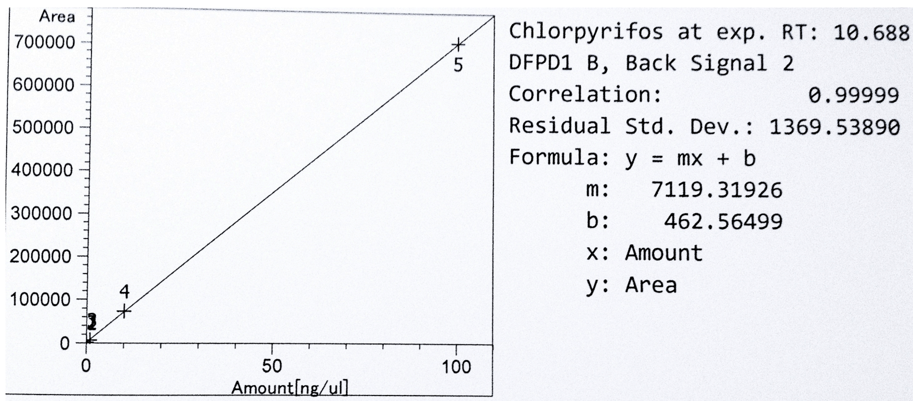

Figure F-3 Chlorpyrifos calibration curve

Table F-1 Quality control of chlorpyrifos

LOD (µg/ml)	LOQ (µg/ml)	%Recovery ± SD n = 9 at 100 ppm
0.01	0.02	107.77 ± 6.57

Table F-2 Value of chlorpyrifos concentration at 100 ppm for %RSD calculation

Concentration of standard chlorpyrifos at 100 ppm (n = 10)	
1) 100.28	6) 98.61
2) 99.89	7) 102.46
3) 99.83	8) 95.68
4) 106.28	9) 102.50
5) 96.83	10) 99.58
mean 100.19	
SD 3.02	
%RSD $= \frac{SD \times 100}{mean} = \frac{3.02 \times 100}{100.19} = 3.01\%$	

BIOGRAPHY

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and Fea's muntjacs (Muntiacus feae) in captive breeding.