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Distribution of Dermal Contamination under the Influence of Difference Spraying Flow Rate among Spray Operator in Tropical Country

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Abstract

Human skin is undoubtedly the major route of exposure to environmental contaminants, particularly when endo- and exo- pesticide drift is unavoidable whenever pesticide is applied. This field analytical study was conducted to determine dermal contamination of spray operator during pesticide application under the influence of difference spraying flow rate at the rice farming village of Selangor, Malaysia. The fluorescent tracer technique was used to quantify the dermal contamination pattern of the spray operator, followed by quantifying the concentration of fluoresceine with the aid of digital fluorometer. In summary, the mixture of pesticides applied to the farmland with higher spray rate (L/min) showed an increased contaminant doses retained on the body surface. In summary, it is recommended that changes in application techniques, setting up buffer zones or selection of low spraying flow rate (L/min) could improve the efficacy and safety of pesticide contamination through dermal pathway.

Keywords: dermal contamination, spraying flow rate, spray operator

1. Introduction

Rice production is vulnerable to a great variety of pests due to the ever changing balance of rice and pest's cycle, organophosphate (OP) is the insecticides widely used by the spray operator during vegetative stage of rice farming (Papademetriou *et al*., 2000).

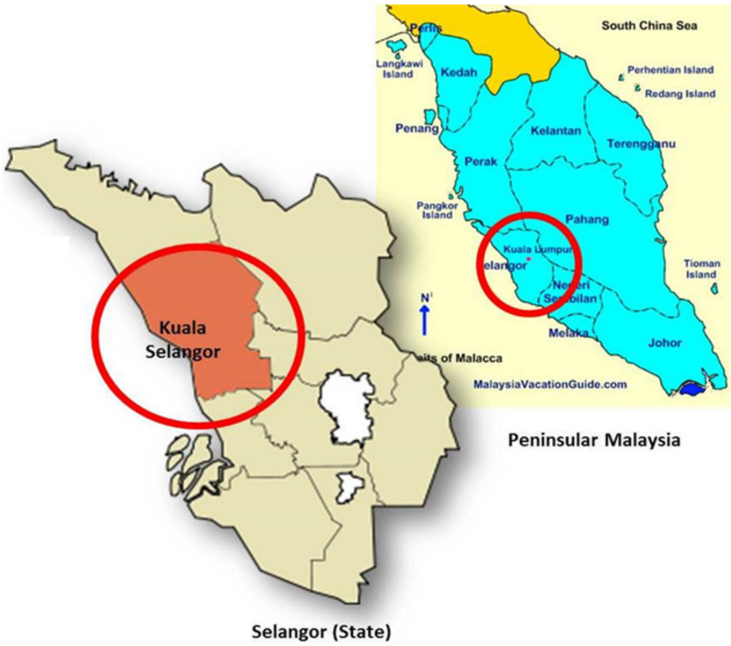
Human adult's skin has a superficial surface area of approximately 1.73m^2, which is undoubtedly the major route of exposure to environmental contaminants (Baharuddin *et al*., 2011; Hashmi and Khan, 2011; Bolognesi, 2003; Schneider et al., 1999). Spray operator may either direct expose to the residues on foliage, soil and groundwater through dermal pathway or through its spray drift (Khan, 2012; Watts, 2010; Blanco *et al*., 2008). Pesticide drift is unavoidable whenever pesticides are applied. Past studies showed that drift could be measured hundreds of yards to hundreds of feet away from the application site (Brady, 2011).

The spray characteristics such as spray droplet spectrum, volume application rates and spray concentrations have been shown to influence the efficacy and safety of pesticides (Baharuddin *et al*., 2011; Dzolkhifli, 2011). Therefore, selection of proper spraying flow rate during pesticide spraying may reduce spray drift and operator contamination. In this study, field observation revealed that mist blower is the most commonly use sprayer to deliver insecticide in paddy farming. The selection of difference spraying flow rate to break spray liquid into spray droplet through hydraulic nozzle is based on individual preference.

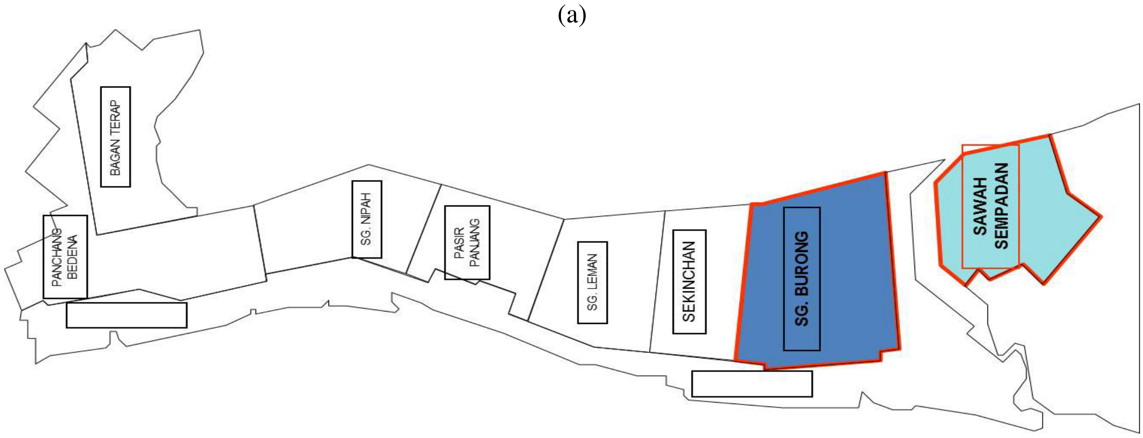
The objective of this study was to evaluate the distribution of dermal contamination applied by mist blower under the influence of spraying flow rate (L/min) among spray operator. This is hypothesized to improve the efficacy of insecticide spraying during rice farming, and understand the dermal contamination to spray operator due to pesticide drift mechanism.

2. Material and Methods

This study was carried out in the rice farming village of *Kampung Sungai Burung* (3,240 hectares) and *Kampung Sawah Sempadan* (2,304 hectares) which located at *Tanjung Karang* (3° 28' 20.455" N, 101° 17' 51.835" W), state of Selangor, Malaysia (Figure 1). Each area with irrigated rice cultivation is neatly subdivided into blocks and lots. Preschool, primary and secondary schools are located between or within farmland blocks or lots.



(a)



(b)

Figure 1. Study Location
(a) Selangor State and Kuala Selangor District, Malaysia
(b) Paddy Field at Sub-District, Tanjung Karang

The fluorescent tracer technique was modified from Fenske (1998) to quantify the spray contamination of the spray operator (Dzolkhifli, 2011). Fluoresceine (Flourescein-Natrium reinst, Sigma) at the concentration of 0.01% was dissolved in the spray solution. Cotton linens (5cm x 5cm) were placed at different locations on the body of the sprayer (Figure 2) based on the location of dermal exposure pads as discussed by USEPA (1987) in "Methods for Assessing Exposure to Chemical Substances".

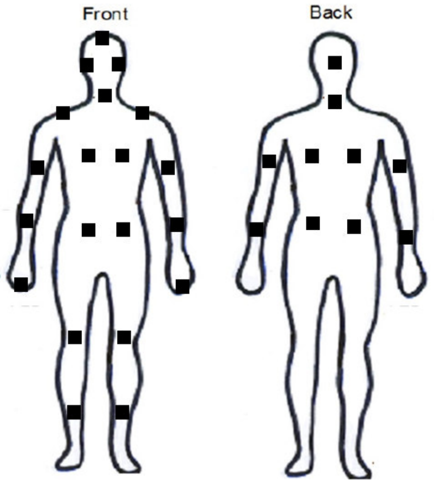


Figure 2. Cotton linens (5cm x 5cm) at Different Body Region

Before starting the spraying activity, the wind speed, temperature and spraying flow rate (L/min) were first determined. Farmers who participated were required to accomplish the spraying task by spraying one acre of paddy in 5 tanks of spraying solution (1 tank = 30ml/L). The farmers were instructed to apply the spray solution with fluoresceine contains as applying pesticide spraying activity as usual. Immediately after finishing the spraying activity, the cotton linens were collected and placed into a dark plastic bag (10cm x 10cm). The tracer was washed off by shaking the individual cotton linen in the glass tube containing 35ml of 0.01M sodium hydroxide for 30 seconds. A digital fluorometer (Sequioa Turner Model 450, Firstenberg Machinery Co., Inc.) was used to measure the concentration of fluoresceine in the solution.

Figure 3. Spray operator was attached with cotton linens as showed in Figure (2) and perform the spraying activity as usual

In order to construct a standard curve of absorbance versus concentration to determine the concentration (ppm) of pesticide deposition based on % relative fluorescence (RF) (Figure 4). The % w/v fluorescent value is directly proportional to the 1 ppm (= 1 mg/kg). Following this linear equation, $y=1x10^8+33.589$, the concentration of the pesticide amount retained on the skin surface was estimated.

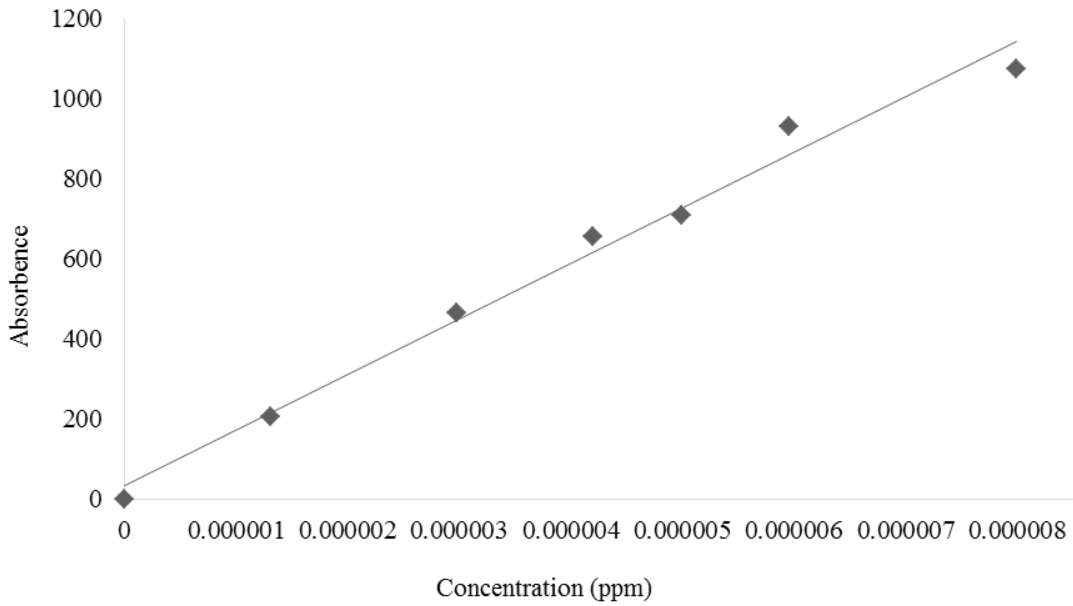


Figure 4. Standard Curve Absorbance versus Concentration

3. Results

Spray operators use low-volume (LV) motorized mist blower spraying device when mixture of OP pesticides were applied to the target farmland. Two common spraying flow rates (2 L/min and 4 L/min) were selected based on individual preference. Figure 5 summarizes the influence of pesticide deposition on the skin when these spraying flow rates were set.

Under the constant temperature of 26.6-32.2°C and 2.0-3.0 km/hour of wind speed, farmers' bodies were covered with relatively higher fluorescein during the spraying flow rate of 4 L/min. The distribution was particularly high in the facial region (0.086ppm), followed by hands (0.053ppm), lower legs (0.051ppm) and forearms (0.046 ppm). A different deposition pattern is observed during spray flow rate of 2 L/min. The fluorescein was recorded to have higher deposition on the back (0.060ppm), followed by lower legs(0.041ppm), thighs (0.037ppm) and upper arms (0.036ppm) when farmer sprayed at 2 L/min.

As shown in Figure 5, by summing up the total amount of fluorescein retained at each body portion (1 ppm=1 mg/kg), an average of 0.322 mg/kg and 0.417 mg/kg were obtained during spray flow rate of 2 L/min and 4 L/min. The total dose received by the farming community is applied by considering the concentration derived from Table 1, such that, 2.59 x 102 mg/kg (at spray flow rate 2L/min) and 3.37 x 102 mg/kg (at spray flow rate 4L/min). It is assumed that the total concentration of the mixture of pesticides received in the contaminated environmental medium is the concentration absorbed into the human body.

The mixtures of OP used in rice farming are listed to calculate the potential dose received. The potential dose received through dermal pathway is estimated by considering the mass fraction, % mass/mass (% w/w) and the total spray water supplied to complete an acre of rice farm. When comparing the total dose received at a different spraying flow rate, there is an overall 30% increase of the total pesticide deposited on farmers' skin when they work at spraying flow rate of 4L/min.

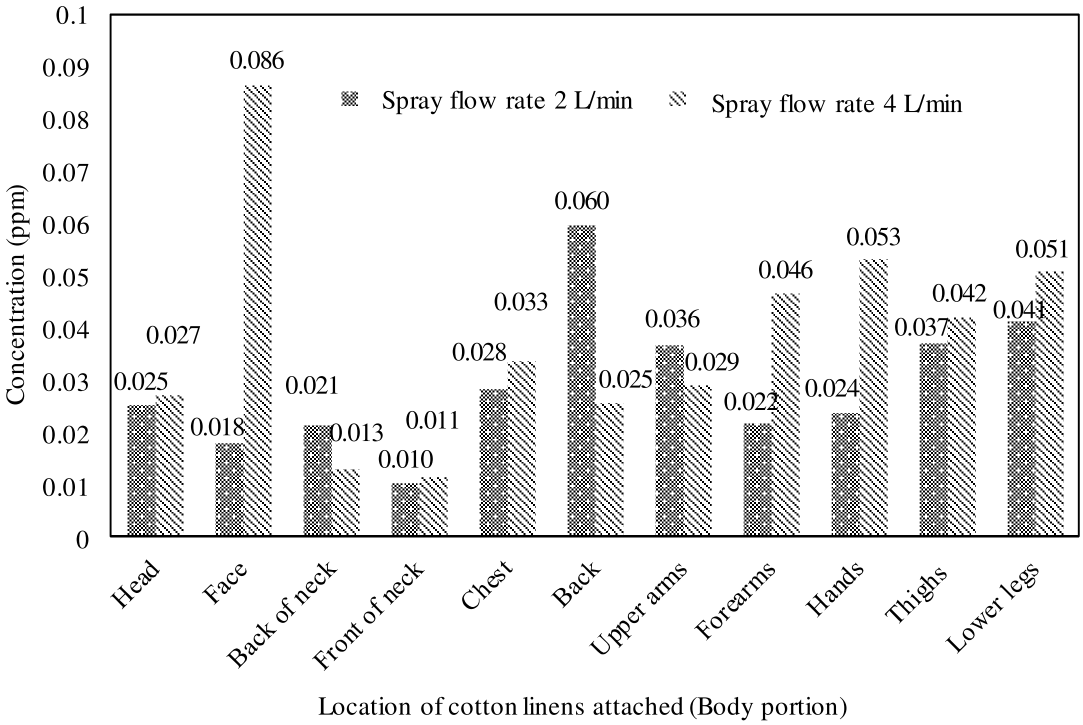


Figure 5. Distributions of Fluorescein Concentration (ppm) on Various Body Parts with Different Spray Flow Rate

Table 1. Potential Dose Received through Dermal Pathway from the Mixture of Organophosphates

OP mixture	Mass fraction (% w/w)	Dose received (mg/kg) [1]	
		[2] Spray flow rate, 2 L/min	[3] Spray flow rate, 4 L/min
Chlorpyrifos	0.46	2.22×10^{-3}	2.87×10^{-3}
Diazinon	0.56	2.70×10^{-3}	3.50×10^{-3}
Dimethoate	0.96	4.63×10^{-3}	6.01×10^{-3}
Fenthion	0.55	2.65×10^{-3}	3.44×10^{-3}
Malathion	0.96	4.63×10^{-3}	6.01×10^{-3}
Quinalphos	0.95	4.58×10^{-3}	5.94×10^{-3}
Trichlorfon	0.95	4.58×10^{-3}	5.94×10^{-3}
Total [4]		**2.59×10^{-2}**	**3.37×10^{-2}**

[1] Consider dose received by farmer when spraying the paddy farmland (per acre) with 5 spray tanks (1 tank=30L)
[2] Total amount retained on skin= 0.322 mg/kg
[3] Total amount retained on skin= 0.417 mg/kg
[4] Assumption: An additive effect happened when exposed to mixture of organophosphates

3. Discussion

In hot climates, approximately 50% of the body surface will normally exposed at any time during application (Ambrige et al., 1990). In fact, study observed that the amount of pesticide mixtures is likely to fall directly on bare skin due to inappropriate personal hygiene's practices and improper personal protective equipment used by spray operator. It is generally accepted that of the total amount of active ingredient falling on unprotected skin some 10% will penetrate into the body (Ambrige et al., 1990). In fact, the metabolic processes in the skin surface can make the lipophilic characteristics of OP compounds more hydrophilic and enhance the penetration through the skin (USEPA, 1992).

As shows in Figure 6, the dermal exposure pathway is affected by the pesticide treated farm in which the mixture of pesticides was absorbed into the soil and leaches into groundwater through pesticide runoff and its spray drift. It is possible for pesticide to be absorbed into the skin directly from the air, transfer to the skin from contact with contaminated surfaces or by submersion of body parts into the substance (Schneider et al., 1999). Under these circumstances opportunities for spray operator dermally contaminated with pesticide will increase. Long-term exposures to pesticide have shown to increase risk of chronic health problems, such as neuro-behavioural changes, liver abnormalities and kidney dysfunction (Whittle, 2010).

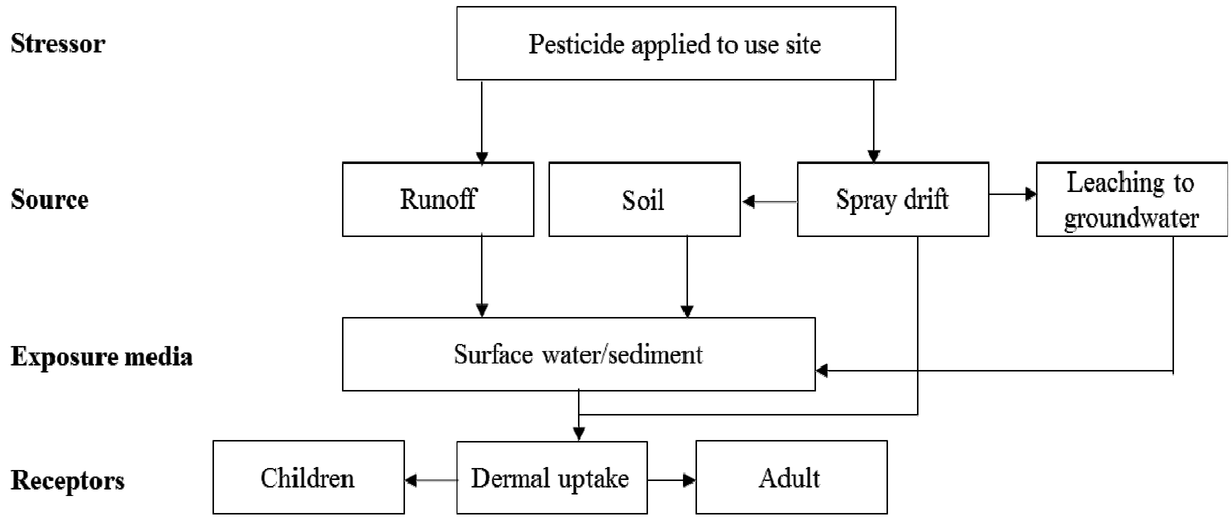


Figure 6. Dermal Exposure Pathway from Pesticide Treated Farm
(Adapted from Brady, 2011)

In this study, most of the farmers used motorized mist blowers to convert the insecticides into droplets for efficient insect coverage in the paddy farms. They would adjust the spray flow rate (delivery rate in liters per minute through the nozzle) according to their preferences. Nevertheless, the fact that farmers could adjust the appropriate flow rate for them to spray as targeted and reduce the spraying drift with the optimum droplet size of the pesticide droplet has rarely been studied (Jones, 2006).

As shown in Figure 5, the lower body parts were reported to have high pesticide deposition during different spray flow rates (L/min). This might be due to farmers' indirect or cross-contamination when they walk through the pesticide-treated plants, especially in the cases of very dense crop foliage (Machera et al., 2002). Besides, farmers were shown to have higher contamination on the back of their bodies at the flow rate of 2L/min. This could be due to the accidental leakage and spillage which occurred during spraying. However, off-target contamination on the farmers' facial region due to pesticide drifting would likely happen when spraying with a higher flow rate of 4L/min.

Since there was insufficient exposure information on the mixtures of OP through dermal pathway from the environment to farm children and adult farmers, this study presumed that 100% of the effective surface loading of pesticides have dissolved in soil and water and were transferred through the dermal pathway to the farming community (Table 1). The estimation of the potential OP mixture retained on the skin by farmers in this study indicated that a substantial amount of OP was deposited on the skin at higher spraying flow rate. This could be explained by the potential environment-surface-skin transfer contamination and the consecutive absorption process (Baharuddin et al., 2011; Hubal et al., 2006). For instance, pesticides droplet from the exo- and endo-drift might be retained on foliage as pesticide residues, or can be transferred back to the body surface during subsequent dermal contact in soil and water (Mattews, 2006).

5. Conclusion and Recommendation

Pesticide update through dermal exposure causes a potentially significant, but understudied health concerns. In this study, mixture of pesticides applied to the farmland with higher spray rate (L/min) showed an increased contaminant doses retained on the body surface. It is now known that the toxicity of pesticides can vary depending on the human-environmental interaction, the health effect usually increases as concentration and duration of exposure increases.

It is recommended to consider soil partition/water solubility, skin permeability, half-life body burden and uptake mechanism to have a better dermal risk estimation of pesticide contamination. Since there is no single alternative to drift problems, it is advised that farmer may first be educated on the changes in application techniques, setting up buffer zones or selection of low spraying flow rate (L/min). This could help to improve the efficacy and safety of pesticide contamination through dermal pathway. In fact, the best solution for drift problems is to replace chemically-based pest management techniques with sustainable alternatives.

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