

Risk Quotient of Airborne Paraquat Exposure among Workers in Palm Oil Plantation

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ABSTRACT

Paraquat is the herbicide widely used at palm oil plantations, although usage in some countries has been banned and restricted. Paraquat spraying was not appropriate procedure could be polluted the environment and lead to health disorders workers. Paraquat could enter the body through inhalation, dermal and ingestion, one of frequent routes through inhalation during spraying weeds in plantation areas. This study aimed was to analyze potential inhalation dose and Risk Quotient to workers at palm oil plantation. This research was a descriptive study with cross sectional design and analysis of environmental health risk methods. Airborne Paraquat residue was collected from 8 workers with occupational activity as a supervisor and sprayer. Airborne Paraquat residue was measured for 25 minutes during spraying by using personal air sampler at worker's breathing zone. Airborne Paraquat residue was detected by High Performance Liquid Chromatography (HPLC) with NIOSH 5003 methods. The average of airborne Paraquat residue was 0.0125 mg/m³, it values was less than the Threshold Limit Value (0.05 mg/m³) of American Conference of Government Industrial Hygienists, but the average of potential inhalation dose was 0.001 mg/kg/day for worker's weight 55 kg, it was value higher than Acceptable Operator Exposure Limit (0.0005 mg/kg/day) and the calculation of Risk Quotient (RQ) was more than 1, it conditions was unacceptable for workers. Although, airborne Paraquat residue were safe, but potential inhalation dose and Risk Quotient (RQ) were unsafe for workers, cause it can be lead to lung function disorders. Therefore, for further studies it was necessary to assess the lung function of workers and the use of personal protective equipment must be completely and standard.

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1. INTRODUCTION

Recently, the use of pesticides were increasing in agricultural and plantation areas, particularly in developing countries including Indonesia, the number of pesticides used and listed as many as 3.207 formulations for agriculture and plantation [1]. Herbicides were widely used pesticides in agricultural and plantation areas, their use was about 50-60% [2], and the widely used herbicides ingredient is Paraquat dichloride [3]. Paraquat (1, 1-dimethyl, 4, 4-bipyrididum) is a toxic herbicides and classified as category II hazard [4]. The uses of Paraquat have been banned in some countries, including 27 countries in Europe and in 10 countries restricted [5], while Paraquat is classified as a restricted pesticide in Indonesia [6].

In developing countries including Indonesia, Paraquat is used freely and easily available on the market. It condition can cause the workers exposure to Paraquat quite high mainly on sprayers and supervisors during spraying in plantation areas [7]. Paraquat exposure to workers during spraying could be through inhalation, dermal and ingestion routes [8]. Paraquat exposure could lead to death because lethality of its very high, with a mortality rate of 70-80% [9].

The average death of Paraquat poisoning were about 60-80%, majority of cases were moderate to severe, deaths were generally due to hypoxia, secondary to pulmonary fibrosis [10]. In addition, the application of Paraquat spraying by farmers was related to respiratory disorders in South Korea [11]. Studies on pesticide applicators in Iowa and North Carolina, USA reported that there was association between shortness of breath and Paraquat exposure [12]. Paraquat concentrations sprayed manually could be deposited in the nose and contribute to internal dose workers [13]. The potential dose of Paraquat can be absorbed into the worker's body through inhalation, ingestion, dermal routes and accumulates in the lung, liver, heart, kidneys and other organs[9], [14].

Previous study in Malaysia reported that Paraquat air concentration measured during 25 min spraying at workers' breathing zone was 0.125 mg/m³ and potential inhalation dose calculated from air concentrations was 0.025 mg/kg/day [15]. Paraquat concentration also found in air was 0.24–0.97 µg/m³ during the measurement of 8 hours occupational exposure to Paraquat in Malaysia [16]. Therefore, it was necessary to measure airborne Paraquat residue, assessment of potential inhalation dose and Risk Quotient at palm oil plantations.

2. RESEARCH METHOD

This research was a descriptive study with cross sectional design and analysis of environmental health risk methods. This study was conducted on August 2016 at palm oil plantation in Banyuasin District South Sumatra Province Indonesia. Airborne Paraquat residue was collected from 8 workers with occupational activity as a supervisor and sprayer. Airborne Paraquat residue was measure for 25 minutes during spraying by using personal air sampler at worker's breathing zone. Airborne Paraquat residue was detected by High Performance Liquid Chromatography (HPLC) with NIOSH 5003 methods.

Data were collected from sprayers and supervisors and measured at worker's breathing zone using personal air sampler during spraying for 25 minutes. Before measuring, flow rate was calibrated by internal calibrator, set the flow rate to 2 L/min. Furthermore, put the personal air sampler on the workers waist and place the filter tube with distance of 30 cm at breathing zone and then stored samples before sending to laboratory for examination. Airborne Paraquat residue was tested in laboratory by High Performance Liquid Chromatography (HPLC) with NIOSH 5003 methods. Potential inhalation dose and Risk Quotient (RQ) were calculated by mathematical equations (1) and (2) [17].

$$I = \frac{C \cdot R \cdot t_E \cdot f_E \cdot D_t}{W_b \cdot t_{avg}} \quad (1)$$

$$RQ = \frac{I}{RFC} \quad (2)$$

The variables were used to calculate potential inhalation dose and Risk Quotient (RQ) i.e. airborne Paraquat residue (C:0.0125 mg/m³), breathing rate (R:0,83 m³/jam), time of exposure (t_E:8 hours/day), frequency of exposure (f_E:250 days/year), duration of exposure (D_t:30 years for non-carcinogenic substances), average time period (duration of exposure x 365 days) and worker's weight (minimum weight, maximum weight, average weight of workers at palm oil plantation and average weight of Indonesian workers) and Acceptable Operator Exposure Limit (AOEL:0.0005 mg/kg/day).

3. RESULTS AND ANALYSIS

3.1. Airborne Paraquat Residue

The results of airborne Paraquat residue were described in Table 1. Based on Table 1 showed that the average of airborne Paraquat residue was 0.0125 mg/m³ and that value was less than Threshold Limit Value recommended of ACGIH (American Conference of Government Industrial Hygienists) [18]. This condition was caused by Paraquat solution used with a 20% solution form and before being sprayed it

was diluted with 100 ml water and mixed into 15 liters of water. Consequently, when sprayed Paraquat particles were more easily fall to the ground and airborne Paraquat residue was slightly.

Table 1. The Results of Laboratory Test of Airborne Paraquat Residue Measured by Personal Air Sampler at Workers' Breathing Zone at Palm Oil Plantation (n=8)

Spraying Period	Airborne Paraquat Residue (mg/m ³)	Threshold Limit Value (mg/m ³)
During Spraying (25 min)	0.0125	0.5*

*ACGIH (2015)

Similar study was reported that airborne Paraquat concentrations at palm oil plantations in Malaysia was 0.125 mg/m³, Paraquat measured using personal air sampling at breathing zone for 25 min during spraying [15]. Airborne Paraquat residue was also found between <0.0001-0.00024 mg/m³ at banana plantations in Costa Rica [19]. In addition, airborne Paraquat residue measured during spraying was found respectively 0.13 mg/m³ and 0.55 mg/m³ [20]. Total Paraquat concentrations in the air was found 0.026 mg/m³ at cotton plantations California [21], while at rubber and palm plantations in Malaysia each were found respectively between 0.001-0.01 mg /m³ and <0.00005-0.09 mg/m³) [22].

3.2. Potential Inhalation Dose of Paraquat Assessment

The results of inhalation potential dose were described in Figure 1. Based on Figure 1 shows that the potential inhalation dose of paraquat exposure were between 0.0007-0.0013 mg/kg/day, the value more than Acceptable Operator Exposure Limit (0.0005 mg/kg/day) [23]. It means this condition was unsafe for workers during Paraquat spraying at palm oil plantation for 8 hours/day.

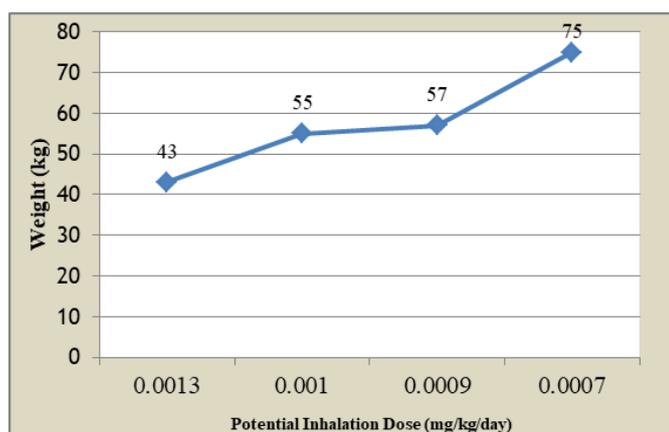


Figure 1. Potential inhalation dose of paraquat exposure

The values of potential inhalation dose at palm oil plantation was more than Acceptable Operator Exposure Limit (0.0005 mg/kg/day) [23]. It means that a potential inhalation dose of Paraquat at palm oil plantations was unsafe for workers during Paraquat spraying for 8 hours/day with the frequency of exposure 250 days/year for next 30 years. According to research at plantations in Malaysia were reported that potential inhalation dose of Paraquat was 0.025 mg/kg/day (breathing rate 1.75 m³/h, time of exposure 8 hours/day, weight 70 kg) [15].

In addition, potential inhalation dose was found about 0.0000163 mg/day (breathing rate of 1.7 m³/h for light working) [24]. The difference of potential inhalation dose of Paraquat was determined by measurements of airborne Paraquat residue, time of exposure, frequency of exposure, duration of exposure, duration of exposure and worker's weight [17]. In addition, the concentration of Paraquat entering the body during spraying was determined by Paraquat evaporation, Paraquat sprayed in droplet form and size of Paraquat particles have a sufficiently large size between 50-100 µm so it can be entered to respiratory tract [24]. However, another study reported that inhalation routes represent relevant exposure routes for internal dose exposure [19] and Paraquat was very toxic through inhalation route [24].

The average of potential inhalation dose was 0.0009 mg/kg/day, which was estimated airborne Paraquat residue at worker's breathing zone during spraying, was 1.8 times higher than the proposed Acceptable Operator Exposure Limit (0.0005 mg/kg/day). It conditions can be lead to respiratory disorders for workers. Therefore, to reduce the exposure of airborne Paraquat residue to the workers during spraying, so the complete use of personal protective equipment is required for workers. In addition exposure time per day and frequency of exposure should also be reduced.

3.3. Risk Quotient of Paraquat Exposure via Inhalation

Risk Quotient was described in Figure 2. Based on Figure 2 showed that the value of Risk Quotient was more than 1, it means that condition was unacceptable for workers during spraying Paraquat at oil palm plantations working for 8 hours/day with frequency of exposure 250 days/year for duration of exposure for the next 30 years. This condition was also unsafe for respiratory health workers. Therefore, it is necessary to risk control management by reducing the concentration of Paraquat in the air, time of exposure, duration of exposure and frequency of exposure.

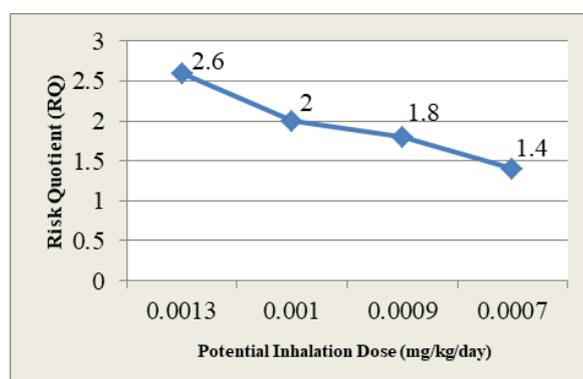


Figure 2. Risk quotient of paraquat inhalation dose at palm oil plantation

Although according to ACGIH that maximum of airborne Paraquat residue was 0.05 mg/m³, but the results of risk control management was reduced maximum of airborne Paraquat residue was only 0.006 mg/m³. Furthermore, the workers may be exposed to Paraquat with time of exposure for 125.3 days per year and frequency of exposure was about 4 hours/day, and the duration of exposure was only the next 15 years. It conditions accordance with WHO recommendations that workers who apply for pesticide spraying may be allowed for 4-5 hours/day [25]. In addition, the guidelines for the use of pesticides in Indonesia also recommended that workers conducting spraying should only be exposed to 5 hours/day [26].

4. CONCLUSION

The study provides important information on airborne Paraquat residue during spraying, potential inhalation dose, Risk Quotient and how to risk control management. Despite the results of Paraquat concentration measurements in the air was less than Threshold Limit Value, but potential inhalation dose of Paraquat more than Acceptable Operator Exposure Limit and Risk Quotient was unacceptable for workers during Paraquat spraying at oil palm plantations. Therefore, it was necessary to risk control management by determining the safe boundary value for airborne Paraquat concentration, exposure time, exposure frequency and duration of exposure.

Recommendations for the workers that workers must be used the personal protective equipment completely and standard during paraquat spraying; for company must be provided the personal protective equipment completely and give punishment to the workers who did not use it; for further studies, it necessary to assess the lung function of workers to early detect pulmonary fibrosis.

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