Determination of Paraquat (Herbicide) Residue Level in Sandy Clay Loam Soil Using High Performance Liquid Chromatography

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Abstract: Pesticide is considered as the most widely used form of agricultural chemical. Pesticide residue is the remaining pesticide on or in soil after pesticide is applied on agriculture soil. Soil is a component that is crucial to life. The research purposely concerned on major effects that could be contributed from medium to unlimited application of pesticide. The soil samples were systematically collected from 5 plots and Paraquat residues concentrations were determined in dissimilar depth of soil layers. The herbicide used was Paraquat that contained Paraquat Dichloride. High Performance Liquid Chromatography (HPLC) analysis detected the peak area volumes of Paraquat in soil samples at level ranging from 0.3 to 5.9 mg/l. The concentration of Paraquat in sandy clay loam soil showed that herbicide leached downward to the depth of 15 cm. The maximum concentration of Paraquat residue was detected at 0 to15 cm of soil depth at 2.783 mg/l. In highly organic soils, adsorption is weaker and Paraquat remains herbicidally active for longer, up to 29 days in one trial on soil with 98% organic matter [1]. Oral dose, LD_{50} for human is equal to 40-60 mg/kg [2] while the lowest fatal dose recorded for human was 17 mg/kg, but even lower doses may be fatal for children [3].

Keywords: Paraquat, pesticide residue, herbicide, sandy clay loam soil, high performance liquid chromatography.

1. INTRODUCTION

Agricultural chemistry is the study of both biochemistry and chemistry which are significant in agricultural production, the processing of crude product into food and beverages, and in environmental monitoring and remediation. These studies highlight the relationships between plants, animals and bacteria and their environment. Agricultural chemistry often intends to preserve or increase the fertility of soil, maintaining or improving the agricultural yield, and improving the quality of the crop. Agriculture systems are at the centre of developing countries' economies and family livelihood. Agriculture soil is defined as the improvement of the uses of soil and boosting of the production of food and fibre crops [4].

Modern agriculture depends quite heavily on the advances that have been made in science and chemistry to maximize the yield of crops and animals products. Fertilizers, pesticides and antibiotics play even popular roles in this field [5].

Soil is a component that crucial to life. Soil is used to grow plants that are generally consumed for food and for animal feed. Soil is extremely complex due to its physical characteristics and chemical reaction occurring in it is essential for instruments used for analysis. Soil consisted of solid portion which is composed of inorganic sand, silt, clay and organic matter which interact to produce large soil features like peds, profiles, pedons and landscape [5].

Fertilizers are added to the soil in crops growing areas to provide nutrients required by the plants. Fertilizers can be divided into two categories, organic and inorganic. Organic fertilizers are decomposed by microorganisms in the soil to release their nutrient. Inorganic or chemical fertilizers contain higher concentration of chemical that may be in short supply in the soil [4].

Pesticides acted as the most widely used form of chemical in agriculture. They are used to kill any undesired organism interfering with agricultural production. A pesticide is a chemical biological agent to control organisms that are considered to be harmful [4].

Pesticides are categorized into four main categories which are herbicides, fungicides, insecticides and rodenticides. Target pests can include insects, plants pathogen, weeds, mollusks, birds, mammals, and fish nematodes (roundworm) that destroy properties and spread diseases or are vectors for diseases. Although the use of pesticides is for human benefits, some have weaknesses such as potential toxicity to human and other animals. Over dose of pesticide causes soil contamination and leave pesticide residue in the soil [4].

Pesticide residue is the remained pesticide on or in soil after it was applied to agriculture soil. When pesticide is absorbed by the crops, it will leach below

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root zone by rain or irrigation. Bacterial oxidation or chemical hydrolysis acted as agents to degrade it in soil and adheres to soil particles [4].

Herbicide is the pesticide used to kill unwanted plants and weeds. Selective herbicides kill specific targets, while leaving the planted crop without giving harm. Herbicides are commonly used in agricultural production system throughout the world and Malaysia plantations are no exception.

Paraquat is the most common herbicide used in plantations crop. It is also the most acute toxic herbicide to be marketed over the last 60 years. Paraquat has been banned or disallowed of use in 32 countries (including the countries of the European Union), mainly for health reasons. Paraquat is acutely toxic and enters the body mainly by swallowing, or through damaged skin, and can also be inhaled [6]. Malaysia banned paraquat in 2002 with all use to be phased out to 2005 and all advertising to cease. In November 2007, the Malaysian government announced that the ban was postponed until further notice. In 2009 the Pesticide Board announced they were waiting for a study on Integrated Weed Management and alternatives on Paraquat, commissioned by the Roundtable on Sustainable Palm Oil (RSPO) before they make the final decision on Paraquat. Paraquat is still on the market in Malaysia, theoretically restricted for use on oil palms less than 2 years old [7].

The efficacy of herbicide in controlling weeds is important, its residual impact should also be considered for environmental safety for all processes which include soil adsorption, breakdown and degradation. The adsorption is binding of pesticides to soil particles and most of the soil-bound pesticides [4]. Transfer in soil is the movement of pesticide downward and spreading away from the target plants [8].

The objectives of the research are to determine Paraquat residue level, concentrations and its effects when applied on agriculture soil, which is in this study, was done on sandy clay loam type of soil. This research also aims to study the extraction of soil with Paraquat residues and Paraquat residue analysis using High Performance Liquid Chromatography (HPLC).

2. EXPERIMENTAL

2.1. Design of Experiment

15 plots of soil samples were collected systematically and each plot of soil samples was taken out at about 15 cm, 30 cm and 45 cm depth. The type of pesticide applied was Paraquat (Paraquat Dichloride). The basic approach to the study was the depth intervals of the soil samples for each plot of lands which were within 0 to15 cm, 15 to 30 cm and 30 to 45 cm. The soil sampling overview is shown as in Figure **1**. The upper depth of the soil has the possibility of containing the highest content of pesticide residues. Soil samples were wrapped with aluminum foils, kept in sealed poly bags and transported to the laboratory immediately.

2.2. Study Site

The study area was based in Kuala Dingin, Selama Perak where sandy clay loam soil was located at Selama Research Centre, Agricultural Chemical Sdn.Bhd., Malaysia.

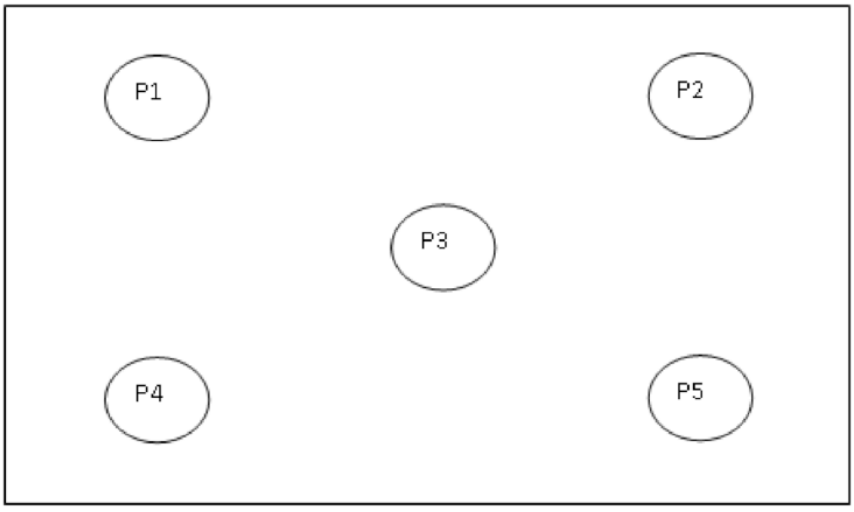

Figure 1: Soil sampling overview.

2.3. Soil Sampling Procedure

2.3.1. Depth Soil Sampling

At each sampling area, one site was dedicated for the collection of soils. Auger was used to bore holes to desired sampling depth of 0 to 15 cm, 15 to 30 cm and 30 to 45cm. The samples were collected directly from the auger.

2.3.2. Collecting Samples with the Auger

Soil sample area was cleared from any surface debris (twigs, rocks, litter). The surface of the soil was removed at depth 15 cm for area of approximately 15 cm in radius around the drilling location. Augering process began by periodically removing and depositing accumulated soils onto aluminum foil spreaded near the hole. The samples were collected after the auger was completely removed from the hole. The soil samples were then transferred into appropriate protected and labelled sample containers with waterproof stickers. The samples were transported to the laboratory and freeze dried. Only soil fractions of 2 mm were used for further analysis [9].

2.4. Soil Extraction and Analysis

2.4.1. Soil Extraction for Paraquat Residue Level

Soil samples were first sieved at 2 mm and then poured into conical flask. The weight was recorded to the nearest 0.1g of sodium sulphates, Na_2SO_4 (granular, anhydrous) and it was mixed into the soil samples to increase the contact surface for free-flowing texture and better mixing of the solvent with the sample.100 ml of methanol was immediately added as the extraction solvent. Soil sample was shaked using orbital shaker at 120 rpm for 4 hours at 25^{o}C.

The extracted soils were then centrifuged at low speed to remove the particles. The extract was decanted and filtered through filter paper in a Buchner funnel that was attached to a clean filtration flask. The mixtures were extracted with methanol three times and separated from the sample by centrifugation. The extracts were prepared for final concentration using rotary evaporator to 1ml at 60^{o}C, and then were analyzed. The extracted samples were stored at 4^{o}C if the analysis deferred [9].

2.4.2. Analytical Method Using High Performance Liquid Chromatography (HPLC)

Standard stock concentration of Paraquat calibration mix solution and blank sample (deionizer distilled water) were inserted together with the samples to be analyzed in each batch to perform Quality Control (QC).The column, mobile phase, flow rate, detection wavelength and injection volume were adjusted first. The samples were injected through auto sampler and detected by photodiode array (PDA) at wavelength UV 254µm.The peak area and retention time were recorded and compared with the calibration curve to determine Paraquat residue concentrations the in soil samples [5].

3. RESULTS AND DISCUSSION

3.1. The Retention Time and Peak Area of Paraquat Standard Solution

The chromatogram in Figure **2** showed the peak area for Paraquat standard solution containing

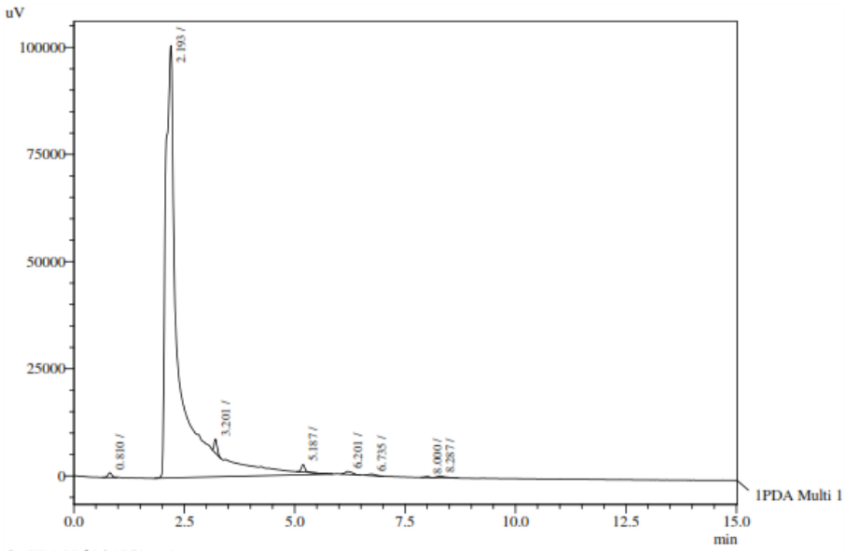

Figure 2: The peak area for Paraquat standards solution.

Table 1: Summarization of Paraquat Standard Solution Data of HPLC

Plot	Retention time	Peak Area
Paraquat Standard Solution	2.193	2153321

Paraquat as the active ingredient. The peak on retention time was 2.193, which matched with the retention time of Paraquat Dichloride compound, hence the standard solution was confirmed to contain certain level of Paraquat concentration. Table **1** summarized the peak area and retention time of Paraquat standard solution.

Table **2** displayed the peak area from each of the soil samples which showed approximately similar retention time at range 2.1± 0.4 min as found in the standard solution but with different peak area volumes. This indicated that each of the soil samples contained Paraquat compound but in different concentrations due to herbicide translocation. The inconsistent peak area trends in the chromatogram could be caused by certain factors that led to different Paraquat concentrations found in each plot of soil samples. The soil samples also contained undefined compounds since other peaks also showed up in the chromatograms and were disregarded as insignificants.

3.2. Summary of Soil Sample Peak Area

Table **3** showed the peak area value acquired from HPLC data analysis of each soil samples. The wide ranged values of peak areas refers to the Paraquat concentrations in the soil samples. The immense peak area value indicated excessive Paraquat concentration. Based from the data collected, there were inconsistent and irregular peak areas found from each soil samples that were collected from distinct plots and depths. Each soil samples showed various values of Paraquat concentrations. The average peak area referred to the average value of peak areas for three soil samples from different depths in the same plot. The average peak area showed in Figure **3** showed the intensity of Paraquat concentration for each plots. The ascending order of Paraquat concentration is Plot 1<Plot 2<Plot 3<Plot 4<Plot 5.

3.3. Calculation of the Actual Concentration of Paraquat in Sandy Clay Loam Samples

The peak areas in the chromatograms represent the paraquat concentrations in the sandy clay loam samples in which the largest proportioned peak area value showed excessively high paraquat concentration. However to determine the paraquat concentration in soil, the actual concentration of paraquat in standard solution must be determined first and then compared to

Table 2: Summarization of HPLC Soil Samples Data

Plot	Depth	Retention Time	Peak Area
1	P1D1	2.176	5153
	P1D2	2.226	1276
	P1D3	-	-
2	P2D1	2.270	2354
	P2D2	2.338	2336
	P2D3	2.343	2288
3	P3D1	2.437	10042
	P3D2	2.422	3661
	P3D3	2.416	3421
4	P4D1	2.470	9987
	P4D2	2.456	6195
	P4D3	2.447	8778
5	P5D1	2.445	8491
	P5D2	2.472	19402
	P5D3	2.487	20866

Table 3: The Summary of Each Soil Sample Chromatography Peak Area Value

SAMPLE	DEPTHS	*PEAK AREA	*AVERAGE PEAK AREA
PLOT 1 SAMPLE			
P1D1	0 – 15 CM	5153	2143
P1D2	15 – 30 CM	1276	
P1D3	30 – 45 CM	0	
PLOT 2 SAMPLE			
P2D1	0 – 15 CM	2354	2326
P2D2	15 – 30 CM	2336	
P2D3	30 – 45 CM	2288	
PLOT 3 SAMPLE			
P3D1	0 – 15 CM	10042	5708
P3D2	15 – 30 CM	3661	
P3D3	30 – 45 CM	3421	
PLOT 4 SAMPLE			
P4D1	0 – 15 CM	9987	8320
P4D2	15 – 30 CM	6195	
P4D3	30 – 45 CM	8778	
PLOT 5 SAMPLE			
P5D1	0 – 15 CM	8491	16253
P5D2	15 – 30 CM	19402	
P5D3	30 – 45 CM	20866	
STANDARD SOLUTION		2153321	

*Peak area value represents the Paraquat concentration on soil sample.
*Average peak area represents the average peak ares value of same plot soil samples.

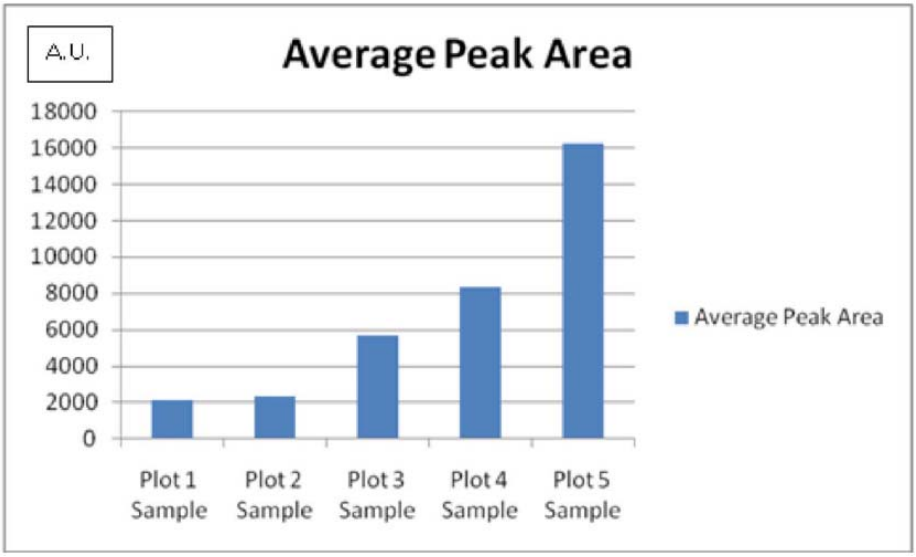

Figure 3: Average Peak Area of soil sample.

the peak area of both standard solution and the soil samples.

The standard solution was made by mixing pure Paraquat solution with distilled water at ration 1:100 and this ration used was the exact ration applied in the

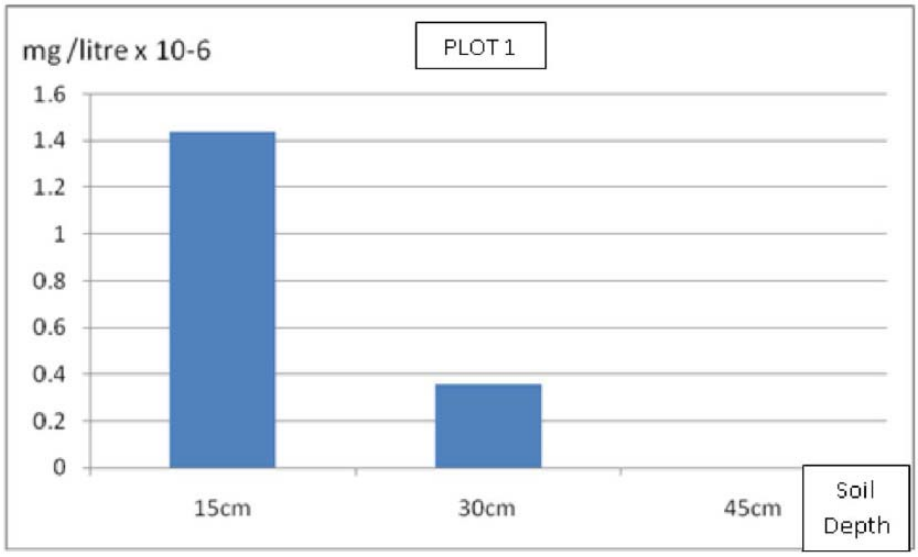

Figure 4: Actual Concentration of Paraquat of soil sampling in plot 1.

field. The actual concentration of Paraquat in standard solution was determined using basic concentration formula.

3.4. The Actual Concentration of Paraquat in Each Soil Sample

Plot 1 was located at the right corner of the field where Paraquat was applied least due to cultivation practices such as plowing. The actual concentration of Paraquat in Plot 1 soil sampling is shown on Figure **4**. The residue of Paraquat in Plot 1 soil sample was decreasing from depth 15cm to 30cm. The Paraquat concentration gradually decreasead from the top to lower soil layer. The retention time for P1D1 and P1D2 were 2.176 and 2.226 respectively. For plot 1 P1D1 soil sample, the residues of Paraquat in sandy clay loam soil was 1.436 mg/l which appeared at 2.176 minutes retention time while P1D2 soil sample showed 0.356 mg/l of Paraquat residues. This plot soil sample was approximately similar with the retention time of Paraquat standard solution. The residues of Paraquat for plot P1D1 soil sample was only 0.2393% compared to the actual concentration of Paraquat.

The Paraquat residue value of soil sample for Plot 2 as shown in Figure **5** revealed gradual decline from depth 15cm to 45cm which means the concentration of Paraquat decreased when it reached the deepest soil depth. The actual concentration of Paraquat value were 0.656, 0.651 and 0.638mg/l for soil sample labelled as P2D1,P2D2 and P2D3 respectively. The retention times for soil samples in Plot 2 were 2.270, 2.338 and 2.343 respectively. The higher density and

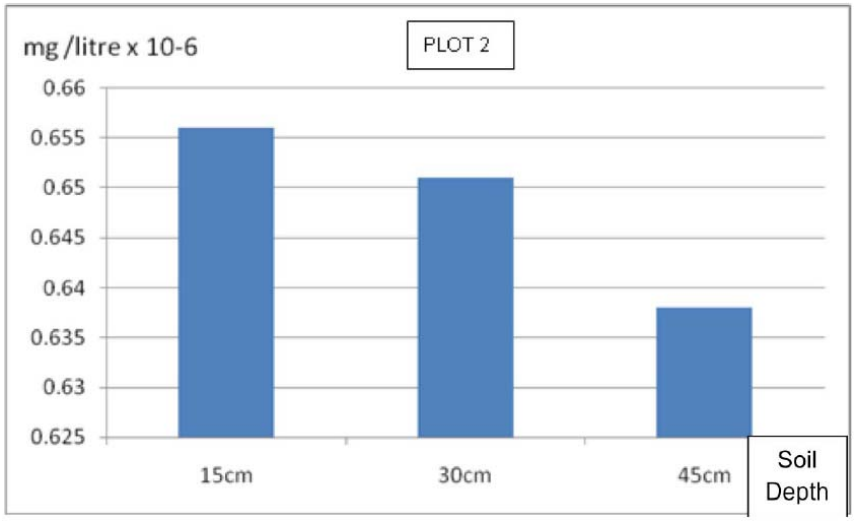

Figure 5: Actual Concentration of Paraquat of soil sampling in plot 2.

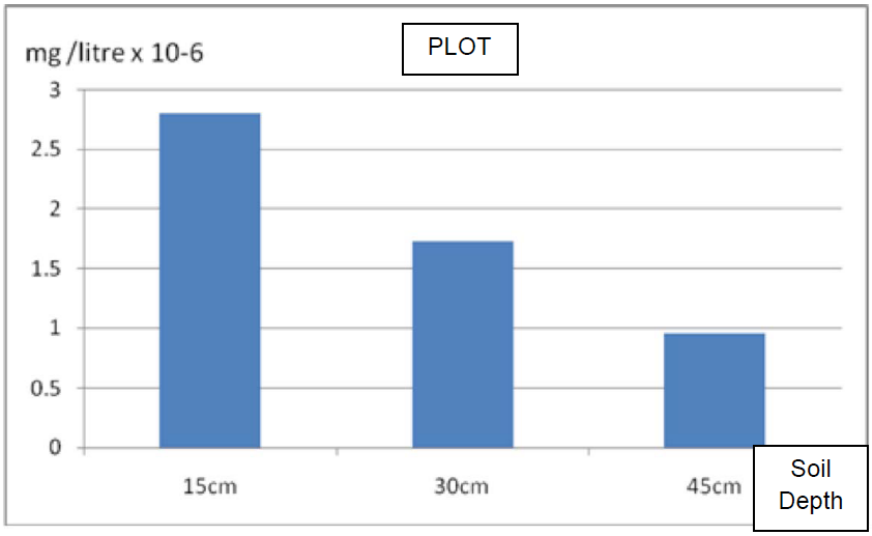

Figure 6: Actual Concentration of Paraquat of soil samplings in plot 3.

concentration from upper soil deposit may leach to the lower soil layer.

Figure **6** showed the actual concentration of Paraquat in Plot 3 soil sample. Plot 3 was located at the middle of the field. The residues of Paraquat in Plot 3 dropped off from soil depth 15cm, 30cm and 45cm. The residues in Plot 3 were 2.798, 1.020 and 0.953mg/l with retention time 2.437, 2.422 and 2.416 respectively. The reason why the peak areas became decreased was due to the translocation that involved the movement of soil-forming materials through the development of soil profile.

The Paraquat residues for Plot 4 as shown in Figure **7** showed up and down reading patterns that revealed no large difference found between these three soil samples. This means that the concentration of Paraquat first decreased, and then increased back. The P4D1 soil sample contained 2.783 mg/l of Paraquat concentration while P4D2 soil sample showed 1.726mg/l of actual concentration of Paraquat. P4D3 soil sample contained 2.446mg/l of Paraquat concentration. This indicated that the top soil layer has no large difference of Paraquat residues compared with deeper soil layers. The reason for amount of Paraquat concentration residues appeared in deeper layer might be due to the numerous plowing practices at the agriculture field in which the disturbances made the Paraquat leached deeper into soil layers with 45 cm depth.

Based from Figure **8**, Plot 5 showed increasing trend of Paraquat residue concentrations from top soil

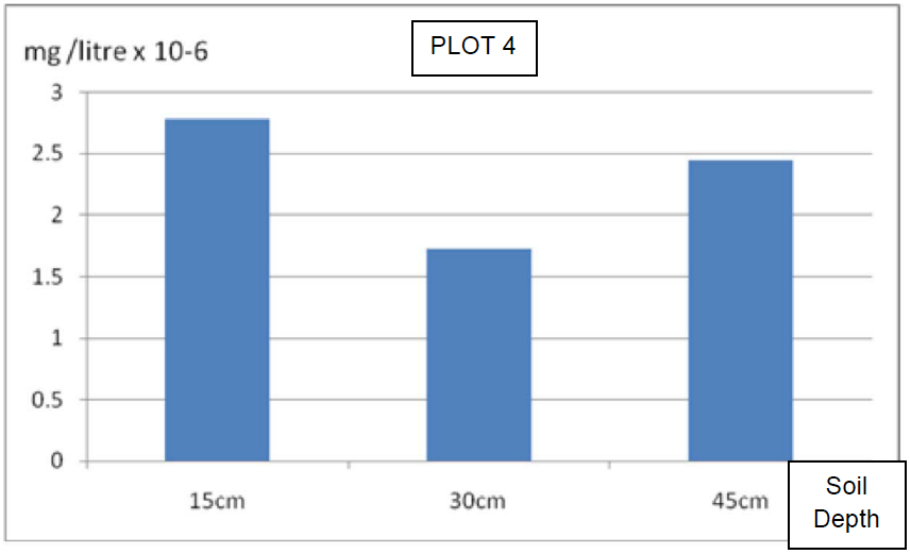

Figure 7: Actual Concentration of Paraquat of soil samplings in plot 4.

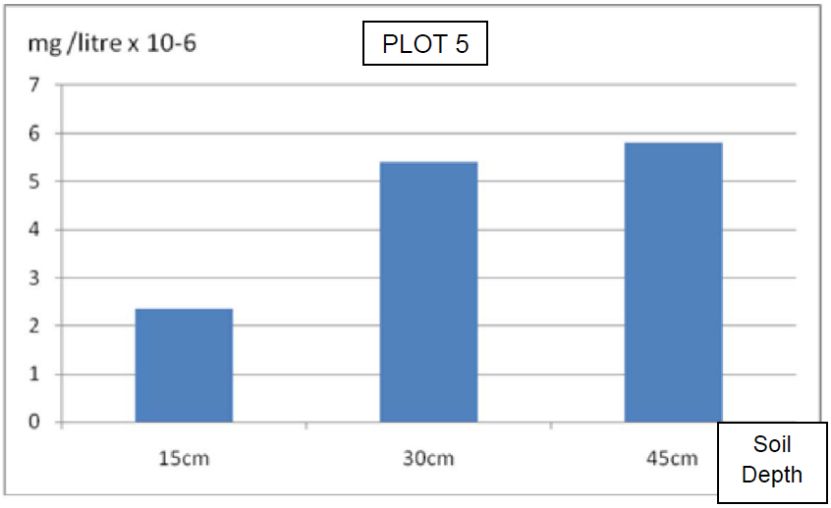

Figure 8: Actual Concentration of Paraquat of soil samplings in plot 5.

layer to deeper soil layer. However, the most significant difference can be seen between plot 5 soil samples and other soil samples. Soil samples in plot 5 consisted of higher amount of residues which were P5D1, P5D2 and P5D3 with 2.366, 5.406 and 5.814mg/l residues concentrations respectively. Plot 5 was located at the edge of the corn field where the location was seldom plowed properly, which then led to higher concentration of Paraquat residues accumulated. Translocation means the movement or change of pesticide product metabolism from one location to another [10]. Usually during raining season, translocation might occurred from the water running through soil transferring materials such as Paraquat residues from upper to lower portion of the soil profile.

Table 4: The Actual Concentration of Paraquat in Each Soil Sample

SAMPLE	PEAK AREA	*FACTOR	*ACTUAL CONCENTRATION IN SOIL SAMPLE (mg/L) x 10/L) x 10^{-6}
PLOT 1 SAMPLE			
P1D1	5153	0.0024	1.436
P1D2	1276	0.0006	0.356
P1D3	0	0.0000	0.000
PLOT 2 SAMPLE			
P2D1	2356	0.0011	0.656
P2D2	2336	0.0011	0.651
P2D3	2288	0.0011	0.638
PLOT 3 SAMPLE			
P3D1	10042	0.0047	2.798
P3D2	3661	0.0017	1.020
P3D3	3421	0.0015	0.953
PLOT 4 SAMPLE			
P4D1	9987	0.0046	2.783
P4D2	6195	0.0029	1.726
P4D3	8778	0.0041	2.446
PLOT 5 SAMPLE			
P5D1	8491	0.0039	2.366
P5D2	19402	0.0090	5.406
P5D3	20866	0.0097	5.814
STANDARD SOLUTION	2153321	1.0000	0.0006

*Factor indicates the peak area of soil sample divided by peak area of standard solution.
*Actual concentration in soil (mg/litre) = Soil sample peaks area value / Standard solution peaks area value X Concentration of standard solution.

In summary, based from Table **4**, the residues of Paraquat or the actual Paraquat concentrations were detected in soil samples at levels ranging from 0.300 to 5.900 mg/litre. The lowest residues of Paraquat was 0.356 mg/l at P1D2 soil sample while the highest residue of Paraquat was 5.814mg/l at P5D3 soil sample.

The presence of paraquat residues were mostly in the first four plots of the upper 0to15cm soil level which indicated that this herbicide could not leach deeper into the soil. The level of paraquat residues detected however were extremely low and did not pose any toxicological concern. The source of Paraquat contamination was difficult to establish but most farmers are aware of the potential of contamination when they applied more than the recommended dosage or released pesticides into the surface of agriculture fields when washing the spray tanks. The vertical movement of Paraquat in the soil was limited due to the adsorption and therefore remained concentrated at the top surface of soil (at 0 to15cm).

Leaching was one of the reason for Paraquat concentration decreased from top to bottom. The flow of Paraquat leaching was downward where the compound with higher density may leach into deeper soil layer enhanced by gravity. Leaching of pesticides in the soil was influenced by adsorption of the pesticide onto the soil particles, water solubility of pesticide, volume of water flow, pH, and the soil texture.

3.5. The Estimation of Paraquat Concentration in Crops

Table **5** showed the estimated Paraquat concentrations in crop which were calculated by recognizing the Paraquat concentration differences between standard solution and the soil samples. In fact, the Paraquat was just an estimation since there were certain factors that could cause the pesticides to drift out from the target pest. Differences of Paraquat concentration between standard solution and soil estimated how much Paraquat were absorbed by crops. The Paraquat concentration in crops can be calculated using the following formula:

Estimated Paraquat concentration absorbed by crops (mg/L) = Standard concentration of Paraquat solution (mg/L) – Paraquat concentration found in soil (mg/L).

3.6. Statistical Analysis

Based from Table **6**, T-test (One sample) was done on five plots of soil samples to test the variances of mean concentration between each plot soil samples.

Table 5: Estimated Paraquat Concentration Absorbed by Crop

Sample	Actual concentration in soil sample (mg/litre) x 10^{-6}	Estimated concentration in crops (mg/litre) x 10^{-3}
PLOT 1 SAMPLE		
P1D1	1.44	1.1986
P1D2	0.36	1.1997
P1D3	0.00	1.2000
PLOT 2 SAMPLE		
P2D1	0.67	1.1994
P2D2	0.65	1.1994
P2D3	0.64	1.1994
PLOT 3 SAMPLE		
P3D1	2.79	1.1973
P3D2	1.02	1.1990
P3D3	0.95	1.1991
PLOT 4 SAMPLE		
P4D1	2.78	1.1973
P4D2	1.73	1.1983
P4D3	2.45	1.1976
PLOT 5 SAMPLE		
P5D1	2.37	1.1967
P5D2	5.41	1.1946
P5D3	5.81	1.1922

Plot 1, Plot 3, Plot 4 and Plot 5 indicated that [t(2) > 0.01] which meant that the soil sample in these plots showed no significant difference compared with the Paraquat standard solution.

Plot 2 indicated that [t(2)= 0.00,p < 0.01] which meant that the soil sample in Plot 2 showed significant difference compared with Paraquat standard solution.

Based on the statistical t-test showed that no significant difference of p values between residues in the soil samples and the pure Paraquat standard solution of containing high amount of accumulation of Paraquat residues that can have impact on the agriculture field.

3.7. Environmental Concerns

Paraquat is very persistent in soil [11]. It binds readily to both clay and organic matter, with adsorption increases with clay content. The soil K_{oc} (sorption coefficient) ranges from 8400 to 40,000,000 [12]. In Thailand, 5.83% desorption was found in sandy loam soils (only 0.17% in clay soil) [13]. Paraquat is assumed to be strongly adsorbed to clay particles, however the US Environmental Protection Agency (EPA) noted that "the potential for desorption does exist" [11]. Adsorption increases with increasing pH, and decreases with increasing acidity [7]. In highly organic soils, adsorption is weaker and Paraquat remains herbicidally active for longer, up to 29 days in one trial on soil with 98% organic matter [1].

Field studies have found half-life (DT_{50}) of 7 to 8 years in the United Kingdom and 10 to 20 years in the United States. The residues in the soil in Europe monitored were found to be between <0.2 to 15 mg/kg [12]. In field studies in Thailand, only 25% of Paraquat remained after 3 months in which the faster degradation was attributed to higher temperatures and intensive solar radiation that caused photodegradation [13].

3.8. Health Concerns

The lethal dose, LD_{50}, is the dose that kills 50% of test animal. Oral dose LD_{50} for human is equal to 40-60 mg/kg [2] while Wesseling noted that the lowest fatal dose recorded for human was 17 mg/kg, but even lower doses may be fatal for children [3].

Paraquat is moderately toxic to mammals and birds [11]. Based on toxicity to rodents, US EPA noted that Paraquat was moderately acute to small mammals, and lethal below 25 ppm after 12 weeks exposure [14]. The European Commission's Scientific Committee on Plant emphasized that Paraquat can be expected to cause lethal and sub lethal effects [15]. Food Agricultural Organization (FAO) claimed that the oral LD_{50} male rat equivalent with 113.5 mg/kg body weight

Table 6: T-Test Comparison of the Mean of Five Soil Sample Plots

One-sample test						
				Test value = 2.193		
					99% Confidence Interval of the Difference	
	t	df	Sig.(2-tailed)	Mean Difference	Lower	Upper
Plot 1	-3.696	2	0.066	-1.59567	-5.8806	2.6893
Plot 2	-287.94	2	0.000	-1.54467	-1.5979	-1.4914
Plot 3	-0.998	2	0.424	-0.60267	-6.5987	5.3934
Plot 4	0.402	2	0.727	0.12533	-2.9686	3.2193
Plot 5	2.147	2	0.165	2.33567	-8.4599	13.1312

One-Sample Statistics				
	N	Mean	Std.Deviation	Std.Error Mean
Plot 1	3	0.5973	0.74780	0.43174
Plot 2	3	0.6483	0.00929	0.00536
Plot 3	3	1.5903	1.04641	0.60414
Plot 4	3	2.3183	0.53994	0.31174
Plot 5	3	4.5287	1.88400	1.08773

(Paraquat ion) was 334 (range 246-457) mg/kg low of Paraquat Dichloride technical while the oral LD_{50} female rat equivalent with 93.4 mg/kg low (Paraquat ion) was 40-200mg/kg low of Paraquat Dichloride technical [16]. Paraquat has higher toxicity to humans than it does to rats.

3.9. Safe Use of Pesticides

The herbicide should be applied evenly on the weeds surface so that the entire weeds near the crops will be exposed to the lethal amount of the chemical. Herbicide should be applied on wilted plants or during the hottest part of the day. Dust is applied only when the wind is calm and plants are dry. Spray should be applied when the wind is no more than 5 to 10 miles per hour. Retreatment may be necessary after rain. Herbicide should be applied only at recommended dosages. Increased amount can be dangerous, cause plant damages and leave harmful residues without improving insect control. Always read and follow mixing and application instructions on the herbicide label for safe and effective weed control [4]. The length of effective control of herbicide varies widely. The longevity of toxic properties varies primarily with the product, formulation, water, pH and environmental conditions. Temperature, humidity, wind and sunlight also affect herbicides. The greater the extreme, the sooner the herbicides are detoxified [4].

4. CONCLUSION

Based on the data analysis from the HPLC result, there were low significant amount of Paraquat residues detected in each soil samples. From the HPLC chromatograms represented, precise peak areas were found in each soil samples and they matched with the peak area of the Paraquat standard solution. The Paraquat standard solution consisted of pure Paraquat concentration at 2.193 min retention time, and the peak areas of the soil samples also showed exactly similar peaks at range 2.1± 0.4 which were approximately at the same retention time as well. Overall, the highest amount of residues was found in top soil level mostly in Plot 1, 2, 3 and 4 ranging from concentration values 0.6 to 2.7 mg/l except for P5D3 soil sample that showed high amount of residues at 5.814 mg/l due to the translocation occurred. The inconsistence of Paraquat concentrations found in different soil layers in each of the five plots was due to the various peak area volumes. The Paraquat residue concentrations obtained through HPLC analysis was insufficient to influence or cause impacts on the agriculture soil and absolutely did not possess the capacity to cause acute toxicity to the crops, animals and the environment. There was also no noticeable and obvious effects found at the agriculture field. However there is a possibility that the Paraquat residues might accumulate over time and cause serious impacts on the agriculture soil after they exceeded the threshold level. This research outputs acted as guidelines for farmers to access the risks and understand the effects from utilizing the herbicide.

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