CHAPTER 2

A SURVEY OF PESTICIDE RESIDUES IN BLOOD OF SCHOOL CHILDREN IN PENINSULAR MALAYSIA

2.1 INTRODUCTION

Persistent organic pollutants including OC pesticides continue to be of concern particularly in developing countries where such chemicals continue to be used on a large scale. Due to its persistent and lipophilic characteristics such chemicals have been detected in sediment (Ayas *et al.*, 1997), water (Ayas *et al.*, 1997; Dua *et al.*, 1996; Dua *et al.*, 1998) and air (Arthur *et al.*, 1976; Coupe *et al.*, 2000; Olden *et al.*, 1996). The presence of the chemicals in a wide range of biota (Beretta *et al.*, 1994; Bordet *et al.*, 1993; Cok *et al.*, 1997; Dommarco *et al.*, 1987; Jensen, 1983; Pardio *et al.*, 1998; Abbott *et al.*, 1981; Mes *et al.*, 1982; Kannan *et al.*, 1994; Rhainds *et al.*, 1999; Siyali, 1972) including humans are also indicative of the seriousness of the problem. Hence, OC pesticide residues have been observed in human breast milk (Beretta *et al.*, 1994; Bordet *et al.*, 1993; Cok *et al.*, 1997; Dommarco *et al.*, 1987; Jensen, 1983; Pardio *et al.*, 1998), adipose tissue (Abbott *et al.*, 1981; Mes *et al.*, 1982; Kannan *et al.*, 1994) and blood (Kannan *et al.*, 1994; Rhainds *et al.*, 1999; Siyali, 1972). In Malaysia, trace amounts of OC pesticides continue to be detected in the environment despite the banned or restricted status of the vast majority of such chemicals (Tan *et al.*, 1994). Currently, amongst the OC pesticides, only lindane and endosulfan are allowed to be used. The continued detection of banned chemicals is attributed to the persistent characteristic of the chemicals in addition to possible illegal applications.

The present chapter examines the exposure of the Malaysian children to selected OC pesticides and its metabolites (lindane, heptachlor, aldrin, dieldrin, endrin, o,p'-DDE, p,p'-DDE, p,p'-DDT, α-endosulfan, β-endosulfan, endosulfan sulfate) as well as two organophosphorous (OP) pesticides, diazinon and chlorpyrifos both of which are

considered as relatively persistent chemicals. An attempt is also made to correlate exposed individuals with potential sources of the chemicals as well as routes of exposure.

2.2 EXPERIMENTAL

2.2.1 Chemicals

1.	Standards of lindane, heptachlor, aldrin, dieldrin, endrin, o,p'-DDE, p,p'-DDE, p,p-DDT, α-endosulfan, β-endosulfan, endosulfan sulfate, diazinon and chlorpyrifos	Chem Service, Inc., analytical standard (99.0% purity)
2.	Anhydrous sodium sulfate	BDH Chemicals, England; analytical grade
3.	n-hexane (Analytical grade)	Fisher Scientific; 99.5% purity

2.2.2 Apparatus

1.	Centrifuge	Eppendorf
2.	Analytical balance	ER-180A
3.	Gas chromatograph-Mass spectrometer	GC-MS (QP5000) Shimadzu

2.2.3 Stock solutions

Stock solutions (100μg/ml) of lindane, heptachlor, aldrin, dieldrin, endrin, op,'-DDE, p,p'-DDE, p,p'-DDT, α-endosulfan, β-endosulfan, endosulfan sulfate, diazinon and chlorpyrifos were prepared in n-hexane and stored at 4°C until further dilution..

2.2.4 Sampling and data collection

The survey conducted between September-November 1998 involved a wide cross-section study of schoolchildren aged between 12-15 years. Eligible respondents were randomly selected and recruited from those with parental consent. Sixty (60) schools from the

identified study sites were randomly sampled. The study areas were divided into three categories referred to as site categories; industrial areas (Klang Valley and Penang), agricultural areas (Cameron Highlands and Kuala Selangor) and control areas with low risk of pollution from either urban or agricultural sources (Kota Bharu and Jerantut). The distribution of the study areas is illustrated in Table 2.2. A total of 577 schoolchildren were randomly selected from the 60 identified schools to participate in the study. A questionnaire including inquiries of socio-economic background, residential and environmental data, school data, diet, outdoor recreation and health history was also included (Appendix 1). The demographic and food consumption characteristics are given in Table 2.3.

2.2.5 Blood sample collection

The skin at the elbow of the supine student was sterilized with surgical spirit and gauze, and tourniquet was tied just below the mid arm. The skin was punctured to draw 5 ml of blood using a 5 ml sterile disposable syringe into the Vacutainer tubes (Becton-Dickinson; sterile, sodium heparin) and stored at -20°C until analysis. 57 students were selected to obtain duplicate samples for quality control.

2.2.6 Method of analysis

All solvents used were of pesticide grade. All glassware used was pre-washed with acetone and hexane.

Before extraction, whole blood samples were homogenised at room temperature. The whole blood sample (1 g) in a 5 ml stoppered test tube was then shaken for 5 minutes with

2 ml of 2% sodium sulfate solution followed by additional agitation for a further 5 minutes following addition of 2 ml of n-hexane. The mixture was then placed in an ultrasonic bath for 20 minutes, and centrifuged for 10 minutes (4500 rpm) until there was a clear separation of hexane and blood mixture. The organic phase was then transferred into a vial and the blood mixture was re-extracted with an additional 2 ml of n-hexane. The pooled extract was dried over anhydrous sodium sulfate, evaporated to dryness under a stream of nitrogen and reconstituted to 0.3 ml n-hexane. 1 µl of the concentrated extract was injected directly into the gas chromatograph without clean-up.

2.2.7 Calibration and quantification

Calibration was carried using external standards. The direct comparison technique using external standards was chosen for the present study because the test substances identified in the sample clearly matched with known standards based on their retention times and selected mass ion sets.

2.2.8 Gas Chromatograph-Mass Spectrometer (GC-MS)

A Shimadzu QP5000 gas chromatograph coupled with mass spectrometer was used for the quantitative analysis of residue of OC pesticides in blood. The J&W DB1 fused silica capillary column (30m x 0.32mm i.d.) was used. The operating conditions for the Gas Chromatograph are as follows:

Oven temperature: Initial temperature 70°C

Ramp 20°C/min to 130°C followed by 5°C/min to 200°C, then from 200°C to 300°C at 15°C/min and hold for 5 minutes and hold for 5 minutes

Injector temperature: 280°C

Interface temperature: 280°C

Carrier gas: Helium (Highly purified)

Carrier gas pressure: 50.0 kPa

Carrier flow rate: 25.0 ml/min

Column flow rate: 2.3 ml/min

Injection mode: Splitless

Injection volume: 2 µl

Mass spectrometer:

The detection was done using quadruple detector with electron ionization mode detection. The ionization potential was 70eV.

Data acquisition mode: Selected Ion Monitoring (SIM)

2.2.9 Statistical analysis

Chi-square test (χ^2) was used to test whether the character frequencies of two or more groups were different from each other or associated in some way. The 95% confidence interval (CI) was also used to measure the precision of the estimated measures for mean pesticide residue levels. The distribution of mean pesticide residue levels among the study areas, duration of stay at current residences, duration of study at current schools and average travel time per day were analysed using ANOVA. All statistical analysis was based on SPSS. The relation between the mean pesticide residues levels and the rate of food consumption in each area was analysed using Canoco for Windows Version 4.02.

Table 2.1. Ions monitored at the SIM mode

No	Compound	m/z 1	m/z 2	m/z 3	Retention time (min)
1	Lindane (γ-BHC)	111	181	217	9.80-11.80
2	Diazinon	137	179	304	11.10-13.10
3	Heptachlor	100	272	274	12.60-14.60
4	Aldrin	261	263	293	13.80-15.60
5	Chlorpyrifos	246	248	318	14.10-16.10
6	o,p'-DDE	246	248	318	16.30-18.30
7	p,p'-DDE	165	235	237	17.50-19.50
8	p,p'-DDT	197	199	314	19.70-21.70
9	α-Endosulfan	195	207	241	16.40-18.40
10	β-Endosulfan	195	207	237	18.00-20.00
11	Endosulfan sulfate	237	272	274	19.20-21.20
12	Dieldrin	79	263	277	17.30-19.30
13	Endrin	272	279	343	17.90-19.90

The total ion chromatogram of OC and OP pesticides are shown in Figure 2.1 and 2.2.

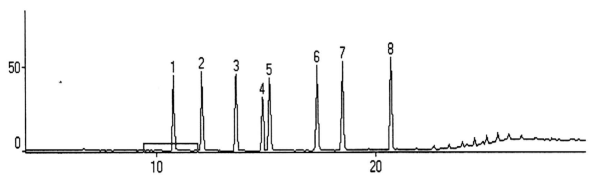


Figure 2.1. Total ion chromatogram of lindane (1), diazinon (2), heptachlor (3), aldrin (4), chlorpyrifos (5), o,p'-DDE (6), p,p'-DDE (7) and p,p'-DDT (8)

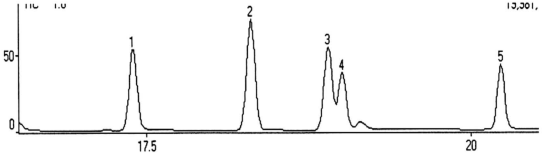


Figure 2.2. Total ion chromatogram of α-endosulfan (1), dieldrin (2), endrin (3), β-endosulfan (4) and endosulfan sulfate (5)

The mass spectra of OC pesticides are shown in Figure 2.3 - 2.13 while the mass spectra of OP pesticides are shown in Figure 2.14 and 2.15.

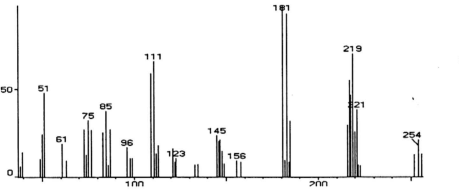


Figure 2.3. Mass spectrum of lindane (γ-BHC)

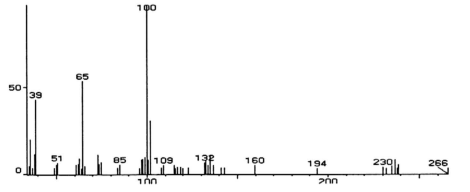
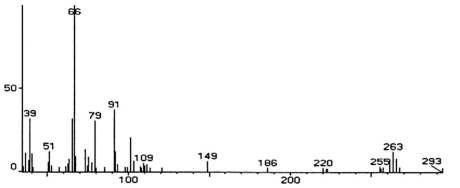


Figure 2.4. Mass spectrum of heptachlor



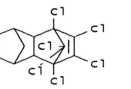
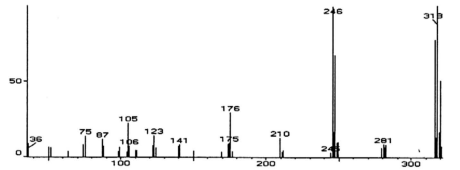


Figure 2.5. Mass spectrum of aldrin



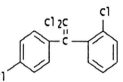
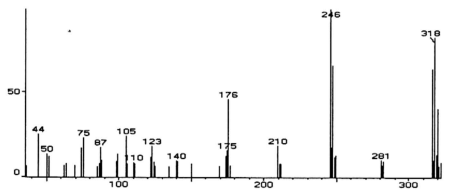


Figure 2.6. Mass spectrum of o,p'-DDE



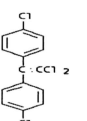


Figure 2.7. Mass spectrum of p,p'-DDE

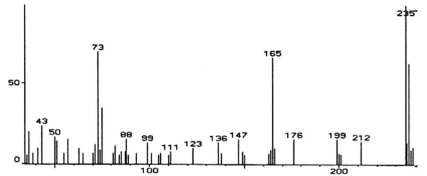


Figure 2.8. Mass spectrum of p,p'-DDT

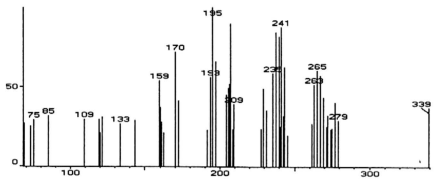


Figure 2.9. Mass spectrum of α-endosulfan

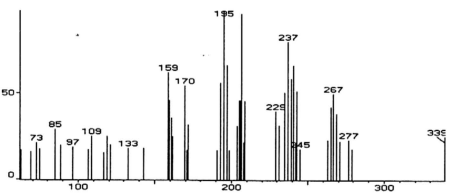


Figure 2.10. Mass spectrum of β-endosulfan

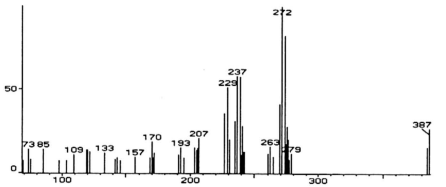


Figure 2.11. Mass spectrum of endosulfan sulfate

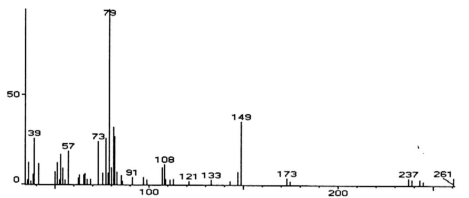


Figure 2.12. Mass spectrum of dieldrin

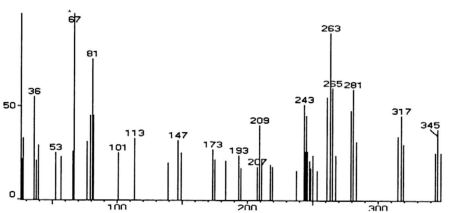


Figure 2.13. Mass spectrum of endrin

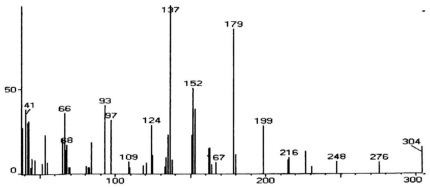


Figure 2.14. Mass spectrum of diazinon

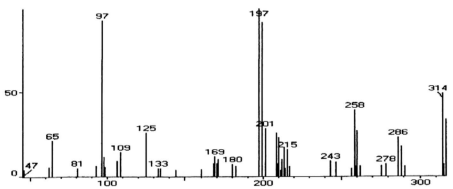


Figure 2.15. Mass spectrum of chlorpyrifos

2.3 PRECISION, ACCURACY AND RECOVERY

Whole blood samples previously determined to be free from the presence of pesticide residues were fortified with 10, 50 and 100 ng of the selected pesticides to validate the accuracy and precision of the analysis.

Detection limits for the chemicals were as follows: 0.1 ng/ml (lindane, o,p'-DDE, α-endosulfan); 1 ng/ml (diazinon, chlorpyrifos, heptachlor, aldrin, p,p'-DDE, p,p'DDT, β-endosulfan, endosulfan sulfate) and 10 ng/ml (dieldrin, endrin).

2.4 RESULTS AND DISCUSSION

2.4.1 Efficiency of the analytical method

Pesticide-free whole blood fortified with 10, 50 and 100 ng/g gave recoveries ranging from 73% to 131% with coefficient variation (C.V.) ranging from 1.8 to 22.3 (Table 2.4).

2.4.2 Precision of repeated GC injections

In determining the error factor contributed by the GC, three different concentrations of the standards solution mixture of lindane, heptachlor, aldrin, dieldrin, endrin, o,p'-DDE, p,p'-DDE, p,p,'-DDT, α-endosulfan, β-endosulfan, endosulfan sulfate, diazinon and chlorpyrifos were repeatedly injected into the GC. The results obtained by repeated injections are tabulated in Table 2.5 - 2.7.

2.4.3 Blood samples

The results of the survey revealed the following levels in blood (nanogram per gram): aldrin, nd - 47.6; dieldrin, nd; endrin, nd; α-endosulfan, nd - 0.6; β-endosulfan, nd; endosulfan sulfate, nd; heptachlor, nd - 3.8; lindane, nd - 5.7; p,p'-DDT, nd - 3.4; o,p'-DDE, nd - 1.4; p,p'-DDE, nd; chlorpyrifos, nd - 10.3; diazinon, nd - 103.0. The results of the survey reported as mean pesticide residue concentrations are given in Table 2.8, together with the corresponding water quality criteria and Maximal Residue Limits (MRLs) of selected foodstuff.

Thirty eight blood samples, comprising 7 % of the total samples collected were found to contain detectable pesticide residues. It was also noted that with the exception of aldrin and heptachlor, the detectable levels did not exceed the respective water quality criteria.

When compared to the corresponding MRLs for a variety of foodstuff (Table 2.9), detectable levels were observed to be below the corresponding MRLs for most of the selected pesticides with the exceptions of aldrin and diazinon which exceeded the limits.

A significant association between ethnic group and exposure was indicated by the observation that the calculated χ^2 was greater than the values obtained from the statistical table (Table 2.10, Appendix 7). Hence, it would appear that ethnic Malays were found to be more exposed to pesticide residues compared to other races. In addition, an association was also observed between the site category and exposure; subjects in agricultural areas were found to be more contaminated in comparison to those from industrial/urban and control areas. However, there was no significant link between sex distribution and exposure although females were found to be more exposed to pesticide residues compared to males (Table 2.10, Figure 2.16). Furthermore, a correlation was observed between the length of stay at current residence and total mean pesticide residue concentrations in blood of contaminated subjects ($p < 0.05$) (Table 2.11). Hence, 87% of the contaminated subjects had lived in their current residence for a period exceeding 49 months. In contrast, no significant correlation could be established between the length of study in the respective schools of the contaminated subjects and total mean pesticide residue concentrations in blood ($p > 0.05$) (Table 2.12). Table 2.13 shows the comparison between the residential areas of contaminated subjects as expressed in terms of industrial, agricultural and control areas and the total mean pesticide residue concentrations in blood. No significant differences were observed as indicated by the p value ($p > 0.05$). Similarly, no significant differences were observed between average travel time of contaminated subjects per day (from home to school and back) and total mean pesticide residue concentrations in blood of contaminated subjects (Table 2.14). Figure 2.17 shows that

there was no correlation between the mean blood pesticide residue concentrations and the rate of food consumption ($p > 0.05$). This showed that dietary intake may not contribute to the detectable levels of pesticide residues.

It was also noted that generally the detectable levels of all the mean pesticide residue concentrations in blood of the present study were lower compared to the other populations, i.e. USA, India, Argentina, Spain and Egypt (Table 2.15).

Table 2.2. Distribution of schools in the study areas and distribution of selected schools in the study area

Study area	Distribution of schools in the study area		Distribution of selected schools in the study area	
	No	%	No	%
Klang Valley	102	46.58	28	46.67
Penang	59	26.94	16	26.67
Cameron Highlands	2	0.91	2	3.33
Kuala Selangor	13	5.94	3	5.00
Kota Bharu	34	15.52	9	15.00
Jerantut	9	4.11	2	3.33
Total	219	100.00	60	100.00

Table 2.3. Demographic data and food consumption rate

Characteristic	All (n=577)	Industrial (n=417) Klang Valley (n=257)	Industrial (n=417) Penang (n=160)	Agricultural (n=50) Cameron Highlands (n=30)	Agricultural (n=50) Kuala Selangor (n=20)	Control (n=110) Kota Bharu (n=90)	Control (n=110) Jerantut (n=20)	All men (n=241)	All women (n=336)
Age(years)[a,b,c]	13.90 (12-15)	13.88 (13-15)	14.05 (13-15)	13.93 (13-15)	13.95 (13-14)	13.69 (12-14)	13.85 (13-14)	13.89 (13-15)	13.91 (12-15)
BMI(kg/m^2)[a,b,c]	20 (11-103)	20 (13-38)	20 (11-32)	19 (15-34)	19 (15-28)	18 (13-35)	27 (14-103)	20 (11-103)	20 (12-38)
Race (%)									
Malay	60.0	56.4	36.9	76.7	45.0	100.0	100.0	56.4	62.5
Chinese	27.7	27.6	50.0	0.0	45.0	0.0	0.0	30.3	25.9
Indian	12.1	15.6	13.1	23.3	10.0	0.0	0.0	12.9	11.6
Others	0.2	0.4	0.0	0.0	0.0	0.0	0.0	0.4	0.0
Food Consumption[a] (meals per week)									
Leafy vegetables	7.25	8.00	7.10	4.60	8.84	5.58	8.25	6.81	7.57
Fruit vegetables	3.07	2.98	3.32	2.80	3.02	2.70	3.75	2.89	3.21
Root vegetables	1.77	1.82	1.94	2.42	0.77	1.42	2.08	1.71	1.81
Fruits	3.08	7.70	6.54	4.74	5.61	7.27	5.18	7.77	6.59
Seafood									
Fish	8.07	6.67	8.62	9.74	7.98	10.58	10.17	8.04	8.10
Others	1.40	1.56	1.91	0.78	2.15	1.27	1.98	1.38	1.41
Canned food	0.65	0.52	0.84	0.62	0.30	0.66	1.25	0.77	0.56
Canned Drinks	1.15	1.50	1.10	0.98	0.84	0.54	0.54	1.27	1.08

Abbreviation: BMI, body mass index

[a] Values shown are mean (range)

[b] All men are statistically different from all women ($p<0.05$)

[c] The six study areas are statistically different ($p<0.05$)

Table 2.4. % Recovery of selected OC and OP pesticides from fortified whole blood

No	Compound	Spiked concentration[a], ng/g		
		10	50	100
1	Lindane	131.4 (4.5)	105.1 (22.0)	99.7 (22.3)
2	Diazinon	81.4 (7.1)	94.0 (13.4)	105.5 (2.0)
3	Heptachlor	109.4 (5.9)	98.7 (10.9)	76.2 (3.9)
4	Aldrin	94.2 (5.8)	97.6 (9.2)	81.7 (3.7)
5	Chlorpyrifos	97.8 (5.2)	99.3 (9.2)	107.6 (1.5)
6	o,p'-DDE	100.3 (5.3)	109.2 (9.5)	92.6 (1.8)
7	p,p'-DDE	121.5 (5.7)	87.7 (8.6)	94.0 (2.1)
8	β-Endosulfan	109.2 (4.3)	90.3 (9.6)	97.1 (13.0)
9	p,p'-DDT	77.2 (18.2)	91.5 (6.3)	73.0 (10.5)
10	α-Endosulfan	104.7 (9.0)	90.5 (15.3)	75.8 (4.1)
11	Dieldrin	100.4 (7.3)	99.7 (15.3)	76.3 (5.8)
12	Endrin	96.8 (9.3)	107.8 (14.7)	88.0 (7.6)
13	Endosulfan sulfate	100.8 (8.2)	76.0 (15.4)	92.5 (8.4)

[a]Mean recovery of five replicates

Figures in parentheses indicate coefficient variation (C.V.)

Table 2.5. Precision of the GC analysis for 100 ng/ml of standards solution mixture

Compound	Area recovered			Coefficient
	1	2	3	Variation (%)
Lindane	72333	69208	68640	2.8
Heptachlor	124841	113654	103964	9.2
Aldrin	17194	16686	16809	1.6
Dieldrin	32204	35321	36420	6.3
Endrin	6658	7416	7978	9.0
o,p'-DDE	456488	466028	483389	2.9
p,p'-DDE	156894	154370	155795	0.8
p,p'-DDT	349390	362682	383218	4.7
α-endosulfan	21059	23096	24132	6.9
β-endosulfan	11507	9858	9519	10.3
Endosulfan sulfate	32268	37306	38303	9.0
Diazinon	41418	42106	42685	1.5
Chlorpyrifos	60455	58251	58743	2.0

Table 2.6. Precision of the GC analysis for 500 ng/ml of standards solution mixture

Compound	Area recovered			Coefficient
	1	2	3	Variation (%)
Lindane	431406	477041	521122	9.4
Heptachlor	971972	1093894	1184529	9.8
Aldrin	97911	106161	117028	9.0
Dieldrin	185579	184563	187840	0.9
Endrin	46148	46550	46397	0.4
o,p'-DDE	2239695	2426066	2663308	8.7
p,p'-DDE	846550	911897	996631	8.2
p,p'-DDT	1606117	1964230	2250021	16.6
α-endosulfan	126467	127039	127829	0.5
β-endosulfan	88962	97153	103992	7.8
Endosulfan sulfate	192565	109809	221533	7.0
Diazinon	208022	216510	240831	7.7
Chlorpyrifos	3197520	344067	377496	8.4

Table 2.7. Precision of the GC analysis for 1000 ng/ml of standards solution mixture

Compound	Area recovered			Coefficient
	1	2	3	Variation (%)
Lindane	704122	675510	665616	2.9
Heptachlor	1266667	1225660	1192503	3.0
Aldrin	156732	152699	153420	1.4
Dieldrin	348897	348341	345868	0.4
Endrin	85122	84420	83725	0.8
o,p'-DDE	3652384	3620624	3614697	0.3
p,p'-DDE	1281378	1277441	1273527	0.3
p,p'-DDT	3350438	3344559	3310726	0.6
α-endosulfan	250174	251406	249062	0.7
β-endosulfan	127350	127142	124418	1.3
Endosulfan sulfate	262866	263739	254106	2.0
Diazinon	364273	347653	348917	2.6
Chlorpyrifos	521587	508240	504560	1.8

Table 2.8. Comparison between mean concentrations of pesticide residues in blood (ng/g) and water quality criteria and MRLs

Compound	Industrial (n=417)	Agricultural (n=50)	Control (n=110)	Water quality criteria (ng/ml)	MRLs of selected foodstuff[a] (ppb)
Aldrin	0.1141	#nd	nd	0.02	6-200
Chlorpyrifos	0.0036	0.9520	nd	6	50-2000
Diazinon	0.3026	nd	nd	10	50-500
Heptachlor	0.0091	0.1340	nd	0.05	4-200
α-Endosulfan	nd	nd	0.0127	10	5-500
Lindane	0.0144	0.2100	0.0436	2	8-2000
o,p'-DDE	nd	0.0134	nd	0.1	40-1000
p,p'-DDT	0.0082	nd	nd	0.1	40-1000

[a] Refer to Table 6 for respective foodstuff

#nd = Not detectable (Below detection limit)

Table 2.9. Maximum residue limits (MRL) for selected pesticides (The Agrochemical Handbook)

Compound	Maximal residue limits (MRL)
Aldrin, dieldrin and endrin	Cereals 0.01ppm; meat, preparation of meat and fats 0.2ppm; raw cow's milk and cream cow's milk 0.006ppm; all feedstuffs except fats 0.01ppm (fats 0.2ppm); fruit and vegetables 0.01ppm
DDT and metabolites, DDE and DDD	Fruit and vegetables 0.1ppm; meat preparations and animal fats 1ppm; raw and whole cow's milk 0.04ppm; feedstuffs except fats 0.05ppm (fats 0.5ppm); cereals 0.05ppm
Endosulfan	Root vegetables 0.2ppm; other fruit and vegetables 1ppm; maize 0.2ppm; other cereals 0.1ppm; all feedstuffs 0.1ppm (except maize 0.2ppm, oilseeds 0.5ppm, complete feedstuffs for fish 0.005ppm)
Heptachlor	Cereals, fruit and vegetables 0.01ppm; meat, meat preparations, animal fats 0.2ppm; raw and whole cream cow's milk 0.004ppm; all feedstuffs except fats 0.01ppm (fats 0.2ppm)
Lindane (γ-HCH)	Cereals 0.1ppm; leaf vegetables 2ppm; tomatoes, stone fruit, grapes 0.5ppm; carrots 0.1ppm; other fruit and vegetables 1ppm; meat, fats 1-2ppm; raw and cream cow's milk 0.008ppm
Chlorpyrifos	Kiwi fruit 2ppm; citrus fruit 0.3ppm; stone and pome fruit, grapes, vegetables 0.2ppm; other fruit 0.05ppm
Diazinon	Cereals, shell fruits 0.05ppm; other fruit and vegetables 0.5ppm

Table 2.10. Comparison of exposed and non-exposed schoolchildren by selected characteristics

Characteristic	Exposed subjects (n=38)	Non-exposed subjects (n=539)	χ^2 calculated	χ^2 (From table)
Ethnic distribution				
Malays	29 (76%)	317 (59%)	4.51	3.84
Others	9 (24%)	222 (41%)		
Sex distribution				
Male	17 (45%)	224 (42%)	0.14	3.84
Female	21 (55%)	315 (58%)		
Site distribution				
Industrial	11 (29%)	406 (75%)	90.70	5.99
Agricultural	19 (50%)	31 (6%)		
Control	8 (21%)	102 (19%)		

Figures in parentheses indicate percentage of respondents

Figure 2.16. Comparison of exposed subjects in various regions by sex

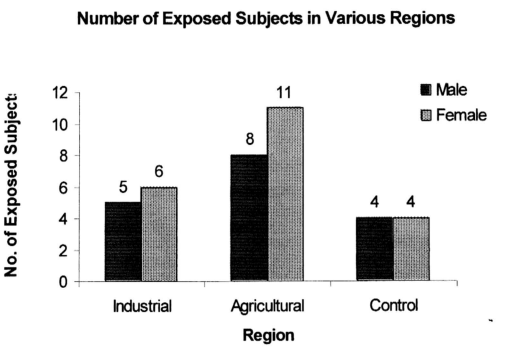


Table 2.11. Comparison between the duration of stay in current residence of exposed subjects and total mean concentrations of pesticide residue in blood

Characteristic	Duration of stay at current residence				
	≤ 48 months	49-96 months	> 96 months	F test	p value
No. of contaminated respondents (n=38)	5 (13%)	9 (24%)	24 (63%)		
Total mean concentrations of pesticide residues in blood (ng/g)	1.2	22.0	2.6	4.940	0.013

Figures in parentheses indicate percentage of respondents

Table 2.12. Comparison between the duration of study at current school among exposed subjects and total mean concentrations of pesticide residue in blood

Characteristic	Duration of study at current school				
	≤ 12 months	13-24 months	> 24 months	F test	p value
No. of contaminated respondents (n=38)	2 (5%)	33 (87%)	3 (8%)		
Total mean concentrations of pesticide residues in blood (ng/g)	0.6	7.7	3.5	0.201	0.819

Figures in parentheses indicate percentage of respondents

Table 2.13. Comparison between residential areas of exposed subjects (site category) and total mean concentrations of pesticide residue in blood

	Area				
Characteristic	Industrial	Agricultural	Control	F test	p value
No. of contaminated respondents (n=38)	11 (29%)	19 (50%)	8 (21%)		
Total mean concentrations of pesticide residues in blood (ng/g)	17.1	3.8	0.8	2.761	0.077

Figures in parentheses indicate percentage of respondents

Table 2.14. Comparison between the average travel time per day among exposed subjects and total mean concentrations of pesticide residue in blood

	Average travel time per day				
Characteristic	≤ 15 minutes	16-30 minutes	> 60 minutes	F test	p value
No. of contaminated respondents (n=38)	11 (29%)	14 (37%)	13 (34%)		
Total mean concentrations of pesticide residues in blood (ng/g)	13.1	6.1	2.8	1.004	0.377

Figures in parentheses indicate percentage of respondents

Table 2.15. Concentration of pesticide residues in general populations from previous and current studies

Subject	Compound	Concentration	Reference
Canada			
Cord blood (n=656)	p,p'-DDE	0.05 – 14.92 μg/l	Rhainds *et al.*, 1999
	HCB	0.01 – 1.40 μg/l	
Spain			
Serum (n=608)	HCB	36.7 ng/ml	Sala *et al.*, 1999
	p,p'-DDE	9.6 ng/ml	
Sweden			
Serum (n=790)	p,p'-DDT	20.2 ng/g lipid	Glynn *et al.*, 2000
	p,p'-DDE	808.9 ng/g lipid	
	o,p'-DDE	2.0 ng/g lipid	
	γ-BHC	1.8 ng/g lipid	
Non-Occupational Exposed (Whole blood)			
United States			
Adults (n=26)	β-HCH	1.40 μg/l	Radomski *et al.*, 1971
	γ-HCH	0	
	Dieldrin	1.49 μg/l	
	p,p'-DDE	15.72 μg/l	
	p,p'-DDT	4.18 μg/l	
Argentina			
Adults (n=20)	β-HCH	23.01 μg/l	
	γ-HCH	0.98 μg/l	
	Dieldrin	1.43 μg/l	
	p,p'-DDE	14.53 μg/l	
	p,p'-DDT	3.18 μg/l	
Children; 5-10 years	β-HCH	6.61 μg/l	
(n=18)	γ-HCH	0.43 μg/l	
	Dieldrin	0.94 μg/l	
	p,p'-DDE	8.13 μg/l	
	p,p'-DDT	4.21 μg/l	
Exposed			
Argentina			
Mother (n=13)	p,p'-DDT	6.85 μg/l	
	β-HCH	11.95 μg/l	
	γ-HCH	0.22 μg/l	
	Dieldrin	1.63 μg/l	
	p,p'-DDE	13.43 μg/l	
	o,p'-DDT	0.27 μg/l	
	Heptachlor epoxide	0.23 μg/l	

Subject	Compound	Concentration	Reference
Exposed Argentina Newborn (n=13)	α-HCH	0.77 µg/l	Radomski *et al.*, 1971
	β-HCH	5.10 µg/l	
	γ-HCH	0.16 µg/l	
	Dieldrin	0.59 µg/l	
	p,p'-DDE	4.72 µg/l	
	o,p'-DDT	0	
	p,p'-DDT	2.54 µg/l	
Egypt Serum (n=31)	#DDT	67.7 ng/ml	Soliman and Ismail, 1997
	DDE	63.8 ng/ml	
	p,p'-DDT	3.9 ng/ml	
	β-HCH	17.6 ng/ml	
	HCB	0.5 ng/ml	
**NHANES II Serum	Aldrin, dieldrin and endrin	1.4 ppb	http://www.atsdr.cdc.gov/toxfaq.html
	Endosulfan	[a]na	
	Heptachlor	na	
	Lindane	1.7 ppb (in blood)	
	p,p'-DDT	> 2 ppb	
	o,p'-DDE	na	
	p,p'-DDE	12.6 ppb	
	Chlorpyrifos / TCP	≥ 5 ppb (in urine)	
	Diazinon	na	
Ahmedabad, India Serum (n = 31)	Aldrin	0.2 µg/l	http://www.atsdr.cdc.gov/toxfaq.html
	Dieldrin	2.15 µg/l	
Malaysia Present study Whole blood (n=577)	Aldrin	[b]nd – 0.1141 ng/g	
	Dieldrin	nd	
	Endrin	nd	
	α-endosulfan	nd – 0.0127 ng/g	
	β-endosulfan	nd	
	*Endo. sulfate	nd	
	Heptachlor	nd – 0.1340 ng/g	
	Lindane	nd – 0.2100 ng/g	
	p,p'-DDT	nd – 0.0082 ng/g	
	o,p'-DDE	nd – 0.0134 ng/g	
	p,p'-DDE	nd	
	Chlorpyrifos	nd – 0.9520 ng/g	
	Diazinon	nd – 0.3026 ng/g	

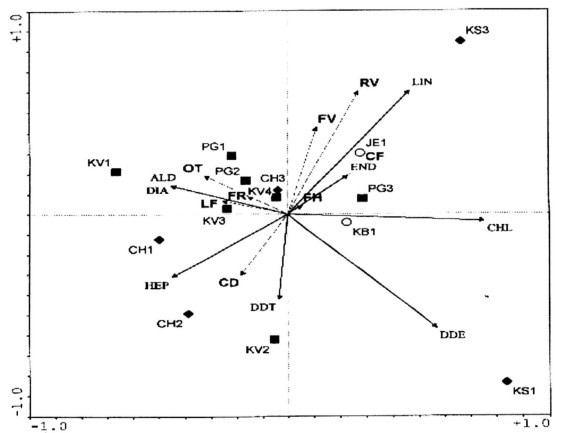
#DDT = DDE + p,p'-DDT + DDD

*Endo. Sulfate = Endosulfan sulfate

**NHANES II = Second National Health and Nutrition Examination Survey conducted by USA between 1976 and 1980

[a]na = Not available [b]nd = Not detectable (below detection limit)

Figure 2.17. Correlation between mean concentrations of pesticide residue in blood and food consumption rate



Abbreviations: 1, Malay; 2, Chinese; 3, Indian; ALD, Aldrin; CD, Canned drinks; CF, Canned food; CH, Cameron Highlands; CHL, Chlorpyrifos; DIA, Diazinon; END, α-Endosulfan; FH, Fish;; FR, Fruits; FV, Fruit vegetables; HEP, Heptachlor; JE, Jerantut; KB, Kota Bharu; KS, Kuala Selangor; KV, Klang Valley; LF, Leafy vegetables; LIN, Lindane; OT, Others (prawns, mussel, etc.); PG, Penang; RV, Root vegetables

2.5 CONCLUSION

The survey indicated the exposure of the Malaysian general population, in particular school children to a wide range of pesticide residues. From the survey, it was also noted that vast majority of Malaysian school children (about 93%) had no detectable exposures to any of the measured pesticides. However, the detectable level of endosulfan in the control samples although low indicated some continuing source of exposure given the short half-life reported in Section 4.3.1. Ethnic Malays were found to be more significantly exposed to the chemicals compared to the other races. Subjects residing in agricultural areas were also found to be more susceptible. Generally the detectable levels of all the mean pesticide residue concentrations in blood of the present study were lower compared to the other populations, i.e. USA, India, Argentina, Spain and Egypt. The survey indicates a need for the proper authorities to conduct a more comprehensive and regular survey to evaluate the health risks associated with exposure to pesticide residues.