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Residual Assessment of Insecticides in Human Breast Milk, Crops and Ecosystem in Horticultural Farming Communities in Accra Ghana

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Abstract: ***This study investigated the current insecticide use patterns of farmers, their activities and practices that lead to occupational exposure and analysis of insecticide residues in cabbage (Brassica olerecea var. Capitata L.), waterbed sediments and human breast milk. Gas chromatography (GC) analysis in the laboratory showed varying levels of HCB, Lindane, P,P'DDE, P,P'-DDD, P,P'-DDT, Chlorpyrifos-ethyl, α –HCH, β –HCH, ɤ-HCH , α –endosulfan, β – endosulfan, ɤ-endosulfan and endosulfan sulfate in waterbed sediments of the Oyansia stream in Accra, cabbage crops collected from the farms, supermarkets and the open market. The levels of residues in samples collected from the supermarkets were higher than those collected from the farms and open market and above the FAO/WHO residue limits. The levels of HCB and P,P'-DDE in breast milk of lactating wives of farmers calculated on whole milk basis were relatively high (1.77µg/kg and 18.21 µg/kg, respectively). As a result of the overuse of insecticides by horticultural growers, a study on the residue levels of insecticides in horticulture crops on the field and on the market and the environment should be conducted systematically to assess the health risks posed by insecticides on humans and the environment.***

Keywords: *Brassica olerecea var. Capitata* L, breast milk, residue levels, sediments, supermarkets, etc

1. Introduction

Horticulture is the backbone of the economy of most African countries (GFPED, 2007). Ghana ranks 6th among the suppliers of horticultural products to the European Union (GFPED, 2007). Pineapples, mangoes and papayalead the fruit exports while yams, chillies and Asian vegetables lead the vegetable trade (ISSER, 2008). The European Union imported almost 90,000 tonnes of fresh fruit and vegetable produce from Ghana in 2007, whichearned the Ghanaian horticulture cluster some €80m (ISSER, 2008). These "non-traditional" exports contribute employment, fiscal revenue and foreign exchange to the economy (ISSER, 2008). However, the share of the horticultural export in total agricultural export in Ghana fell from 22.78% in 2007 to 12.40% in 2009 (ISSER, 2010)[8]. In 2007, 2008 and 2009 40,456, 35,134 and 31,567 MT of pineapples were, respectfully exported while 824, 858 and 435 MT of mangoes were exported over the same period (GEPC, 2010)[6]. This gradual decline could partly be attributed to the activities of insect pests and crop diseases which decrease crop yield (Ntow *et al.,* 2006). The activities of these insect pests and diseases render crops unattractive and are therefore rejected by consumers (Afun *et al.*, 1992). Farmers, in a desperate attempt to protect their crops and investments spray them with hazardous insecticides such as organochlorines and organophosphates and at different application rates and frequency of application (Brempong-Yeboah, 1992). Runoff of these insecticides may contaminate water bodies which may pose serious health problems to human and animals that drink from them, or may contaminate soils (Ntow *et al*., 2006). Chemical residues may also concentrate in crops which can pose health hazards to consumers if the maximum residue limit (MRL) set by the FAO/WHO is exceeded (Ntow, 2006). Non-target flora and fauna concentrate these residues in their tissues and pass them on along the food chain (Koomson, 2003). In Ghana, there is little published information on the environmental effects of agrochemicals and few studies have also been carried out to determine their levels in humans. Consequently, there is much concern over the environmental quality of Ghana and the health of its inhabitants. Intensive vegetable farming areas along the Oyansia stream or the Nima creek in Accra, Ghana provide an opportunity to study the effect of agriculture runoff on the agrochemical levels of small streams in the tropics. In view of the above concerns, the objectives of this study was to determine the residue levels of insecticides in water sediments and cabbage as an epidemiological evidence of human health exposure, residue levels of insecticides in human breast milk and possible toxicological implications of insecticide residues to the health of breast-fed infants in a typical Ghanaian farming community.

2. Methodology

2.1 Experimental Materials

2.2 Reagents and solvents

The reagents and solvents used for the experimental work was:
1. n-Hexane, 99%+ (capillary GC), Sigma 2. Acetone, 99.9% +, Sigma 3. Acetonitrile, 99.8%, BDH 4. Chloroform, 99%, BDH 5. Methanol, 99.8%, BDH 6. Petroleum ether, BDH (pesticide residue analysis) 7. Dichloromethane (puriss. p.a.), Fluka 8. Diethyl ether (purum), Fluka

Standards
The following standards were used for the experiment: 2, 4,5-TCB; aldrin; dieldrin; endrin; HCB; lindane; p,p'DDE; p,p'-DDD, p,p'-DDT; heptachlor epoxide; endosulfan (α and β); endosulfan sulfate and chlorpyrifosethyl 480g/l (97.5% purity). The standards were obtained from the

International Atomic Energy Agency (IAEA) in sealed ampules. They were diluted with insecticide grade hexane.

Apparatus

The following lists of apparatus were used for laboratory analysis and field work:

1) Gas Chromatograph (GC): Hewlett Packard 5890 series II with electron-capture detector nickel source. Column: 30-m capillary column, 0.53 mm ID, fused silica coated with DB-5. Integrator: Hewlett Packard 3396A.
2) Soxhlet apparatus, Electric Oven, Hach Model, pH-meter and Pipette
3) Knapsack CP 15L sprayer

Cleaning of sampling bottles

All the sampling bottles (beakers, pet, conical flasks, measuring cylinders) were thoroughly scrubbed with a brush in hot water and detergent. The bottles were rinsed five times with tap water and twice with distilled water. They were again rinsed with acetone followed by hexane. The bottles were placed overnight in an oven at 300 °C and stored in dust-free cabinets. When not in use the bottles were sealed tightly with pre-cleaned aluminum foil (UNEP *et al*. 1987). In addition, the bottles were cleaned immediately before use.

Sampling

Water-bed sediments

The Oyansia stream also known as the Nima creek which takes its source from the Akwapim mountains and flows through the Opebea House area, behind the Water Research Institute, Plant Pool area, through Dzorwulu and ends up joining the Odaw river was selected for this study. The selection was based on the fact that as many as sixty-eight (68) vegetable farms are located along the stream from the Opebea House area down to Dzorwulu before it joins the Odaw river. The stream is thus likely to be polluted with insecticides. Forty (40) core samples of water-bed sediment (about 1 L) were randomly collected from different points into glass beakers in the upstream and another 40 samples were collected in the downstream in July 2019. The upstream is the area between the Opebea House and Kawukudi junction and the downstream is the area between the Plant Pool and Dzorwulu. The samples were wrapped with aluminum foil, stored on ice and transported to the Water Research Institute Organic Laboratory for analysis.

Cabbage

The sampling was done in September 2019. A total of 50 heads of cabbage were used for this study. Ten heads of cabbage were collected each from farms along the Oyansia River, the Texpo market on the Spintex road, Supermarket A, Supermarket B and Supermarket C to assess the accumulation of insecticides in them. The cabbage heads were wrapped with aluminum foil, stored on ice and transported to the WRI organic laboratory for analysis. The collection of the cabbage heads were done randomly from the various sources.

Human breast milk

Sixty lactating women (20-42 years of age) participated in this study which was done in November 2019. Thirty of them were wives of farmers who grow vegetables along the Oyansia stream and lived at Kanda, Maamobi, Nima, Dzorwulu and Abelemkpe which are suburbs of Accra and also not far from the Oyansia stream. These women were actively engaged in mixing, application of insecticides and also harvesting of vegetables. Only 2 out of the 30 have their own cabbage farms. The other set of 30 lactating mothers were not wives of farmers and lived in Sakumono and Lashibi which are surburbs of Tema. This set of lactating mothers served as the control for the study. About 30 ml of milk samples were expressed manually and directly into clean, labeled glass bottles, stored on ice and transported to the WRI organic laboratory for analysis. Once the milk sample got to the laboratory, they are frozen immediately in a refrigerator until analysis. Analysis of samples

Water-bed sediment

The water layer over the sediment was decanted and discarded. The sediments were stirred with a stirrer to obtain a homogenous sample and then transferred to a pan to air-dry at ambient temperature. Five grams (dry weight) of each of the 40 samples upstream and 40 samples downstream were weighed into an extraction thimble and extracted with 200 ml methanol for 8 hours in a soxhlet apparatus cycling 4-5 times per hour. Fivemilliliter aliquot of the extract was evaporated to dryness over water bath. The residue was dissolved in 1 ml methanol and diluted with 2.5 ml water (FAO/IAEA, 1997). The water-diluted extract was passed through a preconditioned SPE column for analysis by gas chromatography. Analyses were performed with a Perkin-Elmer AutoSystem gas chromatograph equipped with a 63Ni electron capture detector. Separations were on a 30 m x 0.32 mm i.d. capillary column with 0.25µm methyl phenyl phase (Perkin-Elmer Elite-225). The gas flow (helium) was set to 16 ml/min through the column and at 30 ml/min makeup (nitrogen) through the detector. About 1µl of each sample was injected in a split mode at 250 °C, and the oven temperature was programmed as follows: 100 °C for 1 min, increased to 150 °C (10 °C/min), 250 °C (5 °C/min), then at 30 °C/min to 300 °C for 10 min. The detector temperature was 350 °C. The average recoveries for all compounds varied from 80-110%. Repeated analysis also gave a standard error of about 10%. The quantification limits were set to 0.1 µg/kg dry weight for HCB, p,p'-DDE, and heptachlor epoxide; 0.01 µg/kg dry weight for β-endosulfan and endosulfan sulfate; 0.05 µg/kg dry weight for α-endosulfan; and 2.5 µg/kg dry weight for lindane.

Cabbage

Procedures described in FAO/IAEA (1997) were adopted for this analysis. From each of the batch of samples, 10 g (fresh weight) of cabbage fruits was homogenized in a mortar and transferred to a precleaned extraction thimble. This was extracted with 200 ml methanol for 8 hours in a soxhlet apparatus cycling 4-5 times per hour. The extract was passed through a preconditioned SPE column and treated in the same way as described above for water sediments. The quantification limits were set to 0.1 µg/kg fresh weight for HCB, p,p'-DDE, heptachlor epoxide, 0.01 µg/kg fresh weight for β-endosulfan and endosulfan sulfate; 0.05 µg/kg fresh weight for αendosulfan; and 2.5 µg/kg

fresh weight for lindane. In all 50 samples of the cabbage were analyzed.

Human breast milk

The breast milk samples were analyzed by a method described by Weisenberg *et al*., (1985). Milk samples were thawed by stirring. Ten milliliters of each of the 60 samples were homogenized with 40 ml acetone/petroleum ether mixture (1:1). This was centrifuged and the organic phase was poured out. The milk phase was re-extracted twice with two separate aliquots of 30 ml petroleum ether. The organic phase was evaporated to dryness on a water bath (heated from 40 °C to 85 °C). The fat residue was weighed, dissolved in 5 ml hexane, and cleaned up by shaking for 1 min with 2 ml sulphuric acid. One milliliter of the hexane fat fraction was transferred into a glass column (250 mm length), 1.8 mm ID packed with a slurry prepared by mixing 4.5 g silica gel with 10 ml petroleum ether. The column was eluted with two separate organic solvent portions: Fraction 1: 25 ml petroleum ether (HCB, DDE); Fraction 2: 25 ml diethyl ether/petroleum ether 1 + 9 parts (DDT and the rest). Each separated fraction was evaporated and diluted to 2 ml with hexane and an aliquot injected into the GC. The average recoveries for all compounds varied from 78115%. Repeated analysis also gave a standard error of about 12%. The quantification limits were set to 0.1 µg/kg for HCB, p,p'-DDE, and heptachlor epoxide; 0.01 µg/kg for β-endosulfan and endosulfan sulphate; 0.05 µg/kg for α-endosulfan; and 2.5 µg/kg for lindane.

2.3 Calculation of Infants' Daily Intake of Insecticide Residues in Mother's Breast Milk

The calculations were based on the assumption that the daily consumption of milk is about 120g milk/kg body weight per day (WHO/UNEP 1990) and that the milk contains 3.5% w/w fat (WHO 1983, cited in Weisenberg *et al*., 1985). The levels on the fat basis are useful because the insecticides are closely correlated to the fat of the milk.

2.3.1 Calculation of residue levels

Residue levels were calculated using the equation (NRI, 1994) below:

$$\text{Residue level} = \frac{\text{Concentration in the final extract x dilution factor}}{\text{Weight of sample analyzed}}$$

Data analysis

Differences in concentration of the residue levels from the various samples were analyzed by one-way-analysis of variance followed by a Bonferroni test (equal variances assumed) (SPSS software, version 12.0.1 for Windows, SPSS Inc, Chicago, Illinois, USA). The data were analyzed for normal distribution (Kolmogorov-Smirnov test) and LSD test at ($P<0.001$) was used to separate the means.

3. Results

3.1 Insecticides Residue Levels in Water Sediments, Cabbage and Human breast milk

The results of water sediment, cabbage and milk analyses are presented in tables 1, 2 and 3, respectively.

From table 1, the sediment samples show the highest number of insecticide compounds. All the insecticides found in sediment appeared in at least 88% of all the upstream and downstream samples analyzed. The concentration is highest in the sediments for chlorpyrifosethyl (mean 0.77 ± 0.01µg/kg for the upstream and 0.62± 0.01µg/kg for the downstream) and least for ɤ-HCH (mean 0.04± 0.01µg/kg for the upstream and 0.07± 0.01µg/kg for the downstream). P,P'-DDE and endosulfan sulfate were the only insecticides that were present in all the samples. There were significant differences in concentrations of HCB, lindane, P,P'-DDD, Chlorpyrifosethyl, ɤ-endosulfan and endosulfan sulfate in the upstream and downstream sediments. The chromatographic peaks showing the abundance of the various insecticides in the sediments can be found in figure 1. The peaks showed that chlorpyrifos-ethyl is the most abundant and γ-HCH is the least abundant insecticide in the samples, respectively. It can be deduced from table 2 that the levels of detectable insecticides were generally lower in cabbage from the farms and open market than from the three supermarkets. With the exception of samples from Supermarket B, the levels of HCB were below detectable limits. Residues of chlorpyrifos-ethyl were the highest in all the samples taken. There were no significant differences in residue levels of HCH among all the samples whiles residue levels of α-endosulfan was significantly different among the samples analyzed. Residue levels of chlorpyrifosethyl and P,P'-DDT were not significantly different among samples taken from the three supermarkets. Among the three supermarkets, residue levels of P,P'-DDD and P,P'DDE were significantly higher in samples from Supermarket A than those from Supermarket B and Supermarket C which showed no significant difference amongst the two whiles residue levels of ɤ-endosulfan was not significantly different among samples analysed from Supermarket B and Supermarket A. The chromatographic peaks of the various insecticides in the various samples showing the abundance of the various insecticides in the samples can be found in figures 2,3,4,5 and 6.

For the milk samples (Table 3), 53% of those from lactating wives of farmers indicated quantifiable amounts of HCB, whereas 70% of them showed DDE and 37% of them were positive for endosulfan sulfate. In the case of the other lactating mothers, 13% of them indicated quantifiable amounts of HCB and 40% of them contained DDE but none was positive for endosulfan sulfate. No detectable residues of lindane, chlorpyrifos-ethyl, HCH, P,P'-DDD, P,P'-DDT or endosulfan (α and β) were found in any of the breast milk samples. High mean residue levels of HCB and DDE were found in milk samples compared to water sediment or cabbage samples (Tables1, 2 and 3). For example, HCB and DDE were about 40 times higher in breast milk of lactating wives of farmers than in water sediment samples, respectively. This can be found in figure 6. The chromatographic peaks show chromatographic peaks of the DDT and DDE insecticides that P,P'-DDE and lindane were most and least abundant in the breast milk samples showing their abundance can insecticides in the milk samples, respectively.

Table 1: Insecticide residues in water sediments in the Oyansia stream

Insecticide components	Upstream samples		Downstream samples	
	µg/kg (DW) Mean ± SD	Number positive	µg/kg (DW) Mean ± SD	Number positive
HCB	0.68 ± 0.01[a]	36	0.73 ± 0.01[b]	30
Lindane	0.23 ± 0.03[a]	31	0.43 ± 0.02[b]	36
P,P'-DDE	0.35 ± 0.02[a]	40	0.32 ± 0.02[a]	40
P,P'-DDD	0.18 ± 0.01[a]	38	0.22 ± 0.01[b]	39
P,P'-DDT	0.11 ± 0.02[a]	28	0.14 ± 0.01[a]	31
Chlorpyrifos-ethyl	0.77 ± 0.01[a]	38	0.69 ± 0.01[b]	32
α –HCH	0.05 ± 0.02[a]	19	0.07 ± 0.01[a]	21
β –HCH	0.08 ± 0.01[a]	22	0.10 ± 0.01[a]	23
ɤ-HCH	0.04 ± 0.01[a]	12	0.03 ± 0.01[a]	9
α –endosulfan	0.46 ± 0.04[a]	37	0.40 ± 0.02[a]	34
β –endosulfan	0.41 ± 0.06[a]	39	0.45 ± 0.06[a]	38
ɤ-endosulfan	0.50 ± 0.02[a]	39	0.58 ± 0.02[b]	36
Endosulfan sulfate	0.46 ± 0.01[a]	40	0.51 ± 0.02[b]	40

Number of samples= 40. Means of samples on the same row followed by different letters are significantly different at (P<0.001), LSD

Table 2: Mean Insecticide residue levels in cabbage in mg/kg (FW) ±SD.

Insecticide components	Super market A	Super market B	Super market C	Texpo market (open market)	Farms
HCB	<0.01[a]	0.02 ± 0.01[b]	<0.01[a]	<0.01[a]	<0.01[a]
Lindane	0.14 ± 0.01[a]	0.03 ± 0.01[b]	0.03 ± 0.01[b]	0.02 ± 0.01[b]	0.02 ± 0.01[b]
P,P'-DDE	0.51 ± 0.02[a]	0.45 ± 0.01[b]	0.43 ± 0.02[b]	0.22 ± 0.01[c]	0.23 ± 0.01[c]
P,P'-DDD	0.44 ± 0.01[a]	0.41 ± 0.02[b]	0.38 ± 0.01[b]	0.18 ± 0.02[c]	0.20 ± 0.02[c]
P,P'-DDT	0.31 ± 0.02[a]	0.30 ± 0.01[a]	0.29 ± 0.01[a]	0.18 ± 0.02[b]	0.21 ± 0.02[b]
Chlorpyrifos-ethyl	0.53 ± 0.12[a]	0.57 ± 0.11[a]	0.54 ± 0.09[a]	0.51 ± 0.12[b]	0.49 ± 0.12[b]
HCH	0.03 ± 0.01[a]	0.02 ± 0.01[a]	0.03 ± 0.01[a]	0.02 ± 0.01[a]	0.02 ± 0.01[a]
α –endosulfan	0.42 ± 0.14[a]	0.33 ± 0.12[b]	0.39 ± 0.02[c]	0.29 ± 0.03[d]	0.31 ± 0.03[d]
β –endosulfan	0.38 ± 0.03[a]	0.41 ± 0.04[a]	0.30 ± 0.11[b]	0.19 ± 0.01[c]	0.20 ± 0.01[c]
ɤ-endosulfan	0.41 ± 0.05[a]	0.37 ± 0.01[a]	0.22 ± 0.13[c]	0.23 ± 0.11[c]	0.21 ± 0.11[c]

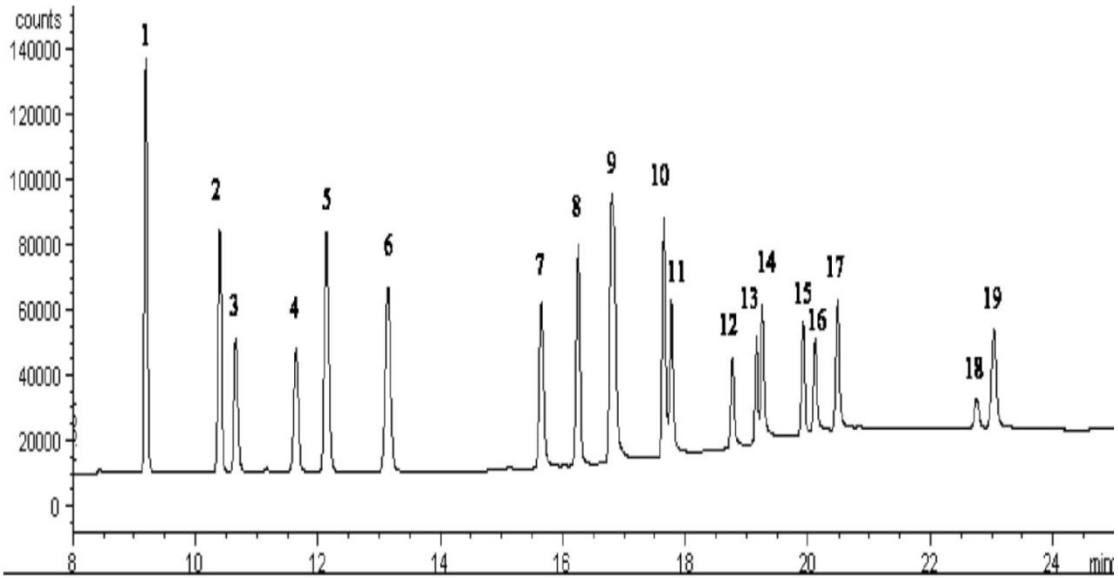
Number of samples= 40. Means of samples on the same row followed by different letters are significantly different at (P<0.001), LSD.

Table 3: Mean insecticide residue levels in breast milk of lactating mothers in µg/kg fat

	Wives of farmers		Other lactating mothers	
Insecticide components	Residue level	Number positive	Residue level	Number positive
HCB	19.7 ± 0.2[a] 1.77*	16	2.7 ± 0.2[b] 0.02*	4
Lindane	0	0	0	0
P,P'-DDE	198.5 ± 0.3[a] 18.21*	21	38.5 ± 0.2[b] 2.51*	12
Chlorpyrifos-ethyl	0	0	0	0
ΣHCH	0	0	0	0
Σ Endosulfan	0.05 ± 0.01[a] 0.12*	11	0	0

*Calculated on whole milk basis (µg/kg). Number of sample= 30

Number of samples= 30. Means of samples on the same row followed by different letters are significantly different at (P<0.001), LSD.



endosulfan; (3) β-HCH; (4) no target compound; (5) α-endosulfan; (6) lindane; (7) heptachlor epoxide; (8) no target compound; (9) HCB; (10) P,P'-DDE; (11) no target compound; (12) γ-HCH; (13) P,P'-DDD; (14) β-endosulfan; (15) P,P'-DDT; (16) α-HCH; (17) endosulfan sulfate; (18) no target compound; (19) HCB

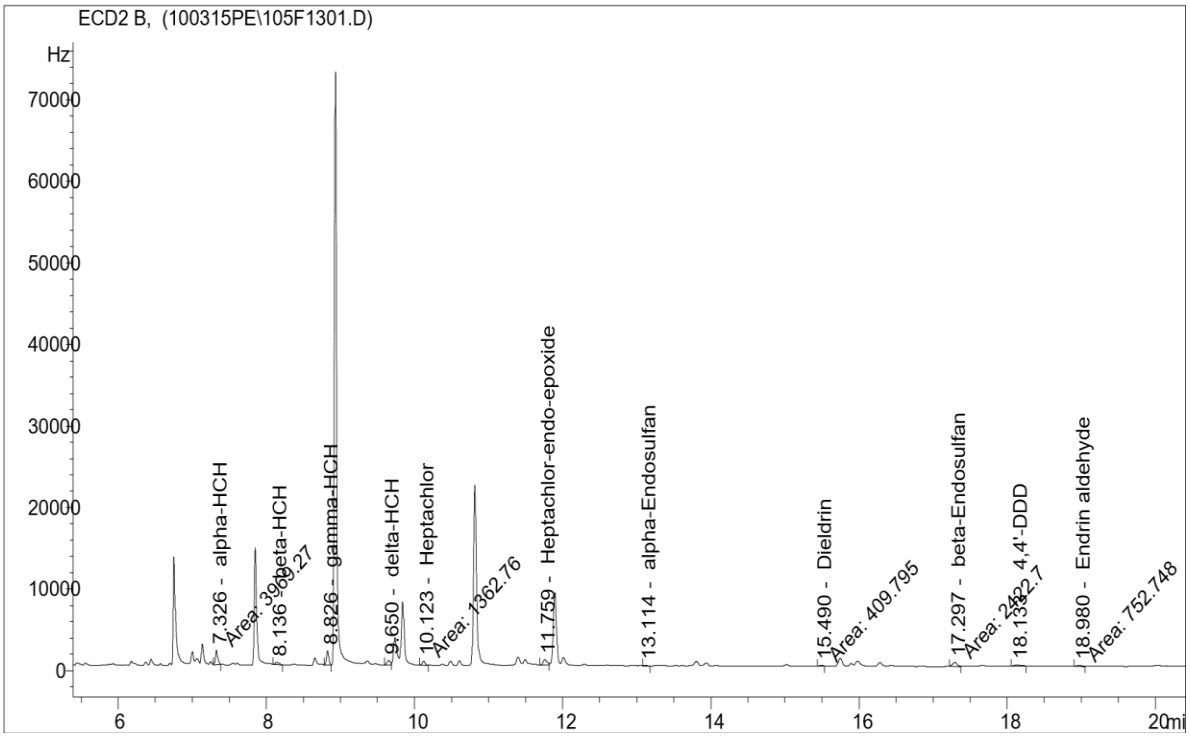


Figure 2: Chromatograms of organochlorine insecticides in cabbage samples from Supermarket A

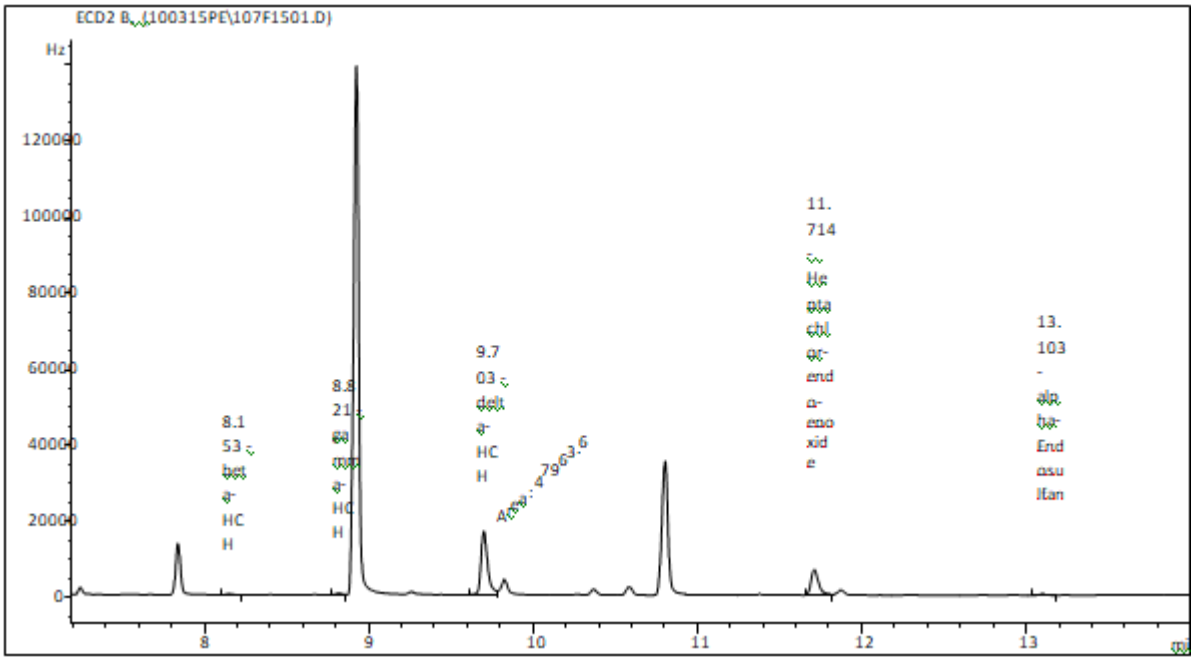


Figure 3: Chromatograms of organochlorine insecticides in cabbage samples from the open market

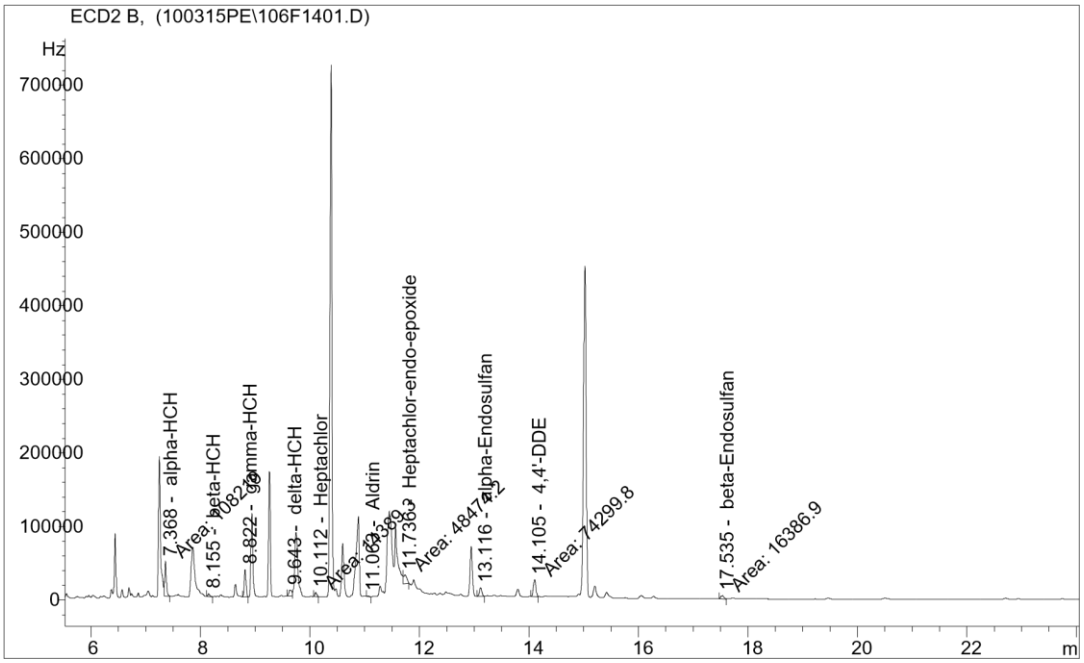


Figure 4: Chromatograms of organochlorine insecticides in cabbage samples from Supermarket B

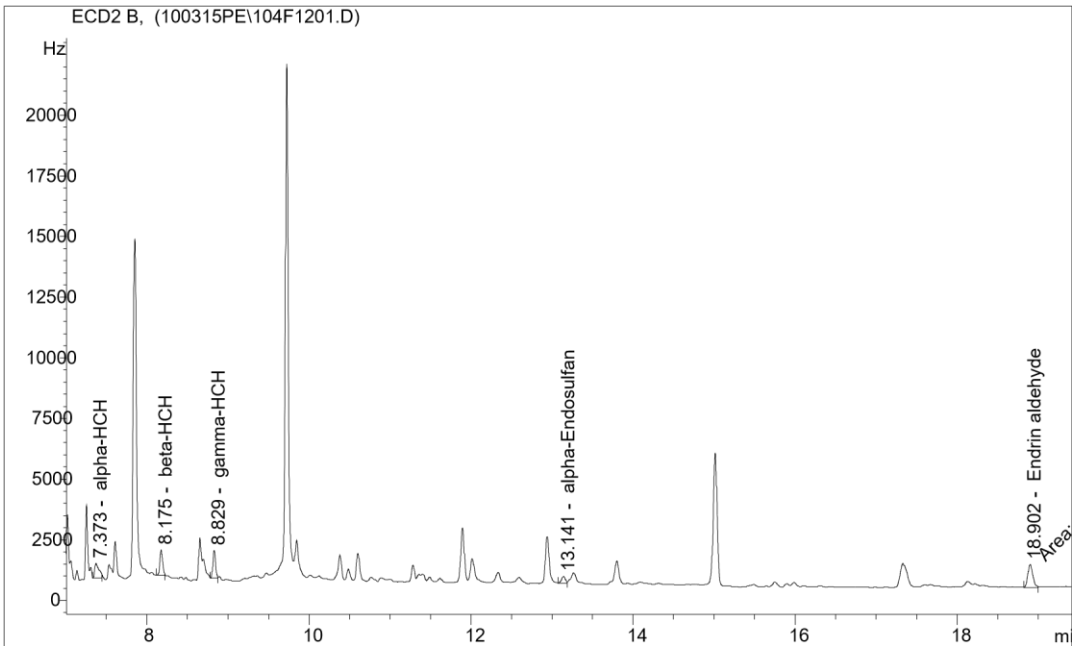


Figure 5: Chromatograms of organochlorine insecticides in cabbage samples from Supermarket C

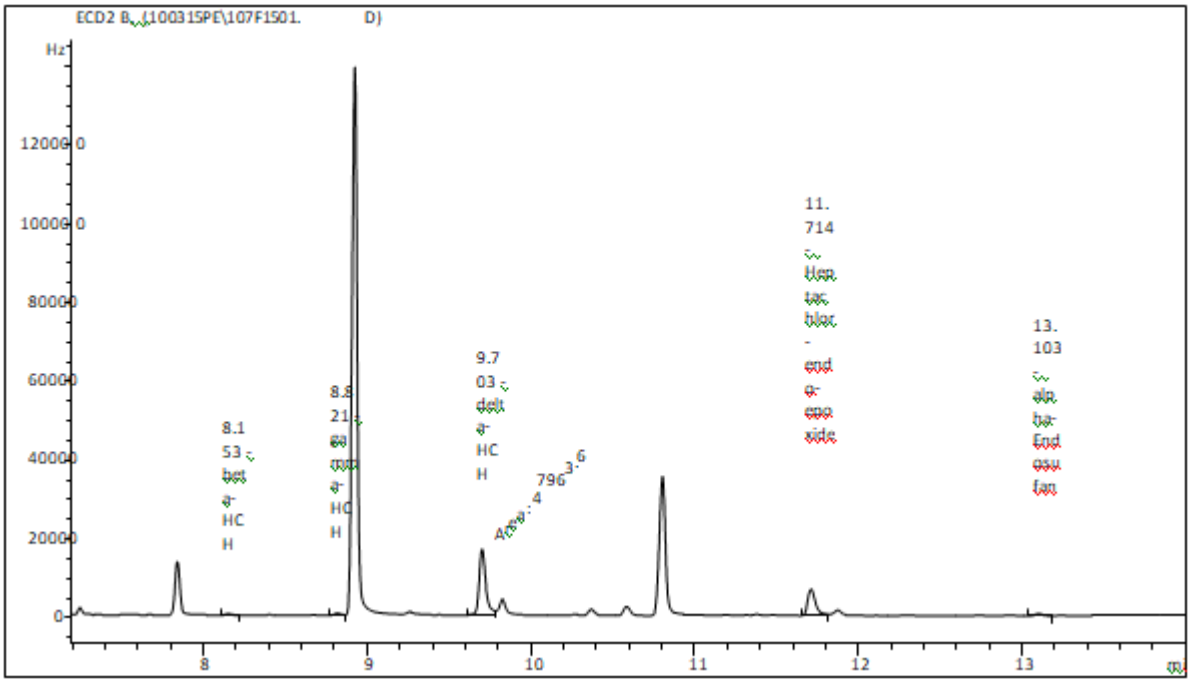


Figure 6: Chromatograms of organochlorine insecticides in cabbage samples from farms

4. Discussion

4.1 Insecticide residue in human breast milk, cabbage and water-bed sediments

Although lindane and endosulfan were not currently usedin horticultural production in Ghana since they have been banned by the EPA since 1992, they appeared in cabbage, breast milk and water-bed sediments sample. This clearly showed that chemicals found their way through illegal routes into the country or there are insecticides on the market that are wrongly labelled or contain active ingredients of these banned chemicals. For all the insecticide residues that appeared in the samples, the concentrations in the sediments were the highest and above the FAO/WHO limits. This could be due to the accumulation of residues in sediment over a period of time. Sediment also serves as a major sink for chemicals applied to crops (Ntow, 2001).

Both lindane and endosulfan persist in all sections of the environment. Persistence patterns vary from climate to climate and also depend on the chemical nature of the pesticide and type of substrate (Zaranyika and Mugari, 1995). Other organochlorine pesticide residues, such as HCB, DDE, and HCH, were detected in the sediment, although these chemicals were not mentioned as being used continuously in agriculture in the area. HCB, DDE and HCH are among the most persistent insecticides and their presence in sediment may be due to previous agricultural, industrial, or health uses.

The differences in the concentrations of lindane and endosulfan in the samples may be due to the fact that the chemicals have different degradation rates. In the study area, different pesticides were applied on crops at different times of the year. In this study, chlorpyrifos-ethyl and endosulfan were the only insecticide residues detected in appreciable quantities in cabbage. Several researchers including Ninsin (1997), Biney (2001), Aboagye (2003), Odhiambo (2005) and Ntow (2006) have studied the occurrence of insecticide residues in tomato, pineapples and cabbage, respectively. Residue levels of insecticides found in cabbage samples in this study was slightly higher than those found in samples analysed by Ninsin (1997) and Ntow (2006) suggesting possible misuse of insecticides on horticultural crops. HCB was present in almost all the milk samples analyzed. Although the levels were low in the breast milk of lactating mothers, the compound has not been available in local agricultural practice. HCB is an industrial waste product and a contaminant in some pesticides (1-3%) and may thus find its way into the environment (Skaare *et al*., 1988). In fact, it has ubiquitous occurrence in the environment (Ntow, 2006). HCB is not only persistent but also lipophilic and therefore accumulates in plant and animal tissues (Skaare *et al*., 1988).

During lactation HCB is mobilized and secreted in the milk. The major component present in the milk samples was DDE, although no trace of the parent compound(DDT) was found. The use of DDT in agriculture, disease vector control, or households has been banned in Ghana since 1992. The main metabolite of DDT is p,p'-DDE, and it is more persistent in the environment (Ntow, 2006). Thus, when the use of p,p'-DDT in a country ceases, their levels decrease more rapidly than the levels of p,p'-DDE. The DDE levels thus reflect previous exposure to DDT, or exposure to DDE through consumption of foods.

4.2 Infants' Daily Intake of Insecticides Residues in Mother's Breast Milk

As shown in Table 3, the mean values of HCB and p,p'DDE in breast milk of lactating wives of farmers were lower than the levels reported in some industrial countries (Weisenberg *et al*., 1985; Skaare, 1988; Kanja *et al*., 1992). The variations in the residue levels among the

individual farmers were not entirely unexpected because many factors influence the results, for example, exposure, age, and weight of farmers, dietary habits, etc (Kanja *et al*., 1992). The presence of HCB and DDE in milk suggests that they can be transferred from mother to newborn babies and fetus through breast milk (Ntow *et al*., 2006).

Using the residue levels in milk, it is possible to estimate infants' daily intake. For the first 3 months of life, an infant consumes an average 120 g of human milk per kg of body weight per day (WHO/UNEP, 1990), the volume consumed per unit weight decreasing with increasing age. A 5.0-kg (average infant body weight in Ghana) infant consuming 120 g of milk daily containing the mean HCB and DDE concentrations found here (1.77 µg/kg and 18.21 µg/kg, respectively) will consume. 0.042 µg HCB/kg/day and 0.412 µg DDE/kg/day. WHO/UNEP (1990)has estimated Acceptable Daily Intakes (ADI) values for HCB and DDT complex (the isomers of DDT and their metabolites). For HCB the ADI-value is 0.6 µg/kg, and-for DDT complex it is 167 µg/kg. About 95% of Ghanaian-born infants will have daily intakes of HCB (0.042 µg/kg) well below 0.6 (µg/kg/day), the acceptable value estimated by WHO/UNEP for infants. Similarly, 80% of Ghanaian-born infants will have daily intakes of DDE (0.412 µg/kg) below 167 p-g/kg/ day, which the WHO/UNEP estimates as a safe intake of DDE for infants. This implies that Ghanaian infants who breast-feed are not presently at any health risk. Thus, breastfeeding could be encouraged in Ghana, and even promoted for good child-mother relationship and also for other nutritional and immunological benefits. Nevertheless, it is very essential that breast milk and other human fluids are kept under regular surveillance with respect to organochlorine insecticide contamination to forestall any danger to life. This is because there is evidence that p,p'-DDE is an androgen antagonist (Keice *et al*., 1995). This compound is generally abundant among DDT metabolites in human as evident in this study. Furthermore, there is evidence that β –HCH is also an environmental estrogen, and this compound is generally abundant among HCH isomers in humans.

If only the risks of organochlorine insecticides are considered, breast milk containing high levels of such contaminants should not be fed to infants. Feeding with milk formula not contaminated by organochlorine insecticides instead of human breast milk is one of the measures for protecting infants from these risks. In human breast milk, however, not only general nutrients but also essential components for infant's growth and development such as secretary IgA, oligosaccharides, lactoferrin and lysozyme, which can increase their resistance to common infections, are present (Kunisue *et al*., 2004b). In addition, long-chain polyunsaturated fatty acids in human breast milk are indispensible for brain development of infants. It is also reported that breast- feeding is associated with sufficiently higher scores for cognitive development than formula feeding (Kunisue *et al*., 2004b). So avoiding breast-feeding may affect the growth and development of infants. Considering all these factors, breast-feeding is essential for the infants, but it is necessary to reduce the levels of DDTs and HCHs in human breast milk in Ghana. It is also necessary to elucidate whether illegal use of DDTs, HCHs, endosulfan and HCBs are present and to continuously monitor temporal trends of these pollutants in Ghana to remedy the situation. However, in the viewpoint of environmental toxicology, elevated DDTs concentrations in Ghanaian human breast milk perhaps underlines higher risk to both mother and infant health and deserves stricter regulation to phase out completely the use of DDTs (Ntow, 2006).

5. Conclusion and Recommendations

The study revealed the presence of persistent, bioacumulative, and toxic DDTS, HCHs, endosulfan and HCB in human fluids and at levels that raise public health concerns. These residues have originated from agricultural activities in the area. Because of their persistent and lipophilic nature, these residues have reached the top of the food chain by bioaccumulation. It is expected that an appreciable build-up of residues with time will occur because of the continuous use of insecticides in the area. Because these compounds are toxic and not environmentally friendly, increased contamination in human fluids may pose serious public health problems.

As a result of the overuse, misuse and abuse of insecticides by horticultural growers, it is recommended that a nation-wide research on the residue levels of insecticides in horticulture crops on the field and on the market as well as the fate of insecticides in crops and the environment be conducted to assess the health risks posed by insecticides on humans and the environment.

Research should be undertaken to develop or validate simple, rapid and useful analytical techniques for insecticide residue analysis for effective monitoring and surveillance of insecticides residue programme on food and water. Insecticides use patterns and residues on horticultural crops on farm, open market and supermarket should be investigated to ascertain their residue status to protect human health.

A monitoring programme for relevant insecticides in foods should be developed, considering the local insecticide use pattern of farmers and prevailing climatic conditions. Monitoring should include the estimation of total pesticide use as well as the occurrence insecticide induced illness or death.

It is further recommended that there should be continuous monitoring and inspection of pesticides products on the market by the various stakeholders such as the EPA, PPRSD of MoFA and CEPS who are involved in the regulation of pesticides so as to prevent the entry and use of unregistered and fake pesticides in the country.

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