Available online at www.elixirpublishers.com (Elixir International Journal)

Food Science

Elixir Food Science 86 (2015) 35386-35390

ISSN: 2229-712X

Organochlorine pesticide residues in vegetables in selected major growing areas in Ghana

Akwasi Akomeah Agyekum[1,2,*], George S. Ayernor[3] and Firibu K. Saalia[3]

[1]Radiological and Medical Sciences Research Institute, Ghana Atomic Energy Commission, P.O. BOX LG 80, Legon, Accra, Ghana.
[2]Applied Radiation Biology Centre, Ghana Atomic Energy Commission, P.O. BOX LG 80, Legon, Accra, Ghana.
[3]Department of Nutrition and Food Science, University of Ghana.

ARTICLE INFO

Article history:
Received: 18 February 2013;
Received in revised form:
24 September 2015;
Accepted: 30 September 2015;

Keywords
Organochlorine,
Bioaccumulation,
Xenobiotics.

ABSTRACT

The occurrence of organochlorine pesticide residues in food matrices has become essential due to the toxicity and intransigence of these xenobiotics. Residue levels of organochlorine pesticides (OCPs) were determined in two leafy vegetables sampled from selected major growing areas in Ghana. The determination was carried out using Gas Chromatography/ Mass Spectrophotometer (GC/MS) procedures. The results indicated that cabbage samples had the widest spread of OCP contamination between the two leafy vegetables analyzed. Residues of pesticides (75%) were found in all samples obtained from Akuapem-Mampong compared to samples obtained from the Accra Metropolis (100%) indicating high occurrence of these xenobiotics in the vegetables collected from farms in Accra. The commonest organochlorine pesticides that were used by almost all farmers were endrin, p, p-DDE, p, p-DDD, p, p-DDT, γ-chlordane, endosulfan sulphate, β-endosulphan, α-endosulphan, β-HCH, α-HCH and lindane. The residual levels of OCPs in cabbage and lettuce clearly indicate that, samples obtained in the city had higher OCP levels compared to samples obtained from the rural areas. The study shows that application of pesticides at higher doses results in higher levels of the chemicals in vegetables thereby exposing the entire Ghanaian population and the consequent health implications. Regular monitoring of OCPs in vegetables and other food matrices is key to prevent their accumulation in the food chain.

Introduction

Contamination of food matrices with organochlorine pesticides (OCPs) has been considered a serious threat to human health due to their high bioaccumulation potential, ubiquity, persistence in the environment, deleterious effect and high toxicity to non-target organisms (Loganathan and Kannan, 1994; Willett *et al*., 1998; Jones and de Voogt, 1999). Organochlorines are ever-present in the environment because of their moderate vapour pressure, low solubility, and low reactivity (Jones & de Voogt, 1999; Wang et al., 2007). Organochlorine pesticides have been applied in Ghana for more than 40 years, for agriculture and public health purposes with their residues having been found in water, sediments and crops and in humans (Ntow, 2001). OCPs production, usage and disposal into the environment have been regulated or prohibited in most countries (Hung & Thiemann, 2002). However, residues of OCPs from historical agricultural applications still persist in many environmental media (Guzzella et al., 2005) and continue to cycle through numerous routes, such as atmospheric transport and runoff (Meijer, Shoeib, Jantunen, Jones, & Harner, 2003;Meijer, Shoeib, Jones, & Harner, 2003). Many studies show that OCPs bioaccumulate in plants from polluted soil (González, Miglioranza, Aizpun De Moreno, & Moreno, 2003). Bio-accumulation levels in plant tissues can reach 10 to 1000 times greater than those in ambient environmental media such as air and water (Blasco et al., 2003). Exposure of humans and animals to high oral doses of OCPs results in paresthesia of the tongue, lips, and face; apprehension; hypersusceptibilty to external (light, touch, sound) stimuli; irritability, dizziness, and vertigo; tremor and tonic and clonic convulsions, nervous tension, muscular weakness, chest pains, severe impairment of spermatogenesis, memory loss and decreasing academic performance (Ecobichon,1996). Recent epidemiological studies indicate that some OCPs may influence the concentrations of thyroid hormones (Meeker, Altshul, & Hauser, 2007), and the possible association between exposure to DDT and various types of cancers in humans, including leukaemia, prostate, brain, and lymphopoietic cancers, non Hodgkins lymphoma and multiple myeloma, have been studied extensively (Beard, 2006; Dreiher & Kordysh, 2006; IARC, 2008; Quintana et al., 2004).

Leafy vegetables cabbage and lettuce are used in most Ghanaian meals regardless of social or economic status. These vegetables suffer attack from pest and thereby receive a lot of pesticide application. Vegetables containing pesticide residue concentrations above the agreed maximum residue level (MRL) may pose hazard to the consumer (Dogherni, Gad-Alla, Elsyes, Almaz, & Salama, 1996; Elliion, Sauve, & Selwyn, 2000; Mukherjee & Gopal, 1996). Ahuja *et al*. (1998) monitored residues of HCH and its isomers endosulfan, dimethoate, monocrotophos, fenvalerate, cypermethrin, quinalphos and the fungicide carbendazim in cauliflowers, cabbage, tomatoes, brinjal, okras, cucumber, french beans and field beans at harvest.

The objective of this study was to determine residual levels and distributions of OCPs in leafy vegetable (cabbage and lettuce) samples from different geographic regions in Ghana

Tele:
E-mail addresses: agyekumakwasiakomeah@yahoo.com

relative to the MRL established by the FAO/WHO Joint Meeting on Pesticide Residues (JMPR).

Materials and Methods

Sampling

Freshly harvested cabbage and lettuce were sampled from farms in the Accra and Akuapem-Mampong areas.

Sample Preparation

Where appropriate stones and stalks were removed and each sample homogenized. Appropriate representative sub-samples were bagged, sealed and labelled accordingly for analysis and storage. Extreme care was taken to prevent cross contamination of residues from one vegetable to the other.

Extraction

Sub samples of the prepared matrices (20 ± 0.1g) were weighed into sample bottles. Forty mL (40± 0.2 ml) of ethyl acetate were added to the sample and macerated for 30 seconds. Twenty grams (20± 0.1g) of anhydrous sodium sulphate and five grams (5 ± 0.1g) sodium hydrogen carbonate were added to the sample and macerated for a further 90 seconds. Samples were centrifuged at 3000 rpm for 5 minutes. Aliquots of (4ml ≡ 2.0g) were pipetted into a round-bottomed flask (50ml). Extracts were evaporated to dryness in a rotary film evaporator (RFE, Bibby RE 200) at 35°C.

Determination Quantification of Organochlorine Pesticide Residues

Quantification of organochlorine was performed using a Varian CP-3800 GC-MS with a CP-8400 Autosampler with an analytical gas column (30m + 10m) EZ guard 0.25mm internal diameter fused silica capillary coated with VF- 5ms (0.25µm film).

Aliquots of 1-2µl were injected into a GC/MS Model. The oven temperature was programmed from 0°C to 180°C and then increased to 300°C at a rate of 5°C/minute and held for one minute. Injector temperature was 250°C. The gas flow rate was: Helium 1.3ml/minute constant flow.

To examine the efficacy of extraction and cleanup, three samples of each batch were spiked with known concentrations (2µg/ml) of organochlorine standards. The limit of determination was set at 0.1mg/kg which equates to a calibration standard concentration of 0.125µg/ml. Blank analyses were performed in order to check interference from the sample. All analyses were carried out in triplicates and the mean concentrations were calculated based on the total number of samples.

Daily intake of OCPs

The daily intake of OCPs (DIM) was calculated by the following equation:

$$\text{DI OCPs} = \frac{(M) \times K \times I}{W}$$

Where (M), K, I and W represent the OCP concentrations in plant (mg/kg), conversion factor, daily intake of vegetables and average body weight, respectively. The conversion factor used to convert fresh green vegetables to dry weight was 0.085, as described by Rattan, Datta, Chhonkar, Suribabu, and Singh, 2005. The average adult and child body weights were considered to be 55.9 and 32.7 kg, respectively, while average daily vegetable intakes for adults and children were considered to be 0.345 and 0.232 kg/person/day, respectively, as reported in the literature (Ge, 1992; Wang, Sato, Xing, and Tao, 2005).

Reagents

Pesticide reference standards, with certified purity of at least 98% were obtained from Dr. Ehrenstorfer GmbH (Augsburg, Germany). Pesticide grade ethyl acetate and acetone were supplied from BDH Laboratory Supplies, England and anhydrous sodium hydrogen carbonate and sodium sulfate analytical grade were purchased from Merck (Darmstadt, F.R. Germany). Solid-phase florisil cartridges column size (500 mg/8 mL) was obtained from Honeywell Burdick & Jacksob (Muskegon, USA). All equipments in the laboratory analysis were washed with water and soap, and rinsed with acetone before use.

Results and discussion

The analysis of the vegetables showed the presence of different pesticides with the following concentrations in cabbage samples: endrin (ranged 0.001- 0.022 mg/kg), p,p'-DDE (averaged 0.001 mg/kg), p,p'-DDD (averaged 0.003–10.8 mg/kg), p,p'-DDT (ranged 0.02–0.022 mg /kg,), γ-chlordane (averaged 0.0003 mg/kg), endosulfan sulfate (averaged 0.006 mg/kg), β-endosulfan (averaged 0.0003 mg/kg), δ-HCH (ranged 0.042-0.063 mg/kg), lindane (averaged 0.01 mg/kg), α-endosulfan (averaged 0.309 mg/kg) and β-endosulfan (averaged 0.006 mg/kg). Other pesticides were also present in the lettuce samples, as kresoxim-methyl (averaged from 0.045 to 0.057 mg/kg, 20% sample).

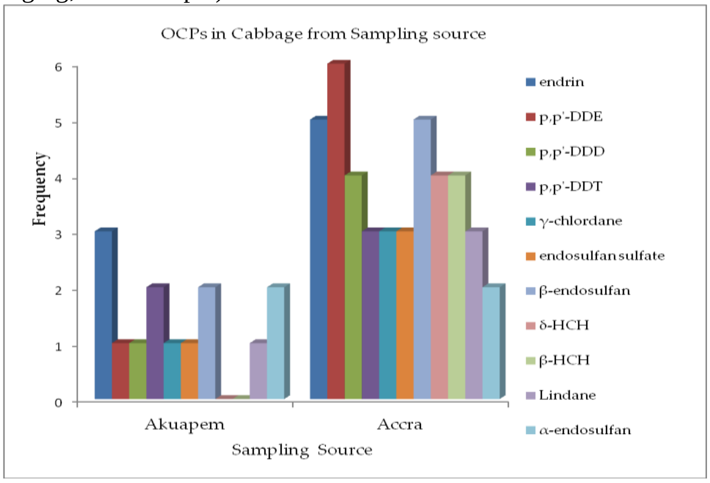

Fig 1.0 OCP residues in cabbage from sampling source

Figures 1.0 and 2.0 shows the frequency distribution of organochlorine pesticide residues according to vegetables that were sampled from the various locations. The commonest organochlorine pesticides that were used by almost all farmers were endrin, p, p-DDE, p, p-DDD, p, p-DDT, γ-chlordane, endosulfan sulphate, β-endosulphan, α-endosulphan, β-HCH, α-HCH and lindane. Cabbage samples obtained from Accra had the widest spread and frequency of OCP residue contamination. In all twelve pesticides were detected in cabbage samples obtained from Accra whereas nine pesticides were detected in samples obtained from the Akuapem-Mampong area.

The concentration of endrin in lettuce was significantly higher ($p < 0.005$) than the concentration in cabbage. These observations imply that farmers are not limited to any particular pesticides, but use a wide scope of them in order to protect the crops and obtain a good harvest. The variation in pesticide residue levels in produce from one farm to the other for the same matrix may be ascribed to the different forms and rates of pesticide application, good agricultural practices, access to extension officers, support from non-governmental organizations, soil organic matter, pH as well as meteorological factors such as temperature, rainfall and solar radiation Yadava and Gupta (1975). β- HCH and δ-HCH isomers detected in most of the samples indicate that technical HCH and lindane have been used widely in Ghana. It may also be attributed to the importunate nature of these chemicals which are lipophilic in nature and may move long distances in surface runoff or groundwater thereby contaminating water bodies that are used for irrigating horticultural crops as reported by Agyekum *et al.*, (2012).

This result may be due to the variation in the nature and magnitude of sprayed pesticides from place to place. The continuous consumption of vegetables, even with only moderate contamination levels, can lead to the build up of pesticide in the consumer and may prove lethal to the human population after long-term exposures. Therefore, food safety is an important area of concern in view of its direct effects on human health.

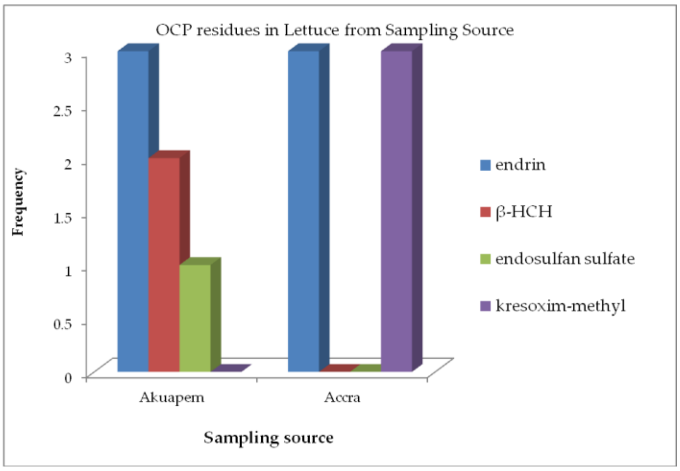

Fig 2.0 OCP residues in lettuce from sampling source

Concentrations compared with MRLs of pesticide residues with their respective samples

Figures (3.0 and 4.0) represent the concentration and maximum residue limits (MRLs) of organochlorine pesticides residues respectively in cabbage and lettuce obtained from sampling sources. The concentrations of all detected pesticides were found within the acceptable limits with the exception of δ-HCH, α-endosulfan and kresoxim-methyl that exceeded the levels established by the FAO/WHO JMPR.

The differences in pesticide residue concentration in vegetable samples are mainly due to use of different pesticides concentrations in different sites depending upon the extent of pest attack. The results could also be explained by the lack of awareness of farmers about the application dose, method of application and the pre-harvest time (appropriate interval between harvesting and pesticide treatment).The findings of this study indicated that the presence of pesticides in the vegetable samples was due to the spraying in high doses of the pesticides onto the vegetables as corroborated by Agyekum *et al*., (2012). This result is consistent with findings of Osman et al. (2010) who monitored pesticide residues in marketed vegetables in Al-Qassim region, Saudi Arabia and found cabbages to be the most contaminated vegetable in that region. This may be as a result of overuse and ineluctably application of random mixture of pesticides to control pests and pathogens.

These reasons have been corroborated by Yadava and Gupta (1975) and Agyekum *et al* (2012), who reported that pesticide breakage or dissipation is influenced by the agroclimatic conditions and the plant response to toxicants. It may also be due to the nature of the soil at the different locations. The results could also be explained by the lack of awareness of farmers about the application dose, method of application and the pre-harvest time (appropriate interval between harvesting and pesticide treatment). This may be as a result of excess and ineluctably application of random mixture of pesticides to control pests and pathogens.

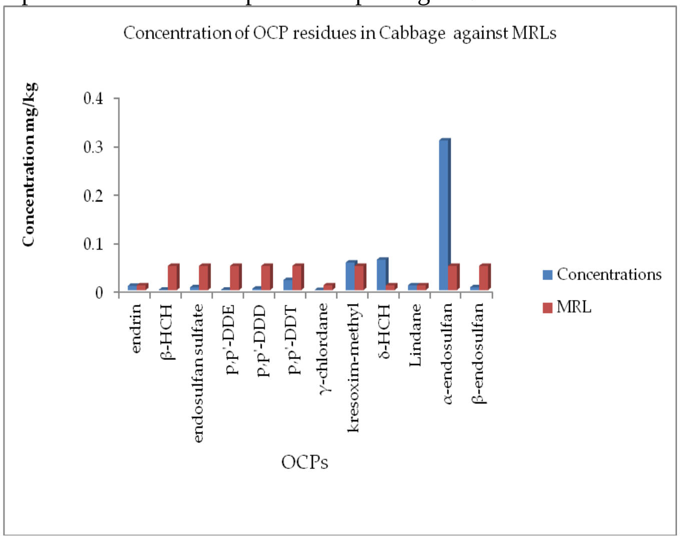

Fig 3.0 Concentration of OCP residues in cabbage against MRLs

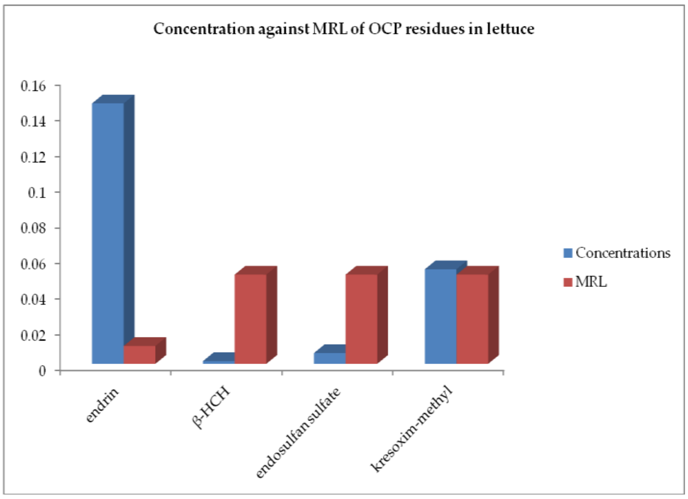

Fig 4.0 Concentration of OCP residues in lettuce against MRLs

Therefore, there is a need to educate farmers concerning the safe use of pesticides in correct doses. Farmers also need to be urgently trained on controlling the use of pesticides just before harvesting the crop, which can reduce the level of pesticide residues in vegetables. The government should also pay more attention to strengthening organic farming and the use of biopesticides from neem tree and jetropha plant in Ghana, which may be helpful in reducing exposure to chemical pesticide. The levels of some chemicals in the crops were higher than the Maximum Residue Levels, hence, extension officers must design workshops for good agricultural practices; and farmers must adhere to good agricultural practices.This study may also be useful in developing a national exposure database to facilitate a risk assessment for children's health due to OCPs pesticides in our daily life.

Daily Intake of OCPs

To assess the health threat of any contaminant, it is imperative to estimate the level of exposure, by detecting the routes of exposure to the target organism. Food is the main source of human exposure to contaminants. The DI values for OCPs were high when based on the consumption of green vegetables. The highest consumption of endrin and β-HCH were from the consumption of cabbage for both adults and children. The findings regarding DI of OCPs of this study suggest that the consumption of cabbage is high compared with lettuce.

Pesticides	Lettuce		Cabbage	
	Adults	Children	Adults	Children
Endrin	7.659×10^{-5}	8.805×10^{-5}	4.721×10^{-6}	5.428×10^{-6}
β-HCH	7.869×10^{-7}	9.046×10^{-7}	5.246×10^{-7}	6.031×10^{-7}
Endosulphan Sulphate	3.148×10^{-6}	3.618×10^{-6}	3.148×10^{-6}	3.618×10^{-6}
Kresoxim methyl	2.780×10^{-5}	3.196×10^{-5}	2.990×10^{-5}	3.437×10^{-5}
p, p'-DDE	ND	ND	5.246×10^{-7}	6.031×10^{-7}
p, p'-DDD	ND	ND	1.246×10^{-6}	6.031×10^{-6}
p, p'-DDT	ND	ND	1.102×10^{-5}	1.266×10^{-5}
γ-Chlordane	ND	ND	1.574×10^{-7}	1.809×10^{-7}
δ-HCH	ND	ND	3.305×10^{-5}	3.799×10^{-5}
Lindane	ND	ND	5.246×10^{-6}	6.031×10^{-6}
α-endosulphan	ND	ND	1.621×10^{-4}	1.864×10^{-4}
β-endosulphan	ND	ND	3.148×10^{-6}	5.381×10^{-6}

Conclusion

The study shows that application of pesticides at higher doses results in higher levels of the chemicals in vegetables thereby exposing the entire Ghanaian population and the consequent health implications. This study could also help in the generation of proxy indicators for large-scale health studies on pesticide exposure and in making policies to implement a remedy to prevent the exposure of children to these pesticides in developing countries like Ghana. Furthermore, this study suggests that spraying pesticides in high doses should be discouraged because it increases the occurrence of pesticide related diseases in developing countries.

Dietary intake of food results in long-term low level body accumulation of heavy metals and the detrimental impact becomes apparent only after several years of exposure. Hence regular monitoring of OCPs in vegetables and other food matrices is key to prevent their accumulation in the food chain.

References

Agyekum, A.A., Ayernor, G.S., Saalia,F.K., and Bediako-Amoa, B: Translocation of Pesticides in Cabbage (Elixir-Food Science 45 (2012) 7988-7989).

Ahuja, A.K., Soudamini, M., Debi, S., Awasthi, M.D., Mohapatra, S., Sharma, D., Reddy, P.P., Kumar, N.K.K., Verghese, A. (1998). Monitoring of vegetables for pesticide residue contamination at harvest. Advances in IPM for horticultural crops. Proc. First Nat. Symposium on Pest management in horticultural crops: Environmental Implications and Thrust, India 15-17 October 98: 243-246.

Al-Rifai, J., & Akkel, N. (1997). Determination of pesticide residues in imported and locally produced honey in Jordan. Journal of Apicultural Research, 36, 155−161.

Anju, R., Beena, K., Gahlawat, S. K., Sihag, R. C., & Kathpal, T. S. (1997). Multiresidue analysis of market honey samples for pesticidal contamination. Journal of Pesticide Research, 9, 226−230.

Antonescu, C., & Mateescu, C. (2001). Environmental pollution and its effects on honey quality. Roumanian Biotechnology Letters, 6, 371−379.

Beard, J. (2006). DDT and human health. Science of the Total Environment, 355(1–3), 78–89.

Bogdanov, S., Ryll, G., & Roth, H. (2003). Pesticide residues in honey and beeswax produced in Switzerland. Apidologie, 34, 484−485.

Blasco, C., Fernández, M., Pena, A., Lino, C., Silveira, M. I., & Font, G. (2003). Assessment of pesticide residues in honey samples from Portugal and Spain. Journal of Agricultural and Food Chemistry, 51, 8132−8138.

Blasco, C., Lino, C., Picó, Y., Pena, A., Font, G., & Silveira, M. I. (2004). Determination of organochlorine pesticide residues in honey from the central zone of Portugal and the Valencian community of Spain. Journal of Chromatography A, 1049, 155−160.

Dogherni, S. M., Gad-Alla, S. A., Elsyes, S. M. A., Almaz, M. M., & Salama, E. J. (1996). Organochlorine and organophosphorous pesticide residues in food from Egyptian local markets. Journal of AOAC International, 79, 949–952.

Dreiher, J., & Kordysh, E. (2006). Non-Hodgkin Lymphoma and pesticide exposure: 25 years of research. Acta Haematologica, 116(3), 153–164.

Ecobichon D.J: Toxic effects of pesticides, in Klaassen CD (ed): Casarett and Doull's Toxicology. The Basic Science of Poisons. 5th ed. New York, McGraw-Hill, 1996; pp 643–689.

Elliion, J., Sauve, F., & Selwyn, J. (2000). Multi-residue method for determination of residues of 251 pesticides in fruits and vegetables by gas chromatography with fluorescence detector. Journal of AOAC INTERNATIONAL, 83, 698–713.

Erdoğrul, Ö. (2007). Levels of selected pesticides in honey samples from Kahramanmaraş, Turkey. Food Control, 18, 866−871.

González, M., Miglioranza, K. S., Aizpun De Moreno, J. E., & Moreno, V. J. (2003). Organochlorine pesticide residues in leek (Allium porrum) crops grown on untreated soils from an agricultural environment. Journal of Agricultural and Food Chemistry, 51, 5024−5029.

Guzzella, L., Roscioli, C., Vigano, L., Saha, M., Sarkar, S. K., & Bhattacharya, A. (2005). Evaluation of the concentration of HCH, DDT, HCB, PCB and PAH in the sediments along the lower stretch of Hugli estuary, West Bengal, northeast India. Environment International, 31, 523−534.

Hung, D. Q., & Thiemann, W. (2002). Contamination by selected chlorinated pesticides in surface waters in Hanoi, Vietnam. Chemosphere, 47, 357−367.

International Agency for Research on Cancer (IARC). (2008). Overall Evaluations of Carcinogenicity to Humans: Update 2008. Available at <http:// monographs.iarc.fr/ ENG/Classification/crthallcas. php>.

Jones, K. C., & de Voogt, P. (1999). Persistent organic pollutants (POPs): State of the science. Environmental Pollution, 100, 209−221.

Li, J., Zhang, G., Qi, S. H., Li, X. D., & Peng, X. Z. (2006). Concentrations, enantiomeric compositions, and sources of HCH, DDT and chlordane in soils from the Pearl River Delta, South China. The Science of the Total Environment, 372, 215−224.

Meijer, S. N., Shoeib, M., Jantunen, L. M. M., Jones, K. C., & Harner, T. (2003). Air–soil exchange of organochlorine pesticides in agricultural soils. 1. Field measurements using a novel in situ sampling device. Environmental Science & Technology, 37, 1292–1299.

Meijer, S. N., Shoeib, M., Jones, K. C., & Harner, T. (2003). Air–soil exchange of organochlorine pesticides in agricultural soils. 2. Laboratory measurements of the soil–air partition coefficient. Environmental Science & Technology, 37, 1300–1305.

Meeker, J. D., Altshul, L., & Hauser, R. (2007). Serum PCBs, p, p0-DDE and HCB predict thyroid hormone levels in men. Environmental Research, 104(2), 296–304.

Mukherjee, I., & Gopal, M. (1996). Insecticide residues in bay food, animal feed and vegetables. Bulletin of Environmental Contamination and Toxicology, 56, 381–388.

Osman, K. A., Al-Humaid, A. M., & Al-Redhaiman, K. N. (2010). Monitoring of pesticide residues in vegetables marketed in Al-Qassim region, Saudi Arabia. Ecotoxicology and Environmental Safety, 73, 1433-1439.

Qu, W. Y., Suri, R. P. S., Bi, X. H., Sheng, G. Y., & Fu, J. M. (2010). Exposure of young mothers and newborns to organochlorine pesticides (OCPs) in Guangzhou, China. The Science of the Total Environment, 16, 3133–3138.

Quintana, P., Delfino, R., Korrick, S., Ziogas, A., Kutz, F., Jones, E., et al. (2004). Adipose tissue levels of organochlorine pesticides and polychlorinated biphenyls and risk of Non-Hodgkin's Lymphoma. Environmental Health Perspectives, 112(8), 854–861.

Wang, J., Guo, L. L., Li, J., Zhang, G., Lee, C. S. L., & Li, X. D. (2007). Passive air sampling of DDT, chlordane and HCB in the Pearl River Delta, South China: Implications to regional sources. Journal of Environmental Monitoring, 9, 582–588.