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ORIGINAL PAPER

Distribution of organochlorine pesticides in atmospheric air of Tamilnadu, southern India

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Abstract Passive air sampling was performed for urban, suburban, coastal, and agriculture air during April 2009–January 2010 in Tamilnadu, southern India, to know the distribution and fate of organochlorine pesticides (OCPs) residues. Exposed polyurethane foam samples (30 ± 2 days) were soxhlet extracted, and the extracts were analyzed using gas chromatography–mass spectrometric method. The total concentrations of 13 OCPs were in the range of not detected (ND)–41,400 pg/m^3. Dichlorodiphenyltrichloroethane, dichlorodiphenyldichloroethylene, heptachlor, and mirex were found predominant during monsoon season. The elevated α/γ isomer ratio of hexachlorocyclohexane (HCH) (5.03) during summer revealed fresh/recent usage of HCH in coastal area. Dichlorodiphenyltrichloroethane ratio shows its fresh application in all the locations during monsoon season, which probably used to contain the diseases causing vectors. Detection of banned pesticides, such as aldrin, dieldrin, and heptachlor in air, indicating their illegal usage/or from old source. Furthermore, mirex, an unregistered pesticide in India, is being reported for the first time in air. More importantly, the obtained information will be used as a valuable baseline data for the management of atmospheric OCPs in future.

Keywords Air pollution · Organochlorine pesticides · Passive air sampling · Gas chromatography–mass spectrometry · India

Introduction

Though organic farming is gaining importance, the application of synthetic pesticides is still practiced in agriculture and for sanitation purposes, pesticide residual prevalence in environmental matrices is an all time environmental concern. The organochlorine pesticides (OCPs) are reported to be associated with soil, water, air, and biota as toxic contaminants (Kang et al. 2001). Their physical/chemical properties including hydrophobicity, lipophilicity, and moderate vapor pressure make them persistent in the environment. OCPs are of special concern due to its toxicity, long-range transport, and potential to bioaccumulate (UNECE, United Nations Economic Commission for Europe 1998).

The worldwide usage of herbicides, insecticides, and fungicides is 49.6, 26.2, and 19.5 %, respectively (Merrington et al. 2002). OCPs are mostly associated with soil but being semi volatile, they disperse in air and get partitioned between gas and particulate phases based on the molecular weight (Sanusi et al. 1999; Sauret et al. 2008). Wind circulation plays a major role in transport and deposition of OCPs around the world. Despite the ban of most OCPs, higher atmospheric levels are still reported in many parts of the world (He and Balasubramanian 2009; Zheng et al. 2010). Further, their trace quantification in distant polar environment signifies its long-range transport and bioaccumulation scenario. Recently, Chakraborty et al. (2010) reported high level of OCPs in the atmosphere of Indian cities such as Agra, Bangalore, Chennai, Goa,

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Mumbai, New Delhi, and Kolkata. Devi et al. (2011) also reported OCPs from high altitude ambient air (at Manipur) in India, with the signature of dichlorodiphenyltrichloroethanes (DDTs).

In India, some of the banned pesticides are permitted in agriculture and vector control activities, for example, DDT is still used for malaria control (Pozo et al. 2011). Similarly, technical hexachlorocyclohexane (HCH) was banned in 1997, but the government of India was permitted to manufacture and use the γ-HCH in the name of lindane. Very recently, endosulfan, a booming teratogen is banned only in few states of India. In Tamilnadu state, 70 % of populations are engaged in agriculture and allied activities to support its economy. It has the cultivated land of around 5,843,000 hm^2, which includes main crops such as vegetables, grains and pulses, turmeric, sugarcane, and oilseeds. The pesticides usage is so intense in cultivation, and even the seeds to be sown are treated (TNAU, Tamil Nadu Agricultural University 2009).

The present study was carried out to understand the spatial and seasonal distribution of 13 OCPs in the atmospheric air covering urban, suburban, agriculture, and coastal areas of Tamilnadu, southern India and to find their possible sources. The samples were collected during summer, premonsoon, and monsoon seasons of the year 2009–2010. The main goal was to establish the baseline data for future monitoring studies.

Materials and methods

Study area

Tamilnadu state is located in southernmost part of India and has a population of about 72,138,958 according to Census of India (2011), and the state is witnessing rapid industrialization, urbanization, and population growth. For the present study, air samplers were deployed at 32 sites covering urban (13), suburban (7), coastal (8), and agricultural (4) locations. The sampling was performed during summer, premonsoon, and monsoon seasons of 2009–2010. The polyurethane foams (PUFs) were exposed for 30 ± 2 days. Details of sampling locations, and geographical co-ordinates and altitude were shown in Fig. 1 and Table S1 (supporting data), respectively.

Passive air sampler

The passive air sampler was indigenously assembled with the available components as per the specifications given in Shoeib and Harner (2002). The sampler consists of two

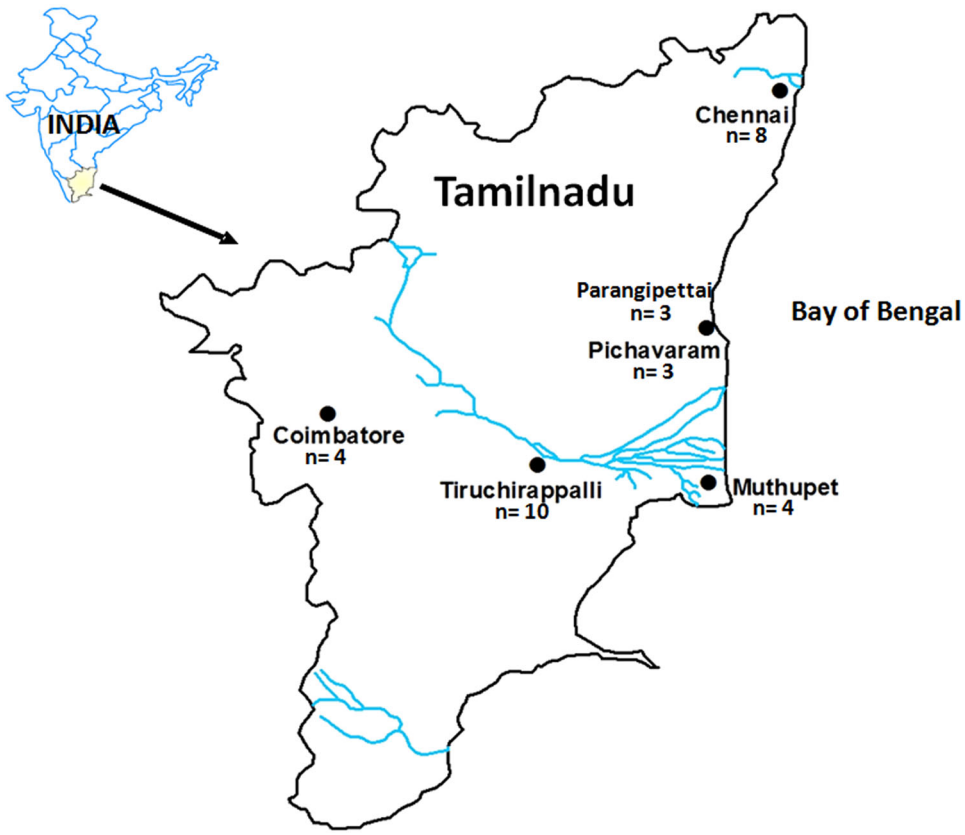

Fig. 1 Map showing the sampling (n = number of sites) locations

domed stainless steel chambers aligned in central axis, to house the PUF disk (15 cm diameter, 1.35 cm thick, 0.0176 g/cm^3 density). The stainless steel chambers provide protection against sunlight, UV rays, direct precipitation, and particle deposition, and also maintain constant wind flow. PUFs were prewashed (methanol) and cleaned by soxhlet extraction (6 h using acetone: *n*-hexane) before installation. The exposed PUFs were wrapped in two layers of aluminum foil, labeled, placed in ziplock polythene bag, and transported to the laboratory in cold condition and kept at −18 °C until extraction.

Standards and chemicals

Organochlorine pesticides standards (α-HCH, β-HCH, γ-HCH, HCB, aldrin, dieldrin, *p*,*p*′-DDE, *o*,*p*′-DDE, *p*,*p*′-DDD, *o*,*p*′-DDD, *p*,*p*′-DDT, and mirex) and internal standard phenanthrene D_{12} were procured from Accu-Standard (New Haven, USA) with a purity of 97.6–100 %. Solvents such as n-Hexane, dichloromethane (DCM), and acetone of GC grade were from Thermo Fisher Scientific India Pvt. Ltd. (Mumbai, India). Silica gel (60–120 mesh size), sodium sulfate (anhydrous), and glass wool were obtained from Himedia Laboratory Pvt. Ltd. (Mumbai, India). All glassware were cleaned in series with soap solution, tap water, hydrochloric acid, deionised water, and acetone, and kept in hot air oven at 250 °C for overnight before use.

Sample extraction

The exposed PUF disk was extracted for OCPs based on the method of Buehler et al. (2001) with minor modifications. Briefly, each PUF was extracted using soxhlet for 6 h using 200 mL of acetone and hexane (1:1). Then, the extract was concentrated to about 1 mL using rotary vacuum evaporator (Buchi R-210, Switzerland) and cleaned up by preconditioned silica gel column (1.3 cm dia. × 24 cm length). After loading the extract, the OCPs were eluted with 25 ml of *n*-hexane: DCM (1:1) and condensed the eluate to about 1 mL using rotary vacuum evaporator, collected in a glass vial and further concentrated to 1 mL under a gentle stream of nitrogen gas. The extract vials were stored at −4 °C until gas chromatograph–mass spectrometer (GC–MS) analysis.

Instrumental analyses

The qualitative and quantitative determination of OCPs was performed by GC–MS (QP2010; Shimadzu), equipped with auto injector (AOC-20i). The analytes separation was performed in a 60 m × 0.25 mm I.D. × 0.25 µm film thickness Rtx column (Restek, PA, USA), and helium was used as a carrier gas at a flow rate of 2 mL/min. The column temperature was programed as 100–150 °C at 10 °C/min, to 250 °C at 5 °C/min, to 280 °C at 2 °C/min, finally to 320 °C at 5 °C/min, and hold for 10 min. About 1 µl of the extract was injected into the injection port (at 250 °C) using auto injector. The mass spectrometer was operated in SIM mode, and the ion source temperature was kept at 230 °C. The electron ionization (EI) unit was operated at 70 eV and at an emission current of 60 µA. Full-scan data were obtained in a mass range of *m*/*z* 35–500. Scanning interval and SIM sampling rate were 0.5 and 0.2 s, respectively.

Quality control and quality assurance

Quality control/quality assurance was performed throughout the analyses. Field and laboratory blanks were performed for each batch of PUF analysis. The blanks (precleaned PUF disks) were extracted and analyzed to confirm their purity. To obtain the recovery percentage, the cleaned unexposed PUFs were spiked with known concentrations of pesticide mixture (13 OCPs), extracted, and cleaned up by silica gel and analyzed as that of the sample. The calibration of OCPs standard was performed in the liner range of 1–200 ng/mL. The calibration curves showed good linearity, with correlation coefficient (r^2) of >0.997. The QA/QC criteria, such as analytes precision, recovery, LOD, and LOQ, were given in Table S2 (supporting data). We regularly took part in interlaboratory calibration exercise organized by International Atomic Energy Agency (IAEA, International Atomic Energy Agency 2012) to check the standard of our laboratory.

Results and discussion

The minimum (min), maximum (max), mean, and median concentration of OCPs in atmospheric air of Tamilnadu, southern India, was listed in Table S3 (supporting data). The concentration of total HCHs (sum of *α*, *β*, and *γ* isomers) ranged from not detected (ND) to 1,232 pg/m^3 (mean 257 pg/m^3; median 47 pg/m^3). The concentration of total DDT (sum of *o*,*p*'-DDE, *p*,*p*'-DDE, *o*,*p*'-DDD, *p*,*p*'-DDD, and *p*,*p*'-DDT) ranged from ND to 2,468 pg/m^3 (mean 345 pg/m^3; median 206 pg/m^3). Among other OCPs, aldrin ranged from ND to 283 pg/m^3 (mean 55 pg/m^3; median 30 pg/m^3), dieldrin from ND to 335 pg/m^3 (mean 78 pg/m^3; median 68 pg/m^3), heptachlor from ND to 1,012 pg/m^3 (mean 220 pg/m^3; median 237 pg/m^3), HCB from ND to 613 pg/m^3 (mean 134 pg/m^3; median 96 pg/m^3), and mirex from ND to 40,155 pg/m^3 (mean 4,609 pg/m^3; median 2,432 pg/m^3).

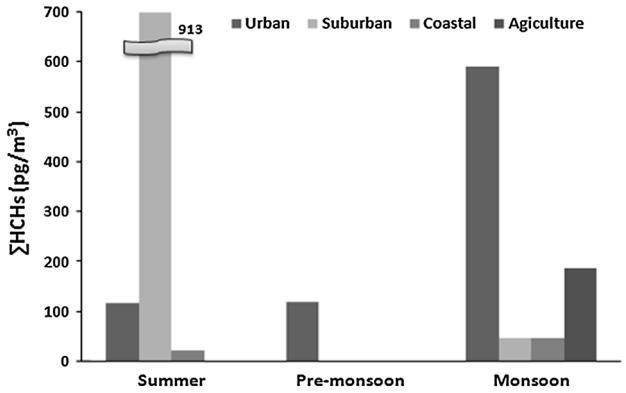

Fig. 2 Seasonal variation in ∑HCHs in atmospheric air

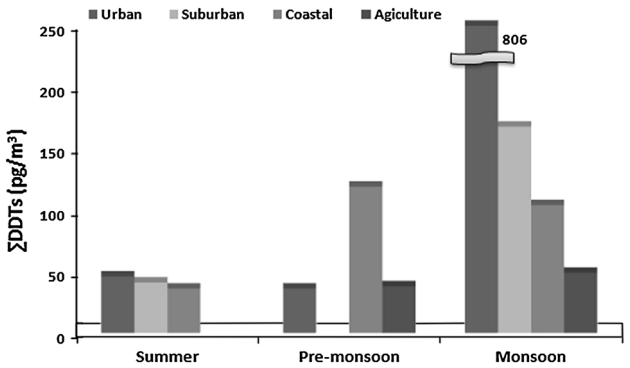

Fig. 3 Seasonal variation in ∑DDTs in atmospheric air

OCPs seasonal variation

The concentration of total OCPs during monsoon season is one to two orders of magnitude higher than in summer and premonsoon seasons. Importantly, the season-wise comparison revealed that HCH isomers were predominant in summer and monsoon seasons (Fig. 2), whereas DDTs were prevalent in all the seasons; however, the trend was decreasing in the order of monsoon > premonsoon > summer seasons (Fig. 3).

Summer season

In summer, only seven OCPs were detected namely α-HCH, β-HCH, γ-HCH, *p*,*p*'-DDE, aldrin, dieldrin, and heptachlor. The levels of OCPs were found decreasing toward suburban, urban, coastal, and agriculture areas (Table 1). The total HCH (sum of α, β, γ) ranged from ND to 1,162 pg/m^3. The technical mixture of HCH production was stopped in India by 1997 (Gupta 2004); however, the detection of α- and β-HCH at high concentration shows the technical mixture usage and/or its presence in lindane as impurity. Further, there is also a possibility of photochemical transformation of γ-HCH to α-HCH in the atmosphere during long-range transport (Barrie et al. 1992). The technical grade mixture used in Asian countries consists of α-isomer (60–70 %) at higher ratio than β, γ, and δ ratios (5–12 %) (Kutz et al. 1991; Iwata et al. 1994).

Among the HCHs, β-HCH was predominantly found (913 pg/m^3) in coastal air. The concentration of β-HCH is due to its persistent and least reactive nature among the four HCH isomers; furthermore, it has low solubility and slow decomposition (Mishra et al. 2012). The β-HCH prevalence can also be due to the long-range transport, which has half-life time of 100 days (Willett et al. 1998). Hayes (1982) suggested the isomerization of γ-HCH to β-HCH in seawater and sediment, so flux from seawater to surrounding air could be the reason for the elevated levels observed in this study. Previously Babu Rajendran et al. (1999) reported higher levels of HCHs residues (up to 35,000 pg/m^3) in atmospheric air of Parangipettai in Tamilnadu, southern India, which is much higher than the present study. Similar to our results, β-HCH was reported at higher level in coastal air at Goa and Mumbai in west coast of India (Iwata et al. 1994). However, Devi et al. (2011) reported low concentration of β-HCH (up to 38 pg/m^3) in Waithou Mountain, northeastern India, than other HCHs (up to 176 pg/m^3).

Among DDTs, only *p*,*p*′-DDE was detected (up to 46 pg/m^3) during summer season (Table 1) and this could be the result of conversion of DDT to DDE in the atmosphere and further DDE is the most stable form of DDT (Atlas and Giam 1988). The volatilization of soil residues may also a reason for OCPs diagnosis in summer. In particular, occurrence of aldrin and dieldrin may be due to its usage as soil insecticides in corn, potato, and other crops and also as termite killer in wooden structures (Ozcan and Aydin 2009).

Premonsoon season

In premonsoon, the average concentrations of Σ_{13} OCPs in coastal, urban, and agriculture air were 1,040, 490, and 90 pg/m^3, respectively. However, OCPs were not detected in air from suburban area. Among HCHs, only γ-HCH was detected in urban location (253 pg/m^3). In case of DDT, *p*,*p*′- DDE was highly detected up to 175 pg/m^3 at coastal region with ΣDDTs constitute higher level (237 pg/m^3) than all other locations. In the present study, higher level of DDE implies recent past or continuing usage of DDT in coastal and surrounding areas, probably for vector control activities such as malaria,(Pozo et al. 2011), and agriculture as well. Since, *p*,*p*′-DDE is more stable end product of DDT (Pandey et al. 2011); it may also account for higher detection than DDT in coastal area. In urban air also, all the metabolites of DDT were detected (Table 1), suggesting its ubiquitous prevalence. The detection of aldrin and dieldrin

Table 1 Mean concentration of OCPs (pg/m^3) in the ambient air of Tamilnadu (during 2009–2010), southern India

Season /area	α-HCH	γ-HCH	β-HCH	*p,p'*-DDT	*o,p'*-DDE	*p,p'*-DDE	*p,p'*-DDD	*o,p'*-DDD	Aldrin	Dieldrin	Heptachlor	HCB	Mirex	ΣOCPs
Summer														
Urban	ND	212	19	ND	ND	46 ± 17	ND	ND	ND	ND	18	ND	ND	295
Suburban	ND	ND	913	ND	ND	41 ± 5	ND	ND	ND	ND	ND	ND	ND	950
Coastal	37	7	ND	ND	ND	36 ± 19	ND	ND	65	39	ND	ND	ND	148
Agriculture	ND	ND	ND	ND	ND	ND	ND	ND	ND	31	ND	ND	ND	31
Premonsoon														
Urban	ND	120 ± 116	ND	ND	21	90 ± 5	18	16	27	51	ND	98	45	490
Suburban	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Coastal	ND	ND	ND	62	ND	175 ± 67	ND	ND	109 ± 111	98 ± 51	128	253 ± 136	210 ± 123	1,040
Agriculture	ND	ND	ND	ND	ND	38	ND	ND	ND	51	ND	ND	ND	90
Monsoon														
Urban	ND	1,150 ± 85	34	1,025 ± 1,312	168	1,230 ± 1,482	ND	ND	115 ± 152	189 ± 128	1,012 ± 922	165 ± 70	350	5,400
Suburban	48 ± 28	ND	ND	220 ± 221	16	410 ± 231	ND	22 ± 2	37 ± 23	86	60	316 ± 28	40,200 ± 7,528	41,400
Coastal	ND	47	ND	52	44 ± 27	217	ND	ND	283	335 ± 321	530	159 ± 183	950	2,600
Agriculture	ND	187	ND	25	62	61	ND	49	27	51	894	613	13,600 ± 1,123	15,500

ND not detected

implies their illegal usage since these pesticides were banned in India from 1990 onwards (IPEN, International POPs Elimination Network 2006).

HCB was the highest detected OCP in premonsoon with a maximum concentration of 253 pg/m^3 at coastal area. Other than coastal area, it was quantified only in urban air (98 pg/m^3). Although it is a banned OCP in several countries (including India), the detection again reminds its illegal usage as fungicide in seed treatment (Barber et al. 2005), etc., or its occurrence as co-contaminant in pesticide formulations such as lindane, (ATSDR, Agency for Toxic Substances and Disease Registry 2002). Heptachlor, another banned pesticide was recorded only at coastal air (128 pg/m^3); however, its use as insecticide is well known and has been earlier reported in India (Pozo et al. 2011). Mirex was widely detected in the range of 45–221 pg/m^3 in all areas, and it is the second highest OCP detected; however, its use is not clearly stated in any of the previous literature and hence unable to point the exact source.

Monsoon season

The monsoon season showed highest OCPs in atmospheric air than in other two seasons; the levels are found in the order of suburban > agriculture > urban > coastal air (Table 1). The mean HCH concentrations ranged from 47 to 1,384 pg/m^3 with γ-HCH as the predominant isomer quantified up to 1,150 pg/m^3. The presence of α- and β-HCH in suburban and urban locations with a concentration ≤50 pg/m^3 may be due to its mere existence as co-contaminants in pesticides. The highest detection of γ-HCH (1,150 pg/m^3) in urban location may be due to its increased usage in vector control spray (fly, flea, cockroach, mosquito, bed bug, and beetle populations). Also, it is used in pharmaceutical products to kill lice and scabies (Ministry of Agriculture, India 2008). Nevertheless, in agriculture also lindane is mostly used to control pests in cotton, sugarcane, pumpkin, cabbage, onion, etc., in Tamilnadu (Ministry of Agriculture, India 2008). Similarly, Pozo et al. (2011) reported high concentrations (up to 4,000 pg/m^3) of γ-HCH in air close to agriculture activities near Delhi, India.

Among DDTs, *p,p′*-DDE and *p,p′*-DDT were detected up to 1,230 and 1,025 pg/m^3, respectively, in urban locations. As of other OCPs, heptachlor (60–1,012 pg/m^3) and HCB (165–613 pg/m^3) were also highly detected. Heptachlor is a banned insecticide (including India), which is used for controlling soil insect and termites, grasshoppers, and malaria-carrying mosquitoes (Pozo et al. 2011). Brubaker and Hites (1998) reported that HCB has relatively high vapor pressure and low water solubility, so it has long atmospheric half-life of 940 days. Also, the presence of HCB may be due to industrial activities including pesticides and other chemicals manufacturing. Often, HCB is an

impurity in pesticides used for agriculture (Bailey 2001). The mirex was found at higher levels than other OCPs in all the locations with the maximum mean concentration of 40,200 pg/m^3 in suburban area, and the distribution pattern shows that mirex was predominant with 80 % of total OCPs. In urban and coastal locations, the concentration did not exceed 1,000 pg/m^3, whereas the suburban and agriculture locations showed higher levels and ranged from 13,600 to 40,200 pg/m^3. Although it is not a registered pesticide in India (Central Insecticide Board 2012), its detection in all locations may be due to illegal usage as stomach insecticide, common insecticide and/or released while burning materials coated with flame retardants (Fisher 1999). However, official records/regulations pertaining the use of mirex as pesticide are not available. Further, mirex is known to be manufactured and used in the name of "Dechlorane, Cyclopentadiene, etc.," in formulation of fire retardants/suppressants, which is used in plastics, rubber, paints, paper, and electrical products. It is also used as pesticides in agriculture in the name of Kepone (USEPA, United State Environment Protection Agency 2009). Apart from the atmospheric air in the present study, Bhuvaneshwari and Rajendran (2011) also reported elevated levels of mirex (up to 17,518 ng/L) in the Cauvery (Kaveri) river water from Tamilnadu, India, confirming its undisclosed usage.

Table 2 Diagnostic ratio of *p*,*p*′-DDT/*o*,*p*′-DDE, and α-HCH/γ-HCH

Season/location	*p*,*p*′-DDT/*o*,*p*′-DDE	α-HCH/γ-HCH
Summer		
Coastal	NA	5.03
Premonsoon		
Coastal	0.36	NA
Monsoon		
Urban	6.11	NA
Suburban	13.42	NA
Coastal	1.17	NA
Agriculture	0.41	NA

NA not applicable

Diagnostic ratio of DDTs and HCHs

In summer, the ratio of α-HCH/γ-HCH was 5.03 (Table 2) for coastal air and the value >1 indicates the fresh usage of

Table 3 Comparison of OCPs mean concentration (pg/m^3) in air from Tamilnadu with Indian and global data

Sampling sites	α-HCH	γ-HCH	*p*,*p*'-DDT	*p*,*p*'-DDE	Year	Reference
Tamilnadu, India						
Urban (13 sites)	–	650	1,025	68	2009 –2010	Present study
Suburban (7 sites)	48	–	220	263	2009 –2010	Present study
Coastal (8 sites)	36	27	57	177	2009 –2010	Present study
Agriculture (4 sites)	–	187	25	50	2009 –2010	Present study
Tamilnadu, India						
Chennai (urban)	1,691	3,562	220	2,061	2008	Zhang et al. (2008)
Portnova (rural/coastal)	410	686	387	161	2008	Zhang et al. (2008)
Cuddalore (rural)	58	231	27	48	2008	Zhang et al. (2008)
Pondicherry (urban)	167	437	55	89	2008	Zhang et al. (2008)
India						
Manipur (urban)	89	80	41	82	2009	Devi et al. (2011)
Manipur (rural)	110	84	27	96	2009	Devi et al. (2011)
Kolkata (urban)	513	625	124	608	2008	Zhang et al. (2008)
Agriculture (7 sites)	292	812	931	247	2006–2007	Pozo et al. (2011)
New Delhi (urban)	298	3,104	34	261	2006–2007	Chakraborty et al. (2010)
Kolkata (urban)	712	1,067	61	268	2006–2007	Chakraborty et al. (2010)
Other country						
Asia	4–145	BDL–68	BDL–131	BDL–58	2004–2005	Pozo et al. (2006)
Africa	BDL–117	0.4–67	BDL	BDL–2	2004–2005	Pozo et al. (2006)
Europe	<14–100	9–390	–	<0.4–2.5	2002	Jaward et al. (2005)
Japan	–	–	4.4–146	1.62–544	2004	Jaward et al. (2005)
Singapore	–	–	<1.9–16	<1.5–10	2004	Jaward et al. (2005)
South Korea	–	–	<1.9–20	<15–25	2004	Jaward et al. (2005)

BDL below detection limit

technical mixture rather than lindane and may be due to effective long-range transport of HCHs (γ-HCH) from other region (Sofuoglu et al. 2004). Absence of HCH in summer season (noncropping season) at agricultural area may be due meager or no usage of pesticides. In premonsoon, the observed *p,p′*-DDT/*o,p′*-DDE ratio for coastal area of 0.36 indicates the past (long term) source of DDT and in monsoon, it was found between 0.41 and 13.7 (Table 2), indicating the fresh usage of DDT all over Tamilnadu province (India). As the insect menace and mosquito breeding are high during monsoon season, the obtained results clearly indicate the proportional usage of DDT to control mosquitoes, etc. The global production of DDT during 2005 was 6,269 metric tons (Klanova et al. 2009), but in India, through National Vector Borne Disease Control Program, 4,930 metric tons of DDT was provided to states during 2008 for vector control (Toxic Links Fact Sheet 2011).

Comparisons of OCPs in Tamilnadu with national (India) and global data

In present study, α-HCH concentration is lower than previous reports at national and international levels (Table 3). Further, the urban γ-HCH levels (up to 650 pg/m^3) were well below the previous report of Zhang et al. (2008) for Chennai (3,562 pg/m^3), but the concentration was comparable with other urban locations in India (Zhang et al. 2008; Devi et al. 2011) and other countries (Asia, Africa, Europe, Japan, Singapore, and South Korea) (Pozo et al. 2006; Jaward et al. 2005). The *p,p′* DDT detected in urban (1,025 pg/m^3) and suburban (220 pg/m^3) areas was the highest reported concentration in India next to Zhang et al. (2008) for Chennai. The atmospheric concentration of OCPs in southeast Asian region (Singapore and South Korea) (Jaward et al. 2005) were lower than our study. The *p,p′* DDE levels in this study were lower than earlier levels for urban India (Table 3); Zhang et al. (2008) reported a high concentration (2,061 pg/m^3) at Chennai, India. The *p,p′*-DDE levels in Africa, Europe, Singapore, and South Korea were quite lower than the concentrations observed in India (Table 3). The past (Zhang et al. 2008) and present studies in India signify that γ-HCH usage is somehow dwindling; however, DDT levels were found higher or comparable than the past observations, which corroborate the dependence on DDT in India is still high to contain mosquito menace.

Conclusion

The PUF passive air sampler was used to determine the spatial and temporal distribution of atmospheric OCPs in Tamilnadu, southern India. The Σ_{13} OCPs were in the range of ND—41,400 pg/m^3 with more contribution of γ-HCH, heptachlor, and mirex. In urban locations, *p,p′* DDT and *p,p′* DDE were detected >1,000 pg/m^3 indicate its present usage. In suburban area, none of the OCPs were detected during premonsoon. Whereas, in monsoon season, high OCPs were detected and it signifies the usage of pesticide in both agriculture as well as non agricultural applications such as disease-causing vector control practices. Detection of banned pesticides such as aldrin, heptachlor, and dieldrin reveals their illegal use and/or long-range transport from other regions. Mirex (nonregistered pesticide) was quantified at elevated levels during monsoon season, and their occurrence may be due to its use as flame retardants in consumer products and subsequent release during burning, etc. According to this study, atmospheric environment in Tamilnadu is contaminated by diverse OCPs, suggesting the need to take measures to reduce their levels, and further, this forms an important baseline data for future national regulation for OCPs usage/emission.

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