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HCH and DDT Contamination of Rural Ponds of India

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The organochlorine insecticides DDT and HCH have been extensively used in India in agriculture and public health programme (Gupta 1986). Several studies from India have shown the occurrence of DDT and HCH in soil (Agarwal et al. 1986), water (Bakre et al. 1990), whole blood (Bhatnagar et al. 1992), and bovine milk (Battu et al. 1989). Frank et al. (1990) found pesticides contamination in rural ponds of Canada, and explained that the contamination was due to both surface water run-off from treated fields during storm events and deposits from spray drifts. HCH and DDT contamination in the major components of rural ponds biota-water, sediment and fish from India have not been studied despite the fact that rural ponds are the major water source for animals, agriculture, and other domestic uses. We present HCH and DDT levels in water, sediment and fish from rural ponds of India.

MATERIALS AND METHODS

Samples of water, sediment and fish were collected from 22 ponds belonging to 13 villages of District Shahjahanpur, U.P. India. Different species of fish were found in 9 ponds out of a total of 22 ponds surveyed. Two rounds of DDT (50% wp) @ 2g/sq.m and 3 rounds of HCH (50% wp) @ 0.3 g/sq.m were sprayed in the respective villages for the control of malaria and other vector borne diseases. HCH and DDT were sprayed randomly depending on their availability with the Health Department. No record of total consumption was available. The last round of spraying was completed in September, 1992. The study was performed in the month of November, 1992.

Four 500 ml water samples from each pond were collected in clean 1-litre glass bottles by immersing them about 30 cm below the surface of water. Samples were collected 1.0 metre from the bank inside and from two sides of the pond and two samples from each side in dark glass bottles, brought to the laboratory and extracted immediately. 50 to 100 gm of the top 6 cm sediment layer were taken from two sides of each pond below the water and collected 1 metre from the bank.

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These samples were brought to laboratory, dried immediately and kept at room temperature until analysis. Fish samples were collected with dip nets. Ponds in which fish were scarce i.e. in which the number of fish in the net sweep were less than five, were referred as ponds without fish. Samples were transported to the laboratory in 2% formalin, washed three times with distilled water, and stored in aluminium foil at -20 C until extraction. All fish samples were identified by the State Fisheries Department.

The extraction of DDT and HCH from water, sediment and fish were carried out as reported earlier (Agarwal et al. 1986). Water samples were filtered using Whatman filter paper No. 1. Filter paper was washed with 50 ml distilled water to remove pesticide contamination. 250 ml water was extracted three times with 50 ml n-hexane for 10 minutes in a separating funnel, and the upper n-hexane layer was pooled and concentrated to 1 ml using vortex evaporator. To 50 gm of dried sediment from each sample, 50 ml distilled water was added and extracted three times with 50 ml methanol in orbital mixer for 4 hour. The extract was pooled, filtered, and concentrated to 1 ml. 3 gm of dry fish tissue from each sample was mixed with anhydrous sodium sulphate at a ratio of 1 : 4 and ground as fine as possible using a mortar. The homogenous powder then was mixed three times with acetone : hexane (1:1 v/v) in an orbital mixer for 2 hour and then filtered. The solid portion was rinsed with methanol. All extracts were pooled and concentrated.

All concentrated extracts from water, sediment and fish samples were cleaned with anhydrous sodium sulphate-alumina columns eluted with n-hexane-benzene (40 : 60). The eluent was evaporated using a vortex evaporator and kept at 4°C until analysis.

Samples were analysed for organochlorine insecticide residues on a Hewlett Packard 5890 gas chromatograph fitted with Ni electron capture detector on 1.5% silicon OV 17 coated on Gas chrom (80-100 mesh) packed glass column. Nitrogen was used as the carrier gas, with a flow rate of 120 ml/minute. The injector, oven and detector temperatures were set at 210, 190 and 220 C, respectively. The HCH and DDT residue peaks were further confirmed in 5% DEGS on Gas chrom Q (100 - 200 mesh) glass column (Agarwal et al. 1986). The identities of the residues also were confirmed by studying the disappearances or shifts in the peak patterns in alkali derivatized samples as compared to underivatized samples (USEPA 1980). All water, sediment and fish samples from one pond were analysed separately and their mean values calculated for determination of insecticide residues in a particular pond. Level of detection for HCH and DDT were 0.1 ng. Below this value was termed as N.D. (not determined). Significance of difference between mean values were calculated by Student's t-test while the correlation between two variables were calculated by Carl Pearson method.

RESULTS AND DISCUSSION

The average percentage recoveries of HCH isomers, DDT and its metabolites in water, sediment and fish were more than 90% in all

cases, and recorded values were not corrected for recoveries.

Table 1. Concentration (ug/L) of DDT and HCH in water samples frorn ponds with fish and without fish

Compound	Ponds fish (n = 9) Mean ± S.D.	Ponds without fish (n = 13) mean ± S.D.
α-HCH	0.131 ± 0.12 (N.D - 0.35)	0.42 ± 0.50 (0.04 - 1.92)
ß-HCH	0.22 ± 0.28 (0.01 - 0.93)	1.92 ± 2.90 (0.11 - 10.11)
Γ-HCH	0.32 ± 0.34 (0.03 - 0.99)	0.42 ± 0.62 (0.12 - 2.30)
δ-HCH	0.11 ± 0.21 (N.D. - 0.68)	0.17 ± 0.23 (N.D. - 0.63)
Total HCH	0.81 ± 0.63 (0.11 - 1.68)	2.94 ± 2.98 (0.25 - 10.91)
o-p DDE	0.11 ± 0.29 (N.D. - 0.88)	0.13 ± 0.23 (N.D. - 0.81)
p-p DDE	0.23 ± 0.26 (N.D. - 0.97)	0.77 ± 0.96 (N.D. - 3.16)
o-p DDT	0.17 ± 0.35 (N.D. - 1.04)	1.75 ± 2.11 (N.D. - 6.29)
p-p DDT	0.16 ± 0.48 (N.D. - 1.45)	1.83 ± 2.78 (N.D. - 9.45)
Total DDT	0.62 ± 0.89 (N.D. - 2.10)	4.48 ± 5.05 (N.D. - 15.29)

N.D. = Not detectable= t (HCH) = 2.0514; p < 0.05; t (DDT) = 4.0386; p < 0.001; Figures in parentheses show range.

Mean concentrations of HCH isomers and DDT metabolites found in water samples from ponds with and without fish are given in Table 1. In ponds with fish, Γ-HCH contributed 40% and β-HCH (28%) of the total HCH residues. HCH was present in all nine ponds under study. Similarly, p-p DDE was 37.2%, o-p DDT 28%, and p-p DDT 27%, respectively, of the total DDT present. p-p DDT was detected in 6 ponds out of nine ponds with fish studied. β-HCH contributed 65.3%, Γ-HCH 14.41%, and α-HCH 14.5%, of total HCH, while p-p DDT was 40.8%, o-p DDT 39.2%, and p-p DDE 17.2% respectively, of total DDT in water samples of ponds without fish. DDT was not detected in two out of 13 ponds.

The mean concentration of HCH isomers and DDT and its metabolites in sediments are presented in Table 2. β-HCH was 49.03%, Γ-HCH 24.10% and α-HCH 18.5% of total HCH in ponds with fish. HCH was detected in all sediment samples. The o-p DDT, p-p DDT and p-p DDE were 38.01, 36.73 and 22.4 percent of total DDT, respectively. In ponds with fish DDT was not detected in the sediment samples

from two ponds. β-HCH was 71.7%, Γ-HCH 15.68% and α-HCH

Table 2. Concentration (ug/Kg) of DDT and HCH in sediments from ponds i) with fish and ii) without fish

Compound	Ponds with fish (n = 9) Mean ± S.D.	Ponds without fish (n = 13) Mean ± S.D.
α-HCH	2.00 ± 2.79 (0.42 - 9.35)	2.94 ± 2.63 (0.59 - 8.66)
ß-HCH	5.31 ± 11.39 (0.78 - 35.62)	34.00 ± 50.84 (1.70 - 165.00)
Γ-HCH	2.61 ± 1.60 (0.61 - 5.50)	7.43 ± 7.50 (1.27 - 27.80)
δ-HCH	0.91 ± 0.75 (N.D. - 2.14)	3.02 ± 3.39 (N.D. - 9.90)
Total HCH	10.82 ± 12.56 (2.66 - 42.72)	47.41 ± 53.33 (4.87 - 176.95)
o-p DDE	1.09 ± 1.46 (N.D. - 3.64)	11.10 ± 14.71 (N.D. - 42.00)
p-p DDE	8.92 ± 10.27 (N.D. - 29.00)	79.12 ± 61.34 (4.30 - 180.00)
o-p DDT	15.09 ± 20.24 (N.D. - 48.00)	02.20 ± 291.09 (N.D. - 908.25)
p-p DDT	40.58 ± 26.00 (N.D. - 78.70)	111.12 ± 204.63 (N.D. - 722.70)
Total DDT	39.69 ± 48.16 (N.D. - 113.80)	403.60 ± 464.57 (4.03 - 1303.20)

N.D. = Not detectable; t (HCH) = 1.9484; $p < 0.1$; t (DDT) = 2.3430; $p < 0.05$

6.2% of total HCH, while, o-p DDT was 50.01%, p-p was 27.5, and p-p DDT was 19.6% of the total DDT in sediment from ponds without fish. DDE was detected in two ponds only.

Fish fauna of the subject ponds included Catla catla, Colisa fasciata Mastocembelus armatus, Channa punctatus, Labeo rohita, Puntius sarana, and the larvivorous Gambusia affinis. HCH and DDT contamination of fish are given in Table 3. β-HCH contributed 78.85%, Γ-HCH 11.9% and α-HCH 9.1 % of total HCH in fish samples. Similarly, p-p DDT was 60.8%, o-p DDT 20.6%, and p-p DDE 16.0% of total DDT. Mastocembelus armatus contained higher concentrations of HCH (mean = 15.077 mg/kg) and DDT (mean = 0.0695 mg/kg) as compared to other fish.

Statistical comparison of DDT in water and sediment from ponds with and without fish showed significant differences in rnean values (t water = 4.0386, $p < 0.001$; t sediment = 2.343. $P < 0.05$). Significant difference was also observed in HCH residue in water and sediment from the two categories of ponds (t water = 2.0514,

P < 0.05; t sediment = 1.9484, P < 0.1).

The HCH and DDT data of water, sediment and fish from the two

Table 3. Concentration (mg/kg) of HCH and DDT in fish

Compound	Mean ± S.D	Range
α-HCH	0.574 ± 0.796	0.003 - 1.792
ß-HCH	4.968 ± 8.756	N.D. - 29.400
Γ-HCH	0.752 ± 1.502	0.012 - 4.184
δ-HCH	0.005 ± 0.015	N.D. - 0.080
Total HCH	6.300 ± 9.825	0.114 - 32.161
o-p DDE	0.139 ± 0.228	N.D. - 0.918
p-p DDE	1.169 ± 1.153	0.003 - 4.660
o-p DDT	1.464 ± 2.051	N.D. - 6.900
p-p DDT	4.303 ± 5.717	N.D. - 17.330
Total DDT	7.077 ± 7.848	0.186 - 22.947

N.D. = Not detectable

categories of ponds were subjected to correlation tests. The correlation coefficient of DDT in water-fish, sediment-fish, water-sediment (ponds with fish) and water-sediment (ponds without fish) were - 0.81 (P < 0.001), - 0.97 (P < 0.001), 0.96 (P < 0.05) and 0.65 (p < 0.5) respectively.Similarly, significant correlation was also observed for HCH in water-fish (-0.78; P < 0.01) and water-sediment (0.75; P < 0.01) from ponds without fish. The correlation of HCH in sediment-fish and water-sediment from ponds with fish were insignificant with r values of -0.15 and 0.50 respectively.

HCH and DDT concentration in water from ponds in many cases were above the maximum permissible limits in drinking water (WHO 1983), which may be due to the extensive use of these insecticides in public health and agriculture and their accumulation in ponds through drains and rain water. The low concentration of insecticides in water of ponds with fish as compared to ponds without fish were due to the uptake of these insecticides by pond fish (Bevenue, 1976). Remarkable differences in the composition of HCH isomers and DDT metabolites between water samples from ponds with fish and without fish was recorded. Presence of p-p DDT, o-pDDT, Γ-HCH accounted due to continuous impact of HCH and DDT by means of sprayaing while the presence of b-HCH and p-p DDE was accounted for the degradation products (Bakre et al. 1990). High value of p-p DDT as compared to p-p DDE implies that the DDT were applied recently. Much variation in the level of HCH and DDT were found from the sediments of different ponds. b-HCH was the most common HCH isomers in all sediments samples while, o-p DDT and p-p DDE were also present in many sediment samples. The concentration of HCH and DDT in sediments were many time than their water concentration. High residue concentrations in sediment as compared to water implies that the insecticides of low water solubility like HCH and DDT settle down to the pond (Lichtenstein, 1969).

Significant amounts of HCH and DDT were sequestered by fish tissue, thereby reducing concentrations of these insecticides in surrounding media (i.e., water and sediment). The tremendous capacity for concentrating pesticides in fish has been illustrated (Macek and Korn. 1970). Mean HCH and DDT concentrations in fish were 5066 and 10,847 times water concentrations in study ponds. In the present study, DDT concentration in 33.33% of fish samples exceeded recommended maximum limits of 5 mg/kg (Public Health Service, USA, 1974). We found 22 mg/kg as the maximum total DDT concentration in a fish.

A comparision of mean water and sediment concentrations of HCH and DDT from the two categories of ponds (i.e. ponds with and without fish) clearly show that mean HCH and DDT residues in pond water without fish were 3.63 and 7.12 times higher as compared to their respective concentration in ponds with fish. Similarly, the sediment HCH and DDT concentrations without fish were 4.38 and 10.17 times higher than values in pond with fish.

Our study clearly show moderate to high level of HCH and DDT contamination of rural ponds of India. In some ponds these concentrations were above the maximum permissible limits degree of contnamination. Present findings clearly show that the HCH and DDT residue in water and sediment from the ponds without fish were significantly higher than ponds with fish, which implies that the introduction of fish may be a tool for the control of pollution of these insecticides in ponds. However, the use of edible fish culture in these ponds should be prohibited, because insecticide consumption by these fishes, and the ultimate transfer of these residues to humans. Recent use of biological methods have shown promising results for the control of vector born diseases like malaria where larvivorous fishes such as Guppy and Gambusia were used to control breeding in these rural ponds (Sharma, 1987). These methods avoid the problem of environmental contamination by insecticides. Gambusia and Guppy are not eaten by humans. Furthermore they concentrate HCH and DDT in ponds and make these ponds suitable for the culture of commercial fish with minimum insecticide contamination even with continued DDT/HCH use.

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