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Organochlorine Pesticide Residues in Middle Stream of the Ganga River, India

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The chlorinated organic pesticides BHC, DDT, Aldrin etc. which are extensively used in agriculture and public health programme are very persistent in nature. As is well known, they are lipid soluble toxic chemicals and cumulative accumulation of low concentrations of these pesticides in the body fat of mammals might pose potential hazards in the long run (Metcalf 1977). These pesticides not only exist in target organism and soil system for a considerable period of time but also enter into natural waters by percolation and runoff from agricultural land and channels, and city sewage from urban site, affecting the quality of various water sources. The persistence of these organochlorines in water has a special significance as they are taken up by unicellular aquatic organisms like plankton and thus enter into the food chain.

Although some reports concerning the pollution of Ganga water by pesticides are available (Sinha 1988; Halder 1990; Agnihotri 1992) but there appears to be no systematic investigations, particularly in middle stream of Ganga and specifically in Varanasi area. Moreover, Varanasi is densely populated city and heavily pressurised by the tourists. It is also famous as one of the most important as well as popular vegetable belt in India. There are about eightyfour ghats situated at the western bank over a span of 10 km and the main city ends in these ghats; the eastern bank is totally agricultural belt. Organochlorine pesticides are extensively used in both the banks for public health and agricultural purpose throughout the year. Thus it was thought worth while to monitore the levels of runoff organochlorine pesticides viz. BHC, DDT and endosulfan along with their isomers and metabolites in the Ganga water in Varanasi area.

MATERIALS AND METHODS

The water samples were collected from different spots along both the banks of the river in between Ramnagar to Rajghat in Varanasi area. Location of the sampling spots are shown in Figure 1.

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Table 1. Monthly Rainfall data for the period 1983 (June-October) to 1992 (June to October).

Month	Average Rainfall, mm									
	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
June	70.8	330.0	36.8	28.7	12.7	18.8	94.5	112.5	68.5	7.1
July	247.2	206.1	475.7	211.3	277.1	365.8	277.0	462.6	101.6	216.6
August	140.7	293.0	283.3	315.2	291.5	202.9	156.6	326.5	450.7	420.6
Sept.	303.4	248.2	95.3	103.9	78.5	63.3	180.4	105.6	276.4	109.1
Oct.	108.1	40.6	33.6	27.0	7.3	0.0	5.2	16.0	0.0	36.6

The water samples were collected on August 17, 1992 during the monsoon period to obtain maximum possible runoff of pesticides. Table 1 shows the consecutive ten years rainfall distribution in the sampling area. Water samples (2.5 L at a depth of 25 cm) were collected in amber glass bottles.

Extraction and clean up were carried out according to the method followed by Halder et al. (1989, 1990). The samples were then analysed with a Hewlett Packard 5890A gas chromatograph equipped with Ni63 ECD coupled with a HP 3392A integrator. Operating parameters for BHC isomers were as follows : 1.8m X 2mm I.D. glass packed (Chromatopack) with 1.5% 0V-17 + 1.95% 0V-210 on chromosorb W.H.P. (80-100 mesh) column; oven 190°C; injector 210°C; detector 300°C and carrier gas, N_2 flow rate 70ml/min., for DDT and endosulfan : 1.8m X 2mm I.D. glass packed with DC-200, W.H.P. (80-100 mesh) column; oven 200°C; injector 210°C; detector 300°C and carrier gas, N_2 flow rate same as BHC. Peaks were identified by retention times.

Identification and quantification were accomplished using reference solutions of analytical grade pesticides, supplied by EPA, USA. 98.7% α-HCH, 99% β-HCH, 99% γ-HCH and 99.2% δ-HCH; 99% p,p'-DDT, 99% o,p'-DDT, 98.9% o,p'-DDE 98.7% p,p'-DDE; 99% α-endosulfan, 99% β-endosulfan and 99% endosulfan sulfate were used as external standard. Recoveries of the compounds ranged from 85-92%, but the residue data in Table 2 and 3 were not adjusted on the basis of these recoveries. Minimum detection limit was 0.01 μg/L. 0.8 to 1 μL of samples were injected in previously conditioning GLC.

RESULTS AND DISCUSSION

Results given in Tables 2 and 3 present the residue levels of organochlorine pesticides found in water sample from thirtyfour collection sites in the middle stream of river Ganga during monsoon. It was revealed from the data that, out

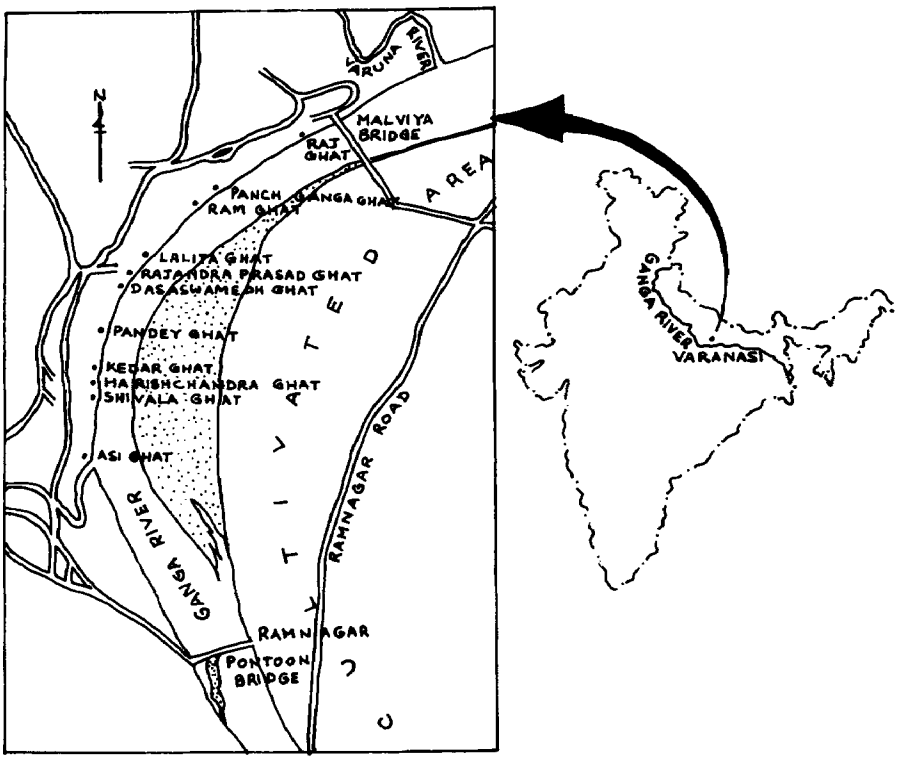

Fig. 1. Sampling locations of the Ganga river.

of thirtyfour samples collected from surface water, the residue of the total HCH was found in thirty samples which ranged from 0.105-99.517 μg/L. The highest residue was found near Rajendra Prasad ghat, lowest in Pandey ghat. In Shivala ghat, Mir ghat, Chowki ghat and opposite to Shivala ghat no traces of HCH was found. γ-Isomer, the most toxic isomer of HCH, was found only in fifteen samples, highest in opposite to Pandey ghat and lowest near Ramnagar (Sepai ghat). According to W.H.O. (1984) guideline for drinking water quality, the safe limit for HCH is 0.01 μg/L and the minimum contaminant level's (MCL's) for γ-isomer of HCH (Lindane) is 4 μg/L. The table 2 shows that the HCH in almost all samples has crossed the W.H.O. limit except Pandey ghat. The safe limit for lindane has crossed only in five samples; those are in Kedar ghat, Rajendra Prasad ghat, opposite to Pandey ghat, Kshemeswar ghat and Ramnagar nala.

Mostly all the samples contained DDT (isomer/metabolite) residue. Highest concentration of DDT was present near Kedar ghat and lowest near Ramghat. Most toxic isomer of DDT (p,p'-DDT) was present in twenty two samples. But there were no traces of o,p'-DDE in any of the samples. According to W.H.O. (1984)

Table 2. Residues of BHC or HCH (α, β, γ and δ isomer) occurring in Ganga water.

Sl. No.	Location	Residue in μg/L				Total μg/L
		α HCH	β HCH	γ HCH	δ HCH	
1.	Asi ghat[$]	0.372	-	0.112	0.235	0.719
2.	Janaki ghat	0.345	-	-	-	0.345
3.	Chait Singh ghat	23.894	-	-	-	23.894
4.	Shivala ghat	-	-	-	-	-
5.	Harischandra ghat	1.238	0.732	0.523	0.417	2.903
6.	Kedar ghat	-	-	15.806	-	15.806
7.	Chowki ghat	-	-	-	-	-
8.	Kshemeswar ghat	10.787	2.448	1.78	0.594	15.609
9.	Pandey ghat	0.105	-	-	-	0.105
10.	Chousathi ghat	1.783	1.186	0.856	0.583	4.41
11.	Dasaswamedh ghat	0.119	-	-	0.136	0.256
12.	Rajendra Prasad ghat	12.693	36.354	14.415	36.354	99.517
13.	Mir ghat	-	-	-	-	-
14.	Lalita ghat	1.291	0.518	0.555	0.292	2.657
15.	Manikarnika ghat	10.485	-	-	0.32	10.806
16.	Scindhia ghat	0.185	-	-	-	0.185
17.	Ram ghat	0.120	-	0.196	0.526	0.843
18.	Panch ganga ghat	1.428	-	-	-	1.428

Table 2 (Contd.)

Sl. No.	Location	Residue in μg/L				Total μg/L
		α HCH	β HCH	γ HCH	δ HCH	
19.	Panch Ganga ghat opp.#	0.235	-	-	0.491	0.726
20.	Ram ghat opp.	3.001	2.03	1.447	0.93	7.409
21.	Mid Stream	18.398	4.031	3.027	2.388	27.844
22.	Manikarnika ghat opp.	0.287	-	-	-	0.287
23.	Rajendra Prasad ghat opp.	0.152	-	-	0.249	0.401
24.	Dasaswamedh ghat opp.	0.837	2.975	-	3.787	7.601
25.	Chousathi ghat opp.	0.27	-	-	-	0.27
26.	Pandey ghat opp.	16.684	4.189	39.505	4.406	64.784
27.	Kshemeswar ghat opp.	30.781	6.616	4.808	3.112	45.319
28.	Kedar ghat opp.	0.928	0.172	-	-	1.101
29.	Shivala ghat opp.	-	-	-	-	-
30.	Asi ghat opp.	0.203	-	-	0.834	1.038
31.	Nagwa ghat opp.	0.324	-	-	-	0.324
32.	Ramnagar (Sepai ghat)	0.209	0.159	0.335	0.213	0.916
33.	Ramnagar nala junction	31.020	8.721	6.193	5.17	51.104
34.	Nagwa nala junction	5.407	-	0.315	-	5.722

opp. = opposite; $ ghat = flight of steps leading to river bank and used mainly for bathing purpose; - = No residue detected.

Table 3. Residues of DDT* and endosulfan isomers/metabolites occurring in Ganga water.

Sl. No.	Location	Residue in μg/L					Total μg/L	
		o,p'-DDT	p,p'-DDT	p,p'-DDE	α-endosulfan	β-endosulfan	DDT	Endosulfan
1.	Asi ghat	-	0.118	13.683	0.817	-	13.801	0.817
2.	Janaki ghat	0.141	0.046	0.054	0.449	0.074	0.243	0.523
3.	Chait Singh ghat	1.276	0.552	0.933	2.766	0.673	2.762	3.439
4.	Shivala ghat	0.105	0.049	-	0.102	-	0.154	0.102
5.	Harischandra ghat	4.426	2.163	2.224	8.714	1.431	8.813	10.415
6.	Kedar ghat	44.908	79.818	18.50	48.828	17.688	143.226	66.516
7.	Chowki ghat	0.895	0.374	3.915	1.632	0.374	5.184	2.006
8.	Kshemeswar ghat	0.153	0.062	-	0.668	-	0.215	0.668
9.	Pandey ghat	0.037	0.032	-	0.591	-	0.069	0.591
10.	Chousathi ghat	30.013	5.085	14.315	39.28	15.348	49.413	54.628
11.	Dasaswamedh ghat	0.231	-	-	- (ES**:1.943)	2.207	0.231	4.150
12.	Rajendra Prasad ghat	1.959	0.427	5.061	4.672	-	7.447	4.672
13.	Mir ghat	13.231	60.00	7.024	20.803	8.175	80.255	28.978
14.	Lalita ghat	0.129	0.062	0.038	0.270	0.075	0.229	0.345
15.	Manikarnika ghat	0.096	0.081	0.031	0.218	0.051	0.208	0.269
16.	Scindhia ghat	0.292	-	-	0.625	-	0.292	0.625
17.	Ram ghat	-	0.135	-	0.037	0.341	0.135	0.378

Table 3 (Contd.)

Sl. No.	Location	Residue in μg/L					Total μg/L	
		o,p'-DDT	p,p'-DDT	p,p'-DDE	α-endosulfan	β-endosulfan	DDT	Endosulfan
18.	Panch ganga ghat	-	0.321	-	0.761	-	0.321	0.761
19.	Panch Ganga ghat opp.	15.507	7.126	1.866	38.957	10.723	24.499	49.680
20.	Ram ghat opp.	0.171	0.027	0.038	0.328	0.076	0.236	0.404
21.	Mid Stream	0.128	0.055	0.051	0.377	0.053	0.234	0.430
22.	Manikarnika ghat opp.	2.286	1.081	1.029	4.761	0.413	4.396	5.174
23.	Rajendra Prasad ghat opp.	14.944	1.842	4.842	1.398	4.886	21.628	6.284
24.	Dasaswamedh ghat opp.	0.212	0.062	0.444	0.662	-	0.720	0.662
25.	Chousathi ghat opp.	2.149	0.142	-	24.352	-	2.291	24.392
26.	Pandey ghat opp.	0.335	-	-	0.086	-	0.335	0.086
27.	Kshemeswar ghat opp.	-	0.256	-	0.083	-	0.256	0.083
28.	Kedar ghat opp.	3.507	1.258	2.934	8.095	1.881	7.70	9.976
29.	Shivala ghat opp.	2.208	0.082	0.085	0.658	0.063	2.375	0.721
30.	Asi ghat opp.	0.073	0.034	-	0.167	-	0.107	0.167
31.	Nagwa ghat opp.	0.921	-	-	0.213	-	0.921	0.213
32.	Ramnagar (Sepai ghat)	22.768	3.684	11.092	25.913	11.258	37.544	37.171
33.	Ramnagar nala junction	13.256	1.985	8.352	18.512	7.103	23.593	25.615
34.	Nagwa nala junction	0.238	-	-	21.189	-	0.238	21.189

*o,p'-DDE = no trace in any sample; **ES = Endosulfan sulfate; - = No residue detected.

the safe limit for DDT is 1 μg/L. Thus the results indicated that at some location DDT concentration exceeded the safe limit. Lastly, endosulfan was also found to occur in all the samples. Endosulfan sulfate, the metabolite toxic to fish, was present only in Dasaswamedh ghat.

The present study revealed that organochlorine pesticide residues were found in almost all the sampling point along both the banks of the river Ganga. The results also revealed that the river water was polluted by pesticides mainly in western bank i.e. ghat region (highest HCH in Rajendra Prasad ghat, DDT and endosulfan in Kedar ghat) than the cultivated eastern banks. This might be due to the enhanced municipal public health activities than the agricultural pest management activities in the monsoon period. But the over all pollution by these pesticides leading to food chain accumulation cannot be ignored. Moreover, fisherman, boatman and local communities in this stretch directly consume the Ganga water as drinking water after sedimentation. Thus the residue level of the organochlorine pesticides of the Ganga might affect the human and other domestic life both indirectly and directly.

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