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Organochlorine Contamination in the Fish of the River Ganges, India

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Abstract

Concentrations of persistent organochlorine residues were measured in economically important fish of the River Ganges from different locations in Bihar. The contamination pattern of organochlorines in fishes from several locations was Dichlorodiphenyltrichloroethanes (DDTs) >Hexachlorocyclohexanes (HCHs) >aldrin>endosulfan. The average wet weight concentrations in the muscles of fishes was; DDTs, 13.6 to 1665.9 ng g^{-1}; HCHs, 115.8 to 1206.8 ng g^{-1}; aldrin, 3.1 to 86.1 ng g^{-1}; and endosulfan 2.9 to 74.5 ng g^{-1}. The study indicates that organochlorine contaminants are still entering the Ganges river system, and suggests that the human population that consumes contaminated fish from the river may be at risk from those contaminants.

Keywords: DDT, HCH, Aldrin, Endosulfan

Introduction

Modern technology, agriculture and the associated development of chemical industries has resulted in the production and release of vast quantities of man-made chemicals. However, while contributing to improvements in the standard of living, some persistent chemicals pose serious environmental problems and ecological impacts. Organochlorine compounds such as the dichlorodiphenyl trichloroethanes (DDTs including DDT, DDE, DDD) are among the most widely known class of contaminants because of their ubiquity, potential for magnification in the food-chain, and harmful biological effects. Considerable amounts of these persistent compounds are still cycling in ecosphere (Loganathan et al., 1994; Tanabe et al., 1988).

Rivers are major repositories of the pesticides applied in the agricultural fields and urban areas of their basins. These hazardous chemicals enter a river system by means of agricultural run-off and sewage. Surface run-off from urban and rural areas where synthetic pesticide, mainly DDT, is sprayed to control the vectors of Malaria and Kala-azar also contributes these materials significantly to the river system. The presence of widely used non biodegradable organochlorine pesticide residues in Indian Rivers have been studied from time to time (Agarwal et al., 1986; Ramesh et al., 1990). The use of organochlorines, banned or restricted in most of the developed countries, still continues in India.

The Ganges is heavily polluted by the annual use of about 2500 t of pesticides and 1.2 million t of fertilizers in its catchment area (Mohan, 1989), but little is known about the concentrations of toxic micro pollutants such as organochlorines and heavy metals in the Ganges ecosystem. Pollution by persistent chemicals is potentially harmful to the higher trophic levels of the food-chain including fish which are able to accumulate contaminant pesticide residues in concentrations several fold higher than in the surrounding water.

Fishes stressed by pesticides show disorders in behaviour, survival, growth, reproduction and respiration (Mani et al 1975). Thus fishes can be used to monitor pesticides residues in the environment and to assess the potential for accumulation of residues in hu-

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mans who consume fish.

Monitoring of organochlorine contaminants in river fishes is vital for conservation, especially in countries such as India, where the use of organochlorine pesticides is increasing and where fish constitutes one of the major food items. The World Health Organisation (WHO) has recommended a minimum of 11 kg of fish per capita annually in the human diet. Consumption of fish contaminated with organochlorine pesticides is thus a severe threat to humans from the health point of view. In this study, we estimated the residual pattern of DDTs, HCHs, aldrin and endosulfan in the tissues of fishes collected from the River Ganges.

Material and Methods

Fresh water fishes were collected from different locations of the River Ganges from Buxar to Rajmahal (Fig. 1) and identified according to Talwar and Jhingran (1991). All the samples were stored at 4° C until analysis. The fish species collected from the respective stations are as follows:

1. Buxar: *Labeo rohita*, *Labeo bata*, *Cirrhinus mrigala*, *Rita rita* and *Eutropichthys vacha*
2. Patna: *Labeo rohita*, *Labeo bata*, *Clupisoma garua*, *Eutropichthys vacha*, *Rita rita*, *Catla catla*, *Wallago attu* and *Silonia silondia*
3. Mokama: *Labeo rohita*, *Labeo bata*, *Catla catla* and *Rita rita*
4. Rajmahal: *Labeo rohita*, *Labeo bata*, *Eutropichthys vacha*, *Rita rita*, *Cirrhinus mrigala*, *Aoriichthys seenghala* and *Aoriichthys aor*

Determination of organochlorine pesticides in fish tissues followed the procedure of Tanabe et al. (1991). Briefly, samples were homogenized with anhydrous sodium sulfate and extracted with mixed solvents of diethyl ether and hexane using a soxhlet apparatus. Extractable lipid content was determined gravimetrically from concentrated aliquot of these extracts. The remaining extracts were then transferred to a glass column with 20 g of Florisil followed by elution with 80% acetonitrile and 20% hexane washed water. The elute was transferred to hexane and the concentrated hexane layer was fractionated by 1.5 g silica gel packed in a glass column (12 mm id). The first fraction eluted with hexane contained P,P'-DDE. The second fraction eluted with 20% dichloro methane in hexane contained HCH isomers (α-, β-, γ-, and δ- HCH), and P, P'-DDD and P,P'-DDT and P,P'-DDT, O,P'-DDD, O,P'-DDE and O,P'-DDT appeared in both fractions, which were combined for a quantification. Each fraction was concentrated after retaining 1 ml for the quantification of aldrin and endosulfan. The extracts were subjected to further cleanup with 5% fuming sulfuric acid in concentrated H_2SO_4.

Quantification of organochlorines was made on a gas chromatography (Varian Aerograph Series 2400) equipped with ^{63}Ni electron capture detector and moving needle type injection port. The GC column was 6 feet x 1/8 inch (I.D.) with 8-100 mesh gas chrome coated with a mixture of 1.5% OV-17 and 1.95% OV-210. The column temperature was programmed for 190° C. The injector and detector temperatures were kept at 250° C. Nitrogen was the carrier gas. Organochlorine pesticides were quantified from individually resolved peak heights with corresponding peak heights of standards. Recoveries ranged from 90 to 105%. Detection limit was 0.1 ng g^{-1} for aldrin and dieldrin and 0.01 ng g^{-1} for all other organochlorines.

Results and discussion

A wide range of organochlorine pesticides such as DDT and its metabolites, HCH and its isomers were detected in fish from the river Ganges. Concentrations of organochlorines in fishes varied, depending on the sampling locations, size, habitat and feeding habit. Carnivorous fishes had the highest organochlorine concentrations followed by detritivorous, omnivorous and herbivorous fishes. Bottom feeders also had high concentrations of organochlorines.

The x^2 was used to test the null hypothesis that the concentration of pesticides in different types of fishes' on the basis of feeding habit are independent of each other. Because the absolute value of calculated x^2 was greater than the x^2 (tabulated at the 5 % level of significance) in all of the fishes (Tables 1-4), it is clear that the concentration of organochlorines in the fishes tested depended on feeding habit. The average wet weight concentration of DDTs and HCHs was maximum in carnivorous fishes (750.2 ng g^{-1}; 587.0 ng g^{-1}) and minimum in herbivorous fishes (152.8 ng g^{-1}; 259.1 ng g^{-1}) while the average concentrations of aldrin and endosulfan did not show significant trends (Fig. 2). Sharma et al (1995) also found that carnivorous fishes accumulated high residues of DDT followed by detritivorous, omnivorous and herbivorous species. Organochlorine pesticide residues were lower in herbivorous fishes than in carnivorous fishes.

Fishes collected from Patna contained the highest wet weight concentrations of DDT (1665.9 ng g^{-1}) and

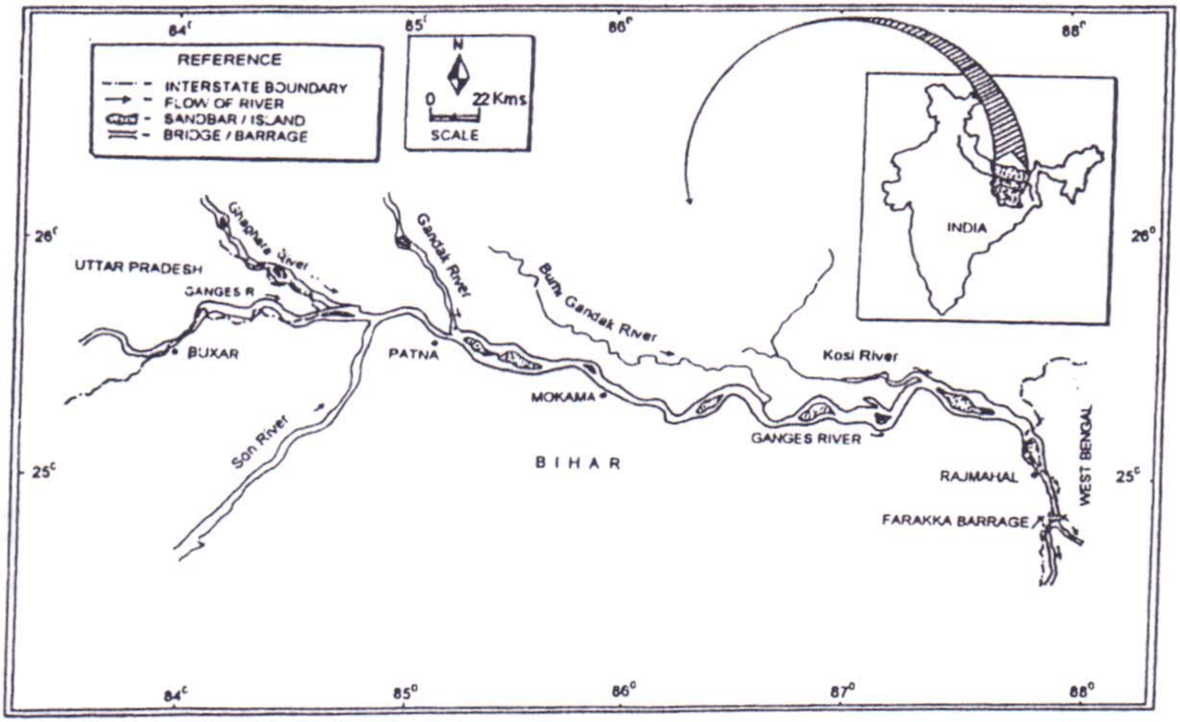

Figure 1 Map of the river Ganga showing different sampling locations.

Table 1 Concentration of organochlorines as ng g^{-1} (ppb) in herbivorous fishes (Talwar and Jhingaran, 1991).

Fish	Size (cm)	Site	DDTs	HCHs	Aldrin	Endosulfan
L. rohita	14	Buxar	215.5	82.3	26.6	3.6
L. rohita	16	Rajmahal	156.7	180.3	53.2	ND
L. rohita	16	Mokama	56.7	628.9	30.8	ND
L. rohita	16	Patna	182.3	145	64.8	8.0

$\chi^2 = 549.9$, D.F.= 9.

the fishes from other locations contained 4 to 20 fold lower concentrations. Fishes collected from the River Ganges at Haridwar contained the highest DDT concentration (3.7 ng g^{-1} wet weight) followed by those collected at Patna (1.3 ng g^{-1} wet weight) as reported by Senthilkumar et al. (1999). Measured concentrations of DDTs in Ganges River fish tend to be greater than those reported in the muscle tissue of several market fish collected in India (Kannan et al. 1995) but lesser than those reported in the muscle of fish collected from the Yamuna River (up to 56 ng g^{-1} wet weight), a tributary of the Ganges, that receives direct discharges of DDT from manufacturing factories (Agarwal et al. 1986). Higher accumulation of DDTs in river fishes might be due to the widespread and continuing use of DDT for malaria vector control in India (Singh et al. 1997). DDT is also used to control the sand fly (*Phlebotomus argentipes* and *P. papatasi*) the vector of Kala-azar disease, in areas near the Ganges. Disposal of wastes from several DDT manufacturing units located along the Ganges

Table 2 Concentration of organochlorines as ng g^{-1} (ppb) in omnivorous fishes. (Talwar and Jhingaran, 1991).

Fish	Size (cm)	Site	DDTs	HCHs	Aldrin	Endosulfan
C. garua	12	Patna	13.6	249	225.1	15.8
E. vacha	14	Patna	176.5	292	ND	62.9
E. vacha	18	Rajmahal	457.1	301.8	ND	9.19
C. catia	16	Mokama	259.4	158.9	80.8	ND
C. catia	18	Patna	382.2	647.1	ND	ND

x^2 = 1520.8, D.F.= 12.

Table 3 Concentration of organochlorines as ng g^{-1} (ppb) in detritivorous fishes (Talwar and Jhingaran, 1991).

Fish	Size (cm)	Site	DDTs	HCHs	Aldrin	Endosulfan
R. rita	16	Rajmahal	57.8	1206.8	ND	13.5
R. rita	14	Buxar	26.6	338.5	86.1	7.9
R. rita	16	Patna	1328	371.5	ND	30.4
R. rita	18	Mokama	324.7	599.6	ND	23.5
C. mrigala	14	Rajmahal	90.4	145.3	43.2	ND
C. mrigala	14	Buxar	53.23	294.6	112.4	24.6
C. mrigala	16	Buxar	114.2	55.2	57.4	2.25

x^2 = 3003.0, D.F.= 18.

Table 4 Concentration of organochlorines as ng g^{-1} (ppb) in carnivorous fishes (Bilgrami, 1991; Talwar and Jhingaran, 1991).

Fish	Size	Site	DDTs	HCHs	Aldrin	Endosulfan
S. silondia	16	Patna	1168	552.8	ND	174.5
A. seenghala	12	Rajmahal	48.3	430.9	ND	118.9
A. aor	25	Rajmahal	118.9	1078.6	16.03	15.6
W. attu	16	Patna	1665.9	285.8	ND	ND

x^2 = 2545.5, D.F.= 9.

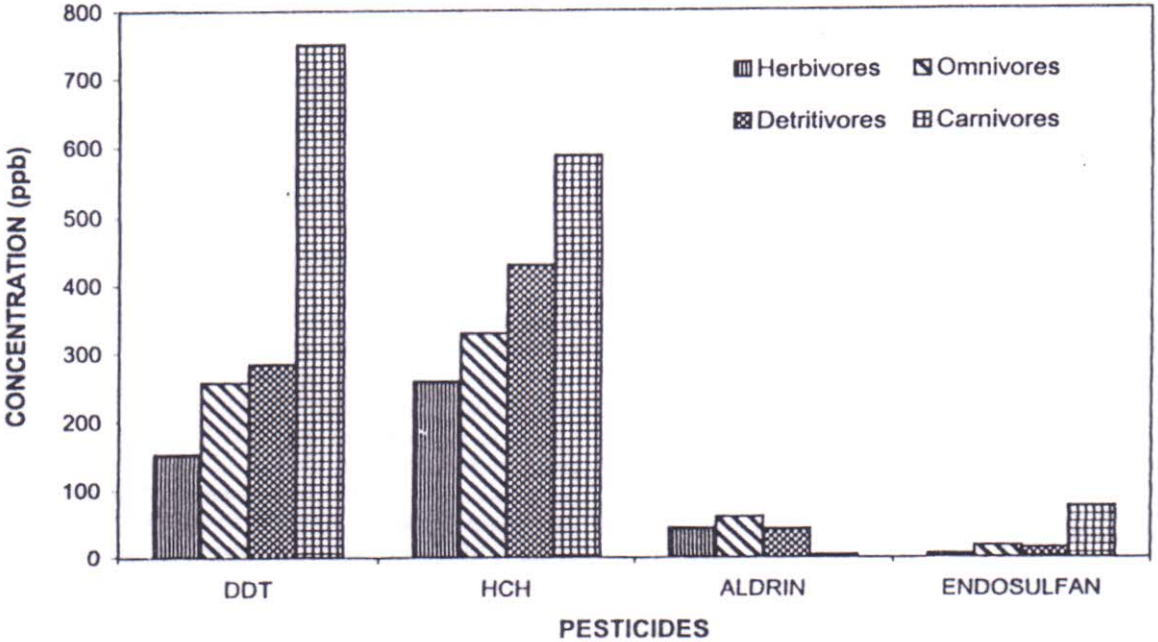

Figure 2 Concentration of different organochlorine pesticides in fish of the River Ganga having different feeding habits.

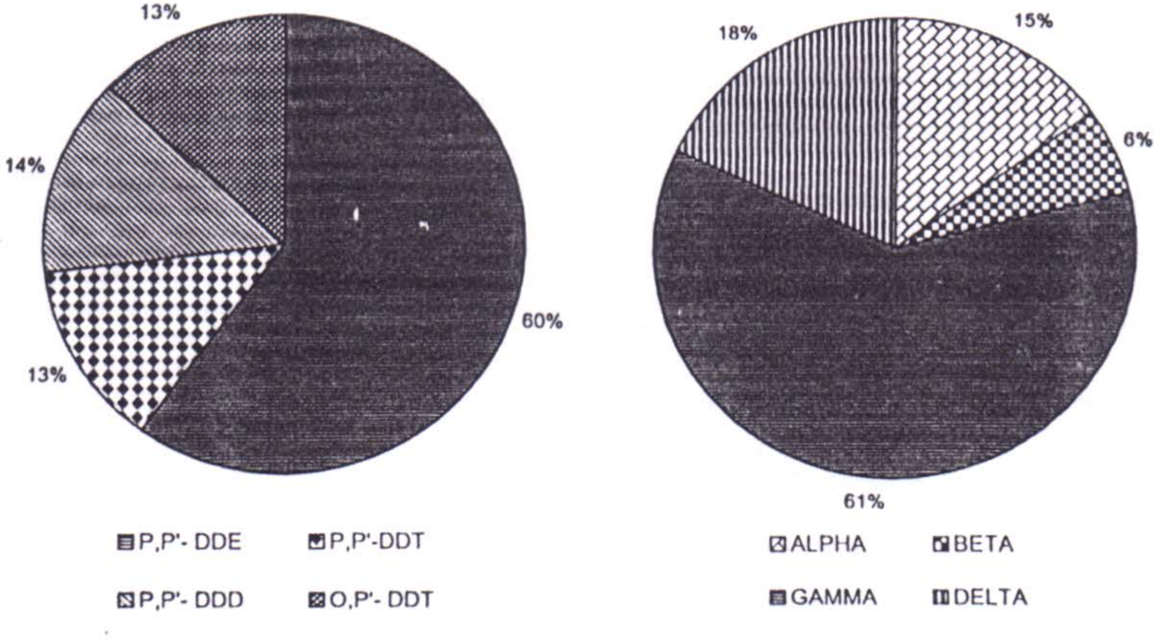

Figure 3 Percentage composition of DDT and HCH in the Fishes of the River Ganges.

River have also contributed to DDT contamination (Mohan, 1989). The major considerations in the case for continuing DDT for anti-malaria spraying have been its cheapness, effectiveness and durability (WHO, 1994). Although the use of HCHs in agriculture has been greater than those of DDTs, the relatively lower concentrations of HCHs in fishes from the Ganges River reflect the lower potential for bioaccumulation. The wet weight concentration of HCHs in fishes in Ganges River from Haridwar to Farakka was 28 to 110 ng g^{-1} (Senthilkumar et al., 1999). Higher concentration of DDTs than HCHs in fishes of Ganges River has been observed during the present study. The result shows that lipophilic, less water soluble and biochemically stable substances such as DDTs are much more strongly bioaccumulated in the aquatic food chain (Kannan et al., 1994). In the fishes studied, P,P'-DDE accounted for a major proportion (49 %) of the total DDT concentrations. Among HCHs isomers, the percentage of γ– HCH (61 %) was maximum (Fig.3). The presence of significant proportions of P,P'DDT and O,P'-DDT reflects the recent input of DDT into the Ganges River and the continuing exposure of local biota. Metabolic transformation of DDT under oxidative conditions forms P,P'-DDE whereas under anaerobic conditions P,P'-DDD is formed (Archer, 1976). Fifty four percent of the DDT in the fish collected from the river dolphins was P,P'-DDD (Senthilkumar et al., 1999). In fishes, P,P'- DDE was <40% of DDT levels, while P,P'-DDT was 5-35% of the DDT in Asia and Oceania (Kannan et al., 1995).

We conclude that the river fishes in the Ganges have high levels of most of the organochlorines including DDTs and HCHs. The presence of significant amounts of DDT and its metabolites reflects the recent usage of DDT in India for control of vectors of Kala-azar. Alternative control measures to fight these menace will have to be found to free the River Ganges from continued loading of such volatile compounds as HCHs and DDTs and thus to help protect humans who eat fish from the river.

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