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POLLUTION POTENTIAL OF PESTICIDES IN THE HINDON RIVER, INDIA

I. Ali
C. K. Jain
National Institute of Hydrology
Roorkee, India

The pollution potential of pesticides in the Hindon river (India) has been studied. The different pesticides monitored include lindane, malathion, BHC, p, p'-DDD, o, p'-DDT, and methoxychlor. Water and sediment samples were collected during the pre- and post-monsoon seasons. The concentrations of pesticides were found to be high in sediments compared to the associated water column. Agricultural runoff is the main source of pesticide pollution.

INTRODUCTION

The possibility of river water pollution with pesticides from agricultural activities has received great attention during recent years. Among various organic, inorganic and biological pollutants, the pesticides are very dangerous and harmful because of their tissue degradation and carcinogenic character in nature (IARC Monographs, 1987). The pesticides are bioaccumulative and relatively stable and, therefore, require close monitoring. According to Indian standards, all pesticides should be absent in drinking water (BIS, 1991). However, as per EEC directives, the maximum allowable concentration is only 0.1 μg/L for any individual pesticide and 0.5 μg/L for total pesticides (EEC, 1988). The WHO has classified the pesticides into five groups on the basis of their hazardous nature. The EPA has also reported characteristics of pesticides and their groundwater contamination potential (Cova et al., 1990).

The major sources of pesticide pollution are agricultural, forestry, industries and domestic activities. However, pesticide pollution through air has also been reported. The dust particles in air absorb the pesticides (due to pesticide spraying for agriculture, forestry and domestic uses) and then contaminate natural water resources, sediments and soil through flushing by rain water (Jain and Ali, 1997). Pesticides enter into the food chain through ground and/or surface water where they are taken up from the contaminated water by plants and animals (Ali and Jain, 1998).

Various reports on pesticides analysis in different matrices have been published in the last few years all over the world, but literature on Indian rivers is very scanty (Clement et al., 1995; MacCarthy et al., 1995; Sharma, 1995; Hartik and Tekel, 1996; Jain and Ali, 1997; Del Pino and Diaz, 1998; Martin-Esteban et al., 1998). The pesticides DDT, DDD, BHC, lindane, malathion, methoxychlor, etc. are the most commonly used in India (Haldar et al., 1989). Few reports are available on the presence of organochlorine pesticides in some water resources near Calcutta (Thakker and Pande, 1986; Thakker and Vaidya, 1992) and in the northeast region (Pathak et al., 1992). Contamination due to pesticides has also been reported in coastal water and sediments (Sarkar et al., 1997; Sarkar and Gupta, 1989). The groundwater contamination by pesticides has been reported in some parts of West Bengal (Chaterji, 1994), and Gujarat (Ali and Jain, 1998).

In view of the toxic and hazardous nature of pesticides, an attempt has been made to study the pollution potential of pesticides in the Hindon River. The importance of pesticide determination lies in the fact that the major land use in the basin is agriculture and agricultural runoff is the most likely source of pesticide pollution in the river. The aim of the present study was to determine the levels of pesticides in river water and sediments.

THE HINDON RIVER

The river originates from Upper Shivalik (Lower Himalayas) and lies between the latitude 28° 30’ to 30° 15’ N and longitude 77° 20’ to 77° 50’ E in western districts of Uttar Pradesh, India (Figure 1). The river is highly polluted due to industrial, municipal and agricultural activities of the region (Jain and Sharma, 1998). The climate of the region is semi-arid due to significant diurnal variations in the temperatures. The average annual rainfall is about 1000 mm, the major part of which is received during the monsoon period. The soil texture of the area is loam to silty loam. The major land use in the basin is agricultural. The quality and quantity of the river water is affected by municipal and industrial effluent as well as direct surface runoff from agricultural fields. The physico-chemical characteristics of the waste effluents and their impact on river water quality have been reported in an earlier report (Jain and Sharma, 1998).

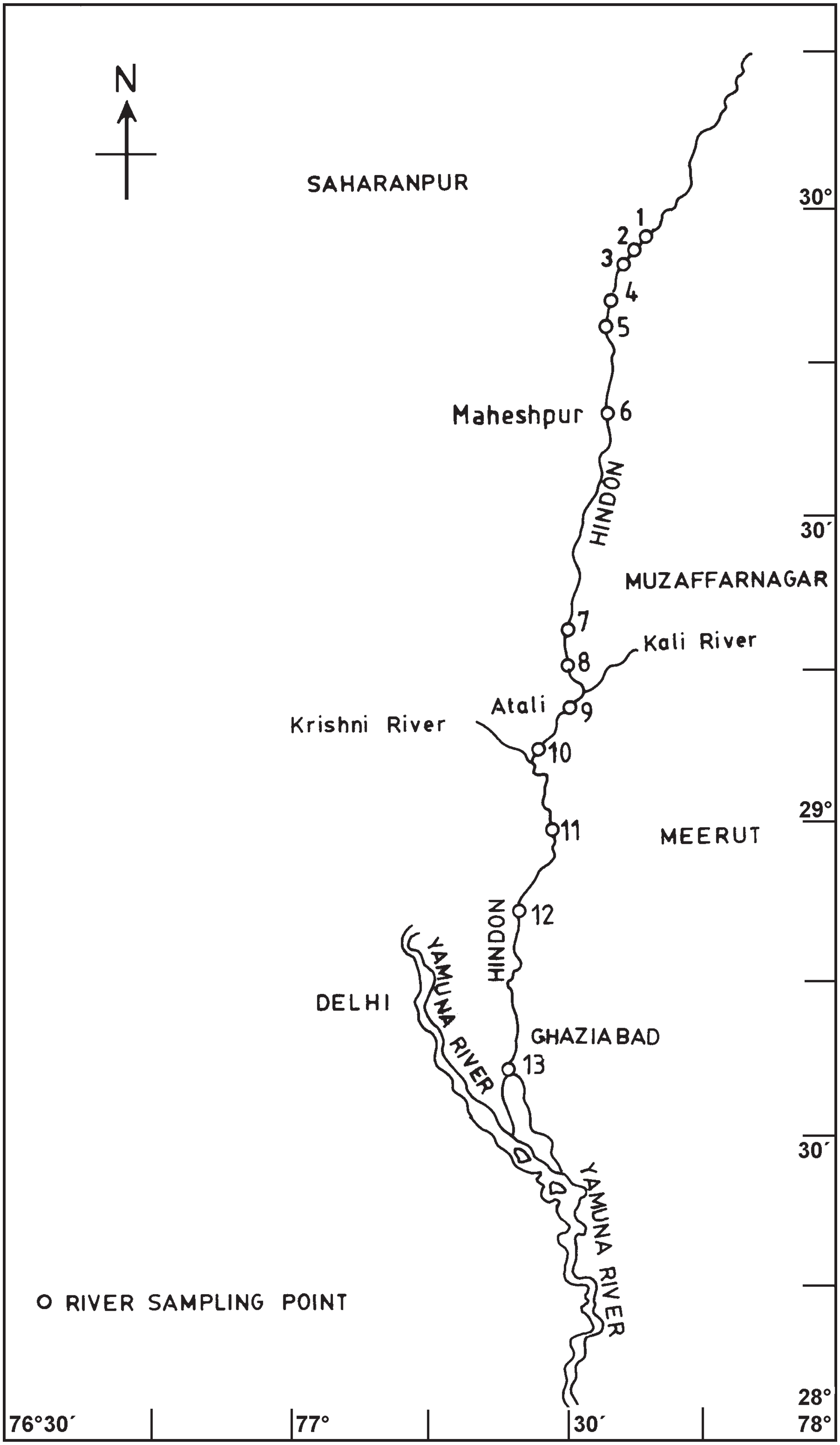

Figure 1. The Hindon River showing the location of sampling point.

ANALYTICAL METHODOLOGY

The water samples were collected using a standard water sampler (Hydro Bios, Germany) in pesticide grade solvent prewashed glass containers closed with teflon lined caps while the sediment samples were collected using a Ekman dredge in precleaned polyethylene bags. Two sets of samples were collected during May 1998 (pre-monsoon) and October 1998 (postmonsoon) and stored at 4°C till further processing.

All the pesticides and solvents used were of chromatography grade and were obtained from Merck, Germany. The pesticides were extracted with n-hexane and concentrated with the help of Kuderna-Danish assembly. Two hundred and fifty ml of water sample was shaken with 30 mL of n-hexane in a separating funnel for 30 minutes. An n-Hexane layer was allowed to separate from water for about 10 minutes. The same procedure was repeated for three times. For the extraction of pesticides from sediment, l0 g of sediment was extracted with 30 mL of n-hexane three times.

The three fractions of n-hexane were mixed together and concentrated to 10 mL using a Kuderna-Danish assembly. The moisture in the concentrated extract was removed by adding an hydrous sodium sulphate.

The qualitative and quantitative analysis of the pesticides was carried out by gas chromatography (Aimil-Nucon Model 5700) using Electron Capture Detector (ECD). The standard solutions of lindane, malathion, BHC, p,p’-DDD, o,p’-DDT and methoxychlor were prepared in n-hexane. The instrument was calibrated with these pesticides. The chromatograms of the external individual standards and their mixtures were recorded. The values of the retention times obtained with the external standards were used for the identification of different pesticides in water and sediments of the Hindon River .

The column used was made of glass, Ch. W.H.P., OV-17 (3%), mesh size 80-100 (120 cm x 3 mm). The temperatures of the column, injector and detector were 240, 250 and 275°C, respectively. Optimum separation conditions were achieved through extensive experimentation. The carrier gas used was nitrogen and its flow was maintained at 60 mL/min. Two µL of the sample extract was injected for analysis into the gas chromatograph and concentration of different pesticides determined. The confirmation of the pesticides was carried out by internal standard addition method.

RESULTS AND DISCUSSION

The concentration levels of different pesticides detected in water and sediments of the Hindon River are given in Table 1 and 2, respectively. The presence of these pesticides were identified by a comparison method, i.e., the retention times of the standard pesticides were used to identify the unknown pesticides present in the samples. The presence of these pesticides was further confirmed by the addition of known amount of external standard in the sample. It has been observed that by the addition of known standard in the sample, the peak area and height of the corresponding pesticide increased proportionately.

Concentration Levels of Pesticides in Hindon River Water

In the pre-monsoon season, lindane was detected only at one site, i.e. Santagarh, while during the post-monsoon season it was found at eleven sites with a maximum concentration of 2.18 µg/L at Behreki. Malathion was detected at nine sites during the pre-monsoon season and its concentration varied from 0.09 to 1.52µ/L. During the post-monsoon season the concentration of malathion varied from 0.06 to 1.62µg/L, with a maximum value at Maheshpur. BHC was detected at seven sites during

Table 1. Concentration of Pesticides (μg/L) in the Hindon River Water

S. No.	Location	Lindane		Malathion		BHC		p, p'-DDD		o, p'-DDT		Methoxychlor	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1	Behreki	ND	2.18	ND	ND	0.15	1.64	ND	ND	0.10	ND	ND	ND
2	Ghogreki	ND	1.46	ND	ND	ND	0.10	ND	ND	ND	ND	ND	ND
3	Santagarth	0.52	1.09	0.09	0.13	ND	ND	ND	ND	ND	ND	ND	ND
4	Nandi	ND	0.19	1.52	ND	ND	ND	2.38	ND	ND	0.38	ND	ND
5	Sadhauli Hariya	ND	ND	1.00	1.50	0.11	ND	ND	0.95	ND	0.10	ND	ND
6	Maheshpur	ND	2.06	0.95	1.62	0.21	0.10	ND	ND	ND	0.17	ND	ND
7	Budhana	ND	0.24	0.33	0.83	ND	0.05	ND	ND	ND	2.28	ND	0.60
8	Chandheri	ND	0.12	0.12	0.86	ND	0.10	ND	ND	ND	ND	ND	0.71
9	Atali	ND	0.19	0.52	ND	0.11	0.36	ND	ND	ND	1.03	ND	0.60
10	Barnawa	ND	0.20	0.50	0.06	0.10	0.58	ND	ND	ND	0.60	ND	0.50
11	Daluhera	ND	0.42	0.48	0.44	0.05	5.61	ND	ND	ND	0.86	ND	1.50
12	Surana	ND	ND	ND	0.52	ND	0.72	0.15	ND	ND	2.00	0.15	0.93
13	Mohan Nogar	ND	0.49	ND	1.51	0.11	0.81	0.15	ND	ND	0.46	0.11	ND

Pre = Pre-monsoon Post = Post-monsoon ND = Not detected

Table 2. Concentration of Pesticides (μg/L) in bed sediments of the Hindon River

S. No.	Location	Lindane		Malathion		BHC		p, p'-DDD		o, p'-DDT		Methoxychlor	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1	Behreki	ND	ND	5.22	22.95	3.89	14.00	ND	ND	ND	9.50	ND	ND
2	Ghogreki	1.50	ND	ND	19.27	2.96	8.06	ND	13.6	ND	ND	ND	ND
3	Santagarth	0.52	ND	ND	15.00	2.21	50.20	ND	ND	ND	10.43	ND	ND
4	Nandi	0.50	21.0	ND	27.25	2.00	ND	ND	7.50	ND	ND	ND	ND
5	Sadhauli Hariya	0.50	7.28	ND	33.17	2.00	10.50	ND	ND	ND	ND	ND	56.67
6	Maheshpur	0.48	ND	0.50	32.53	1.86	15.86	ND	ND	ND	ND	ND	32.20
7	Budhana	0.47	ND	0.40	ND	1.80	95.89	ND	ND	ND	7.56	ND	8.90
8	Chandheri	0.43	1.81	0.31	ND	1.70	27.46	ND	20.94	ND	ND	ND	12.43
9	Atali	0.40	3.40	0.15	9.95	1.61	ND	ND	35.65	ND	ND	ND	16.35
10	Barnawa	0.21	1.90	0.11	4.11	1.42	ND	ND	ND	ND	7.41	ND	ND
11	Daluhera	ND	7.31	0.10	45.5	2.52	16.81	0.52	ND	ND	ND	ND	ND
12	Surana	ND	1.50	ND	ND	1.51	ND	ND	8.92	ND	ND	ND	11.29
13	Mohan Nogar	0.30	34.31	0.10	10.10	0.21	ND	0.05	12.68	ND	2.60	ND	17.34

Pre = Pre-monsoon Post = Post-monsoon ND = Not detected the pre-monsoon season, and its concentration varied from 0.05 to 0.21 μg/L. During the post-monsoon season, BHC was found at ten sites and its concentration varied from 0.05 to 5.61 μg/L. The p,p'-DDD was detected only at three sites during the pre-monsoon season and only at one site during the post-monsoon season. The o,p'-DDT was detected only at Behreki during the pre-monsoon season, at a concentration of 0.10μg/L, while during the post-monsoon season o,p'-DDT was detected at nine sites at concentrations varying from 0.10 to 2.28μg/L. Methoxychlor was found only at two sites during the pre-monsoon season and at six sites during the post-monsoon season. The presence of various pesticides at different locations during the pre-monsoon and post-monsoon seasons indicates that the use of these pesticides is not uniform in the adjoining agricultural fields. No specific trend was found in the concentration of different pesticides. It is clear from these results that the concentration of pesticides were higher in the post monsoon season as compared to the pre-monsoon season. The increase in concentration during the post-monsoon season is attributed to the runoff contribution from agricultural fields.

Concentration Levels of Pesticides in Hindon River Sediments

Sediments play a major role in the pollution regime of a water body. They reflect the current quality of the water system and can be used to detect the presence of contamination that does not remain soluble after discharge into surface water. The sediment of the river acts as a good adsorbent for a variety of pollutants. Therefore, an assessment of both the sedimentary and aqueous phase should be undertaken to adequately characterise the aquatic environment. Furthermore, the analysis of sediments eliminates the problem of erratic fluctuations, which are often observed in water.

In the pre-monsoon season, lindane was absent at Behreki, Daluhera and Surana while at other places the concentration ranged from 0.21 to 1.50 μg/g. During the post-monsoon season, lindane was detected at eight sites with a concentration range from 1.50 to 34.31 μg/g. Malathion was detected at eight sites during the pre-monsoon season and at ten sites during the post-monsoon season. BHC was detected al all the sites during the pre-monsoon season, with a concentration range of 0.21 to 3.89μg/g, while it was found only at eight sites during the post-monsoon season. The p,p'-DDD was detected only at two sites during the pre-monsoon season and six sites during the post-monsoon season. The o,p-DDT and methoxychlor were absent at all the sampling sites during the pre-monsoon season while they were detected at a few sites during the post-monsoon season. The wide range of fluctuations and presence/absence of these pesticides at various sampling locations indicates that there is no regular use of these pesticides in the region.

The agricultural origin of the river pollution is clearly indicated from the presence of various pesticides at different locations in the river. The higher concentration of pesticides during the post-monsoon season indicates the influence of agricultural runoff. Pesticides are being transported from the cropland either by being absorbed onto the eroded soil particles or directly in runoff water.

CONCLUSION

The quantitative determination of pesticides in the aquatic environment is an important part of water quality management because of the carcinogenic and hazardous nature of the pesticides. The study of water and sediment samples of the Hindon river indicated the presence of lindane, malathion, BHC, p,p'-DDD, o,p'-DDT and methoxychlor. The concentrations of these pesticides was found to be greater in the post-monsoon season as compared to the pre-monsoon season. This may be attributed to the runoff from agricultural fields. The amount of pesticides was found to be higher in sediments than in the associated water column. The higher concentration of pesticides in sediments is attributed to the adsorption characteristics of the sediments. It is suggested that low toxicity pesticides be used in agricultural fields to reduce the risk of pesticide toxicity. Possibilities should also be explored to use other methods of pest control.

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ADDRESS FOR CORRESPONDENCE
Dr. C.K. Jain
National Institute of Hydrology
Environmental Hydrology Division
Roorkee 247 667
India

E-mail: ckj@nih.ernet.in