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Residues of DDT and HCH in Major Sources of Drinking Water in Bhopal, India

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The large scale use of organochlorine insecticides (OCIs) in developing countries has caused serious concern due to their persistence in the environment. OCIs are characterized by their stability for long periods which may lead to toxicological implication on the terrestrial and aquatic ecosystem (Aruda et al. 1988, Cochieri and Arnese 1988, Sarkar and Sen Gupta 1988). About 55000 tons of pesticides are used in agriculture and public health every year (Sen Gupta and Quasim 1985). Continuous use of pesticides to combat pests of this contamination of water has led to spillage and percolation to subsoil systems and water bodies has been a matter of concern even in the developed countries, in view of their risk to communities consuming polluted drinking water. This is the first report of its kind about the residual presence of major OCIs such as HCH and DDT in different sources of water (Wells, handpumps and ponds) samples in and around Bhopal, India.

MATERIALS AND METHODS

A total number of sixty water samples from different wells, handpumps and ponds were collected from various locations in and around Bhopal, India for the analysis. Each sample of water in replicates of eight was taken (one liter) in 2L separatory funnel and mixed with 3 x 150mL distilled n-hexane (Spectrochem Pvt. Ltd. Bombay), shaken for 30 min. The organic phase was separated from aqueous phase. The extraction was carried out successively with 3 x 50mL n-hexane. The combined extract was concentrated to volume of 10 mL with vaccum rotary evaporator at 50°C dissolved in 25 mL distilled acetonitrile (Spectrochem Pvt.Ltd. Bombay) and washed with (4 % w/v) 450 mL sodium sulphate. It was extracted again with 3 x 25 mL portion of n-hexane. The combined n-hexane extract was concentrated to a volume of 1 mL. Each sample was cleaned up prior to GLC analysis using a neutral two step procedure to eliminate known interfering compounds. The n-hexane extract was applied to a mixed phase prewashed chromatographic column containing 1 x 5 cm bed of anhydrous sodium sulphate at the bottom followed by 1 x 10 cm of activated charcoal (E.Merck India Ltd.) in approximately 600 mg celiite 545 (Fishers Scientific) and eluted with 40 mL 5% benzene/hexane.

The benzene samples was concentrated to a volume of 1mL and the solvent system was changed to n-hexane. It was then applied to a 1 x 25 cm bed

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of 2% activated silica gel (Glindia Ltd.) and eluted with n-hexane. The fractions containing OCIs were collected , concentrated and transferred to 2 mL volumetric flask and made to a volume of 2 mL in n-hexane. The samples were stored in the absence of light prior to GLC analysis.

Aliquots of the concentrated samples were injected to precalibrated CHEMTECH 3865 chromatograph equipped with ^{63}Ni electron capture detector. A glass column (1.5 m x 2 mm i.d) packed with 1.5% OV-17 + 1.95% QF-1 on 100-120 mesh chromosorb WHP was used. Operation temperatures were programed at 195, 200 and 220°C for column, injector and detector respectively. Purified nitrogen gas passing through silica gel and molecular sieves was used as carrier gas at a flow rate of 60 ml/min. Data for gas chromatographic analyses were further confirmed by TLC.

Procedural blanks, consisting of all reagents and glass ware used during analysis were periodically determined to check the cross contamination. Since no compound that interfered with organochlorine was detected, the sample values were not corrected for procedural blanks. Recovery studies with fortified samples have indicated that over all recovery value exceeded 92%. Results were not adjusted for percent recovery. Identification and quantification were accomplished using a known amount of external standard received from United State Environmental Protection Agency. Pesticides and Industrial Chemical Repository (MD-8) Research triangle Park, NC, USA.

RESULTS AND DISCUSSION

The concentrations of OCIs in water samples are summerized in Table 1. HCH and DDT were found in all the samples subjected to GLC analysis. Water samples of wells showed the minimum residual content of total HCH (mean concentration of 4.654 ppm) and total DDT (mean concentration 5.794 ppm) which varied between 1.576-7.747 and 3.153-9.356 ppm respectively. It is of interest to note that the percent content of alpha, beta and gamma isomers of HCH was found to be almost same in all the three different sources of water. Among the three isomers, the content of alpha was maximal (52-53%) followed by beta (33-37%) and gamma (9.7-14%). Reports have shown that gamma isomer is most susceptible to degradate in microbial environment (Benzet and Matsumura 1973, Jangnow et al. 1977, Mathur and Saha 1977). The low level of gamma isomer in the water samples seems to be associated with this factor. It is known that chlorinated organic waste in water helps in increasing the microbial population (Pelon and Mayo 1987). It is therefore possible that in waters of Bhopal such an enlarged population of microbes are playing the major role of the degradation leading to the formation of larger levels of alpha and beta HCH. DDT is an insecticide which is still indiscriminately used in several developing countries (Metcalf 1973, Sarkar and Sen Gupta 1988, Bridges et al. 1963). In our present study we have found DDT in almost all the samples of water. pp'-DDT and its metabolites such as pp'-DDD have also been found in almost all the samples of water. pp'-DDT and its metabolites such as pp'-DDE and pp'-DDD was found to persist in higher concentrations (88-91%). op'-DDT was also detected in all samples and its content was between 8.5-15% of the sum of the total DDT content.

Table 1. Residues of DDT and HCH (ppm) in water systems in and around Bhopal, India.

Compounds	Sample Source Wells	Hand-pumps	Ponds
Alpha-HCH	2.429 (0.560-4.00)	3.271 (1.360-5.280)	5.243 (2.148-8.741)
Beta-HCH	1.729 (0.667-3.096)	2.262 (0.889-3.852)	3.283 (0.880-4.80)
Gamma-HCH	0.496 (0.109-0.811)	0.597 (0.357-1.031)	1.415 (0.109-3.608)
Total HCH	4.654 (1.576-7.747)	6.130 (4.320-8.718)	9.941 (6.221-15.58)
pp'-DDE	0.055 (ND-0.157)	0.092 (0.035-0.353)	0.065 (ND-0.204)
op'-DDT	0.882 (ND-2.593)	1.759 (1.203-2.546)	1.370 (ND-2.778)
pp'-DDD	2.595 (0.900-7.410)	7.818 (3.927-16.00)	13.252 (1.20-27.36)
pp'-DDT	2.624 (ND-8.00)	4.879 (4.00-5.455)	1.372 (ND-6.182)
Total DDT	5.794 (3.153-9.356)	14.548 (10.392-22.34)	16.059 (3.674-34.771)

Each value represents mean of Replicates of eight.

Since pp'-DDT is known to undergo metabolic conversion and dehydrochlorination (Matsumura 1973), presence of pp'-DDE and pp' DDD encountered in this study might be due to such metabolic process. The sum of mean concentration of pp'-DDE and pp'-DDD are higher than that of pp'-DDT. The concentration of op'-DDT was also significant in the samples taken for analysis.

The OCIs and their metabolites have been implicated as carcinogenic and esterogenic agents (WHO 1974, Bulger and Kupfer 1985). The potential accumulation and conversion of organic chemicals in drinking water have been determined by Komsta et al., 1988, Ventura and Rivera 1986. The transmigration of OCIs through food chain and drinking water may lead to higher accumulation of residues in human system leading to pathophysiological and related health effects.

It is also important to note that the analytical results reported herein are for a limited number of drinking water samples and may not be representative of OCIs concentration at other locations of Bhopal.

While no information is available on the extent of population that are exposed to OCI contaminated water sources in different regions of the country including Bhopal, yet the consumption of such contaminated water, warrants for proper regulatory measures both for the use of pesticides as well as to protect the sources of drinking water. The present study has hinted about the possible trend of pesticide percolation into the sources of drinking water. The problem therefore assumes a greater dimension and calls for regular monitoring of drinking water on a national basis.

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