Bull. Environ. Contam. Toxicol. (1991) 47:381–385
© 1991 Springer-Verlag New York Inc.

Environmental Contamination and Toxicology

Residues of Organochlorine Pesticides and Polycyclic Aromatic Hydrocarbons in Drinking Water of Ahmedabad City, India

J. P. Jani,[1] C. V. Raiyani, J. S. Mistry,[1] J. S. Patel, N. M. Desai, and S. K. Kashyap

[1]Department of Pharmacology, School of Medicine, University of Pittsburgh, Pittsburgh, Pennsylvania 15261, USA and National Institute of Occupational Health, Meghani Nagar, Ahmedabad-380016, India

The ubiquitous environmental pollutants organochlorine pesticides (OCP) and polycyclic aromatic hydrocarbons (PAH) have been extensively studied for their toxicity. Monitoring of OCP and PAH residues has always been considered important for controlling human exposure. As compared to several other countries, the higher body burden of OCP in Indian general population (Jani et al. 1988b) is indicative of higher exposure to these chemicals. Recent studies have shown higher residues of OCP in food commodities including human mother's milk (Jani et al. 1988a; UNEP/WHO, 1983). The levels of OCP in drinking water is still a matter of concern and practically nothing is known about the residues of PAH in drinking water in India. This is the first report of its kind regarding the residues of OCP and PAH in drinking water of Ahmedabad City, the sixth largest city of India with a population of more than 2.5 million.

MATERIALS AND METHODS

Two liter drinking water samples (n=60) from 10 different locations (residential as well as industrial) of Ahmedabad City, India were collected for the analysis. At least 5 samples were obtained from each sampling location during May 1987 to July 1987. For the extraction of OCP, 1 L of water was transferred in a separating funnel and extracted with 3 x 100 mL HPLC grade hexane. The extracts were washed with 100 mL of 2% sodium sulphate solution and concentrated to dryness. The residues were dissolved in 0.2 mL of hexane and 5 μL of each sample was used for preliminary GC analysis. As dieldrin and PCB were absent in all the samples, the samples were subjected to sulphuric acid clean-up (UNEP/WHO, 1983). A Perkin-Elmer gas chromatograph

Send reprint request to Dr. J.P. Jani at the above address.

(3920B) equiped with a Ni^{63} electron capture detector and a glass column (6 ft x 1/4 in.) packed with 1.5% OV-17 + 1.95% QF-1 on chromosorb WHP (100/120) was used for the final OCP analysis. The confirmation of OCP was done using a column packed with 5% OV-17 on chromosorb W (100/120). Injector, column and detector were operated at 230, 210 and 300 ^{0}C, respectively. 5% argon in methane (60 mL/min) was used as carrier gas.

For the extraction of PAH, 1 L sample was mixed with 100 mL of methylene chloride in a separating funnel. After gentle shaking for 15 min the organic phase was isolated. The procedure was repeated twice using 50 mL of fresh methylene chloride. Parallel to each set of 5 samples, a water sample pre-extracted with methylene chloride and spiked with 18 PAH standard mixture was processed as described above for quality control. All the three methylene chloride extracts of each sample were combined, concentrated to dryness using a rotary evaporator and the residues were redissolved in 3 mL of cyclohexane for liquid:liquid extraction with nitromethane (Hoffmann and Wynder 1960). Nitromethane fraction was concentrated to dryness (0.2-0.4 mL) and spotted on a thin layer chromatographic plate prepared from silicagel-G along with the reference PAH mixture (NBS 1647). The plate was developed in a close chamber using benzene:hexane (5:95, v/v) (Negishi 1978). The fluorescent bands of reference PAH and that of samples were marked under ultra violet light. The PAH from absorbent were eluted in benzene, concentrated to dryness and the residues were redissolved in 200 μL of chloroform:methanol (1:1, v/v) for HPLC analysis. A Beckman (340) HPLC equiped with an absorbance detector (160) was used for PAH analysis. PAH separation was achieved upon a C-18 Ultrasphere-ODS (150 x 4.6 mm, 5 μm, Altex) column. The flow rate of mobile phase (methanol:water, 80:20, v/v) was 1 mL/min and the eluent was monitored at 254 nm with 0.005 AUFS. Quantitation of PAH and OCP was done by comparing height or area of unknown PAH with that of satndard PAH of known concentration.

RESULTS AND DISCUSSION

No difference was found in the levels of OCP and PAH in municipal or well water samples that were obtained from industrial or residential areas. Therefore, the levels of OCP and PAH presented in this report are combined. The results of OCP in the drinking water samples of Ahmedabad City, India are shown in table 1. Hexachlorocyclohexane (HCH), dichlorodipheneyl-trichloroethane (DDT) and 2,2-bis(p-chlorophenyl)-1,1-dichloroethylene (DDE) were the only chlorinated pesticides found in the samples. Other organochlorine compounds such as PCBs, aldrin, dieldrin, chlordane,

Table 1. Residues of OCP (ng/L) in drinking water of Ahmedabad City, India.

Compounds	Mean	Median	Range
α-HCH	63.85	32.00	10.70- 444.40
γ-HCH	159.43	46.30	16.60-1800.00
β-HCH	34.47	20.00	00.80- 244.30
Total-HCH	256.99	86.90	23.90-2488.70
p,p'-DDE	5.15	2.30	00.60- 35.70
o,p'-DDT	18.25	6.90	01.10- 180.35
p,p'-DDT	24.49	13.50	05.90- 98.77
Total-DDT	47.42	24.40	10.90- 314.90

n (number of samples) = 57

Table 2. Residues of PAH (ng/L) in drinking water of Ahmedabad City, India.

Compounds	Mean	Median	Range
PAH Up to 3 Rings			
Naphthalene	00.00	00.00	00.00- 00.00
Acenaphthylene	52.66	39.96	17.24- 112.84
Acenaphthene	145.22	00.00	00.00- 787.20
Fluorene	251.92	225.60	00.00- 501.33
Phenanthrene	346.89	187.33	31.79-1868.20
Anthracene	14.91	5.33	00.74- 100.73
PAH With 4 or More Rings			
Fluoranthene	420.71	130.11	38.44-2534.62
Pyrene	911.49	347.03	80.52-4711.84
Benz(a)anthracene	172.17	51.51	11.45- 919.85
Chrysene	220.57	68.65	19.25- 998.46
Benzo(e)pyrene	40.23	00.00	00.00- 307.68
Perylene	12.11	00.00	00.00- 117.12
Benzo(b)fluoranthene	77.82	21.59	00.00- 398.64
Benzo(k)fluoranthene	77.15	18.42	00.00- 296.58
Benzo(a)pyrene	94.13	52.36	00.00- 368.33
Dibenz(a,h)anthracene	40.02	00.00	00.00- 197.32
Benzo(g,h,i)perylene	25.27	00.00	00.00- 196.35
Indeno(1,2,3-cd)pyrene	6.08	00.00	00.00- 61.20

n (number of samples) = 57

heptachlore, heptachlore epoxide and endrine were absent in all the samples. The median levels of total HCH (α, β and γ-HCH) and total DDT (p,p'-DDE, o,p'-DDT and p,p'-DDT) were 86.9 ng/L and 24.4 ng/L, respectively. However, the highest residues of total HCH (2489 ng/L) and total DDT (315 ng/L) were several time higher than their median levels. Furthermore, γ-HCH and p,p'-DDT contributed more than 50% of the total HCH and total DDT residues, respectively. Recent report from India has shown very high residues of total HCH (5-10 ppm) and total DDT (6-16 ppm) in water samples collected from Bhopal City, India (Dikshith et al. 1990). Our results show that the OCP residues in drinking water of Ahmedabad City, India are significantly low.

The mean, median and range of individual PAH found in the present study is given in table 2. Out of 18 PAH determined in the present study, naphthalene was absent in all the samples whereas phenanthrene, anthracene, fluoranthene, pyrene, benz(a)anthracene and chrysene were found in all the samples. The median level of pyrene (347.03 ng/L) was the highest followed by fluorene (225.6 ng/L) and phenanthrene (187.33 ng/L). The median level of benzo(a)pyrene (52.36 ng/L) ranked sixth among all the 18 PAH though the highest level of 368.33 ng/L was found in one sample. The maximum allowable concentration (MAC) for benzo(a)pyrene or for total PAH in the drinking water is not established in India. However, the median level of benzo(a)pyrene (52 ng/L) found in the present study is 2 and 10 times higher than MAC for benzo(a)pyrene in USA (28 ng/L, Rugen et al, 1989) and USSR (5 ng/L, Shabad 1978), respectively. Similarly, the median level of total PAH (1.15 μg/L) found in the present study is much higher than MAC for total PAH (0.2 μg/L) established for European drinking water (WHO 1970).

The daily intake of total OCP and PAH was calculated on the basis of their median values and considering the daily intake of 2000 mL of water (Ishimaru et al. 1990). The calculated daily intake of total OCP and PAH through drinking water of Ahmedabad City, India was 222.6 and 2295.74 ng, respectively.

REFERENCES

Dikshith TSS, Raizada RB, Kumar SN, Srivastava MK, Kulshrestha SK, Adholia UN (1990) Residues of DDT and HCH in major sources of drinking water in Bhopal, India. Bull Environ Contam Toxicol 45:389-393.

Hoffmann D, Wynder EL (1960) Short term determination of carcinogenic aromatic hydrocarbons. Anal Chem 32:295-296.

Ishimaru T, Inouye H, Morioka T (1990) Risk assessment of drinking water in a reservoir contaminated by PAH's originated from road traffic. Sci Total Environ 93:125-130.

Jani JP, Patel JS, Shah MP, Gupta SK, Kashyap SK (1988a) Levels of organochlorine pesticides in human milk in Ahmedabad, India. Int Arch Occup Environ Health 60:111-113.

Jani JP, Patel JS, Shah MP, Varia MR, Shah YH, Gupta SK, Kashyap SK (1988b) Dichlorodiphenyltrichloroethane and hexachlorocyclohexane in human adipose tissue of the Indian population. Scand J Work Environ Health 14:201-204.

Negishi T (1978) Determination of polynuclear aromatic hydrocarbons contaminated with chlorinated hydrocarbon pesticides. Bull Environ Contam Toxicol 19: 545-548.

Rugen PJ, Stern CD, Lamm SH (1989) Comparative carcinogenicity of the PAHs as a basis for acceptable exposure levels (AELs) in drinking water. Regul Toxicol Pharmacol 9:273-283.

Shabad LM (1978) Blastomogenic hazard of chemical pollution of the human environment. In: Toxicologija, Total of Science and Technique, Moscow, pp 7-58.

UNEP/WHO (1983) Assessment of human exposure to selected organochlorine compounds through biological monitoring. Slorach SA, Vaz R (eds.), Swedish National Food Administration Publication, Uppsala, Sweden.

WHO (1970) European standards for drinking water (2nd Ed.), WHO, Geneva.

Received March 3, 1991; accepted April 4, 1991.