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Use of HCH (BHC) and Its Environmental Effects in India

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HCH (hexachlorocyclohexane), popularly known as BHC, was introduced in India in 1949 to control insect pests of agricultural importance. Although, its main use is still in agriculture, it is also being used in the public health sector in smaller amounts since 1960. Ever since its introduction, 575 thousand tonnes of HCH have been used in the country till todate (nearly 500 thousand tonnes in agriculture and 75 thousand tonnes in public health sectors, respectively). The current annual consumption of HCH is nearly 36 thousand tonnes (30 thousand tonnes in agriculture and 6 thousand tonnes in public health). The large-scale usage of HCH has led to its near ubiquitous presence in the Indian environment, including human and animal tissues. The situation at present is not very alarming, but the continued use of HCH will certainly pose a problem in coming years. Although it has been claimed that the half-life of HCH in Indian environment is around three months as compared to 4–5 years in the temperate regions, there is a need to confirm these findings. Acute poisoning due to HCH has been reported from the various parts of the country more than once and there is a risk to health due to chronic exposure. There are indications that the presence of HCH residues in women can lead to abortions and premature delivery. Further, HCH is a known carcinogen. Keeping these facts in view there is an urgent need to phase out HCH from the Indian scene by 2000 AD. Besides, the residues of HCH should be monitored in various components of the environment in various agro-climatic zones of the country.

Key Words: HCH, Environmental pollution

India being a tropical country has more than its share of pests and diseases in both agriculture and public health (Mehrotra 1979a and b, 1983a). The importance of pesticides in controlling these pests is very well recognized even in integrated pest management (Mehrotra 1985). HCH, being cheap, reliable and broad spectrum insecticide was one of the first to be introduced in the country for use in agriculture. It was introduced in India in 1949 (Banerjee 1979). Although, HCH was introduced mainly for agricultural use, its use in public health sector, specially in the control of insect vectors of malaria, was started in 1960. The use in public health was mainly for controlling insect

vectors which had developed resistance to DDT. From the time of its introduction till todate nearly 575 thousand tonnes of HCH has been used in the country (500 thousand tonnes in agriculture and nearly 75 thousand tonnes in public health sector). Current annual consumption of HCH is around 36 thousand tonnes (30 thousand tonnes in agriculture and 6 thousand tonnes in public health sector). The projected demand of HCH is around 60 thousand tonnes annually by the year 1990 (39 thousand tonnes in agriculture and 21 thousand tonnes in public health sectors) (GOI 1984). As it is, HCH constitutes nearly 50% of the total pesticides used in the country and that too mostly in agricultural sector.

The use of HCH in agriculture on large scale has been mainly because of its certain peculiar properties: it is persistent with fumigant action, non-phytotoxic (except to cucurbitaceae) at the concentration normally used, but at higher concentrations may cause root deformation and polyploidy. It is generally more toxic than DDT to most insect pest species and can also be used as a soil insecticide. There are 5 important isomers of the compound, of which *gamma*-isomer or lindane has insecticidal properties whereas *beta*-isomer is the most stable. Commercially available HCH contains 13% of lindane. Keeping in view these properties it has been recommended for wide variety of crops and that is why the consumption of HCH has been going up since the time of its introduction in the country (table 1). There has been nearly 20-fold increase in HCH consumption from 1955 to 1980, a quantum jump in its consumption in agricultural sector was seen between 1965 and 1970 (table 1) as a result of the introduction of, and increase in area under, high-yielding varieties during this period.

HCH has been recommended in agriculture for controlling wide varieties of pests of paddy, maize, sorghum, cotton, sugarcane, groundnut, mustard and rapeseed, gram, pea and various plantation crops (ICAR 1961, 1981, GOI 1970). Usually the recommended doses of application of HCH are 3–5 kg a.i./hectare, but recently as high as 12.5 kg a.i./hectare has also been recommended (ICAR 1985 a and b). Because HCH is stable, highly fat-soluble and having low water-solubility, it tends to stay in the environment. In this respect it can be termed as an ideal environmental pollutant. Although the knowledge regarding the extent of environmental pollution due to pesticides including HCH in India is fragmentary, nevertheless, the subject has been reviewed from time to time by various workers in a number of symposia (Bindra & Kalra 1973, Agnihothrudu & Mithyantha 1978, Edwards et al. 1978, Raychaudhuri & Gupta 1979, Attri et al. 1982, Krishna Murti 1984). Scientific

Table 1 *Consumption of HCH (BHC) in India (in tonnes)*

Year	NMEP*	Agri-culture	Total
1955	—	1603	1603
1960	644	3247	3891
1965	618	6873	7441
1970	750	16166	16196
1971	2250	14000	16250
1972	1500	15850	17350
1973	2250	18000	20250
1974	6000	18000	24000
1975	2689	21235	23924
1976	6400	18190	24590
1977	3780	24820	28600
1978	11000	24254	35254
1979	6853	24976	31829
1980	2150	26610	28760
1981	4588	23778	28366
1982	8717	23661	32378
1983	10632	21757	32389
1984	6519	29481	36000

*NMEP—National Malaria Eradication Programme

data collected so far to assess the environmental load of HCH in ecosystem relevant to India are summarized in tables 2–14.

HCH Residues in Soil

Soil has been recognised as the main sink of pesticides used in agriculture. In case of HCH it becomes still more important because it has been recommended as a soil insecticide for various crops (ICAR 1981). Despite the fact that it has been extensively used in agriculture, detailed information on the levels of residues of HCH in Indian soils is meagre. Venkataramaiah and Singh (1973) extensively studied the HCH residues in soils of the coffee plantations in Kallar region of Karnataka. Their study showed that the HCH residues ranged from 0.025 to 124 ppm up to 15 cm top soil and were not detectable below 60 cm. A survey of Punjab soils conducted in 1976-77 for pesticide residues showed that only one sample out of 91 had a detectable amount of HCH. However, a later study revealed extensive amounts of HCH levels in the soil samples collected from villages around Ludhiana (Kalra & Chawla 1983). Residues of HCH in Punjab soils ranged from traces to 0.053 ppm and that *alpha*, *beta*, *gamma* and *delta* isomers were present. Highest concentrations were those of *beta*-isomer. The persistence of HCH and its isomers in the soil under various crops has also been reported. Agnihotri et al. (1974) showed that γ HCH applied to the first 15 cm of the soil was lost within 6 months of its application. This, however, is in contrast to what Chawla and Chopra (1967) reported (i.e. 50% HCH remained in soil even after a 9-month period). A very fast dissipation of HCH from the clay loam soil has been reported (Srivastava & Yadav 1977). It has also been shown that HCH can be adsorbed by the soil particles and that adsorption is highest in acidic laterite soil followed by black, red and *kari* soils. Clay soils retain very little, if any, HCH. The adsorption of HCH on soil is dose-dependent. HCH is degraded in the soil, the rate of degradation being dependent on the moisture and organic contents of the soil (Wahid & Sethunathan 1980). It is degraded very fast under paddy soil conditions. However, *gamma* isomer of HCH is degraded faster than the *beta* isomer (Siddaramappa & Sethunathan 1975, 1976, Mathur & Saha 1977, Sahi et al. 1976, Pal et al. 1980). The half-life of HCH in Indian soils have been shown to be around 4 months (Agnihotri et al. 1977). This finding needs confirmation because had it been so, one should not encounter HCH residues in the environment.

HCH in Water

Despite the importance of pesticide residues in aquatic systems, very few studies have been made regarding the HCH residues in water Visweshwariah et al. (1976) analysed water samples collected from ponds in the coffee plantations at Chikmaglur district of Karnataka and showed the presence of HCH. The concentration of HCH ranged between 0.02 and 0.2 ppm, the insecticide, however, could not be detected in the silt of ponds of the area. Drinking water was shown to contain 0.02 – 6.16 ppm of HCH in the same area (Venkataramiah & Singh 1973). Kalra and Chawla (1981a) analyzed about 20 samples of water collected from Ludhiana and Muktsar in Punjab for pesticide residues. The mean HCH level detected was 0.9 ppb. The tap water, however, did not show any HCH.

HCH Residues in Cereals and Animal Feed

Cereals and pulses: Since the average Indian diet is predominantly vegetarian and the cereals along with pulses constitute its major portion, these commodities have been surveyed from time to time. Earlier survey by

Table 2 *Contamination of cereals and pulses with HCH residues in India*

Location Period	Samples analysed	Samples contaminated	Mean range (ppm)	Reference
		Wheat Grain		
Ludhiana (1979)	23	23	Tr.–4.0	Kalra & Chawla (1981a, 1983)
Ferozepur (1979)	9	9	0.02–32.4	,,
Sangrur (1979)	10	10	0.41–30.0	,,
Sangrur (1980)	26	26	0.2–10.50	,,
Bombay: Urban (1978)	21	6	5.1–13.9	Noronha et al. (1980)
Bombay: Rural (1979-80)	20	12	0.05–7.3	,,
		Wheat Flour		
Punjab (7 cities) (1976)	140	116	Tr.–12.0	Joia et al. (1978)
Sangrur & Ludhiana (1980)	24	22	Tr.–17.6	Kalra & Chawla (1983)
		Maize Grain & Flour		
Punjab	10	10	Tr.–1.0	Kalra & Chawla (1981a, 1983)
		Cereal & Cereal Products		
Hyderabad	594	144	Tr.–20.8	Lakshminarayana & Menon (1975) and Lakshminarayana (1980)
		Paddy & Rice		
Bombay: Rural (1979-80) Paddy	10	4	0.01–0.2	Noronha et al. (1980)
Bombay: Urban (1978) Rice	20	13	4.2–11.2	,,
Ludhiana (1980) Rice	10	10	Tr.–0.10	Kalra & Chawla (1981a, 1983)
		Sorghum & Bajra		
Bombay: Rural (1979-80) Sorghum	29	18	0.01–0.8	Noronha et al. (1980)
Bombay: Rural (1979–80) Sorghum	2	2	0.01–0.2	,,
		Pulses		
Hyderabad (1968–79)	161	16	Tr.–10.0	Lakshminarayana (1980)
Hapur	81	31	7–87	ICAR (1967)
Mysore	37		23.5	Majumdar (1973)
Ludhiana	10	8	Tr.–0.05	

Bindra et al. (1973) showed that 4 out of 54 samples of wheat grain had detectable amounts of HCH. Later work not only confirmed the existence of HCH residues in grains but also showed that it is prevalent in various parts of the country and that its concentrations were higher than those reported for DDT (Mehrotra 1985). The existence of HCH in Punjab on wheat grain, wheat flour, maize grain and flour has been reported by Kalra and Chawla (1981a, 1983). The survey of cereal and cereal products in Andhra Pradesh revealed that HCH was present in nearly 25% of the samples (Lakshminarayana & Menon 1975, Lakshminarayana 1980). Noronha et al. (1980) showed the presence of HCH residues in paddy, rice, sorghum and bajra in Maharashtra. The data presented in table 2 suggest that HCH is present in nearly every commodity and that its concentrations have gone up over the years. This may perhaps be due to increased use of HCH in agricultural sector. Considerable amounts of HCH residues in the spices exported from India have also been reported by Sullivan (1980) (table 3).

Vegetables and fruits: Extensive surveys for the pesticidal residues on vegetables and fruits have been conducted over the years in various regions of the country. The surveys have been conducted at Hyderabad (Lakshminarayana 1980), Punjab (Kalra et al. 1978, Kalra & Chawla 1983, Gupta & Kalra 1983), Karnataka (Visweshwaraiah & Jayaram 1972) and Haryana (Verma 1980). The data of these surveys are summarised in table 4. All the samples of leafy vegetables collected in Karnataka showed the presence of high levels of HCH. Okra, brinjal, cabbage, cauliflower, radish, tomato and turnip had HCH residues in more than 40% of the samples collected in Haryana and Andhra Pradesh. Similar results have also been reported from Punjab (Kalra & Chawla 1981a, 1983).

Table 3 *Residues of HCH in spices exported from India*

Commodity	HCH Residues (ppm)
Black pepper	0.2–0.22
Celery seed	0.8–0.68
Dill seed	0.14
Turmeric	0.04–0.6
Ginger	0.02–1.19
Fennel	0.01–3.52

After Sullivan (1980)

Vegetable oils and oilseeds: HCH residues were common in the market samples of vegetable oils of groundnut, mustard, sesame, coconut, cotton seed, rice bran, linseed and rapeseed collected from Punjab, Uttar Pradesh and Andhra Pradesh. The overall level of HCH residues varied from traces in Hyderabad to as high as 0.71 ppm in mustard oil in Lucknow (Siddiqui et al. 1980). Mustard oil was also found to be contaminated in Punjab where its level was 0.31 ppm (table 5). By and large, HCH residues in oils and oil seeds were of the same order as DDT (Mehrotra 1985). Despite the widespread occurrence of HCH in vegetable oils, hydrogenated oils were free of pesticide residues except at Lucknow where the HCH residues as high as 0.98 ppm were encountered (Siddiqui et al. 1980).

Milk and milk products: The data on residues of HCH in bovine milk and its products show a widespread occurrence of HCH in various parts of the country (tables 6 & 7). The residues of HCH were found to be highest in Hyderabad and in the rural areas of Ferozepur and Sangrur in Punjab. The milk was least contaminated in the urban areas of Punjab and Uttar Pradesh. An extensive survey of HCH residues in butter in various parts of the country undertaken by Kalra and Chawla (1981a, 1983) indicated that

Table 4 *HCH Residues in vegetables and fruits*

Locality Period	Samples analysed	Samples contaminated	Commodity	Level of Residues (ppm)	Reference
Ludhiana (1975-1976)	40	40	Potato	Tr.–0.05	Kalra et al. (1978)
(1979)	51	30	Potato Carrot raddish cauliflower okra tomato brinjal	Tr.–0.09	Gupta & Kalra (1983)
Karnataka	300	300	Leafy vegetables	10.5–20.0	Visweshwaraiah & Jayaram (1972)
Hyderabad (1968-79)	78	12	Leafy vegetables	Tr.–8.0	Lakshminarayana (1980)
	323	57	Starchy vegetables	Tr.–6.0	,,
	847	55	Other vegetables	Tr.–4.0	,,
	60	28	Grapes	Tr.–1.5	,,
Hissar (1979)	66	12	Summer vegetables okra cucurbits brinjal	0.84–6.03	Verma (1980)
	68	9	Winter vegetables radish mustard tomato turnip	1.31–3.80	
	61	12	Mixed vegetables	Tr.–3.5	,,

the butter was invariably contaminated with HCH in Punjab, Haryana, Uttar Pradesh, Rajasthan, Gujarat, Andhra Pradesh, West Bengal and Tamilnadu. Highest concentrations of HCH residues in butter were observed in West Bengal and Andhra Pradesh (table 7). Residues of HCH in butter were mainly due to β-HCH although *alpha* and *gamma*-isomers were also detected. By and large, the HCH residues in butter exceeded the maximum levels of HCH reported in 12 countries in the West. *Desi ghee* (clarified butter) invariably contained HCH residues (table 8). An interesting study by Kapoor et al. (1980) revealed that contamination of bovine milk with HCH was

Table 5 *Residues of HCH in the market samples of oils and oil seeds in India*

Commodity	Locality	Residue level (ppm)	Reference
		Oils	
Groundnut	Hyderabad	Tr.	Lakshminarayan (1980)
,,	Punjab	0.141	Battu et al. (1980)
,,	Lucknow	0.112–6.421	Srivastava et al. (1983)
,,	Sitapur	0.3–2.4	,,
Mustard	Punjab	0.310	Battu et al. (1980)
Sesame	,,	0.165	,,
Coconut	,,	0.02	,,
Cotton seed	,,	0.147	,,
Rice bran	,,	0.637	Kalra & Chawla (1983)
Linseed oil	,,	Tr.	,,
Rape seed oil	,,	Tr.	,,
Mustard oil	Lucknow	0.71	Siddiqui et al. (1980)
Hydrogenated oil	,,	0.98	,,
Coconut oil	,,	0.46	,,
		Seed	
Cotton seed	Punjab	0.79	Kalra & Chawla (1983)

Table 6 *Residues of HCH in bovine milk in India*

Locality	Samples analysed	Samples contaminated	Mean (ppm)	Reference
Ludhiana	14	14	0.05	Kalra & Chawla (1983)
Jullundur	10	10	0.03	,,
Ferozepur	16	16	0.40	,,
Sangrur	14	14	0.38	,,
Hyderabad			Traces—5.0	Lakshminarayana (1980)
Lucknow			0.057	Saxena & Siddiqui (1982)

Table 7 *Residues of HCH in butter in India*

Locality	Range
Punjab	
Amritsar	1.47–1.65
Bhatinda	0.76–0.83
Ludhiana	0.61–1.2
Sangrur	1.86–11.79
Gujarat	
Anand	1.33–1.59
Mehsana	1.51–2.48
Palanpur	0.62–1.32
Andhra Pradesh	
Hyderabad	0.8–8.2
Uttar Praddsh	
Aligarh	3.5–3.8
Bareilly	0.35–0.46
Tamil Nadu	
Coimbatore	0.98–1.29
Madras	1.33–1.42
Others	
Calcutta (W.B.)	3.14–5.69
Ratlam (M.P.)	0.71–1.2
Bharatpur (Rajasthan)	1.24–2.13
Rohtak (Haryana)	1.74–1.95
Bangalore (Karnataka)	1.18–2.1
Chandigarh	1.28–1.63
Delhi	0.61–0.9

According to Kalra and Chawla (1981a, 1983)

Table 8 *Residues of HCH in ghee samples from various parts of the country*

Location	Residues (ppm)
Andhra Pradesh (1978)	6.4
Punjab	2.2–6.8
Rajasthan	2.8
Uttar Pradesh	3.5–5.8

Source: Sandhu (1979), Kalra et al. (1983) and Lata et al. (1984)

Table 10 *Tissue distribution of HCH in goat, buffalo and chicken*

Tissue	Mean residue level (ppm)		
	Chicken	Goat	Buffalo
Muscle	0.109	0.018	0.012
Brain	0.162	0.068	0.076
Liver	0.195	0.032	0.038
Body fat	3.879	0.536	0.165
Bone marrow		0.203	0.252

Source: Kaphalia and Seth (1981)

Table 9 *HCH residues in the market samples of meat, poultry, fish and eggs*

Commodity	Locality period	Range (ppm)	References
Meat	Hyderabad (1967–79)	Tr.–2.0	Lakshminarayana (1980)
Chicken	Lucknow	0.014–14.104	Kaphalia & Seth (1981)
Chicken	Ludhiana	0.001–0.06	Kalra & Chawla (1983)
Goat	Lucknow	0.01–1.522	Kaphalia & Seth (1981)
Goat	Ludhiana	0.004–0.496	Kalra & Chawla (1983)
Sheep	Ludhiana	Tr.–0.21	,,
Buffalo	Lucknow	0.006–0.485	Kaphalia & Seth (1981)
Pig	Ludhiana	Tr.–0.21	Kalra & Chawla (1983)
Fish	Ludhiana	Tr.–1.12	,,
Eggs	Bombay	0.14–1.01	Banerji (1979)
Eggs	Ludhiana	0.06–0.62	Kalra & Chawla (1983)

partly due to the use of HCH in malaria control programme.

Meat and poultry: Samples of meat of goat, sheep, buffalo, pig, chicken and fish show the presence of significant amounts of HCH residues (tables 9 & 10). The residues were comparatively higher in chicken meat in Lucknow than in Ludhiana. Similarly, goat meat showed more HCH residues in Lucknow than in Ludhiana. A detailed study by Kaphalia and Seth (1981) reported the presence of high amounts of HCH in various body tissues of goat, buffalo and chicken collected in and around Lucknow. Chicken, by and large had highest concentration of HCH residues when compared to goat and buffalo. Of the various tissues highest concentration of HCH was seen in body fat of chicken followed by goat and least in buffalo. Eggs in Andhra Pradesh and Punjab were found to contain HCH residues (Lakshminarayana 1980, Kalra et al. 1978). Recently in Punjab 10 out of 13 samples of eggs analyzed for residues of HCH showed its presence at concentrations ranging from 0.06 to 0.62ppm (Kalra & Chawla 1983).

The residues of HCH in different fishes of Punjab has been reported by Kalra and Chawla (1983). Mean residue levels (ppm) of HCH detected were 0.031 in *Singhara*, 0.123 in *Malhi*, 0.247 in *Rohu*, 0.059 in *Sohal*, 0.033 in *Khangra*, 0.026 in *Sarmahi* and 0.149 in *Chakar*. Bulk of these residues consisted of *alpha*, *beta* and *gamma*-isomers of HCH.

Animal feed: Because of the importance of residues in animal feed in contaminating animal products including milk it is important to know the HCH residues in animal feed. It is rather unfortunate that very limited information is available on this point in the various parts of the country. Samples of oil cake which is most commonly used as animal feed, when analysed, revealed the presence of HCH. It was present in cotton seed cake (0.05 ppm) in Ludhiana, (0.27ppm) Muktsar and (0.058 ppm) Ferozepur. Mustard seed cake was contaminated at a level of 0.058 ppm in Ludhiana and groundnut seed cake to the extent of 0.03 ppm. The residues consisted mainly of α-isomer and the other isomers, β and γ were present in very small quantity (Kalra & Chawla 1981a). The residues of HCH in other animal feeds like wheat straw and fodder were also observed (Kaphalia 1982). The highest level of HCH in wheat straw was found to be 6.6 ppm and in wheat bran 1.69 ppm. The residues in other products are given in table 11.

HCH Residues in Wild Life

The residues of HCH have been reported from the wild birds namely, egret, crow, kite and vulture. The residues were detected in nearly every tissue of the body. Blood plasma and brain usually had higher concentration of HCH when compared to DDT. Although all the three isomers—*alpha*, *beta* and *gamma* were detected, the *gamma*-isomer predominated (Kaphalia et al. 1981).

Table 11 *HCH residues in animal feed sample in Punjab*

Commodity	No. of samples analysed	No. of samples contaminated	Mean residue level (ppm)	Range (ppm)
Gram seed husk	16	16	0.172	0.02–0.837
Wheat straw	32	32	0.67	Tr.–6.6
Wheat bran	4	4	1.69	Tr.–2.9
Mixed straw and Fodder	4	4	0.20	0.06–0.71
Fodder	4	4	0.10	0.01–0.29

Source: Kalra and Chawla (1983)

Table 12 *HCH residues in the human tissues in India*

Location and year	No. of samples analysed	No. of samples contaminated	Level of residue (ppm)		Reference
			Mean	Range	
			Adipose tissue		
Bangalore	67	—	7.01	0.26–94.54	Chatterjee (1979)
			5.05		Gupta et al. (1982)
Bombay	34	—	1.62	0.2–7.23	Chatterjee (1979)
Calcutta	45	45	1.6	0.13–4.84	Gupta et al. (1980)
			0.45		Mukherjee et al. (1980)
Chandigarh	10	—	2.4	0.22–11.03	Chatterjee (1979)
Lucknow	—	—	2.3		Kaphalia & Seth (1979, 1983)
Ludhiana	51	51	4.3	Tr.–30.05	Chawla et al. (1980)
			Blood		
Lucknow					
Children			0.038		Kaphalia & Seth (1979, 1983)
Female			0.034		Siddiqui et al. (1981 a & b)
Male			0.075		

Table 13 *HCH residues in the milk of lactating females*

Locality	Level of residue (ppm)		References
	Mean	Range	
Ludhiana	0.108	Tr.–0.82	Kalra & Chawla (1981b; 1983)
Muktsar	0.220	0.02–0.77	,,
Lucknow	0.14		Siddiqui et al. (1981b)
Lucknow	0.20		Saxena & Siddiqui (1982)

Table 14 *HCH and its isomer residues in whole cooked meal samples*

Diet samples	No. of samples	Residues in micrograms/meal			
		α HCH	γ HCH	β HCH	Total HCH
Vegetarian					
Mean	20	6.45	3.26	9.88	19.59
Range		(0.37–14.28)	(0.14–8.38)	(1.25–23.39)	(1.77–42.18)
Non-vegetarian					
Mean	20	7.28	2.86	13.12	23.26
Range		(0.80–12.36)	(0.16–6.08)	(2.02–29.13)	(2.98–47.57)

Source: Gupta et al. (1982b)

HCH Residues in Human Tissues

Near ubiquitous presence of HCH residues in the environment and its property of bio-amplification through food chain leads to the accumulation of significant amounts of HCH residues in the human tissues. The residues of HCH have been reported from adipose tissue (Dale et al. 1965, Chawla et al. 1978, Chatterjee 1979, Gupta et al. 1980, 1982a, Kaphalia & Seth 1979, 1983), blood (Kaphalia & Seth 1979, Kaphalia 1983), cerebro-spinal fluid (Kaphalia & Seth 1979) and in the umbilical cord blood collected between 24 to 48 hr after child birth (Siddiqui et al. 1981a). The information on the occurrence of HCH residues in human tissues is summarized in table 12. It is evident that there are tremendous variations in the HCH residues in human adipose tissues in various parts of the country. The limited studies conducted so far suggest that higher concentrations of HCH residues are seen in Bangalore than in Bombay, Calcutta, Chandigarh or Lucknow. In Punjab the HCH residues were seen in all the fifty samples of adipose tissues analysed. There were more HCH residues in the samples obtained from rural populations than urban populations. The HCH residues mainly consisted of *alpha, beta* and *gamma*-isomers and the *beta*-isomer usually predominated. Sex or dietary habits did not significantly influence the concentration of HCH residues. It has been suggested that wherever β-isomer is predominant it is due to the old exposure to HCH. In newly exposed individuals α and γ-isomers of HCH predominate (Kalra & Chawla 1983).

Besides the adipose tissues the presence of large amounts of HCH in the milk of the lactating women have been reported from various parts of the country (Kalra & Chawla 1981b, 1983, Siddiqui et al. 1981 a & b, Saxena & Siddiqui 1982) (table 13). The presence of such high concentrations of HCH in the breast milk collected from lactating mothers after child birth is really alarming as the neonates consuming such a breast milk will have a significantly high intake of HCH (Siddiqui et al. 1981b).

The high concentrations of HCH seen in human tissues are because of the presence of high amounts of residues in the diet. It has been estimated that the daily intake of HCH in an average Indian vegetarian diet is 19.59 μg and that of non-vegetarian diet is 23.26 μg (table 14). This amount of HCH in the Indian diet is 2 to 20 times higher than the corresponding diets in other parts of the world (table 15).

Hazards due to HCH Residues in the Environment

The concentrations of HCH present in the environment, although not actually toxic,

Table 15 *Average dietary intake of HCH residues in various countries*

(μgm/person/day)

Country	HCH isomer	Gamma HCH
Australia	—	Tr.
Canada	2.5	2.0
Czechoslovakia	53.0	—
East Germany	—	10
Italy	16.7	5.4
U.K.	—	4.4
U.S.A.	1.1	0.2
Yugoslovakia	62.0	—
India:		
Vegetarian	57.0 (135)*	10.0 (27)*
Non-Vegetarian	72.0 (147)*	9.0 (20)*

*Figures in parenthesis are the estimates of the maximum values of dietary intake of HCH

certainly pose a problem of chronic toxicity. The mammalian toxicity of the various isomers of HCH differs tremendously; *alpha* HCH has low acute and chronic toxicity but has cumulative toxicity (acute oral LD_{50} for rat being 500 mg/kg body weight); *beta*-HCH has low acute but has high chronic and cumulative toxicity (acute oral LD_{50} for rat being 6000 mg/kg body weight); *gamma*- HCH has low acute and chronic toxicity (acute oral LD_{50} being 125 to 200 mg/kg body weight); *delta*-HCH has low acute and chronic toxicity but it is irritant to mucous membranes (acute oral LD_{50} for rat being 900 mg/kg body weight). Keeping this in view the recommended ADI (acceptable daily intake) is 0.005 mg/kg body weight for *alpha*-HCH, 0.001 mg/kg body weight for *beta*-HCH and 0.0125 mg/kg body weight for *gamma*-HCH (Martin 1957, Negherbon 1959). The ICAR (1967) had recognised some of the incidences of HCH poisoning to fish, wild life and plant protection workers. Acute poisoning due to HCH has been recorded in India on large scale a number of times (Gupta 1975, Khare et al. 1977, Nag et al. 1977, Misra & Nag 1984). Acute poisoning due to HCH leads to epileptic, grand mal, petit mal, myoclonic and mixed type of seizures and neurocular manifestations. HCH is also known to induce spontaneous abortions and abnormal delivery (Saxena et al. 1980, 1981). HCH is also a known carcinogenic chemical. From the safety point of view DDT is far safer than HCH.

Conclusions and Recommendations

(1) Till todate 500 thousand tonnes of HCH has been used in agricultural sector and nearly 75 thousand tonnes in public health sectors. This has led to development of resistance in insect vectors of malaria and a few insect pests of agricultural importance.

(2) HCH is present in various components of the environment. The extent of HCH residues are at present not very high but are showing increasing trend in certain parts of the country specially in milk and milk products. This should be a cause of concern and ways and means may be found to decrease the environmental load of HCH.

(3) Significant amounts of HCH are seen in the human and wild life tissues. This should be a cause of concern.

(4) Repeated demonstration of the occurrence of high amounts of HCH in the milk of lactating women is a matter of grave concern and should be immediately looked into.

(5) HCH constitutes nearly 50% of the total pesticides consumed in the country. There is an urgent need for scientific studies to find out suitable substitutes to replace this insecticide in the agricultural sector. It should be phased out in such a manner so that it is totally eliminated from the environment in the next 5 to 10 years and certainly by 2000 AD.

(6) It is urged that HCH and other pesticides be monitored in various agro-climatic zones and urban areas of the country on a permanent basis.

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