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# Contamination of Organochlorine pesticides (OCPs) in India

[1]Ningombam Linthoingambi Devi and [1]⋆Priyankar Raha
[1]Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences,
Banaras Hindu University, Varanasi-221005, UttarPradesh, India
⋆Email corresponding author: priyankar_raha@yahoo.com

## Abstract

The use and contamination of selected organochlorine pesticides (DDT, HCH, endosulfan, Aldrin, Dieldrin, Heptachlor) in India is reviewed in this paper. To meet the food demand of increasing population, the modern agriculture practices involve an increase usage of pesticides which results in OCPs contamination of the environment. Due to modern agriculture practices an increase in use of pesticides to meet the food demand of increasing population which results in OCPs contamination of the environment. The levels of pesticide contamination in agricultural soils were found to be higher. Additionally organochlorine pesticides (OCPs) were found to be residue in different foods and also detected in human fats, due to their bioaccumulating and persisting nature.

**Keywords:** *Organochlorine pesticides; Soil; Food; Human*

## 1 Introduction

Organochlorine pesticides (OCPs) are ubiquitous contaminants the occurrence of which in the environment is of special concern due to long persistence to degradation and the toxicity of their constituents (Simonich and Hites, 1995; Tolosa et al., 1995). Organochlorine pesticides, such as dichloro diphenyl trichloroethane (DDT) and its metabolites viz. dichloro diphenyl dechloroethane (DDD),dichloro diphenyl ethylenediene (DDE),dichloro diphenyl acetic acid (DDA), hexachlorocyclohexane (HCH), cyclodienes (aldrin, dieldrin, endrin), chlordanes (heptachlor, heptachlor epoxide, cis-chlordane, trans-chlordane, cis-nonachlor, trans-nonachlor, and oxychlordane), HCHs ($\alpha, \beta, \gamma, \delta$-isomers), mirex, and industrial chemicals like PCBs, are ubiquitous environmental pollutants (Kannan et al., 1992, 1995, 1997a, 1997b; Loganathan et al., 1995; Senthil Kumar et al., 1999, 2001a, 2001b, 2005, 2008). They enter the soil by deposition from air, drift, or by washing-off from plant surfaces during rainfall or irrigation. These compounds are mainly found associated with organic matter in soil and lipid tissues of organisms because of their strong hydrophobic (lipophilic) character. Organochlorine pesticides have a long history of wide use in agriculture (Loganathan and Kannan, 1994; Tanabe and Tatsukawa, 1984). India is presently the second largest manufacturer of basic pesticides in Asia. It ranks 12th globally. The main use of pesticides in India is in agriculture and public health sector to combat the various pests and diseases that affect man. To achieve this goal, the production of basic pesticides commenced with the manufacture of benzene hexachloride (BHC) in 1952, followed by DDT. Since then, the production of pesticides has increase tremendously. Organochlorine pesticides (OCPs) especially DDT and HCH were used extensively till recently both for agricultural and sanitary purposes (Kumar et al., 2006; Pandit et al., 2001, Devi et al.,2011, 2013). It is estimated that about 25,000 MT of chlorinated pesticides was used annually in India and DDT accounted over 40% of this group (Mathur, 1993). Although DDT has been banned for agricultural use, India has sought exemption under Stockholm Convention for use of 10,000 tons of DDT for restricted use in the public health sector. The National Malarial Program (NAMP) used 3750 tons of DDT in the year 2001, in rural and peri-urban areas for residual spraying (Gupta, 2004). Therefore, in this research article, the contamination by organo-chlorine pesticides in agricultural soil and their effect on the environment and living being is reviewed.

## 2 Consumption of OCPs in India

The use of synthetic pesticides started in 1948–49 with the use of DDT for malaria control and HCH for locust control (Gupta, 2004; NAMS, 2005). The Indian pesticides production industry started with the setting up of a HCH technical plant at Rishra near Kolkata in 1952. Shortly after, Hindustan insecticides Ltd. set up two units to manufacture DDT. India is one of the few remaining countries still engaged in the large scale manufacture, use and export of some of the toxic chlorinated pesticides, such as (DDT), hexachlorocyclohexane (HCH) and pentachlorophenol (PCP) (Sarkar et al., 2012). The main consumption of organochlorine pesticides in India is in agriculture and public health sector to control the various pests and diseases that affect human being. Later in the mid nineties, 145 pesticides were registered and the production was approximately 85,000 metric tones. Further, the bulk of pesticide production includes insecticides (Anonymous, 2002) and India stands second largest manufacture of pesticides in Asia. However, the consumption of pesticides is slightly decreasing probably due to shift of farmers towards biopesticides, natural plant sources (Das et al., 2002; Gupta, 2003). In Indian agriculture 54% of the total pesticides are consumed on cotton cultivation and nearly 20-25% are used for the control of sucking pests

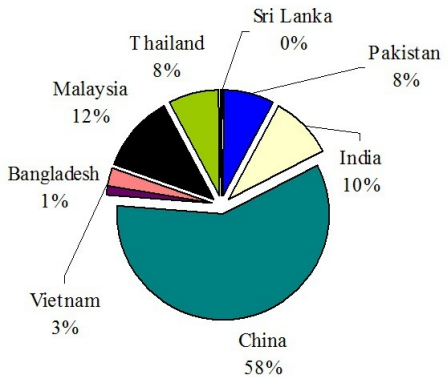


Figure 1: Annual pesticide consumption in different countries (Abhilash and Singh, 2009)

and bollworm (Puri et al.,1999).Some of the pesticides like HCH ($\gamma$-HCH is allowed),DDT and malathion are still preferred by the small farmers because they are cost effective, easily available, and display a wide spectrum of bioactivity. Out of the total consumption of pesticides, 80% are in the form of insecticides, 15% are herbicides, 1.46% is fungicides and less than 3% are others. In comparison, the worldwide consumption of herbicides is 47.5%, insecticides are 29.5%, and fungicide, 17.5% and others account for 5.5% only. In India usage of several of OCPs has been restricted or banned during the last decade as shown in Table 1.

Table 1: Current status of organochlorine pesticides in India (UNEP, 2003; Singh et al., 2007)

| Compounds | Status in India | Year |
|---|---|---|
| Aldrin | Banned | 1996 |
| Chlordane | Banned | 1996 |
| DDT | Restricted use | 1989 |
| Dieldrin | Restricted use | 1990 |
| | Complete Ban | 2003 |
| Endrin | Banned | 1990 |
| HCH | Banned | 1997 |
| Heptachlor | Banned | 1996 |

## 2.1 Contamination and its effects

Organochlorine pesticides are endocrine disrupting chemicals they are subtle effects on the human hormone systems (Lemaire et al.,2004).The health effects of these compounds are depend on the specific pesticides the level of exposure, the timing of exposure and individual. Many studies has identify that exposure to organochlorine compounds can cause the cancer and other health effects.DDT has linked with pancreatic cancer, increase in breast cancer risk etc. (Garabrant et al., 1992; Cantor et al., 1992; Dich et al., 1997). Occupational exposure during manufacture of pesticides and formulation of pesticides in industrial settings and their application in field could affect to human body. Further, the non-occupational exposure/indirect toxic effects may be due to pollution of the ecosystem or habitat as a whole such as from water, air and food could lead to.

### 2.1.1 OCPs reside in agricultural soils

The aldrin and dieldrin compounds are suggested high persistency of the chemical in the environment. Aldrin is under complete ban in country, which has been used as anti-termite agent against potato crops earlier. Dieldrin and endrin are now banned for manufacture and use in India. Additionally aldrin residues in ground water were also observed (Singh et al., 2005; Singh et al., 2006). Higher concentrations of DDT have been detected in the Indian agricultural soils (Table 2). Although, India has banned DDT for agricultural use in 1989, it is still used in the public health sectors for malaria control (UNEP, 2003) and residues have been found to persist in river water (Halder et al., 1989). The aging process of DDT in soil was determined by Schmitt et al. (1990) and uses of technical HCH (99% lindane) were reported (Iwata et al., 1993). The fate of HCH in the environment and the efficiency of its microbial degradation, depends on certain biotic and abiotic factors like availability of HCH degrading microbes, temperature, pH, moisture, texture and organic content of soil, etc. (Lal, 1983). These factors vary from site to site depending on seasonal changes and properties of the soils and are responsible for variation in concentration among sampling sites and within two depths at the same site (Van Veen et al., 1997). Frequent occurrence of -HCH in higher concentration (Nayak et al., 1995) in spite of complete restriction on the use of technical HCH may also be due to its highly persistent nature (Dogra et al., 2004). Endosulfan is a broad-spectrum insecticide-cum-miticide, which is extensively used on many important crops and use of endosulfan on agricultural crops has been permitted in the country. The endosulfan is manufactured and used in India (UNEP, 2003) and the residues of HCH,DDT as well as endosulfan were found in ground water of old city India, Varanasi (Raha et al.,2003. Further heptachlor usage has been banned in the country in 1996, but still it is found in the soil. Heptachlor is metabolized to heptachlor epoxides in the soils, plants and animals, which is more stable in biological systems. Heptachlor epoxides adsorb strongly to the soil and are very resistant to biodegradation (Keith, 1997). Further, heptachlor epoxides have the potential to enter the human food chain because it accumulates in dairy products and in the tissues of meat, fish and poultry (USEPA, 1986).The applied OCPs (viz.2,4-dichlorophenox acetic acid) in the cultivated soil were also accumulated in the sub-surface layer of soil profile (Gupta et al.,2012) through leaching and persisted for long period.The ground water as well as surface water bodies (viz. river, lake, sea and ocean) in India were contaminated with OCPs leaching and runoff (Agrawal et al.,2010).

### 2.1.2 OCPs residue in food

Organochlorine insecticides are potentially toxic, highly persistent and resistant to biodegradation and readily accumulate in human body tissues, causing a variety of health hazards (such as thyroid disruption, reproductive effect, cancer etc.) (Ceron et al.,1995).Even after the replacement of organochlorine insecticides

Table 2: Residue of OCPs in agricultural soils of India

| Compounds | Thiruvallur | Unnao | Agra | Farrukhabad | Haryana | Delhi | Haryana |
|---|---|---|---|---|---|---|---|
| HCH | 13-617 | 0.08-7 | 160-1230 | 0-430 | 48-162 | 199.8 | 212.2 |
| DDT | 13-268a | 0-74b | – | 0-940 b | 0-45 b | – | – |
| Endos | 18-592 | 0-13 | 0-160 | – | – | – | – |
| Aldrin | – | 0-1.57 | 90-720 | 0-10 | – | – | – |
| Dieldrin | – | 0-0.47 | 250-1390 | 0-26 | – | – | – |
| Heptachlor | – | 0-1.45 | 0-730 | – | – | – | – |
| References | Jayashree and Vasudevan, 2006 | Singh et al., 2007 | Singh, 2001 | Agnihotri et al., 1996 | Kumari et al., 1996 | Prakash et al., 2004 | Prakash et al., 2004 |

a o,p-DDT+p,p-DDT
b o,p-DDT+p,p-DDT+p,p-DDE+p,p-DDD

by organophosphorous insecticides, consumer products like edible crops, fruits, milk and soil show substantial levels of organochlorine pesticide residues. Organochlorine insecticide residues, especially DDT and HCH have been detected in man and his environment (Jensen, 1983; Banerjee et al., 1997). High levels of DDT and HCH have been reported in human blood, fat and milk samples in India (Chatterjee et al., 1980; Raha et al., 1999). Analysis of human exposure to selected organochlorine compounds shows, that the residue levels of p,p-DDE [1,1-Dichloro-2,2-bis (p-Chlorophenyl) ethylene] and BHC (benzene hexachloride) were found to be persistent and higher in the human milk samples (Slorach and Vaz, 1983), until the ban was imposed on their use in 1960s (ICMR, 2001). The presence of organochlorine pesticides in general and BHC DDT in particular has been detected in edible crops, fruits, soil, milk and other consumer products (Kannan et al., 1980). Some food samples were analyzed from Chennai and Chidambaram (Kunisue et al., 2004). The Chennai city obtained the food supply from nearby villages. Variety of foods was collected from open markets and super markets in Chennai and Chidambaram. Almost all the Indian foodstuff like cereals, rice, wheat, meat, egg, vegetables infant formulae and human milk were found to be contaminated (Agnihorti,1999) with different persistent toxic substances (Figure 2), and most of them were at least contaminated with the classical organochlorine pesticides, DDT and HCH (Kaphalia and Seth, 1983; Kaphalia et al., 1985; Lal et al., 1989; Kunisue et al., 2004).

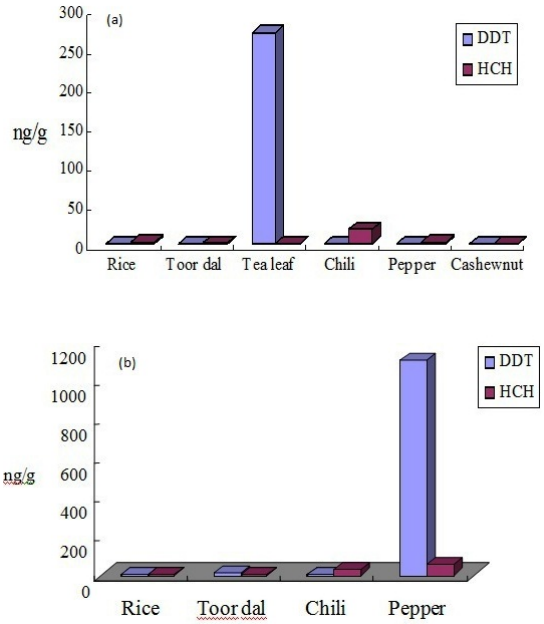


Figure 2: DDT and HCH contamination in foods of (A) Chennai (B) Chidambaram (Source: Subramanian et al., 2007)

### 2.1.3 OCPs residue in human fat

In India, where users are often illiterate, ill-trained and do not possess appropriate protective devices, the risks are magnified (Levine, 1992). The Poison Information Centre in National Institute of Occupational Health (NIOH), Ahmedabad reported that OP compounds were responsible for the maximum number of poisoning (73%) among all agricultural pesticides (Dewan and Saiyed, 1998). The residues of DDT and HCH compounds were found in human fat samples, which were collected from different sates of India. Studies were conducted by the NIOH to monitor the pesticide residues in human fat samples and the percentage of residues of DDT and HCH compounds are displayed in Figure 3. The maximum DDT residues were detected in age group of 25-39 years and the higher levels of HCH residues were found for the group above 40 years of age (Jeyaratnam, 1985). More accumulation of DDT were detected in every states of India when compared with HCH compounds, possibly it may be due to more persistent nature of DDT (ICMR, 2001). From Delhi sample 58% of HCH was found to be higher than other states (Figure 3). Residues of organochlorine insecticides, especially DDT and HCH have been detected in human population and environment over the world (Subramanian and Soloman, 2006). However, on comparison, very high levels of these have been reported in human blood, fat, and milk samples in India (Bhatnagar, 2001). Residues of pesticides from food commodities were monitored by all India co-coordinated research project on pesticide residues under the Indian Council of Agricultural Research, New Delhi, through their centers located in different parts of the country. It was found that 51% of food commodities were contaminated with pesticide residues and out of these 20% had pesticide residues above the maximum residue limit (MRL) values, as compared to 21% contamination with only 2% above the MRL on worldwide basis (Agnihotri, 1999).

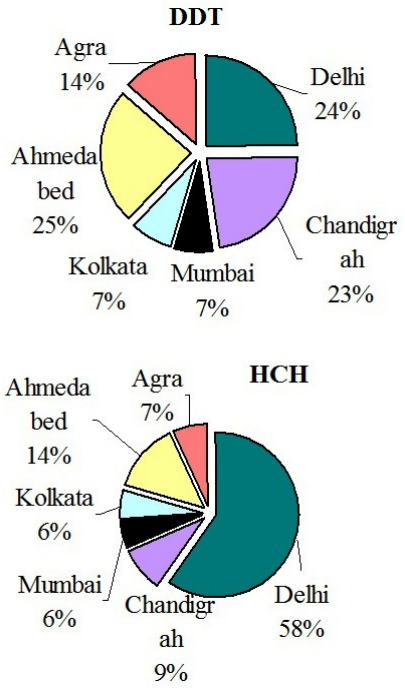


Figure 3: DDT and HCH residue (ppm) in human fat samples in general population in India (Sources: Ramachandran et al., 1984; NIOSH, 1990)

## 3 Conclusion

Indian agricultural soils were found to be contaminated by some of the organochlorine pesticides. The DDT and HCH compounds were found as residues in rice, pulse, tea leaf, chili, pepper and cashew nut. However, highest contamination of DDT and HCH was detected for tea leaf and pepper at Chennai and Chidambaram. Furthermore, human fat samples from Delhi and Ahmedabed were detected with higher accumulation of DDT and HCH, when compared with other states like Agra, Kolkata and Mumbai. Therefore, we must give the awareness programme to the Indian farmers about the hazards of organochlorine pesticides in living beings and our surrounding environment.

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