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Chapter 9

Persistent Toxic Substances in India

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Abstract

Over the past few decades there has been a steady increase in the use of many pesticides for agricultural and disease control purposes in developing countries including India. Apart from this, India is now becoming an industrially developed nation, compelling it to use several other man-made chemicals for its ongoing industrial development. In spite of the fact that India has promulgated several laws for the control of such chemicals, in practice, there has been little control over their production and usage. As a result, there has been widespread contamination of the Indian environment and biota, including human, by all these chemicals. Most recent studies have shown that, in contrary to the popular belief that the developed nations are the prime sources of the highly toxic chemicals such as PCDDs/DFs, India is also contributing such chemicals to the global environment in considerable quantities. Many popular articles and scientific publications have shown a grim situation in several sectors of human life in India with regard to xenobiotic chemical contamination. Our group at the Center for Marine Environmental Studies (CMES), Ehime University has been carrying-out monitoring and toxicological studies of many of those chemicals in India for the past three decades. Apart from our works, sizable literature is available on the status of contamination of persistent toxic substances (PTS) such as DDTs, PCBs, PCDDs/DFs, PBDEs, HBCDs, OTs, etc. Viewing from a global pollution point of view, a detailed review of the available information on PTS pollution in India is necessary for planning and executing control measures to restrain their expansion on a wide scale. With this view in mind, this review provides information on the history of usage of PTS in India, their occurrence in the aquatic and terrestrial environment and in the flora and fauna. Finally the review provides a brief account of the laws

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governing the manufacture and usage and the management practices of those chemicals.

9.1. Introduction

In the Asian region India plays a prominent role in the context of global distribution of persistent toxic pollutants. India is the highest populated (1.04 billion—as per 2004 statistics) nation in the world—next only to China (1.29 billion), industrially developing, has a transforming economy, but still depends heavily on agriculture. India still fights with large numbers of seasonal vector borne diseases. Above all, India is a generic giant (Dave, 1996; Gupta, 2004), manufacturing and using large quantities of pesticides. Now India is in a stage of examining the problems of pesticides and industrial chemicals and potential solutions in the aftermath of the Green Revolution and the ongoing industrial development. In the light of such a situation and also in the present era of implementation of Stockholm Convention which has come into as a legally binding document on May 17, 2004, a detailed review on the present status of available information on these chemicals in India will provide valuable information from the global pollution perspective.

In the year 2003, a furor erupted in India on the issue raised by a prominent nongovernmental organization (NGO) that many popular soft drink brands had high levels of pesticides. Later, after many expert sittings and debates, a high level committee reported unequivocally to the Parliament that soft drinks do have pesticides (India Today, February 16, 2004). This seems to be only the tip of a massive iceberg. Not much has been done after this either by the Indian government or by the multitude of industries in India on such problems, as ever in the past. The multitude of scientific publications and popular articles which have appeared during the last three decades on the existence of several persistent toxic substances in India did not attract much attention of the public and policy makers in the country.

The detection of remarkably high concentrations of DDTs and HCHs in the air off the western coast of India by Tanabe and Tatsukawa (1980) and the continuous downward fluxes of HCHs from air to water in Bay of Bengal and Arabian Sea by Iwata et al. (1993a,b, 1994) suggest higher amount of transport of organic chemicals from India via atmosphere. Tanabe et al. (1982a,b) showed that, apart from the amount of usage and volatilization characteristics of the chemicals concerned, the meridianal circulation of the atmosphere, particularly the mass flows in the troposphere also contributes to the atmospheric transport and global distribution of organic compounds worldwide. The authors also suggested that the reason for the considerable levels of HCH and DDT compounds in the Antarctic Ocean may be their transport from countries like India, situated in lower latitudes, which are still using persistent chemicals in their agriculture and vector control practices and also in many of their industrial practices.

Such factors make India an area of great concern while evaluating the global status, transport and distribution of persistent toxic substances, because of its increasing and uncontrolled use of chemicals, their distinctive climatic conditions, excessive population, multitude of diseases, intensive agriculture, increased industrialization, etc. (Allsopp and Johnston, 2000).

9.2. History of PTS usage in India

The history of vector control in India can be divided broadly into pre-DDT and post-DDT eras. Before 1936, most of the vector control measures used was confined to methods such as the use of larvivorous fishes, oils, Paris green and provision of proper drainage systems (Covell, 1928, 1941; Viswanathan, 1941; Johnson, 1965). In 1944, DDT was introduced in the mosquito control program (Singh, 1962) and later extended to bring several million population under the ambit of National Malaria Eradication Program (NMEP) (Raghavendra and Subbarao, 2002). Later, in areas where local vectors had developed resistance to DDT, HCH and then malathion were used alternatively (Rajagopal, 1977). During the 1980s insecticides belonging to synthetic pyrethroid group were introduced in India in the public health program. Carbamate group have not yet been introduced for public health sprays in India. DDT has been banned from agricultural usage in the 1980s and HCHs had been phased out of the program in the year 1997 (Raghavendra and Subbarao, 2002). India is one of the countries that had been permitted to use DDT for their vector control programs, under Stockholm Convention, and also the chemical has been targeted at present, by the Government of India for phase out over the next few years.

India was a stagnant economy at the time of independence. The turn around in industrial growth seems to have started in the 1980s attaining a growth rate of 12% in the year 1995–1996 (Abid Hussain—Discover India—http://www.meadev.nic.in/). The composition of the industry has also undergone significant transformation since independence in 1947. Now India is considered as the 10th industrially developed nation in the world. The Indian chemical industry has been among the fastest-growing sectors of the Indian economy. The country is rapidly becoming one of the most dynamic generic industries in the world. In fact, between 25 and 33% of all genetic manufacturers worldwide are located here (Dave, 1996). The present day India is a growing giant in the information technology sector apart from the rapid growths in automobile, shipping, aviation, textile industries, each releasing some sort of chemicals in to all the three major compartments of the Indian environment viz. atmosphere, water and soil.

Because of its overcrowded metropolis, as in any other developing country, India also has problem with the management of its varied solid wastes comprising domestic, biomedical, agricultural and industrial wastes. Dumpsites of such wastes have been found to be the sites of production of the most dreaded pollutants of the persistent organic pollutants (POPs) group, the dioxins and furans (Minh et al., 2003; Kunisue et al., 2004).

The other reason for a prominent PTS pollution is, India is yet to formulate a comprehensive policy on pesticides and other chemicals. The Insecticides Act, 1968 does regulate the manufactures, registration, use, export and import of pesticides in the country but does not have much control on its consumers. There are many other policy decisions and Acts on environmental management in India which will be discussed later in this chapter. India has already banned the use of 9 of the 12 POPs slated for ultimate elimination from the world use in a United Nations treaty adopted in Stockholm on May 23, 2001. The three remaining POPs include PCBs, DDT and dioxins and furans.

As a result of such extensive use of agricultural and industrial chemicals and uncontrolled production of wastes the entire Indian environment and biota such as its atmosphere (Ramesh et al., 1989), freshwater sources (Pillai, 1986; Rehana et al., 1996; Babu Rajendran and Subramanian, 1997), estuaries (Bhattacharya et al., 2003), coastal and offshore areas (Sarkar and Sen gupta, 1988a,b; Iwata et al., 1993a; Sarkar et al., 1997), inland soils (Kawano et al., 1992), fish (Babu Rajendran et al., 1992, 1994; Das et al., 2002), birds (Tanabe et al., 1998a), bats (Senthilkumar et al., 1999b), river dolphins (Kannan et al., 1993, 1994; Senthilkumar et al., 1999a; Subramanian et al., 1999), food stuff (Kannan et al., 1992) marine mammals (Tanabe, 2002; Tanabe et al., 1993) and human milk (Tanabe et al., 1990) have been reported to be loaded with multitude of mixtures of POPs.

Apart from the POPs, other persistent organic chemicals such as butyl tin compounds (BTs) (Iwata et al., 1994; Tanabe et al., 1998b; Tanabe et al., 2000; Sudaryanto et al., 2002), polybrominated diphenyl ethers (Ueno et al., 2004) and the compounds like tris(4-chloropheyl) methane (TCPMe) and tris(4-chlrorphenyl) methanol (TCPMOH), the chemicals occurring as impurities in DDT formulations (Minh et al., 2000a) were also reported to be present in various environmental and biotic media of India and surrounding seas.

In spite of all such widespread contamination, the implementing agencies responsible for the control of POPs and other persistent toxic substances (PTS) pollution does not seem to be well informed on the nature and extent of pollution in the Indian environment and biota. It is high time, that India hasten the processes of controlling the use of not only the POPs but also all hundreds of the dangerous organic chemicals now in use for agriculture, disease control and industrial processes, by finding out cleaner alternatives. There is also urgent need for development of gathering information, information exchange, drafting plans, implementation of plans, awareness creation and educating the public, man-power development, research, curbing the production and usage and regular monitoring, in the order of priority.

9.3. Why India is important from global PTS pollution perspective

India is the seventh largest country in the world and the second largest nation in Asia with an area of 3.28 million sq. km. (land 2.97 million sq. km and water 0.31 million sq. km) (CIA – World Fact book; http://www.cia.gov/cia/publications/factbook/geos/in.html). According to Indian census statistics in an area of 2.4% of the total expanse of the world it supports over 15% of the world population. Further, in this land area, India supports 5% of the world's life forms (Gaur, 1994). The country's wild life comprises over 75,000 animal species which include 300 species of mammals and 1200 species of birds. In addition, there are over 15,000 species of flowering plants. On a land mass of only one fiftieth of the world, the diversity of birds is most beautifully exemplified by one sixth of the world's total avian diversity, the creatures of the nature most vulnerable to the organic pollutants.

As already shown in previous paragraphs, being a typical agrarian state India has been using large quantities of agrochemicals. The use of industrial chemicals has been increasing at a faster rate than the other countries with similar economies, because of its higher industrial growth rate among the industrially developing countries. Apart from these factors, the open dumping sites in the suburban areas of its nine metropolis and other cities are contributing to the PTS load by the unintentional production of chemicals like dioxins and furans.

Of course, India is one of the major contributors of certain organochlorine compounds like HCHs and DDTs to Arctic region, along with China and Soviet Union (Macdonald et al., 2000). For example, Macdonald et al. (2000) found that global use of technical HCH and historical measurements of alpha-HCH concentration in the atmosphere of Arctic region showed two significant declines, one in 1983 when China banned the use of technical HCH and another around 1990 when India banned technical HCH usage in agriculture. In an experiment conducted at a paddy field in southern India Tanabe et al. (1991), Ramesh et al. (1991) and Takeoka et al. (1991) noticed rapid volatilization of HCHs, low residues in the soil and paddy plant when compared to their presence in the atmospheric levels and rapid removal to the atmosphere. Such experiments and surveys indicate the prominence of India in the contribution toward global pollution of toxic chemicals.

The climatic conditions in India facilitate its role as a global contamination source for persistent toxic substances. Many geographers characterize the climatic changes in India as violent. There are often abrupt changes on the onset of monsoon rains, sudden flooding, rapid erosion, extremes of temperatures, tropical storms and unpredictable fluctuations in rainfall (www.indianchild.com/climate_india.htm). By all these, India represents wide range of climates.

India, being a vast country, there are sharp variations in temperature from place to place and from season to season. In summer, the temperature may occasionally go up to 55°C in the deserts whereas in winter the temperature goes as low as −45°C at Leh in the Himalayas. Indian temperature and monsoonal changes are very much complex. Indian monsoons are components of large-scale circulation system. Two prominent monsoons, the southwest monsoon (June–October) and northeast monsoon (October–January) occur at various months of the year along the west and east coasts of India, respectively (Ramesh Kumar et al., 1999a,b; Ramesh Kumar and Sreejith,, 2005). All these factors alter the distribution and transport of the semi-volatile persistent organic pollutants and makes India as a prominent contributor to the global contamination of PTS chemicals.

9.4. Persistent toxic substances in the Indian environment

9.4.1. PTS in Indian atmosphere

Many processes lead to translocation of organochlorines within the global environment, e.g., from the continent to the oceans (Goldberg, 1975) or from source regions to less contaminated remote regions (Wania and Mackay, 1993; Wania and Daly, 2002). In this respect, India can very well act as a source for many POPs on a global scale. Volatilization of organic pollutants from Indian soils has been reported by many authors in the late 1980s by measuring the reduction from soil in hot climates (Kaushik, 1989; Samuel and Pillai, 1989) on the two intensively used insecticides in India, DDTs and HCHs. Following this, Ramesh et al. (1989) reported the climatic differences in the levels of DDTs and HCHs in rural Indian atmosphere. The vital contribution of volatile PTS chemicals from India to the global environment has been shown by the schematic representation of HCH release in a paddy field in India (Fig. 9.1) by Takeoka et al. (1991) which shows that more than 99% of the total HCH applied in one crop season is removed to the air before the next cropping season. Even though, the rates of transportation of different organic chemicals differ depending upon their physico-chemical properties, the existing climatic conditions in a tropical country like India may considerably alter the global contamination by persistent toxic substances through long-range atmospheric contamination. In a study in India, Thailand, Vietnam, Solomon Islands, Japan, Taiwan and Australia, Iwata et al. (1994) found apparently higher concentrations of DDTs in the Indian cities, Goa, Bombay (presently Mumbai) and Calcutta (presently Kolkata). Further, the atmospheric distribution of PTS in India implied the presence of sporadic emission sources. Babu Rajendran et al. (1999), in the air samples collected during 1993–1994 from South India reported comparable concentrations of both DDTs and HCHs without any temporal variation.

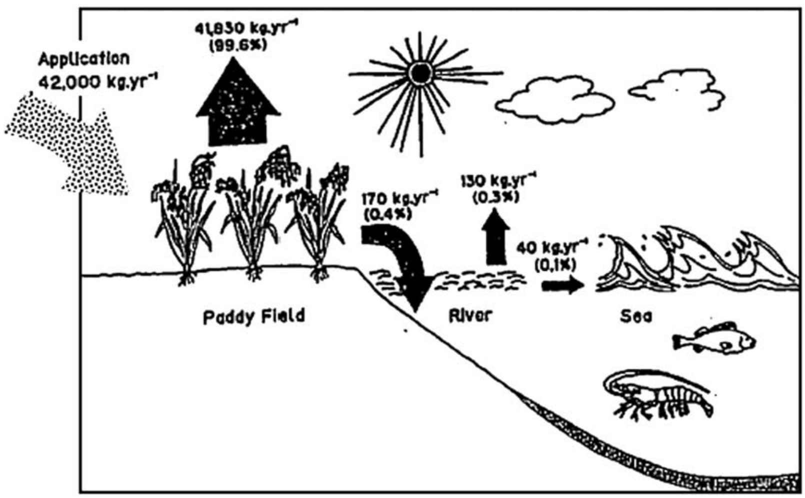

Figure 9.1. Schematic representation of the flux of HCH in Vellar river watershed, South India (*Source*: Takeoka et al., 1991).

Most of the works on the atmospheric concentrations of persistent toxic substances in India are only on the above stated chemicals and as far as our knowledge goes, not much interest has been shown in measuring the atmospheric levels of other organic pollutants in India as was shown on measuring the levels in the aquatic and biotic environment. After the mid-1990s, it seems that measuring the atmospheric levels of persistent toxic substances in the tropical countries slowly waned. The reasons may be the ultra low levels of these chemicals in the air leading to the tedium of measuring them. On the other hand, measurement of PTS in the other environmental compartments like water and sediments and the biota has increased in recent years.

9.4.2. PTS in the aquatic environment of India

Indian scenario of concern over diffuse pollution sources in water quality management may be very much special with its extremely varying rainfall and river flows, traditional as well as modern agriculture, use of water ways for varying life processes like bathing, washing, animal wading, domestic and industrial waste disposal, etc., apart from scant respect for rules, regulations and laws. Surface wash off of pollutants from agricultural sources is dominant only during the peculiarly short flood season and major proportion are normally carried away into the atmosphere leaving only very minor quantities to be transported by the water runoff.

9.4.2.1. Freshwater environment

Agarwal et al. (1986), Ray and Gupta (1986), Singh et al. (1987) and Rehana et al. (1995) on their works conducted on major rivers of India such as Ganga, Yamuna, Tapti, Narmada, Krishna, Cauvery, Godavari, etc. stated that the direct and mostly untreated disposal of waste leads to contamination of rivers and lakes chronically affecting their environment. The discharge of uncontrolled agricultural, industrial and domestic wastes, which is a normal phenomena in any part of India, polluting the streams and rivers, seep into deeper layers of the soil, thus polluting the ground water sources as well as pore waters in the nearby areas.

There are many efforts in measuring the pesticide levels in the water of the major rivers of India from the 1980s to recent years. The works of Pillai (1986) and Aleem and Malik (2005) in River Yamuna, Ansari et al. (2000), Nayak et al. (1995) and Singh et al. (2004) on River Ganges are some such examples of sporadic case studies. Several organochlorines and organophosphorus compounds occur at measurable concentrations in the River Yamuna (Table 9.1) and River Ganges (Table 9.2), two prominent rivers in India. Ramesh et al. (1990), Tanabe et al. (1991) and Takeoka et al. (1991) conducted several case studies and spraying experiments in a South Indian river for a period of more than one year and found that the levels of two of the prominent insecticides HCHs and DDTs fluctuates in line with the cultivation practices and sharp seasonal changes in the year, as a result of which only a meager portion of the pesticides applied in the

Table 9.1. Pesticide residues in the Yamuna River water at Okhla

Pesticide	Concentration (ng l^{-1})
Organochlorines	
T-BHC	25±6.2[a]
T-endosulfan	114±19.8
p,p′-DDE	1.6±0.26
p,p′-DDT	8.8±1.9
o,p′-DDE	3.9±0.86
o,p′-DDT	ND[b]
Dieldrin	2.1±0.34
Aldrin	0.9±0.06
2,4-D	0.6±0.02
Organophosphorus	
Dimethoate	0.9±0.08
Methyl parathion	1.7±0.65
Malathion	1.9±0.72

[a]Mean±SD.
[b]ND = not detected.

Table 9.2. Residual pesticidal load of Ganga strech at various stations (values are in ppb)

Pesticides	Stations		
	Kachla	Fatehgarh	Kannauj
Organochlorine			
Aldrin (HCH)	2.81	1.17	1.81
α-BHC	1.73	2.33	3.01
DDD (TDE)	0.88	1.30	2.41
DDT	3.33	5.19	5.33
Dieldrin	0.66	4.11	0.49
Endosulfan	ND	ND	0.75
Endrin	ND	1.14	1.04
Lindane	0.56	ND	ND
Organophosphorus			
Dimethoate	0.41	0.49	0.56
2,4-D	0.06	ND	ND
Methylparathion	0.50	0.49	0.16

Note: ND = not detected.

area was drained to the sea via rivers and streams. Their findings were supported by the studies of Babu Rajendran and Subramanian (1997) in the perennial river Kaveri of southern India showing the prominence of these chemicals in the region in wet months and their elimination during hot months. An interesting work is available on the fates of HCHs, DDTs and endosulfan in the surface water samples of the rain fed and snow fed rivers and streams of Himalyas at altitudes ranging from 300 to 1120 m (Sarkar et al., 2003) showing a sharp difference in the patterns of pollution from of the plains in India.

There are documentations of several pollutants in the river basins of India which were not followed-up by continuous monitoring and/or corrective measures. Further, the studies at the same place at the same season of different years or at places very near to each other at the same time reveal varying levels of persistent toxic substances. Based on the available limited knowledge on the PTS levels in Indian ground and surface water resources, it can only be summed up that there is a certain ambiguity of the situation in which Indian people are undergoing considerable life-long exposure. In the case of water studies, data are available from some rivers like Ganges, Gomti, Yamuna, Kaveri, Vellar, etc. but the data are difficult to interpret. The data reveals varying levels of POPs like DDTs, aldrin and dieldrin and also other chemicals like HCHs and BTs in different seasons. Certainly the tedium of sampling and analysis, lack of manpower and facilities and support from the government obviates the Indian scientists from undertaking a full fledged survey on the PTS levels in the Indian aquatic environment. With a visible growth of industries and ever-existing agriculture and public health activities, an entirely new paradigm of activities for surveying and controlling the aquatic pollution by PTS is the need of the hour in India.

9.4.2.2. Seas and oceans

The situation with regard to marine pollution by PTS is particularly important in India from the view point of the enormous and uncontrolled use of pesticides by its mostly illiterate farmers and health workers, increasing use of industrial chemicals for feeding its growing industries, and ever increasing domestic wastes coupled with its tropical climate with high temperature and heavy rains underlining the possibility of global transport of all these chemicals from point sources. There are a number of rivers along the east and west coast of India through which a large amount of PTS are being transported into the marine ecosystem thereby causing a great concern on the quality of the coastal marine environment. Further, India has a long coast line of about 7000 km. Considerable number of monitoring works on the PTS could be seen in the 1980s and the 1990s from the Indian estuaries and coastal environment after which the attention of environmentalists working on Indian samples seems to have diverted to the biotic material.

As early as in 1980, Tanabe and Tatsukawa (1980) observed the existence of all the classical organochlorines (HCHs, DDTs and PCBs) in the air and water samples collected at Bay of Bengal, Arabian Sea and Indian Ocean in various cruises during 1975–1979. Remarkably high concentrations of ΣDDT and ΣHCH in the air and surface waters off the western coast of India in the Arabian Sea than in the Bay of Bengal were observed. The follow up studies by the same authors in the eastern Indian Ocean, western and northern Pacific and Antarctic Oceans (Tanabe et al., 1982a,b, 1983) showed that the HCH levels in the northern hemisphere were higher than in the southern hemisphere depending largely on their extensive use in the Asian continent, especially leading to the spread of HCHs pollution on a global scale from India. In fact FAO (1979) reported that the consumption of technical grade HCH in India during 1975–1977 was 77,000 mt—extraordinarily high in comparison with that of other nearby countries. This has been substantiated by the finding of high concentrations of HCH residues in the western coast of India in the years closely following this (Tanabe and Tatsukawa, 1980; Bidlemen and Leonard, 1982).

Sarkar (1994), in a chapter on the occurrence and distribution of persistent chlorinated hydrocarbons in the seas around India, stated that isomers of HCH, aldrin, dieldrin and PCBs occur in water of different regions of the Indian Ocean and surrounding seas with remarkable variations in the levels of DDT between the coastal and open ocean waters. PCBS were found to be relatively in higher amounts in the surface waters of southwest Indian Ocean than the eastern Indian Ocean which he has attributed to the larger input of these chemicals from the African coast.

Most recently, Babu Rajendran et al. (2004) collected two seawater samples one each from the Chennai commercial harbor and Cuddalore fishing harbor and sediment samples from six stations in the southeast coast of India along the coastal line of Bay of Bengal. They found that the water samples had higher levels of HCHs than DDTs but the sediment samples near the major cities along this coast showed a reverse trend.

Generally, not much work was available in the published literature on the levels of persistent toxic substances in the waters along the coastal areas of India. Most of the data available are on the two classic organochlorine pesticides, DDT and HCH and some sporadic reports on PCBs, BTs, cyclodines and some other organophosphorus pesticides in the coastal environmental samples. Neverthless, some recent works showed the presence of other compounds like PBDEs, BTs, dioxins and related compounds in the Indian terrestrial and aquatic animals, necessitating the need for a survey of the aquatic occurrences for these and many other chemicals in India.

9.4.3. PTS in Indian soils and sediments

Since the early 1980s, human activity along the coastline of India has developed rapidly. People from inland cities and countryside have migrated to near coastal regions to find work and livelihood based on farming, agriculture, fishery and industry. This has invariably added to the direct inputs of various solid materials into the estuaries, inter tidal and coastal areas. The cumulative effect of the PTS residues in Indian coastal environment can be expected to be considerable in view of the fact that 25% of the India's population lives in the coastal areas (Sarkar, 1994).

Only very few studies have reported the contamination by PTS in the Indian terrestrial soils and riverine and coastal sediments (e.g., Pillai, 1986; Sarkar and Sen Gupta, 1987, 1988a,b, 1991; Ramesh et al., 1991; Sarkar et al., 1997; Sethi et al., 1999; Senthilkumar et al., 2001; Pandit et al., 2002). A review on the available information on PTS in the soils and sediments of India may be an essential prelude for understanding their effects on wildlife and human through bioaccumulation and biomagnification.

9.4.3.1. Terrestrial soils

Despite the low average consumption of pesticides, in the sporadic reports available, it could be seen that even the roadside dusts, rural and urban soils and the underwater sediments are contaminated. Many pesticides are degrading the Indian environment, even though faster dissipation and possible degradation of POPs chemicals like HCHs and DDTs were observed in Indian soils by the tropical climate of India (Pillai, 1986). Such a phenomenon of dissipation in the dry season was substantiated by Ramesh et al. (1991) in the river sediments (Fig. 9.2). Further, the relative flux of residues into the aquatic environment is smaller than the amount volatilized to the atmosphere in tropical countries like India (Tanabe et al., 1991).

Fast disappearance of HCHs from the paddy soil in India were also reported by Chawla et al. (1984) in Ludhiana, Punjab where the levels in soil decreased by 95% in 112 days, by Kathpal et al. (1984) in Hisar, Haryana where a 99% reduction was noticed after 100 days of application. Samuel et al. (1983) found 50% reduction of the HCH applied on soil in Delhi in 30–45 days. In India, the climatic conditions determine the

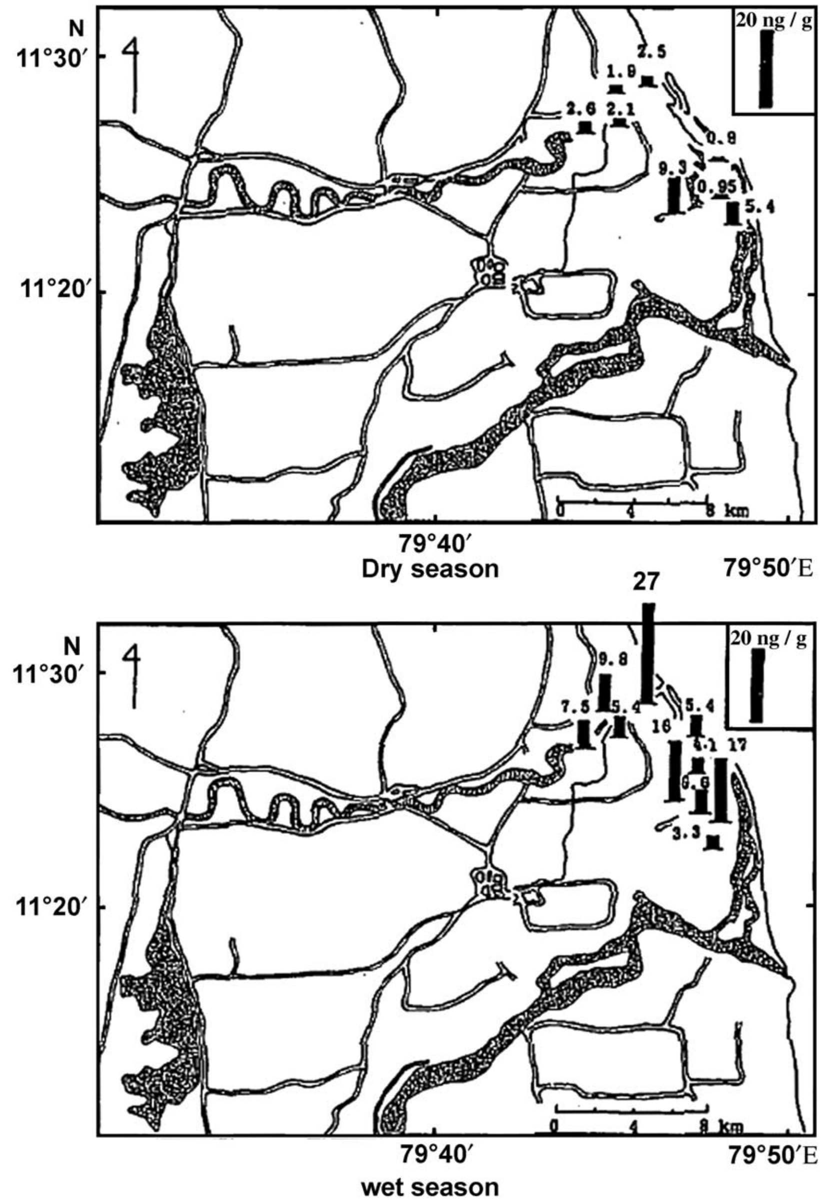

Figure 9.2. Spatial distribution of HCH concentrations in Vellar river and Pichavaram mangrove sediments. Numbers on the top of each bar represent the concentrations detected at the respective sampling points (*Source*: Ramesh et al., 1991).

distribution of chemicals in the environment, including the soils (Kawano et al., 1992). Many of the studies in Indian soils (e.g., Ramesh et al., 1991; Tanabe et al., 1991; Babu Rajendran and Subramanian, 1999; Senthilkumar et al., 2001; Suresh Babu et al., 2003) underline the fact that HCHs and possibly other chemicals with similar physico-chemical properties are lost from soil layers under the subtropical conditions in India thus leading to their widespread global distribution. Apart from such studies in the 1980s and early 1990s, not much work is available on the existence of classical organochlorines such as HCHs, DDTs, PCBs levels in the terrestrial soils of India.

Most recent findings showed that the dumping site soils in India ranks third in the average concentrations of PCDDs/DFs next to the Philippines and Cambodia and followed by Vietnam (Minh et al., 2003). The magnitude of contamination in the common and agricultural soils were very much lower than the dumping soils, suggesting that open dumping sites in India are becoming a potential source of dioxins and related compounds. Further, the PCDD/DF homologue profiles of the dumpsite soils from India (Fig. 9.3) synchronized with the profiles reported for the soils representing environmental sources of these chemicals (municipal waste incinerator emissions) from United States (Brzuzy and Hites, 1995). On the other hand, the profile from the control site soil from India resembled those from urban soils, sediments and atmospheric deposition samples from various locations of the world (Baker and Hites, 2000), confirming the fact that the municipal dumping sites of India act as reservoirs and sources of these chemicals.

9.4.3.2. River and marine sediments

Several studies have reported the contamination of PTS in the sediments under Indian rivers, estuaries and coastal waters (Sarkar and Sen Gupta, 1991; Iwata et al., 1994; Sarkar et al., 1997; Sethi et al., 1999; Pandit et al., 2001; Babu Rajendran et al., 2004). Many PTS have been detected in the sediment samples of major rivers in India and especially DDTs, HCHs and cyclodine compounds were found to be predominant. As in the case of water samples, profound seasonal changes in the levels of these chemicals were found in the sediments of the rivers Yamuna and Ganges (Agnihotri et al., 1996; Sethi et al., 1999; Guzzella et al., 2005).

It was often observed that, even after heavy usage of persistent insecticides like HCHs and DDTs in India in the previous three decades, the residues in coastal sediments remained constant and lower than the levels that can not be normally expected after such heavy use (Sarkar and Sen Gupta, 1987; Pandit et al., 2001, 2002). Logically, based on all the

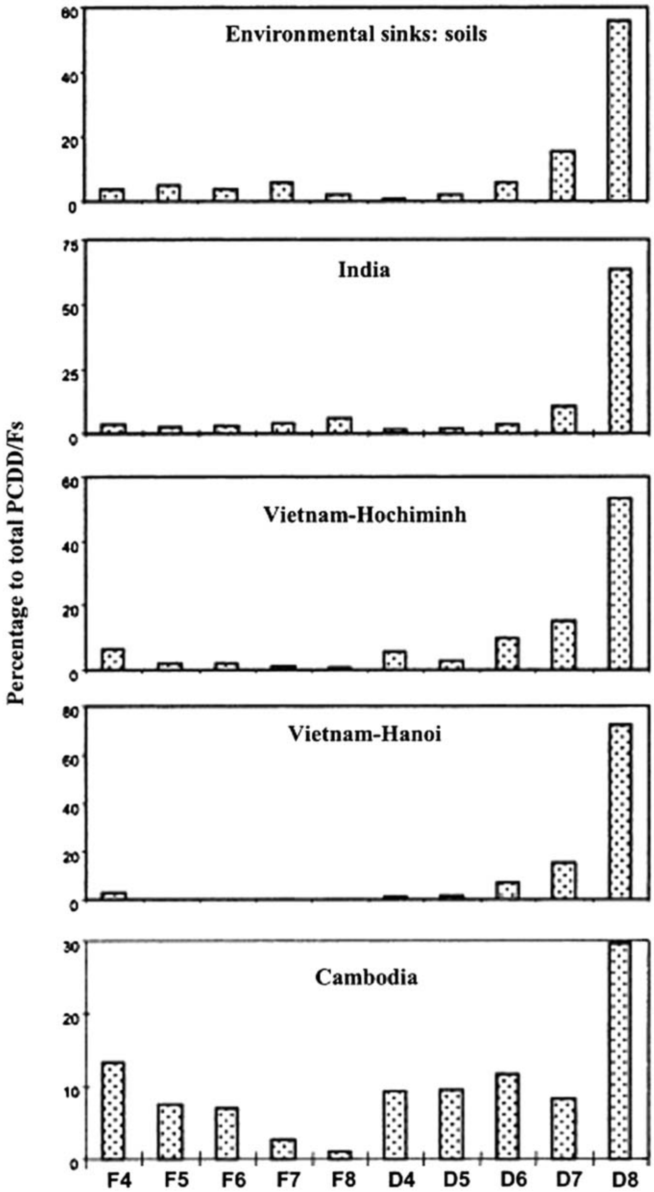

Figure 9.3. Homologue profiles of PCDD/DFs in soils from agricultural and urban areas (control sites) in Asian developing countries in comparison to the profile of samples representing environmental sinks (urban soils). Vertical bars represent the percentage of each homologue to total PCDD/F concentrations. F and D refer to dibenzofurans and dibenzo-*p*-dioxins, respectively. Numbers Figures indicate the degree of chlorination (*Source*: Minh et al., 2003).

available scientific literature, such a phenomenon can be confirmed by the fact that the Indian tropical environment is better suited and more congenial for transportation and decomposition of such chemicals. Most recently, Babu Rajendran et al. (2004), based on the water quality criteria/ guidelines designated some coastal locations of the Bay of Bengal came to the same conclusion of the previous authors that the declining trend on the environmental burden of these persistent pollutants are due to their decreasing usage and also the favorable tropical climate for easy removal from source.

Iwata et al (1994) in their study on the geographical distribution of persistent chemicals in the environmental matrices of Asia and Oceania found that the distribution patterns of organochlorines in the sediments showed smaller geographical variations (Fig. 9.4) when compared to air (Fig. 9.5) and water (Fig. 9.6). When comparing these figures it could be seen that HCH and DDT showed a clear regional trend with higher values in the tropical region than in Japan and Australia. HCH residue levels in air and water were found to be particularly higher in India. But a uniform distribution of these OCs in sediments may be explained by their rapid evaporation from water phase to atmosphere because of the prevailing high temperature.

The studies of Ballschmiter and Wittilinger (1991), Sunito et al. (1988) and Iwata et al. (1994) indicates that levels of semi-volatile chemicals used in India, as in similar tropical countries, are gradually redistributed to colder regions on a global scale, leaving only lower loads in the Indian environmental matrices. Although some of these chemicals show higher values in the environmental compartments (e.g., HCHs in atmosphere), majority of PTS that are used in India will be carried away by air and water to far away regions of the globe with advancement of time, leaving only lower levels of residues in the biota, except in organisms near to local sources.

9.5. PTS in Indian flora and fauna

9.5.1. Plants

India is one among the mega-biodiversity nations in the tropical belt. Both plants and animals belonging to many orders comprising many genera have been analyzed in the world for their PTS content for understanding the levels, toxic effects, metabolism, etc. Starting from zooplankton to human, many animals have been analyzed for their PTS content but not much information is available on plants. Generally, the

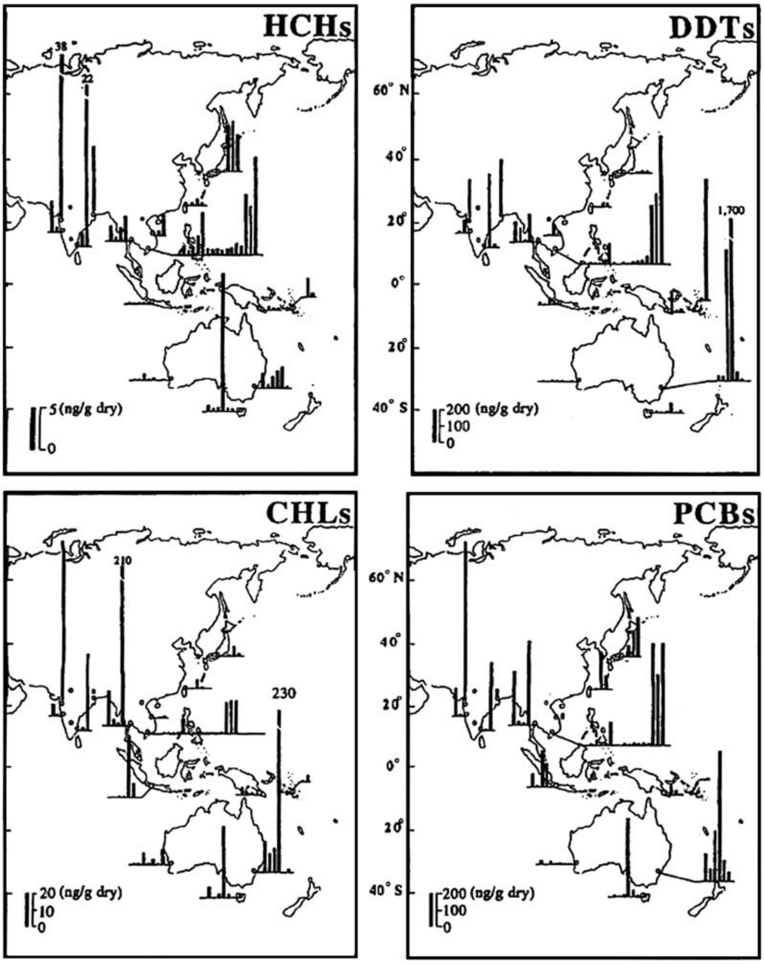

Figure 9.4. Distribution of persistent organochlorines in river and estuarine sediments from the eastern and southern Asia and Oceania (*Source*: Iwata et al., 1994).

available scientific literature on PTS pollution in Indian environment and biota, especially with regard to the information on the floral assemblages of India are less when compared to those available from developed nations, because of the lack of instrumental and manpower facilities. Considerable amount of information is available on the agricultural soils but not actually on the plants themselves. At the same time, some information is available on the plant products (food stuff) of India (See Section 9.7 of this chapter). With regard to paddy plants, it was found that notwithstanding

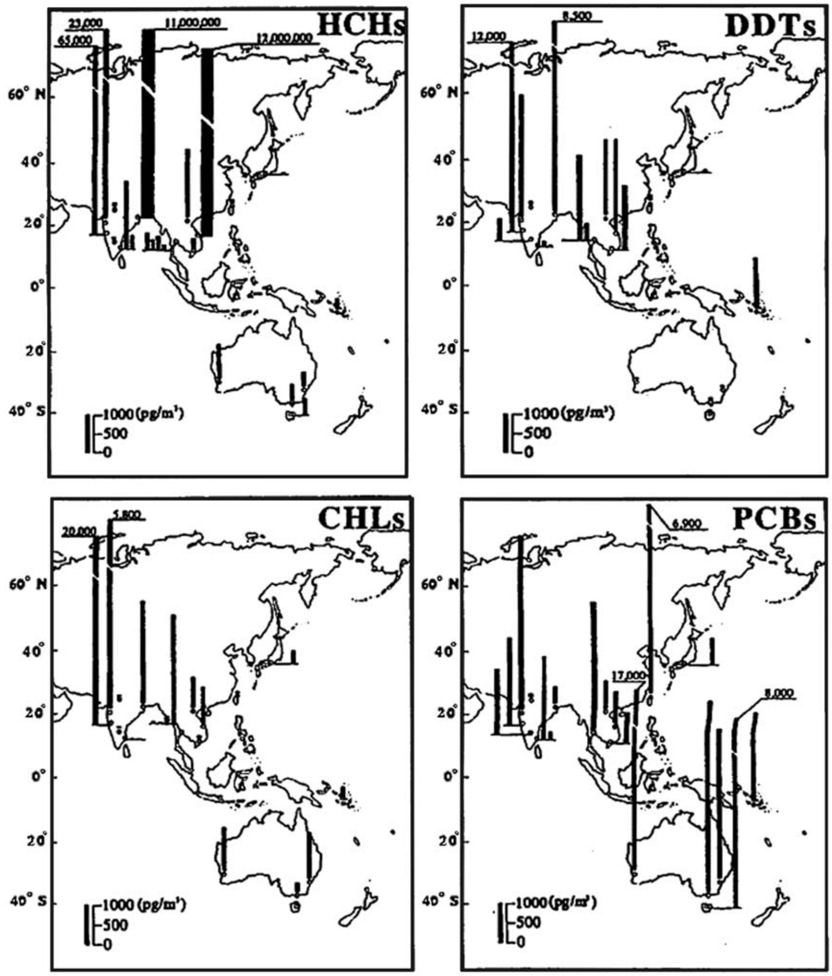

Figure 9.5. Distribution of persistent organochlorines in river and estuarine air from the eastern and southern Asia and Oceania (*Source*: Iwata et al., 1994).

several possible variations, only a meager amount of HCHs sprayed remained in the plant leaves (Fig. 9.7) two weeks after application, the major portion of which was carried over to the atmosphere. In the same way Suresh Babu et al. (2003) found higher amounts of both the chemicals in the husk rather than in the grain, straw and root of Basmati rice (*Oryza sativa*). Even then the levels were low compared with environmental levels. Most of the information in India on samples of plant origin are on the food products rather than on plants.

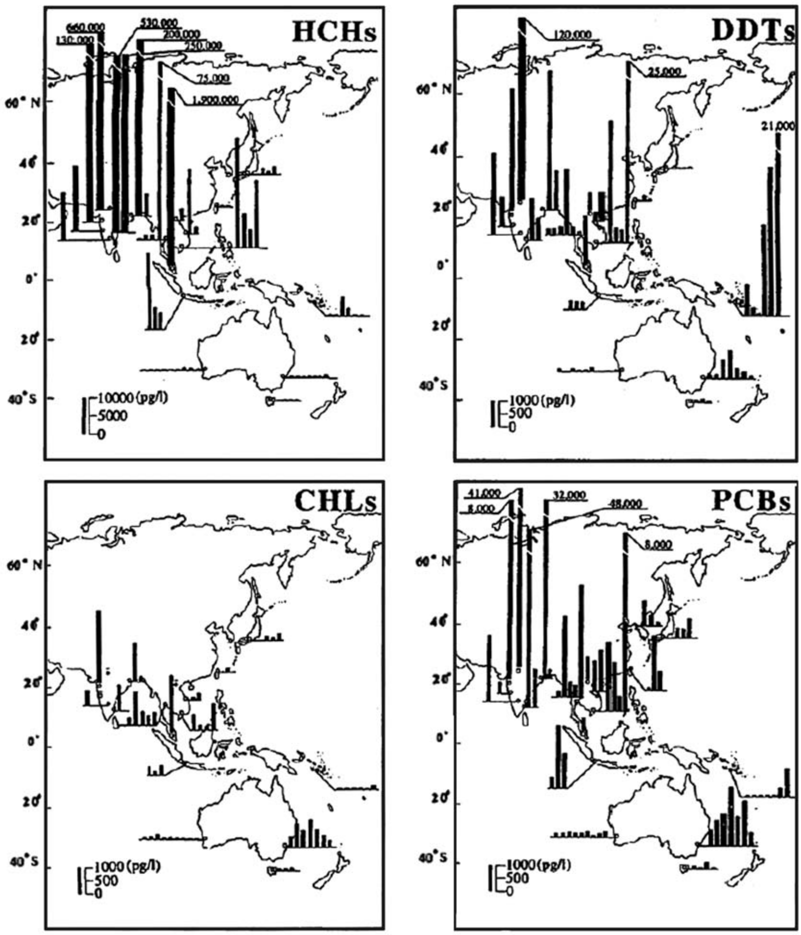

Figure 9.6. Distribution of persistent organochlorines in river and estuarine water from the eastern and southern Asia and Oceania (*Source*: Iwata et al., 1994).

9.5.2. Animals

As in many developed and some developing nations, Indian wildlife have been widely surveyed for the distribution and toxicology of many of the PTS chemicals. The animals widely surveyed are mussels (Ramesh et al., 1990; Kan-atireklap et al., 1998; Sudaryanto et al., 2002), birds (Ramesh et al., 1992; Sethuraman and Subramanian, 2003; Kunisue et al., 2003a,b; Watanabe et al., 2005), bird-eggs and bats (Senthilkumar et al., 2001), fish (Kannan et al., 1995; Das et al., 2002), river dolphins (Kannan

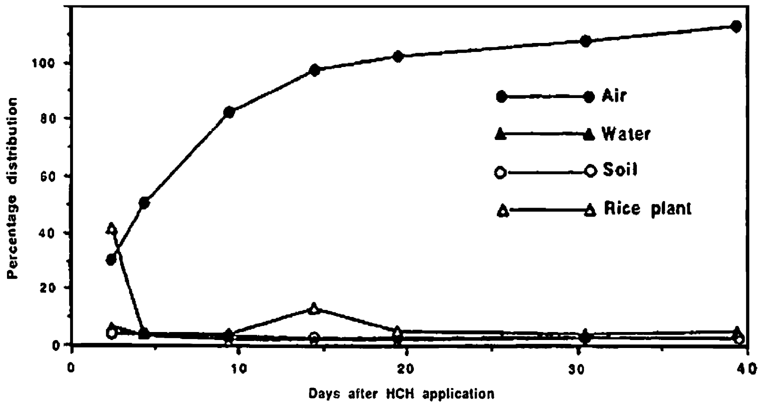

Figure 9.7. Residual amounts (%) of HCH in various compartments of the experimental paddy field (*Source*: Iwata et al., 1994; Tanabe et al., 1991).

et al., 1994; Senthilkumar et al., 1999a; Subramanian et al., 1999) and marine mammals (Tanabe, 1999; Tanabe et al., 1993; Karuppaiah et al., 2005).

9.5.2.1. Zooplankton

Sarkar (1994) while reviewing the occurrence and distribution of persistent chlorinated hydrocarbons in the seas around India found that among these chemicals, compounds of DDT family was abundant in the northeastern Arabian Sea as also observed by various other authors of his group (Kureishy et al., 1978; Kannan and Sen Gupta, 1987; Shailaja and Sen Gupta, 1990; Sarkar, 1991). These authors reported a concentration of up to 500 ppb DDTs in the zooplankton of this region. They have attributed such high concentrations in zooplankton to the input of huge amounts of DDT into the coastal water through agricultural drainage from the adjoining areas and river runoffs and also due to the availability of rich organic matter in the areas on which the OCs adsorb and are in turn fed by the zooplankton. Sarkar (1994) also found varying levels of PCBs (17.6–105 ppb) comprising of 31 congeners in zooplankton from the Arabian Sea, the levels being higher in coastal samples and steadily decreasing towards offshore regions. According to the authors the source of PCBs is the coastal industrial installations. Other than these works, nothing could be seen in the literature on the levels of PTS in Indian planktonic organisms.

9.5.2.2. Mussels

Ramesh and co-workers found that in green mussels (*Perna viridis*), the concentration ranges of OCs are in the order of HCHs > DDTs > PCBs (Ramesh et al., 1990). The green mussels collected from the same or nearby locations in India by Ramesh et al. (1990), Kan-atireklap et al. (1998) and Monirith et al. (2003) showed a clear chronologically decreasing trend in the case of HCHs and DDTs (Fig. 9.8), showing that the restrictions imposed on their usage by the Government of India are effective and the Indian environment is becoming cleaner in the case of these classical organochlorines. Further Kan-atireklap et al. (1998) found measurable levels of butyl tin compounds (ΣBTs = MBT + DBT + TBT) which were lower in international comparison, in most of their green mussel samples.

HCHs was always higher in the mussel samples in India in international comparison during all the above years showing that India has been using enormous quantities of this chemical since its introduction. The DDTs levels were also comparatively higher than the developed countries, but the PCBs, HCB, CHLs and BTs levels were lower. Further, the continuing contamination by one or the other chemicals in the coastal region of India as revealed by the available literature on mussels is a matter of concern. Other than the above-cited literature, to our knowledge, no other work on the PTS chemicals in mussels of India has been carried out so far. It may be informative, if the mussels are analyzed in future to render a clear picture on the PTS contamination in India (Tanabe and Subramanian, 2006).

9.5.2.3. Fish

Ramesh et al. (1992) by carrying out an elaborate survey in the Bay of Bengal region on the trends of persistent organochlorine contaminants in wildlife stated that, unlike in the case of birds where a wide variation could be seen, differences of OCs in fish were generally comparable to values reported from other locations of the world, suggesting that the bioavailability of the contaminants to the aquatic fauna is less due to the smaller flux and shorter residence time of these chemicals in the tropical climate of India. Interestingly, the works of Das et al. (2002) on DDTs in the catfish (*Tachysurus thalassinus*) from the Bay of Bengal region south of Bangladesh, Guruge and Tanabe (2001) in mullets from Sri Lanka and Senthilkumar et al. (2001) in the different fish species collected from southern Bay of Bengal points out the complicated sources of

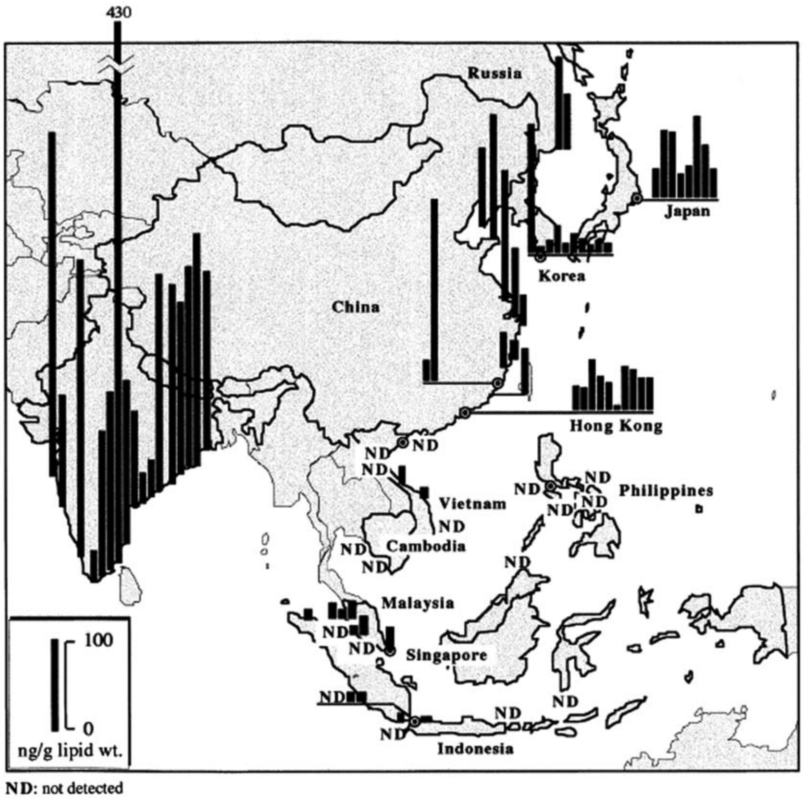

Figure 9.8. Distribution of concentrations of HCHs in mussels collected from coastal waters of some Asian countries (*Source*: Monirith et al., 2003).

contamination to the coastal waters of Bay of Bengal by the input from surrounding countries.

Generally, the contamination of HCHs and DDTs in fish (both inland and marine) reflects the trends of their usage in the adjacent terrestrial area during the time of sampling. Greater concentrations of HCHs than DDTs in Indian fish, despite the higher bioaccumulation potential of DDTs might be due to the increased consumption of HCHs and the phasing out of DDTs from usage in agriculture earlier than HCHs. The trend is slowly changing and the levels of both these pesticides are going down in Indian wildlife and foodstuff, which is evident from our most present data.

Apart from POPs chemicals, data are available on butyltin contamination in Indian fish. Similar to some Oceanian countries, these chemicals were widely detected in fish muscle tissues from many Asian countries including India, suggesting their widespread contamination. Kannan et al. (1995) analyzed few samples from several countries and found that fish from Bangladesh contained relatively high butyltin concentrations with a maximum of 109 ng g^{-1} wet wt. followed by those from India up to 79 ng g^{-1} wet wt. (Table 9.3).

The authors further found that in India, the marine fish collected from the coastal regions of the cities Mumbai (Bombay) and Kolkata (Calcutta) contained higher concentrations of buytltin than those from the inland city Delhi because the marine fish might have been greatly contaminated by antifouling paints and sewage from inland areas compared to those from inland fish (mainly freshwater species).

In general the dietary intake of classical organochlorines like DDTs, HCHs, etc. are decreasing at present and that of the other modern chemicals like BTs also do not exceed the average daily intake (ADI) in India. But the varying conditions of contamination in fish depending on multitude of parameters warrants a continued surveillance of the sources and factors that control the concentrations of these chemicals in fish, which are one of the major food items and also a major source of persistent chemicals to humans.

9.5.2.4. Birds

India is a haven for bird and has over 1200 species of birds from 20 orders and 17 families and also receives millions of migrating birds every year (Ali, 1979; Gaur, 1994). But only limited numbers of publications are available on the occurrence and effects PTS levels in Indian birds. It has long been reported that migratory as well as resident avian species of India gets contaminated by various PTS chemicals to different extent. Infochange India News (http://infochangeindia.org/toxictours) has stated that the Saurus cranes and white peaked vultures living in India are in danger of pesticide toxicity, by the chemicals like aldrin, dieldrin, heptachlor and DDT.

As early as in 1981, Kaphalia and co-workers reported measurable levels of organochlorine pesticide residues in some wild Indian birds. Later, a report from the Mahala water reservoir of Jaipur, India (Misra and Bakre, 1994) has reported the presence of HCHs, aldrin and DDTs in the resident and migratory bird species like fantail snipe, red wattled lapwing, blackwinged stilt, flamingo and pied wagtail. Several reports were published by the research group at the Center for Marine Environmental Studies at Ehime University of Japan on the occurrence of PTS chemicals in Indian birds through their work in the last two decades

Table 9.3. Concentration ranges (ng g^{-1} wet wt.) of BTs in fish from different regions of the world

Location (year surveyed)	MBT	DBT	TBT	References
Alaska, USA (1981–1984)	na	na	280–900	Short and Thrower, 1986
East, Gulf and Pacific Coast, USA (1986–1991)	20–190	17–1300	26–610	Krone et al., 1995
The Netherlands (1993)	23–41	13–183	9.2–67	Stab et al., 1996
River Elbe and North Sea, German (1993)	89[a]	55[a]	66–490	Shawky and Emons, 1998
Baltic Sea, Poland (1997)	8.0–43	8.0–530	17–2700	Senthilkumar et al., 1999
Japan (1992)	na	3.9–49	8.9–450	Suzuki et al., 1992
Otsuchi Bay, (1994–1995)	<9.0–66	1.8–60	4.2–210	Takahashi et al., 1999
Otsuchi Bay, Japan (1996)	na	na	10–20	Harino et al., 1998a
Osaka Port, Japan (1996)	25–83	2.0–18	11–250	Harino et al., 1998b
Australia (1990–1992)	<4.0–42	<0.36–3.1	<0.13–13	Kannan et al., 1995a
Oceanian countries (1990)	<4.0–8.0	<0.36–0.98	<0.13–0.15	Kannan et al., 1995a
India (1989)	<5.6–78	<0.36–0.65	<0.13–1.6	Kannan et al., 1995a
Bangladesh (1994)	<5.6–170	<0.36–15	0.47–3.0	Kannan et al., 1995a
Thailand (1994)	<5.6	1.6–2.6	1.3–13	Kannan et al., 1995a
Vietnam (1990)	<5.6	<0.36–0.78	<0.13–0.90	Kannan et al., 1995a
Taiwan (1990)	<5.6–13	0.36–2.1	0.13–5.2	Kannan et al., 1995a
Taiwan (1997)	2.8–11	5.8–16	nd	Hung et al., 1998
Malaysia (1998)	2.5–7.4	<1.3–13	2.4–190	Sudaryanto et al., 2004
Indonesia (1991)	<5.6–10	0.41–4.8	<0.13–3.7	Kannan et al., 1995a
Indonesia (1998)	0.93–14	<1.5–18	1.4–52	This study

Note: All values originally reported as butyltin-Sn or butyltin-Cl concentrations are converted here to butyltin ions, nd = not detected, na = no data available.

[a]Maximum concentration.

Table 9.4. Mean concentration (ng g^{-1} wet wt.) of organochlorines in Indian wild birds according to feeding habit

Trophic group	*n*	HCHs	DDTs	PCBs	HCB
Inland piscivores and scavengers (cattle egret, pond heron, Brahmney kite, pariah kite)	17	1400	480	25	0.20
Coastal piscivores (Kingfisher, brown-headed gull, black-headed gull)	7	680	380	36	0.98
Insectivores (swallow, lapwing, Kentish, plover)	8	250	190	42	0.24
Omnivores (chicken, house crow, jungle crow)	17	190	64	15	0.08
Granivores/occasionally insectivores (duck, Water hen, parakeet)	7	23	1.9	7.0	0.07

(Ramesh et al., 1992; Tanabe et al., 1998a; Tanabe 2000; Senthilkumar et al., 2001; Kunisue et al., 2003a,b). Sethuraman and Subramanian (2003) also found considerable levels of HCHs and DDTs in several species of migratory and resident birds collected from the state of Tamil Nadu, southern India. Very clear differences in the PTS loads based on feeding habits of the birds from India were observed as inland piscivores & scavengers > coastal piscivores > insectivores >omnivores > granivores (Table 9.4) by these authors identical to the pattern that was observed by Fybe et al. (1991) in Latin American birds and Frank et al. (1977) in the birds collected from Kenya.

All these reports showed that the HCH residue levels in Indian birds were quite high, while the PCB and DDT concentrations were lower than in the birds from developed nations. One of these studies (Tanabe et al., 1998a) also showed that the migrating birds that stop over in India are heavily exposed to HCHs.

Trends of PTS in the birds from India can classified as those in (1) strict residents (living in the same region for their entire life span), (2) local migrants (which migrate only between Himalaya and South Indian regions), (3) short-distance migrants (those breeding in central Asia, southern Russia, central China, Gulf of Oman, eastern Russia, southern Europe and the Middle East) and (4) long-distance migrants (which have their breeding grounds in northern Europe, eastern to southeastern Russia, western Europe to eastern Russia, Arctic Russia, the Middle East, Papua New Guinea and Australia). Residue patterns of organochlorines in most resident birds were in the order of HCHs > DDTs > PCBs > CHLs = HCB. In general, the contamination pattern observed in the birds collected in India indicates higher exposure to HCHs and DDTs and low concentrations of PCBs in strict residents and local migrants (Senthilkumar et al., 1999b).

It is interesting to note that from the variations in the levels of dominant organochlorines in the migratory birds wintering and breeding in India, their species-specific migratory routes could be determined. It was reported that the migratory birds collected from India have their stopover sites and breeding grounds in China, Russia or around Persian Gulf, Red Sea, Caspian Sea and Mediterranean Sea regions (Fig. 9.9) (Kunisue et al., 2003a).

While Tanabe et al. (1998a) found clearly low concentrations and body burdens of PCBs, DDTs and HCHs in females of little ringed plover, common redshank and white-cheeked tern collected from India, sex related tissue accumulation was not found in Indian birds by Ramesh et al. (1992).

Highest concentrations of HCHs, DDTs and PCBs were found in the egg yolks of house crow followed by sparrow, red jungle fowl, spotted dove, collard dove, white wag tail, turkey, baya weaver and blue rock pigeon by Senthilkumar et al. (2001). In general, in the granivorous or paaserine birds, accumulation of organochlorines in eggs was less than that in omnivorous birds like house crow and sparrow.

A recent finding that the residue levels of organochlorines and PCDDs/DFs and their toxic equivalents (TEQs) in the breast muscle of crows from Perungudi, the dumping site for the municipal wastes of Chennai city were significantly higher than those from Chidambaram, the reference site situated 250 km south of the dumping site reiterates the earlier findings in the soils by Minh et al. (2003). The estimated bioconcentration factors of individual congeners indicated soil as one of the prime sources of dioxins and related chemicals to crows and also the molecular size of the congeners play a significant role in their bioconcentration (Watanabe et al., 2005).

The residue levels of HCHs observed in the birds collected during 1995 (Tanabe et al., 1998a) were greater than those observed by Ramesh et al. (1992) in the birds collected during 1987 and 1991 in the same location. Levels of DDTs and PCBs have also increased slightly during this period, showing the continued exposure or increased pollution by these compounds in India during the period. Because of the recent ban or restrictions on HCHs and DDTs in India, the concentrations in biota may go down, but it may be expected that PCBs contamination in India may increase due to rapid industrialization. Further, the detection of other PTS chemicals like PCDDs/DFs in Indian birds indicates a new paradigm of pollution erupting in Indian birds and the birds wintering there.

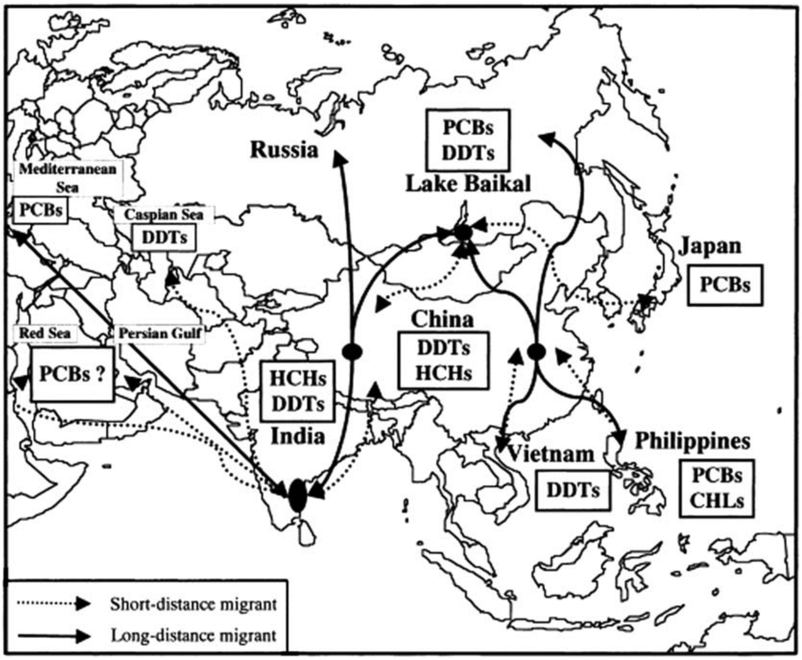

Figure 9.9. Migratory patterns predicted from accumulation features of organochlorines in migratory birds collected from the Philippines, Vietnam, India and Lake Baikal (Russia). Organochlorines in a square represent dominant contaminants in respective area (*Source*: Kunisue et al., 2003a).

9.5.2.5. Mammals

9.5.2.5.1. Terrestrial mammals

In land-based mammals of India most of the works were carried out in the animals which are normally used as food by humans. For example Seth and Kaphalia (1983) found low levels of DDTs and high levels of HCHs in the slaughter house samples. Another Indian study (Nigam et al., 1998) found 10–33 μg kg^{-1} DDT and 10–295 μg kg^{-1} HCH in food animals. Some of these have been reviewed by the Global Environmental Facility under the umbrella of the United Nations Environment Programme (UNEP Chemicals, 2002). There are many other data available on the mammalian food animals and their products from India and we will give a brief account under Section 9.7 of this chapter.

9.5.2.5.2. Aquatic mammals

While browsing through the literature we could find only very few publications on the levels of HCHs, DDTs and PCBs in three species of marine mammals of India, *Sousa chinensis*, *Tursiops truncatus and Stenella longirostris* (Tanabe et al., 1993; Karuppaiah et al., 2005) and one species of river dolphin, *Platanista gangetica* (Kannan et al., 1993; Subramanian et al., 1999; Senthilkumar et al., 1999a). Later the samples from some of the above specimens were used for measuring the other organic contaminants like butyltin compounds (Iwata et al., 1994) and tris(4-chlorophenyl)methane (TCPMe) and tris(4-chlorophenyl)methanol (TCPMOH) (Minh et al., 2000a) and also to explain certain parameters in organochlorine accumulation in cetaceans (Kannan et al., 1994; Minh et al., 2000b).

Among the organochlorine compounds measured in these three species of marine mammals from the southeast coast of India, Tanabe et al. (1993) found that the concentrations of DDTs ranked first, followed by PCBs, HCHs and HCB (Table 9.5). In spite of its low levels in the Indian environmental samples and terrestrial biota (Ramesh et al., 1989, 1990, 1991, 1992; Tanabe et al., 1990; Kannan et al., 1992) DDTs were found to be predominant in the blubber tissues of the dolphins collected from the coastal areas of southeastern India.

A wide range of organochlorines were detected in the blubber, muscle, liver and kidney of four Ganges river dolphin (*Platanista gangetica*) specimens (Kannan et al., 1993) in the order of DDTs > PCBs > HCHs > aldrin and dieldrin > heptachlor and heptachlor epoxide > HCB, similar to that observed by Tanabe et al. (1993) in the dolphins of Bay of Bengal. Levels of DDTs in the blubber were 10–30-fold higher than those of PCBs. Subramanian et al. (1999) analyzed further specimens of Ganges river dolphins and one milk sample collected from different locations of river Ganges and found that the accumulation pattern of organochlorines as DDTs > PCBs > HCHs > CHLs > HCB was same as previously reported in Ganges river dolphins by Kannan et al. (1993) and in marine dolphins of India by Tanabe et al. (1993).

In the blubber samples of three spinner dolphin (*Stenella longirostris*) specimens, Iwata et al. (1994) found very low levels of butyl tin compounds (2 ng g^{-1} wet wt.) of tri-, di- and monobutyl tins. In the same three specimens Minh et al. (2000a) found 31 ng g^{-1} (8.7–63) of TCPMe and 36 ng g^{-1} (10–58) of TCPMOH in the blubber which are lower than the values found in marine mammals from the colder mid-latitude oceans. Other than the above-cited works, we could not find any other literature providing information on the quantities of persistent toxic substances in the tissues of aquatic mammals of India.

Prudente et al. (1997) compared the data from humpback dolphin and spinner dolphin of Bay of Bengal (Tanabe et al., 1993) in a global comparison of PTS in 11 species of male odontoceti and (Fig. 9.10) and found

Table 9.5. Concentration of persistent organochlorine residues in blubber of dolphins from Porto Novo (Bay of Bengal) coastal waters, South India

	Concentrations (ng g^{-1} wet wt.)												
Sample no.	α-HCH	β-HCH	γ-HCH	δ-HCH	ΣHCH	*p,p′*-DDE	*p,p′*-DDD	*o,p′*-DDT	*p,p′*-DDT	ΣDDT	PCBs	HCB	Fat (%)
Spinner dolphin (*Stenella longirostris*)													
DO(01)90	63	160	27	19	270	1700	3800	540	3400	9400	470	13	22
DO(03)90	94	230	39	12	380	16,000	1600	150	4700	22,000	580	13	48
DO(07)90	27	110	10	11	160	11,000	1000	96	3300	15,000	410	3.6	69
DO(08)90	16	36	4.2	3.6	60	3700	140	43	630	4500	240	1.1	43
DO(01)91	410	330	100	21	860	23,000	2600	610	9200	35,000	950	13	48
Bottlenose dolphin (*Tursiops truncatus*)													
DO(02)90	24	82	15	10	130	4700	1000	12	160	5900	390	4.8	69
DO(05)90	33	90	15	4.1	140	6100	840	5.4	59	7000	370	12	53
DO(09)90	5.8	50	3.8	3.8	63	2100	17	6.5	9.8	2100	670	13	40
DO(02)91	15	160	12	5.2	190	9200	3700	46	1300	14,000	630	2.8	67
Humpback dolphin (*Souse chinensis*)													
DO(04)90	29	150	18	2.8	200	5600	1500	40	3700	11,000	960	4.6	52
DO(06)90	110	960	47	6.3	1100	10,000	850	20	690	12,000	1800	0.5	93
DO(03)91	39	150	19	9.4	220	9300	2000	20	3100	14,000	920	2.6	91

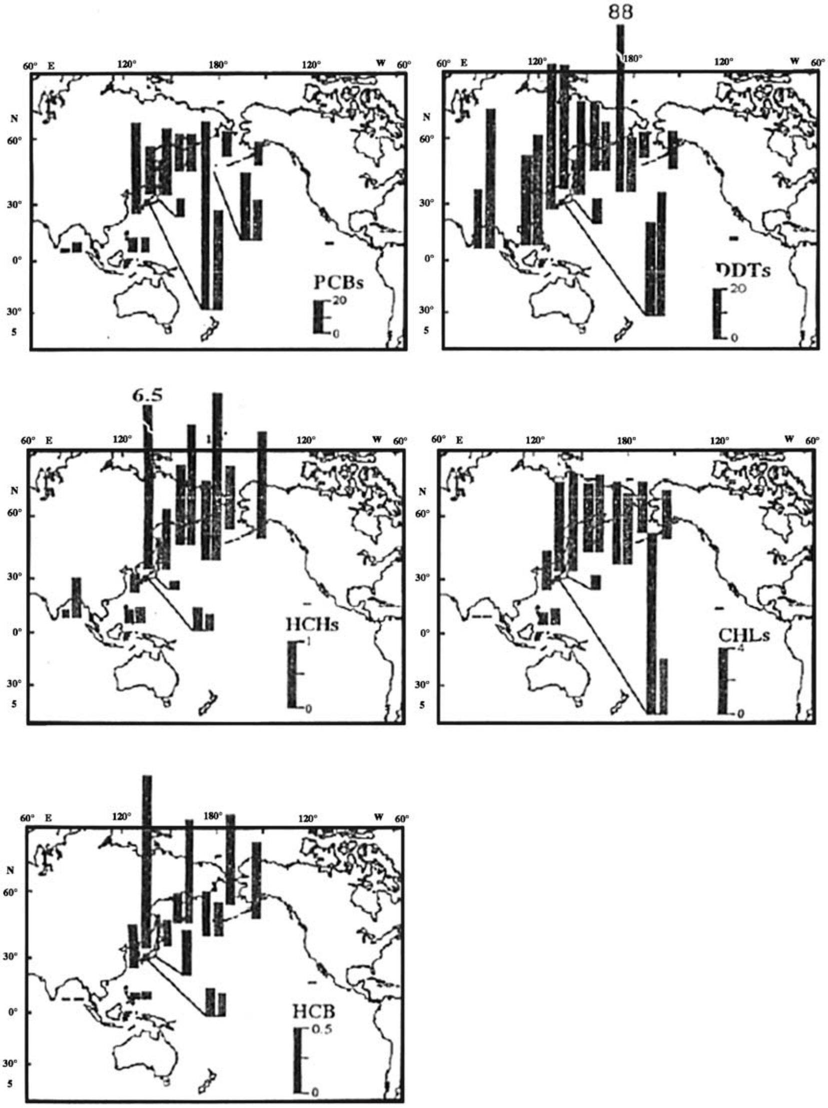

Figure 9.10. Distribution of DDTs, PCBs, HCHs, CHLs and HCB residue levels μg g^{-1} wet wt.) in odontoceti animals from various locations of the North Pacific, Indian Ocean and nearby seas (*Source*: Maricar et al., 1997).

high concentrations of DDTs in the blubber of tropical water species, indicating the current usage of DDT in the tropics and the less movable nature of this compound via long-range atmospheric transport. HCH levels in animals inhabiting cold and temperate waters were higher than those inhabiting tropical waters, a result that was perhaps reflective of easier atmospheric transport of the chemical from the tropical source to northern sinks.

Minh et al. (2000a) while comparing the contamination of persistent endocrine disruptors in cetaceans from the North Pacific and Asian coastal waters including Indian specimens showed that the latitudinal distribution of TCPMe and TCPMOH in cetaceans from North Pacific Ocean and Asian coastal waters was similar to DDTs, suggesting the less transportable nature of these compounds. Toxic evaluation of coplanar PCBs using TEQs concept indicates an increasing impact on the animals of mid-latitudes. On the other hand, the cetaceans at lower and higher latitudes, including the dolphins from Bay of Bengal, India are not under threat by dioxin like congeners of PCBs.

Apart from the above species, it was shown by Kannan et al. (2005) that the Irrawaddy dolphins from the Chilika Lake (Chilika Lagoon) of India had the same pattern of distribution of OCs as observed in the above four species of aquatic mammals of India, with DDTs as the predominating compound followed by HCHs, PCBs, HCB, TCPMe and TCPMOH in order.

9.6. PTS in Indian human

In spite of the large amount of data available on the classical organochlorines and other chemicals in wild animals all over the world only very limited works are available on PTS levels in human samples, most of the recent works being in human breast milk (Tanabe and Subramanian, 2006). From the late 1990s there has been a steady increase in the works on PTS in Indian human samples. The most widely used samples from human are the human milk followed by blood, liver, hair, muscle and urine.

9.6.1. Blood

Testing of the blood serum samples conducted in India regularly by some research groups, especially by the National Institute of Occupational Health (NIOH) shows temporal reduction of HCHs, DDTs and HCB in the blood serum of healthy volunteers from Ahmedabad area in the year 2001 when compared with the samples of the 1980s (Bhatnagar, 2001; Bhatnagar et al., 2004) which may be due the imposition of restrictions on the usage of these chemicals for agriculture in India. Levels of DDTs reported from Delhi in the year 1980 (Ramachandran et al., 1984) and

1985 (Saxena et al., 1987) were higher than in Ahmedabad. HCHs in the year 1982 (Ramachandran et al., 1984) from different cities of India were very much higher than those reported by Bhatnagar (2001) and Bhatnagar et al. (2004) in Ahmedabad samples. Studies from another urban area (Lucknow) in the samples of the 1980s showed comparable levels to Ahmedabad samples (Kaphalia et al., 1981; Siddiqui et al., 1981a) while Rao and Banerji (1989) found somewhat higher levels of PCBs in human blood samples from Bombay (Mumbai), showing the tedium in having a generalized picture of human PTS contamination in India.

An attempt by the scientists at the NIOH, Ahmedabad, India to provide a database on the residues of total PTS chemicals in Indian human blood serum showed that the total organochlorine insecticide content is in an average of 200 ppb with a range of 58.3–321 ppb. Among these chemicals HCHs and DDTs were the chief contaminants and the order of persistency was HCH $>$ DDT $>$ dieldrin $>$ oxychlordane $>$ heptachlor $>$ aldrin. Heptachlor epoxide and HCB were not present (Bhatnagar et al., 1992).

Interestingly, a study on German children and adolescents showed that two girls of the age of 10 and 13 (born to an Indian father and a German mother), who had a holiday stay in India had DDE plasma levels of 11 and 12 μ gl^{-1} while the range values for samples from 130 children were between 1.46 and 2.09 μ gl^{-1}, respectively. DDTs were also higher in those two children (1.44 and 1.11 μ gl^{-1}) while the corresponding range values were from 0.02 to 0.06 μ gl^{-1}, respectively. The authors have argued that higher accumulation of these chemicals might have probably obtained through exposure in India during their recent holidays (Heudorf et al., 2003) showing the possibility of the higher amount of exposure to these chemicals by Indian resident population.

9.6.2. Urine

Almost all the PTS chemicals being lipophilic, non-degradable and not easily excreted from animal bodies were not found in considerable concentrations in the animal excreta like feces and urine. The only study by Singh et al. (2004) on impact assessment of sewage treatment plants on the environmental quality of the waste disposal area in Varanasi and Kanpur, two big cities in India showed that the mean values of HCHs and DDTs in the urine samples of the people in the exposed area were higher than those living in unexposed areas, the levels being lower than those in blood of the same subjects. Other than these, we could not find any other data available in the published literature on the levels of PTS in Indian human urine or feces.

9.6.3. Fat

The presence of organochlorine pesticides in Indian human fat samples have been reported by various authors as early as from the 1960s (Dale et al., 1965; Ramachandran et al., 1973, Bhaskaran et al., 1979; Siddiqui et al., 1981a). Studies conducted to monitor pesticide residues in autopsy fat samples from different parts of India indicated a nationwide variation (Anonymous, 2001), increasing age trends of organochlorines with the maximum DDT residues in age group of 20–39 years and no sex difference for both the chemicals (Jeyaratnam, 1985). Later, Bhatnagar (2001) in his review article on pesticide pollution in India told that the wide variation of HCHs and DDTs seen among different populations may be due to the geographical variations in consumption and usage pattern, chemical intensity, efficiency of absorption, age, nutritional status and integrity of the organs.

Apart from such complications that may occur during the accumulation of PTS chemicals in humans, interesting chronological patterns of the ratios between HCHs and DDTs were observed in the studies conducted in the 1960s and 1980s in India. For example DDT concentrations in Indian human adipose tissue collected in the year 1964 were nearly 18 times higher than the HCHs (Dale et al., 1965) than in the samples collected during 1971 by Siddiqui et al. (1981b) in which the DDTs were only 1.5 times higher than HCHs. Increased usage of HCHs both in agriculture and vector control and the restrictions imposed on DDT usage in between those years might be the reason for such a temporal increase of HCH levels in human tissues in India (Tanabe et al., 1990).

In an interesting work in Farah, Mathura District, India, Dua et al. (1998) collected the skin lipids from face and blood from the occupationally exposed and unexposed volunteers and found that the levels of both HCHs and DDTs were higher in the samples obtained from the exposed group. They have also found an increase in the levels of both the compounds in Delhi population when compared with the data reported in previous publications on the concentrations in the adipose tissue collected a decade before in Delhi (Ramachandran et al., 1984) and several other parts of India (Kaphalia and Seth, 1983), reflecting the intensive use of these pesticides for malaria control in the sampling area.

9.6.4. Milk

Indian breast milk could be used as a sort of indicator for understanding the biological specificity in the accumulation of organochlorines in the tropical environment as well as assessing the extent of environmental pollution in similar countries by these chemicals (Tanabe et al., 1990). In an interesting study in the southeastern locations, Madras (Urban), Chidambaram (semi urban), Nattarasankottai (rural) and Parangipettai (fishing village) (Table 9.6), HCHs concentrations followed the different exposure patterns of the donors. At Chidambaram and Nattarasankottai, where higher levels of HCH isomers were observed in breast milk all the donors were living in an agricultural area and had some connection with agriculture and most of them were vegetarians. Lower levels of HCHs were found in the samples from Madras and Parangipettai, where all the donors were nonvegetarians. This indicates the fact the intake of HCH isomers through foodstuff of animal origin is not significant in India. Indeed high levels of HCHs have been documented in vegetables (Lal et al., 1989), cereals (Noronha et al., 1980) and edible oils and oil seeds (Dikshith et al., 1989) from India.

Unlike HCH isomers, regional differences in DDT concentrations and effect of dietary habits on human uptake were found to be smaller (Tanabe et al., 1990). The authors also reported the occurrence of PCBs in Indian human breast milk for the first time (120 ng g^{-1} fat wt.) which were very much lower than those in developed nations like Japan (1100 ng g^{-1} fat wt.—Yakushiji et al., 1979) and USA (1500 ng g^{-1} fat wt.—Wickizer et al., 1981) but were only slightly higher than in Vietnam (100 ng g^{-1} fat wt.) and Thailand (60 ng g^{-1} fat wt.) (WHO, 1988). Unlike in developed countries where fish were found to be the prime source of PCBs to human through diet (Watanabe et al., 1979; Noren, 1983), the milk samples from fisherwomen of Parangipettai, who consumed fish almost every day did not have higher concentrations of PCBs or other OCs, implying that the major source of OCs contamination is not present in coastal areas in India but probably lie in the inland regions. Further to this, in the northern Indian state of Punjab, the human milk samples from intensive cotton growing areas had significantly higher concentrations of both HCHs and DDTs than those in samples from areas where cotton is sparsely grown (Kalra et al., 1994), the median values of DDTs (0.52 μg g^{-1} fat wt.) and HCHs (0.19 μg g^{-1} fat wt.) in samples of human milk from cotton growing areas being higher than those from most other countries in the world.

Banerjee et al. (1997) found 3.4 times higher levels of HCHs in 61 milk samples from Delhi than those from Lucknow (Siddiqui et al., 1981a). Sanghi et al. (2003) found endosulfan, malathion, chloropyrifos, methyl-parathion and HCHs in human milk samples collected from Bhopal, India. Again, with respect to the classical organochlorine pesticides in mothers' milk in big cities and rural areas in the present decade, Nair et al. (1996) found 1.27 mg l^{-1} fat wt. of DDTs and 0.33 mg l^{-1} fat wt. of

Table 9.6. Concentration of HCHs, DDTs, and PCBs (ng/g of fat) in human milk from South India

Sample no.	Fat content (%)	HCHs					DDTs				
		α-HCH	β-HCH	γ-HCH	δ-HCH	ΣHCH	*p,p'*-DDE	*p,p'*-DDD	*p,p'*-DDT	ΣDDT	PCHs
CM1	0.48	2100	18,000	310	320	21,000	770	<1.0	260	1000	27
CM2	1.9	270	4700	19	29	5000	370	9.5	100	640	21
CM3	3.3	290	6700	28	17	7000	840	<1.0	160	1000	660
CM4	2.2	380	4500	40	30	5000	1300	17	240	1600	23
CM5	0.26	1300	6500	150	130	8100	340	<1.0	160	500	26
CM6	0.80	310	1100	130	100	1600	32	<1.0	71	100	30
CM7	1.5	410	7200	49	56	7700	880	<1.0	210	1100	72
CM8	2.4	490	3800	51	82	4400	180	<1.0	69	250	30
CM9	3.1	160	3200	6.3	9.3	3400	1700	<1.0	210	1900	270
CM10	1.5	1600	24,000	52	54	26,000	2100	<1.0	270	2400	770
CM11	3.4	360	6900	21	21	7300	750	<1.0	96	850	52
Mean		700	7900	78	77	8800	840	2.4	170	1000	180
		(8)	(90)	(1)	(1)	(100)	(83)	(0.2)	(17)	(100)	
CP1	15	100	940	12	15	1100	68	<1.0	46	110	7.0
CP2	4.1	160	1800	21	20	2000	960	<1.0	320	1300	19
CP3	4.4	110	950	23	29	1100	240	<1.0	100	340	190
CP4	4.1	270	3700	51	17	4000	4700	30	1400	6100	47
CP5	1.3	140	2200	0.0	13	2400	300	<1.0	110	410	32
Mean		170	2200	24	20	2400	1600	6.0	400	2000	72
		(7)	(91)	(1)	(1)	(100)	(80)	(0.3)	(20)	(100)	
M1	3.3	410	3300	76	26	3800	79	14	140	230	480
M2	4.3	150	2800	4.4	96	3100	1300	16	<1.0	1300	26
M3	1.7	240	1600	17	27	1900	590	10	230	830	20
M4	2.0	190	1800	14	8.2	2000	650	13	64	730	37

Table 9.6. (*Continued*)

Sample no.	Fat content (%)	HCHs					DDTs				
		α-HCH	β-HCH	γ-HCH	δ-HCH	ΣHCH	*p,p′*-DDE	*p,p′*-DDD	*p,p′*-DDT	ΣDDT	PCHs
M5	2.0	140	2400	16	20	2600	290	14	160	460	21
M6	0.95	170	3500	25	11	3700	790	18	240	1000	86
Mean		220	2600	25	31	2900	620	14	140	760	110
		(8)	(90)	(1)	(1)	(100)	(81)	(1)	(18)	(100)	
N1	1.8	1100	16,000	46	25	17,000	3500	43	390	3900	29
N2	2.7	490	11,000	82	29	12,000	2500	33	440	3000	31
N3	5.1	340	1500	63	51	1900	95	< 1.0	48	140	3.3
		640	9500	60	35	10,000	2000	25	290	2300	21
		(6)	(93)	(0.6)	(0.4)	(100)	(87)	(1)	(12)	(100)	

Note: Values in parentheses indicate percentage compositions of HCH isomers and DDT compounds.

HCHs in Delhi mothers' milk. Most recently, the mothers in four villages near Agra had around 170–179 ng g^{-1} fat wt. of DDTs and 123–131 ng g^{-1} fat wt. of HCHs in their milk (Kumar et al., 2006). Further, Nair et al. (1996) found in mothers from Delhi that their breast milk contained 4.5 times higher DDTs than in blood serum and also there was a significant positive correlation between both these levels. They also found that the breast milk sampled during first feeding after childbirth showed 80% more residues of DDT and HCH when compared to maternal blood. Also, the primipara mothers showed 1.15 and 2.3 times more DDT and HCH residues in the breast milk, respectively when compared to multipara mothers. Most recently Kumar et al. (2006) found DDT and its metabolites and HCHs in 95% of the mothers' milk samples collected from the remote villages in Agra region of northern India.

Apart from classical organochlorines, not much literature is available on the occurrence of other PTS compounds like butyltins, polybrominated diphenyl ethers, etc. in Indian human breast milk. Indian Council of Medical Research (ICMR) in their news bulletin of the year 2004 has indicated that they could detect PCDDs and PCDFs in the human milk samples collected from Ahmedabad, Vadodara and Surat cities (http://icmr.nic.in). They have found that the TEQs of dioxins and related compounds in their samples ranged from about 2 to 16 pg g^{-1} lipid weight of human milk.

These compounds are the byproducts of incineration, uncontrolled burning and industrial processes. These may reach the people living around these sites via inhalation or through food chain by the consumption of products from farm animals and birds grazing in those sites; this will be certainly reflected in the milk of mothers living around these sites.

This has prompted Kunisue et al. (2004) to quantify the levels of dioxins and related compounds (DRCs) such as polychlorinated dibenzo-*p*-dioxins, polychlorinated dibenzofurans and coplanar polychlorinated biphenyls in the human breast milk from women living near dumping sites of municipal wastes in India and compare them with the samples from a reference site and also with similar sites from other developing countries. DRCs were found in all the samples from Indian dumping and reference sites demonstrating that residents of both the sites were exposed to these contaminants. They have also found that the mean concentrations of PCDDs in human breast milk from Indian dumping sites were the highest among the samples from Asian developing countries they have analyzed. The range and mean concentrations were in the decreasing order as India (290 (150–780) pg g^{-1} lipid wt.) $>$ Philippines (190 (29–730) pg g^{-1} lipid wt.) $>$ Cambodia (49 (14–170) pg g^{-1} lipid wt.) $\geq$ Vietnam (32 (15–130) pg g^{-1} lipid wt.). At the same time the concentrations of PCDFs were in the decreasing order as follows: India > Philippines ≥ Vietnam ≥ Cambodia. In India, the concentrations of PCDD/DFs in human breast milk from dumping site were significantly higher than those from reference sites, whereas levels of these contaminants in human breast milk from Cambodia and Vietnam were not very much different between the dumping and reference sites. These results indicate that significant pollution sources of PCDD/DFs are present in the dumping site of India and that the residents living near them have been exposed to relatively higher levels of these contaminants than residents in the other countries evaluated in this study. Further studies in Kolkata and various other cities in India reveal similar patterns of OCs including DRCs (Kunisue, unpublished data). Kashyap et al. (2004) also made some preliminary observations on the levels of DRCs in human milk from Ahmedabad, India.

Further, a comparison of TEQ levels of these chemicals (PCDDs/DFs and coplanar PCBs), calculated using WHO TEFs in Indian human milk with other developing and developed nations showed that the Indian value (38 pg TEQs g^{-1} lipid wt.) were comparable with or higher than those from developed nations, suggesting that Indians residing near the dumping sites are exposed to DRCs as the general population of developed nations; the TEQs levels in Cambodia (9.2 pg TEQs g^{-1} lipid wt.), the Philippines (12 pg TEQs g^{-1} lipid wt.) and Vietnam (13 pg TEQs g^{-1} lipid wt.) were lower. There are reports claiming that the DRCs in human breast milk decreased recently in developed nations (La Kind et al., 2001) because of the installation of highly efficient incinerators and strict regulations on the production and usage of such chemicals. In this context, the fact that the levels of DRCs are higher in Indian human milk is noteworthy, not only from the viewpoint of local pollution but also from a global point of view.

Another interesting new finding by Sudaryanto et al. (2005) has revealed the occurrence of the popular flame retardant chemicals, polybrominated diphenyl ethers (PBDEs) in human milk collected during 2000–2004 from urban areas of the Asian countries, Japan, Korea, China, Philippines, Vietnam, Cambodia, Indonesia, Malaysia and India. They have also deducted the popular organochlorines in all those milk samples. The order of magnitude of the organohalogens is DDTs > PCBs > HCHs > CHLs > HCB > PBDEs., Unlike OCs, concentrations of PBDEs did not correlate with the age of the mother and parity, possibly because of the relatively short period of the usage of PBDEs in India and the different exposure pathways of PBDEs and OCs. Unlike HCHs and DDTs, the mean level of PBDEs in Indian milk samples is low when compared with other countries; yet the finding attains its importance from the fact that India is a fast developing country, especially in the field of electronics and computers, in the manufacture of which PBDEs and related compounds are used in plenty.

9.7. PTS in Indian food items

Despite the fact that the average consumption of pesticides are still low in India, (05 kg ha^{-1}) against 6.6 and 12 kg ha^{-1} in Korea and Japan, respectively, there has been widespread contamination of food commodities with pesticide residues, basically due to their non-judicious use. In a recent review Gupta (2004) has stated that in India, 51% of food commodities are contaminated with pesticide residues and out of these, 20% have residues above the maximum permissible residue levels on a worldwide basis.

The first report of contamination of food commodities in India was the report of pesticide poisoning of wheat flour in 1958 (Karunagaran, 1958). Following this, there are plenty of market and field surveys of almost all the vegetarian and non-vegetarian food items of India mostly on the pesticides rather than other PTS chemicals, reviewing all of which will be a task more than the necessity of the present review.

Regular food contamination surveys in India are being conducted since the 1970s (Agnihotri et al., 1974; Joia et al., 1978; Noronha et al., 1980; Kalra et al., 1983; Lal et al., 1989; Kannan et al., 1992; UNEP Chemicals, 2002). As a general rule, milk and its products followed by edible oil were found to contain the highest levels of residues, unlike in the developed nations where fish and meat had the highest levels (Dikshith et al., 1989; Dhaliwal, 1990; Kannan et al., 1992, 1997; John et al., 2001; Battu et al., 2004, 2005). Apart from these, almost all the Indian foodstuff like cereals, rice, wheat, meat, egg, vegetables infant formulae and human milk were found to be contaminated with different PTS chemicals, and most of them with at least the classical organochlorine pesticides, DDT and HCH (Kaphalia and Seth, 1981; Kaphalia et al., 1985; Lal et al., 1989; Kunisue et al., 2004). Above these, assessment of vegetarian and non-vegetarian diets was undertaken by Gupta et al. (1982), Rekha et al. (2006) and Battu et al. (2005). These works reported that 21% of the total pesticide residues intake via Indian food is contributed by milk. Organochlorines were observed in higher concentrations in rice and wheat follwed by carbamates, organophosphorus and pyrethrites. It was also reported that dairy products are the prime sources for both HCHs (70%) and DDTs (87%) while dairy products (31%), pulses (27%) and vegetable oils (20%) are the three main sources of PCBs for human in India (Fig. 9.11) (Kannan et al., 1992).

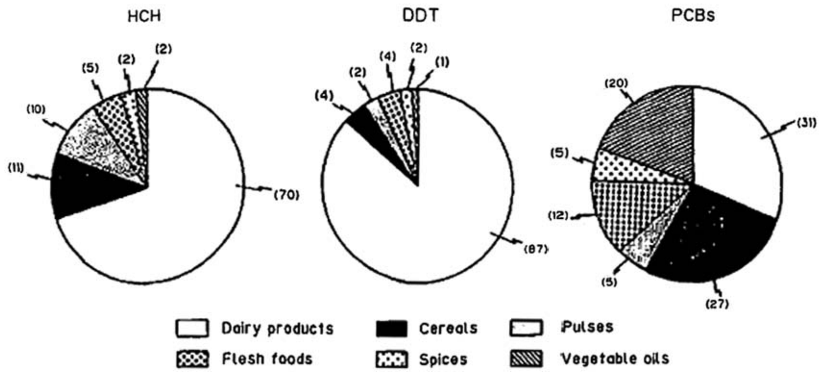

Figure 9.11. Contribution by different classes of foodstuffs toward the dietary intakes of ΣHCH, ΣDDT, and PCBs by Indians. [Figures in parentheses indicate the percentage (*Source*: Kannan et al., 1992).]

9.8. Management of toxic chemicals in India

In 1976, when Indian parliament passed the 42nd amendment of its constitution safeguarding the environment, it became the first country in the world to do so. Essentially, The Water (Prevention & Control) Act, 1974 can be considered to be truly the first regulation on environmental management in India. At present, there are several pollution regulations in India (Harish C. Sharma—www.petroleumbazaar.com/Library/Pollution) viz.:

1. The Water (Prevention & Control of Pollution) Act, 1974 and its amendments;
2. The Water (Prevention & Control of Pollution) Cess Act, 1974 and its amendments;
3. The Air (Prevention & Control of Pollution) Act, 1981 and its amendments;
4. The Environment (Prevention) Act, 1986 and its amendments (a) National Environmental Tribunal Act of 1955 and (b) National Environmental Appellate Authority Act of 1977;
5. Hazardous Waste (Management and Handling) Rules, July 1989 and
6. The Public Liability Insurance Act, 1991 (Sharma, 1994, 1999).

The Public Liability Insurance Act 1991 is the first regulation which gives strong power to the other five pollution regulations. These Acts regulate the agencies polluting various environmental and biotic matrices. Even before this, India already had The Insecticides Act, 1968 to regulate the manufacture, registration, use, export and import of pesticides in the country. There existed already is the Prevention of Food Adulteration Act (PFA) 1954, giving power to the government for punishing food adulteration with unwanted materials including toxic chemicals.

Under the Water Act, 1974, Central Pollution Control Board and State Pollution Control Boards were formed and given power to govern all the pollution regulations since then and any other to be put in regulations in the future. The Chairman and members of the Boards are appointed by respective governments from various interest groups such as corporations, public health, engineering, agriculture, forestry, fishery, etc. The boards advise their respective governments on any matter concerning the prevention and control of pollution in their area of jurisdiction. The boards have authority to take samples and analyze any matter from the industries and other polluted environments and make recommendations to the government.

Apart from the above regulations, the government issued many policies such as:

1. The National Forest Policy;
2. The National Wildlife Action Plan;
3. Forest (Conservation) Act;
4. The Policy Statement for Abatement of Pollution;
5. The National Conservation Strategy;
6. Policy Statement on Environment and Development, etc.

At present the regulatory agencies are now enforcing the regulations fairly strictly by taking legal actions against the erring industries and persons. There has been some control on the unmindful pollution by industries at present because of the enforcement of the principle "Polluter pays" for the damage. The Ministry of Environment and Forests and some related departments of Government of India are empowered to take steps even for the summary closure of polluting industries and to curtail the activities of the polluting agencies. There are many NGOs and public interest groups keeping a watchdog approach in order to prevent possible violations of environmental regulations by big farming societies and industries.

The government encourages measurement of the pesticide and other chemical contamination of soil, water and food that has been a much-researched subject in India since the 1970s. Several national and international agencies carry out regular research on toxic chemicals, especially on pesticides in India. In 1986, The Indian Council of Medical Research (ICMR) began a project on surveillance of food contaminants in India and found that 51% of the food items tested were contaminated with various pesticides and 20% of them had pesticide levels above the maximum permissible residue limits. The National Institute of Oceanography (NIO) began research on pesticides in 1984. According to a research report by Dr. Anupam Sarkar and others, Indian marine environment has been contaminated by different classes of pesticides. The Department of Science and Technology of the Government of India set up a Programme Advisory Group in 1988 for regular monitoring of food grains and pulses for their pesticide levels. In 1992–1993, The Consumer Education Research Centre (CERC), Ahmedabad, along with the National Institute of Nutrition (NIN), undertook the testing of pesticide residues in food. The CERC, in another investigation (Insight—the consumer magazine, May–June 2000), found that the most of the wheat flour brands of India are contaminated with lindane, DDT, aldrin, dieldrin and ethion. Studies by Toxic Link found various toxic persistent chemicals in water, fish and clams collected from India (Toxic Link, Nov. 2000).

Green Peace in an effort in evaluating the levels of toxic chemicals in Asian countries such as India, Pakistan, Nepal and Bangladesh found that several of the locally banned or severely restricted pesticides are freely available in these countries. The Pesticide Action Network, Asia and the Pacific based in Malaysia undertook case studies on endosulfan poisoning in the State of Kerala, jointly with International POPs Elimination Network (IEPN) based in Kerala State, India. The scientists from the Center for Marine Environmental Studies of Ehime University, Japan under the Asia Pacific Mussel Watch Program surveyed the countries surrounding Indian Ocean region for several of the POPs chemicals. Dr. Shinsuke Tanabe, the Leader of the Program, as one of the findings of their still continuing research efforts in the region, states that almost all the countries in the region, India, Vietnam, the Philippines, Cambodia, etc. act as global pollution sources of different classes of POPs chemicals. In their work together with scientists from Annamalai University, India they found that foodstuffs and other wildlife collected from different regions of India contained PTS Chemicals like HCHs, DDTs, PCBs, PBDEs, BTs, etc. They found India as a main source of HCHs to global environment while Vietnam is the source for DDTs and Japan for PCBs in the region they have surveyed.

Even beyond all such rules and policies and efforts of the Government of India and other non-governmental agencies, it is an obvious fact that the levels of many of the persistent toxic chemicals in the Indian environment, food stuff, wildlife and human are one among the highest in the world. As opined by many of the public interest groups and NGOs, India has no shortage of strong teethed regulations to control the pollution by PTS chemicals starting from their source(s) to the environment. What is obviously lacking is the strict enforcement of the existing rules and regulations.

9.9. Conclusion

Apart from the legal formalities and several ethical, religious and social problems that are to be considered in collecting wildlife and environmental samples, especially in India, a very much religious country, where a considerable proportion of the subjects are illiterate, considerable amount of literature is available on PTS in India; an evaluation of which shows a wide spread contamination of organochlorine pesticides and other industrial chemicals in the environment, wildlife and humans to the levels which can cause serious concern because of their severe and already proven toxic implications.

In a popular news article that appeared in www.newindpress.com on October 1, 2004, a study by the Mumbai (Bombay, India) based Blackstone Research Institute has stated that the onset of slowdown among the men in Delhi is at the age of 35 years while Mumbai men begin to suffer from it only at 41. Kolkata and Chennai men were on par, experiencing the slowdown at 45 years of age. The news article also has shown that men experience such andropause due to decline of testosterone levels in their blood. Already it has been shown that many PTS chemicals are having endocrine disrupting and estrogenic characteristics. These chemicals cause disruptions in sex characteristics of individual animals and also decrease fertility rates in some wild species (Colborn et al., 1996; Reijnders et al., 1999; Tanabe, 2000). Sexual dysfunction in many marine species like fish and shellfish and eggshell thinning in some bird species led to reduced reproductive success in individuals having high POPs concentrations in tissues and organs (Reijnders et al., 1999; Konstantinou et al., 2000; Van der Oost et al., 2003). One of our earlier studies has also shown that the testosterone levels in the blood of Dall's porpoises decreased significantly with increase in the levels of DDTs in their blubber (Subramanian et al., 1987).

Interestingly, evaluation of the data obtained in India on the levels of OCs, especially DDTs, were found to be higher in many of the environmental and biotic samples. This fact may be considered as a matter of serious concern. There may be several medically proved factors that may cause the 'slow down' of the Indian men at an early stage. But the fact remains; higher levels of PTS chemicals in Indian environment and human may also have an added effect on their early andropause; this may also have teratogenic effects on perinatal children by transfer through placenta and breast milk from mother. So far, no direct evidence is available linking human sexual dysfunction and fertility problems and the PTS chemicals. But there is ample evidence to believe that in countries like India with uncontrolled usage of estrogenic chemicals, the environmental levels are sufficient enough to cause several toxic implications in wildlife as well as human. This is certainly high time for the government and related agencies take a serious look on the matter and take urgent necessary steps.

The data available on the Indian POPs pollution scenario shows need for every concern. But the interest shown by the concerned agencies is very minimal for reasons obvious. The participation by NGOs and public is not encouraged in this critical issue. Effort by the scientific community is waning for want of encouragement and should be stimulated in a systematic and coordinated fashion. As a first step to this, available information on the existence of PTS, their distribution, transport and bioaccumulation in the Indian environment and biota should be gathered in a systematic manner.

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