Bull Environ Contam Toxicol (2012) 88:303–310
DOI 10.1007/s00128-011-0496-4

Status of Organochlorine Contaminants in the Different Environmental Compartments of Pakistan: A Review on Occurrence and Levels

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Received: 4 August 2011 / Accepted: 1 December 2011 / Published online: 16 December 2011

Abstract This review evaluates and summarizes the results of the studies of organochlorines-contaminated water, sediment/soil and biota in Pakistan. Pattern of occurrence of each contaminant class from different study sites is followed as DDTs > Cyclodiens > HCHs > PCBs. The studies conducted in the surrounding areas of the demolished DDT manufacturing units and obsolete pesticides stores of country showed extremely highest values of $\sum$DDTs, which differ significantly ($p < 0.05$) than those reported from the agricultural areas and fresh water bodies of the country. HCHs, heptachlor, dieldrin, and HCB were also reported in many studies, but the concentrations are comparable among all the locations in the country. The authors suggested surface run-off, dumping of waste from industries and contamination from obsolete pesticides and demolished OCPs manufacturing units as the major sources in Pakistan. Information on PCBs is scares and studies on assessment of PCBs occurrence, and spatial trends in various environmental matrices needs special attention to produce the scientific publication. The results draw attention that POPs contamination must be considered as a priority environmental concern due to their use in agricultural and industrial sector.

Keywords OCPs · PCBs · Water · Sediment/soil · Biota · Pakistan

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Persistent Organic Pollutants (POPs) including Organochlorine pesticides (OCPs) and Polychlorinated Biphenyls (PCBs) are of international concern owing to their negative impact to both wildlife and human being due to lipophilic properties (Sanpera et al. 2002; Burger et al. 2007; Eqani et al. 2011). Although the use of OCs compounds has significantly declined in past two decades but some of OCPs and PCBs are still in use in developing countries because of their low cost and versatility in industry (Syed and Malik 2011; Eqani et al. 2011; Tariq et al. 2007).

Pakistan, being signatory to the Stockholm convention in 2001, have no specific regularity mechanism to control and monitor OCPs and PCBs level in various environmental matrices (Malik et al. 2011). These chemicals are not included in the NEQS (National Environmental Quality Standard) list on priority chemicals of concerns. According to Khawaja (2003), Polychlorinated biphenyls are mainly used in industrial activities and in particular as coolant and insulator in transformer oil with a 4,000 MT/annum demand and the quantity of used transformer oil is <1,500 MT/annum. On the other hand, Pakistan also holds one of the largest stockpiles of outdated pesticides in the world, and few studies also documented the severe pollution in the vicinity of these chemical warehouses in different parts of the country (Ahad et al. 2010; Syed and Malik 2011). According to Ahad et al. (2010), the quantity of outdated pesticides in different provinces of Pakistan have been estimated to be 3,805 tonnes in Punjab, 2,016 tonnes in Sindh, 179 tonnes in KPK (Khyer Paktoon Khaw), and 128 tonnes in Balochistan while stock of 178 tonnes lies with the Federal Department of Plant Protection, out of which 2.54 tonnes are OCPs. On the other hand, demolished factories of OCPs in different parts of the country, where thousand kilograms of DDTs and other OCPs are dumped, are also one of the important sources of the OCPs

pollution in the different environmental compartments of Pakistan.

Scarce information is available on the occurrence of organochlorine contaminants in different environmental matrices in Pakistan. During last 40 years, over 51 scientific studies were conducted which reported the residual effect of OCPs and PCBs in different environmental matrices in Pakistan. Among these studies, only ten studies provided the OCPs related data from various water bodies in the Country. This document summaries the results of these studies and predicts the real picture of OCPs contamination and their spatial trends in different environment matrices. This document also provides important information to evaluate the contribution of Pakistan towards POPs emission in global environment and effectiveness of control measures taken by regional and international authorities under Stockholm convention in developing countries.

Occurrence and Distribution of Organochlorine Contaminants in Water, Sediment/Soil and Biota from Pakistan

Widespread use of some chemicals (OCPs and PCBs) for agricultural and nonagricultural purposes resulted in contamination of water, sediment, and biological organisms in Pakistan, which is of particular concern (Figs. 1, 2). This scenario highlighted that proper attention should remunerated to promote the scientific research which provides necessary information on the current levels and distribution of these chemicals in different environmental compartments, alternative products and processes to reduce and eliminate OCPs and PCBs. However, in Pakistan a limited number of studies have been conducted on the POPs contamination of different environmental matrices in Pakistan. Major hindrance to produce the data of POPs is the lack of technical expertise and laboratory facilities in the country. Only few laboratories have sufficient analytical facilities that can measure specific organochlorine chemicals in traces. However, in spite such limitations a few of studies reported on the levels of organochlorine chemicals in different environmental compartments. The results of published studies conducted at different locations and intervals from 1990 to 2011 is discussed in detail below.

Organochlorines Contamination in the Surface and Ground Waters from Pakistan

In Pakistan, only few studies have been conducted to investigate the occurrence and distribution of OCPs in surface and ground waters (Table 1). For the very first time Parveen and Masud (1988a) reported the contamination of organochlorines in the cattle drinking water samples collected from Karachi ranging from traces 16.7 μg/L. Among the studied chemicals, BHC was the dominant of all organochlorines with maximum concentration of 16.7 μg/L and detected in 8% of the total samples. On the other hand, DDTs were detected in 3% of studied samples. The authors suggested the source of BHC from surrounding industrial activities, while DDE and DDT may come from surrounding contaminated soils. Analysis of shallow ground water samples collected from Faisalabad district resulted in the contamination of endrin (0.1–0.2 μg/L) in 30% of collected samples (Jabbar et al. 1993). The endrin due to its insecticidal properties is mainly used for crop protection. These samples were collected from cotton growing area, which reflected its large scale use. Another study by Ahad et al. (2001) from cotton growing area of Multan district reported the contamination of endosulphan (0–0.13 μg/L) and γ-HCH (0.1–0.11 μg/L) in the ground water. In this study most of the water samples exceeded the MRLs (maximum residual levels) for each compounds, suggesting the extensive use of these pesticides in these areas. In Pakistan, ground water contamination is more likely to happen because of many factors including soil characteristics, shallow water tables, and intensive spraying (Jabbar et al. 1993; Tariq et al. 2004, 2007). For example, ponding irrigation is very common in Pakistan resulted in contamination of surface and ground water due to faster water flow infiltration. Tariq et al. (2004) reported the contamination of endosulphans and some other pesticides in the surface and ground water samples collected from different agricultural districts of Pakistan Viz; Bhawalnagar, Rajanpur, Muzafarghar, and Dera Ghazi Khan. This study reflected wide scale historical use of pesticides, which may reach to surface/ground water via surface runoff from agricultural fields, direct spray on water ponds to control mosquitoes and other insect to protect animals, infiltration of different chemicals via heavily rainfall (Ahad et al. 2001; Tariq et al. 2004). Heavily pesticides application has also been reported from plains of Sindh and KPK (Khyer Paktoon Khaw) provinces. Ahad et al. (2000) conducted a study in the tobacco growing areas of Mardan district in KPK, which showed the relatively higher concentration of different pesticides ranging from 0 to 0.45 μg/L in ground water samples. Among targeted pesticides in this study, only one organochlorine chemical namely endosulphan was studied, which occurred in more than 30% of samples and ranged from 0.0 to 0.02 μg/L. This study reflected the use of high doses of pesticides in tobacco fields (8–10 sprays on each crop), which may reach the groundwater by infiltration of these chemicals into deep soil due to heavily rainfall (Ahad et al. 2000; Tariq et al. 2004).

OCPs (DDTs in particular), are still in use for sanitation campaigns against vector borne diseases in developing

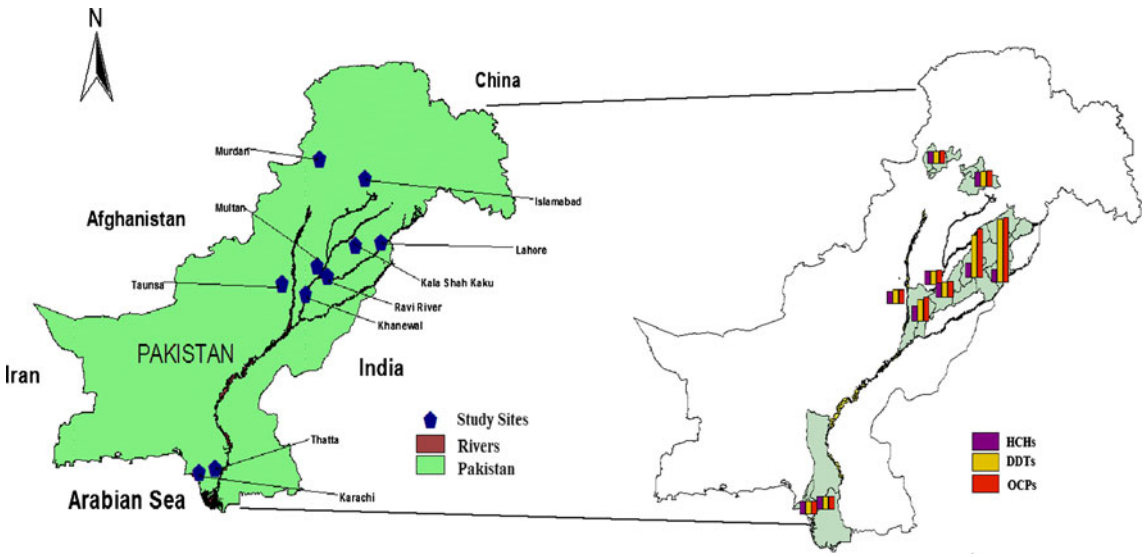

Fig. 1 The study locations discussed in the article along with the contribution of OCPs

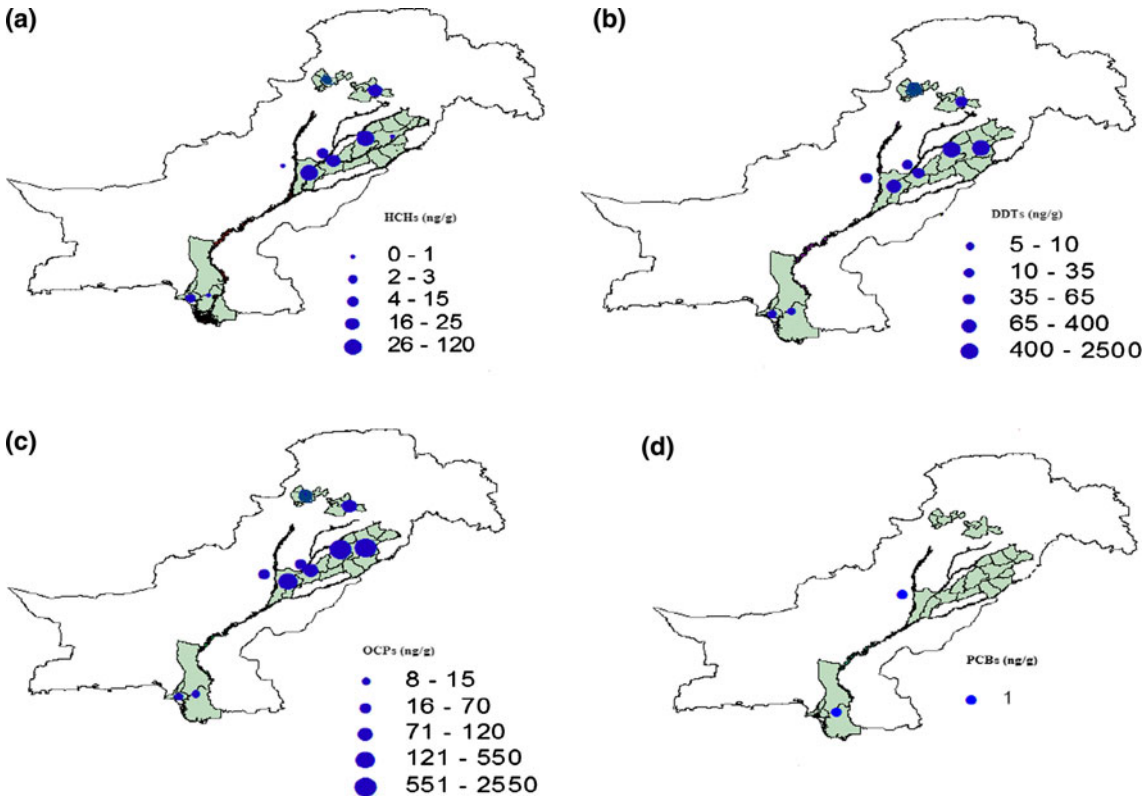

Fig. 2 (**a**) HCHs, (**b**) DDTs, (**c**) $\sum$OCPs and (**d**) PCBs levels in the different country parts

countries including Pakistan, where its illegal use cannot be ignored (Malik et al. 2011). On the other hand, large quantities of obsolete pesticides are also stored at many locations in the country, which resulted in the contamination of different environmental matrices including; water, sediment, and biota (Eqani et al. 2011). Asi et al. (2008) reported the existence of DDTs and its metabolites in the water samples collected from different areas of Punjab province. The DDTs and its metabolites (17–1,006 ng/L) were found frequently in all the collected samples from all the sampling locations. The high concentration of DDTs metabolites in this study reflected the historical use of DDTs in the different areas of Punjab, Pakistan. Few samples collected from district Khanewal, a cotton growing

Table 1 Organochlorines contamination (μg/L) in the surface/ground water collected from the different area of Pakistan (1990–2010)

Sampling location	Water type	No. of samples	β-HCH	γ-HCH	BHC	Heptachlor	Endrin	Dieldrin	DDE	DDD	DDT	Reference
Karachi	Surface water	79			Traces-16.7				Traces		Traces	Parveen and Masud (1988a)
Faisalabad	Shallow ground water	10					0.1–0.2					Jabbar et al. (1993)
Mardan	Ground water	12										Ahad et al. (2000)
Multan	Ground water	12		0.0–0.11								Ahad et al. (2001)
Punjab, Districts	Ground water	37										Tariq et al. (2004)
Punjab, Districts	Surface and ground water	21							0–0.72	0–0.82	0–1.06	Asi et al. (2008)
NWFP, Nowshera.	Surface and ground water	9									70–400	Jan et al. (2009)
Obsolete Pesticides, Pakistan	Surface and ground water	33	0.09	0.16		0.02–0.17	0.05	0.06	0.04	0.03	0.06–0.11	Ahad et al. (2010)
Rawal Lake, Islamabad	Surface water								0	0.8–2.39	0.96–2.87	Iram et al. (2009)

area, showed highest values of p, p'-DDT (>1,000 ng/L), which is about ten times more than the allowable limits set by USEPA and European Union. Ahad et al. (2010) collected water samples in different areas of country near obsolete stores and reported large concentration of OCPs (μg/L) ranging from 0 to 15.7 (median; 0.29), 0.25 to 0.78 (median; 0.36), and 0.11 to 0.83 (median; 0.21) for KPK, Punjab, and Sindh provinces, respectively. Maximum concentrations (15.7 μg/L) were found in the samples collected from Amangrah demolished DDTs manufacturing unit, which resulted in the sever contamination of DDTs of surrounding areas. Generally, OCPs were mainly imported from Europe to Pakistan, but to meet the local demands of DDTs, it was also produced locally in different parts of country. Some manufacturing units are reported in KPK (Nowshera), Punjab (Lahore), and Karachi (Tariq et al. 2007). After ban on the production and use of DDTs in world, these manufacturing units have been demolished in Pakistan and huge quantities of DDTs and some other pesticides were dumped in the surrounding. On the other hand, improper storage and handling of abandoned pesticides in such demolished unit had resulted greater chances of risk of contamination. Jan et al. (2009) documented such worst situation in the surrounding area of a demolished factory in Nowshera. In this study, nine samples were analyzed for DDTs contamination and concentration ranged from 70 to 400 μg/L. By comparing such high concentration with other studies conducted nearby demolished factories (Asi et al. 2008; Ahad et al. 2010), clearly indicated that the results reported by Jan et al. (2009) are extremely high and do not agree with other studies.

Intensive farming activity, rapid urbanization, and indiscriminant industrialization are well documented as significant sources of contamination of organochlorines in the natural aquatic system (Malik et al. 2011; Syed and Malik 2011). Industrial based chemicals including PCBs, PBDEs, and PAHs may contaminate the freshwater ecosystem by surface run-off from contaminated land, atmospheric deposition, and open dumping of municipal waste (Farooq et al. 2011). In Pakistan, only one study is reported on the OCPs contamination in the freshwater ecosystem of Pakistan. In this study Iram et al. (2009) recorded the huge concentrations of p, p'-DDT (0.96–2.87 μg/L) and DDD (0–2.5 μg/L) from the Rawal and Simbly lakes located in Islamabad. Such high concentration reflected recent as well as historical use of DDTs in the vicinity.

Organochlorines contamination in the Sediments/Soils from Pakistan

A large number of studies have been documented in the different parts of the world on the organochlorine-contaminated

sediments, because of their potential for various biological effects such as teratogenicity, carcinogenicity, neurotoxicity and immunotoxicity (Eqani et al. 2011). In Pakistan, only few studies reported the status, distribution, and sources of organochlorine contaminants in soils and sediments collected from different locations of the country (Table 2).

During 1991, first systematic study was conducted by Bano and Siddique which documented the concentration of some OCPs (Table 2) in sediments collected from Karachi coastal area. Trends of detected OCPs in sediments of coastal area were followed as: dieldrin > DDT > heptachlor > β-HCH > DDE. The samples were collected from five sampling stations viz: Karachi, Korangi, Creek area, Hawksbay, and Manora channel, with highest concentration measured from sediments of Hawksbay and Korangi. The authors suggested main sources associated with agriculture runoff and indiscriminant industrial activities. Moreover, upstream flow of polluted water from different rivers of Pakistan, which pass through different agricultural and industrial area of the country, may carry the contaminated sediment and resulted in the high levels of these pesticides in the coastal area (Eqani et al. 2011; Malik et al. 2011). Another study by Jabbar et al. (1993) also reported similar results as reported by Bano and Siddique (1991). In this study the samples were collected from cropland of KPK province and results showed the highest concentrations of dieldrin (3.1–9.6 ng/g) as compared to any other OCPs measured in the study (Table 2). In KPK huge quantities of pesticides are sprayed on different crops (tobacco, maize, sugarcane etc.) from many years and also reported in different environmental compartments including surface and ground water, soil and biota (Ahad et al. 2001; Tariq et al.2007). In present study, authors suggested that huge concentration of dieldrin and other OCPs (especially DDT metabolites) may be originated from agricultural wide scale usage of these chemicals.

Pakistan exhibits diverse climatic conditions and is enriched with plenty of freshwater resources. Rivers, canals, streams, and dams are the major water resources in Pakistan, which irrigate most of the cropland and are used for drinking purposes (Eqani et al. 2011). Streams locally known as "nullahs" which feed the main rivers and flow through alluviul plains of the country. These streams are very important especially in flooding season, as these local nullahs collected rain water from plains of Pakistan, which used for irrigation purposes. However, these nullahs receive large amounts of industrial and municipal effluents without prior treatment from different small industrial and municipal drains, resulted in the degradation of natural aquatic ecosystem including streams and Rivers (Malik and Nadeem 2011). Nullah Dehg, an important water

Table 2 Organochlorines contamination (ng/g) in the surface sediment/soil collected from the different area of Pakistan (1990–2010)

Sampling location	HCHs	HCB	Heptachlor	Hepta.Epoxide	Endrin	Dieldrin	DDE	DDD	DDT	PCBs	References
Coastal area, Karachi	1.1–3.5		2.7–9.2			0.5–12.5	0.06–0.16		2.7–9.2		Bano and Siddique (1991)
Cropland Soils					0.2	3.1–9.6	0–2	2	0–0.2		Jabbar et al. (1993)
Degh Nullah, Lahore	Traces	0.1–94					0.8–82	181–2032	62–2041		Tesheen et al. (1994)
Haleji lake, Thatta, Sindh		0.4–1.7							0–6.5	Traces	Sanpera et al. (2002)
Taunsa barrage										0.3–0.9	Sanpera et al. (2003)
Rawal Lake, Islamabad	0–19.5			0–16.13	0		0–32.4	0–35.8	0–42.2		Malik et al. (2011)
River Chenab, Pakistan	0–9.2		0–41.6	0–11.3			0–14	0–19.1	0.20		Malik et al. (2011)
River Ravi, Pakistan	0–8.3		0–42.3	0–13.2			0–24.5	0–19.4	0–28.1		Malik et al. (2011)
Kala Shah Kaku soil	0–119		0–31		0–114	0–7.6	47–146	55–212.5	0–1537.9		Syed and Malik (2011)
River Chenab, Pakistan	2.06–18.15								7.64–59.88		Eqani et al. (2011)

feeding tributary of the River Ravi located near Lahore, receives industrial waste from different industrial areas which deteriorates the quality of this stream. Tehseen et al. (1994) collected sediment samples from Dehg Nulla Lahore to present the contamination status of OCPs and reported highest concentrations of DDTs(62–2041 ng/g), DDD (181–2032 ng/g), DDE(0.8–82 ng/g). The values of DDTs recorded in this study were higher in comparison to literature reported throughout the world. The authors suggested sources from DDT- formulation factory in vicinity of the sampling area (Kala Shah Kaku), from where DDT entered into the Nullah (stream) system by surface runoff. The manufacturing unit was established at Ittehad Pesticides in 1973. This industry was later on merged into Ittehad Chemical Industries Kalashah Kaku, Lahore. The annual production of 2,020 metric tons per year when it was operational. The liquid and powdered DDT products of the industry were used for various anthropogenic activities i.e. to kill insects and in particular to the agricultural activities. In 1994, this manufacturing unit of DDT was closed, as use of OCPs was banned in all over the world. However, the industry is still in operation and most surprisingly thousands kilograms of the chemical residues were dumped off in the surrounding soils of Ittehad Chemical Industries. Amount of OCPs residues are still present in higher concentrations at the dumping sites in the surrounding areas of the industry. A recent study by Syed and Malik (2011) reported very high concentrations of DDTs and other OCPs including HCHs and cyclodiens (Table 2) in the surrounding area of this factory. This recent study by Syed and Malik (2011), when compared with OCPs-contaminated data reported by Tehseen et al. (1994), clearly indicated that results of latter study is conflicting and extremely high than the recent data. Probably, in 1994 this unit was active and such high concentrations reflected the dumping of the waste of this factory.

On the other hand, Pakistan holds largest stockpiles of OCPs with thousand kilograms of DDTs in chemical warehouses located in different parts of country (Jan et al. 2009). Due to improper storage and rough handling, most of the containers are damaged, sacks are rotten, metal drums are corroded, and pesticides are leaked out or continuing to leak, which resulted in the contamination of different environmental media including; water, sediment, and biota (Eqani et al. 2011). A study by Ahad et al. (2010) reported on the concentration and distribution pattern of OCPs in soil and water samples collected from obsolete pesticide stores in three provinces of Pakistan. The results clearly indicated that soil samples mainly contained DDTs followed by lindane and heptachlor. The contamination levels for KPK, Punjab, and Sindh provinces were in range of 247–9,157, 214–10,892 and 86–1,139 mg/kg, respectively. This study evidently indicated the alarming situation regarding the contamination of toxic chemicals, which may result in the sever contamination of other environmental media including ground water, vegetation, etc. This study also stresses the urgent need to control the emission of these pesticides in the surrounding environment of these chemical warehouses.

Sanpera et al. (2002) measured considerable levels of OCPs in the sediment collected from Haleji Lake and Thatta (Sindh) ranged from 0 to 10 ng/g. Among OCPs, DDTs (0–6.5 ng/g) were found predominately in all the sediments samples followed by HCB (0–2.5 ng/g). This study indicated intensive agricultural activity in the surrounding areas as an important source of the OCPs in the study sites. However, upstream flow of industrial chemicals along with municipal waste can also be suspected to contribute towards sources of studied chemicals in the current study. This study is unique as this is first and last study till date which reported on the presence of PCBs in the sediments of Pakistan (Haleji Lake and Thatta (Sindh).

More recently, a comprehensive study by Eqani et al. (2011) provided the first systematic data on the distribution of OCPs in sediments of River Chenab, Pakistan. The authors highlighted OCPs contamination is one of the important environmental issues due to excessive use of these pesticides in agriculture and industrial sector. A selected river stretch of 200 km was monitored during two sampling seasons (summer and winter, 2007–2009). DDTs, HCHs, heptachlor and dicofol were the dominant OCPs detected in the sediments of River Chenab. High concentration of p, p'-DDT (7.5–53.6 ng/g) in sediments in both monitoring seasons, reflected the recent use of parent DDT compound while presence of DDD (5.3–22.8 ng/g) and DDE (9.5–22.9 ng/g) in most of the sediment samples suggested its contamination mainly from aged agricultural soils. Besides the predominance of DDTs, heptachlor was also measured in huge concentration and ranged from 14.3 to 35.8 ng/g. The authors highlighted that sources of OCPs contamination mainly related to agricultural and industrial activities in the study area. Another study by Malik et al. (2011) also documented the OCPs contamination in sediments of three water bodies of Pakistan Viz; River Chenab, River Ravi, and Rawal Lake. Overall pattern of detected OCP residues in sediments from three locations was in the order: Rawal Lake Reservoir > River Ravi > River Chenab. Residual concentrations of DDT metabolites (N.D. −64.6 ng/g) were higher when compared to its isomers (N.D. −42.4 ng/g), showing both recent and historical use of this chemical. The results of DDTs concentration were also comparable with above mentioned study of Eqani et al. (2011), which was carried out in the same study area. Greater concentration of DDD, DDE, and p, p'-DDT was measured in sediments collected from Rawal Lake Reservoir, which is located in the capital city of Islamabad.

Greater concentrations of DDTs are suspected to come in the sediment of Rawal Lake from nearby health center namely NIH, where these chemicals were extensively used and stored in past to eradicate the malarial infection. Among DDT isomers, residual concentration of *p*, *p*′-DDT was more prevalent, which reflected the current input of this chemical in the fresh water reservoir. HCHs exhibited highest concentration in River Ravi and the sediments collected from River Chenab were also shown considerable levels of OCPs. Both of the monitoring sites on River Chenab and River Ravi in this study were located in district Khanewal, which is famous cotton growing area in the country. The results reported by Malik et al. (2011) can be justified by the fact that huge pesticides application are reported in this area, which ultimately entered the River's sediment by surface runoff from surrounding contaminated land (Farooq et al. 2011).

Organochlorines Residues in the Biota from Pakistan

Organochlorines contamination in various food commodities from Pakistan have been reported including milk (Parveen and Masud 1988b), fruits and vegetables (Masud and Hassan 1995; Hussain et al. 2002). Few studies also reported the residues of organochlorines (OCs) in blood serum and fat samples in residents of the Balochistan, Sindh and Punjab Provinces (Naqvi and Jahan 1999; Parveen and Masud 2001) and they have also correlated higher incidence of cancer rate in Pakistan during the years 1994–2002. In another study, Pesticide Poisoning Center, Nishtar Hospital, Multan, Pakistan (Ahmad et al. 2002) have registered 370 patients that were pesticide victims (73% males and 27% females). Exposure to OCs associated with fish consumption contributed large percentages (67% of chlordane and 60% of PCBs) in the total exposure from all foodstuffs (Dougherty et al. 2000). However, to our knowledge, only few studies were reported on organochlorine-contaminated fish from different water bodies of Pakistan. Munshi et al. (2004) reported the Organochlorine accumulation in marine water of Pakistan. This study was carried out at Karachi coastal area including Korangi creek, Bulleji, Manora channel, Keamari and Ghas bunder harbor and two edible fish species (Mugil and Mushka) were analyzed. Generally, the trends of organochlorine chemicals in this study were followed as: DDT (100 $\mu g\ g^{-1}$ lipid wt.) > PCBs (80 $\mu g\ g^{-1}$ lipid wt.) > Cyclodiens (30 $\mu g\ g^{-1}$ lipid wt.) > HCHs (5 $\mu g\ g^{-1}$ lipid wt.). DDTs concentration (up to 309 $\mu g\ g^{-1}$ lipid wt.) in fish samples (n = 155) were relatively high but these concentration are still lower than highly contaminated coastal areas of the world. The authors suggested that both urban and industrial activities in vicinity of Karachi harbor are the major sources of pollution. Another study by Saqib et al. (2005), also reported the contamination of organochlorines in the muscle, liver, and gills of the fish (three Labeo species) collected from Kalri and Haleji lakes, Pakistan. These results are consistence with other studies conducted in the region (Sanpera et al. 2002), showed the dominance of DDTs in all the samples. Some other OCPs including dieldrin and aldrin were also detected in some of samples, and authors described that agricultural runoff from surrounding cropland is the main source of pollution in this area.

Colonial water birds at the upper level of the food chain make them a suitable indicator of persistent organic environmental contamination (Sanpera et al. 2002; Malik et al. 2011) and have been suggested as useful organisms for monitoring POPs. Ardeidae are important indicators of environmental degradation caused by toxic chemicals in wetlands, and there are only a few studies in Pakistan that use colonial water birds as an ecological indicator of OCP contamination. Information on organochlorine contamination of Ardeidae in Pakistan is rather limited. Example, (Sanpera et al. 2002) measured POPs in eggs of little egrets from selected wetlands of Pakistan.

This study documented the biomagnification of organochlorine in the food web of Pakistan and showed very high levels of DDTs (mean; 750 ng/g; lipid wt.) in the prey and eggs samples of Bubulcus ibis (Cattle egrets). Another recent study by Malik et al. (2011) is extremely important and evidence of the bioaccumulation of these OCPs (especially DDTs) in the food web of Pakistan by using Bubulcus ibis (Cattle egret), a water colonial bird, as bioindicator. DDT residues can cause both acute and chronic health disorders including thinning of eggshells and reduction of hormonal level necessary for female birds to lay eggs. DDT may cause direct mortality of birds by directly affecting the nervous system even in birds like robins that feed relatively low on the food chain (Burger et al. 2007; Malik et al. 2011).

Conclusions and Recommendations

This review documented the studies conducted in Pakistan on OCPs in water, sediments/soils and biota, which accounted DDTs as dominant and primary contaminant and minor contribution of HCHs and other. In Pakistan little documented information is available on PCBs contamination in different environmental matrices. The results drew attention that POPs contamination must be considered as an important environmental issue due to their excessive use in agricultural and industrial sector. Detailed studies related to monitoring, assessment, distribution trends, sources identification and ecotoxicological effects on biological organisms are urgently required.

References

Ahad K, Anwar T, Ahmed I, Mohammad A, Tahir S, Aziz S (2000) Determination of insecticide residues in the ground water of Mardan Division, NWFP, Pakistan; a case study. Water SA 26:409–412

Ahad K, Hayat Y, Ahmad I, Soomro MH (2001) Capillary chromatographic determination of pesticides residues in groundwater of Multan Division. Nucleus 38:145–149

Ahad K, Mohammad A, Mehboob F, Sattar A, Ahmad I (2006) Pesticide residues in Rawal Lake, Islamabad, Pakistan. Bulletin of Environ Contam Toxicol 76:463–470

Ahad K, Mohammad A, Khan H, Ahmad I, Hayat Y (2010) Monitoring results for organochlorine pesticides in soil and water from selected obsolete pesticide stores in Pakistan. Environ Monit Assess 166:191–199

Ahmad R, Ahad K, Iqbal R, Muhammad A (2002) Acute poisoning due to commercial pesticides in Multan. Pak J Med Sci 18:227–231

Asi MR, Hussain A, Muhmood ST (2008) Solid phase extraction of pesticide residues in water samples: DDT and its metabolites. Int J Environ Res 43–48

Bano A, Siddique SA (1991) Chlorinated hydrocarbons in the sediments from the coastal waters of Karachi (Pakistan). Pak J Sci Ind Res 34:70–74

Burger J, Fossi C, McClellan-Green P, Orlando EF (2007) Methodologies, bioindicators and biomarkers for assessing gender-related differences in wildlife exposed to environmental chemicals. Environ Res 104:135–152

Dougherty CP, Holtz SH, Reinert JC, Panyacosit L, Axelrad DA, Woodruff TJ (2000) Dietary exposures to food contaminants across the United States. Environ Res 84:170–185

Eqani SAMAS, Malik RN, Mohammad A (2011) The level and distribution of selected organochlorine pesticides in sediments from River Chenab, Pakistan. Environ Geochem Health 33:33–47

Farooq S, Eqani SAMAS, Malik RN, Katsoyiannis A, Zhang G, Zhang Y, Li J, Xiang L, Jones KC, Shinwari ZK (2011) Occurrence, finger printing and ecological risk assessment of polycyclic aromatic hydrocarbons (PAHs) in the Chenab River, Pakistan. J Environ Monit 13:3207–3215

Hussain S, Masud T, Ahad K (2002) Determination of pesticides residues in selected varieties of mango. Pak J Nutr 1:41–42

Iram S, Ahmad I, Ahad K, Muhammad A, Anjum S (2009) Analysis of pesticides residues of Rawal and Simly Lakes. Pak J Bot 41(4):1981–1987

Jabbar A, Mausad ParveenZ, Ali M (1993) Pesticide residues in cropland soils and shallow ground water in Punjab Pakistan. Bull Environ Contam Toxicol 51:268–273

Jan MR, Shah J, Khawaja MA, Gul K (2009) DDT residue in soil and water in and around abandoned DDT manufacturing factory. Environ Monit Assess 155:31–38

Khawaja MA (2003) Polychlorinated biphenyls (PCBs) problem in Pakistan. SDPI Res News Bull (May–June 2)

Malik RN, Nadeem M (2011) Spatial and temporal characterization of trace elements and nutrients in the Rawal Lake Reservoir, Pakistan using multivariate analysis techniques. Environ Geochem Health 33:525–541

Malik RN, Rauf S, Mohammad A, Eqani SAMAS Ahad K (2011) Organochlorine residual concentrations in cattle egret from the Punjab Province, Pakistan. Environ Monit Assess 173:325–341

Masud SZ, Hassan N (1995) Study of fruits and vegetables in NWFP, Islamabad, and Balochistan for organochlorine, organophosphorus and pyrethroids pesticides residues. Pak J Sci Ind Res 38:74–80

Munshi AB, Detlef SB, Schneider R, Zuberi R (2004) Organochlorine concentrations in various fish from different locations at Karachi Coast. Mar Pollut Bull 49:597–601

Naqvi SNH, Jahan M (1999) Pesticide residues in serum and blood samples of the people of Karachi. J Environ Biol 20:241–244

Parveen Z, Masud SZ (1988a) Organochlorine pesticide residues in cattle drinking water. Pak J Sci Ind Res 31:53–56

Parveen Z, Masud SZ (1988b) Monitoring of fresh milk for organochlorine pesticide residues in Karachi. Pak J Sci Ind Res 31:49–52

Parveen Z, Masud SZ (2001) Studies of pesticide residues in human blood. Pak J Sci Ind Res 44:137–141

Sanpera C, Ruiz X, Llorente GA, Jover L, Jabeen R (2002) Persistent organochlorine compounds in sediment and biota from the Haleji lake: a wild life sanctuary in south Pakistan. Bull Enviro Contam Toxicol 68:237–244

Sanpera C, Ruiz X, Lorente GA, Jover L, Jabeen R, Muhammad A (2003) Persistent organic pollutants in little egret eggs from selected wetlands in Pakistan. Arch Environ Contam Toxicol 44:360–368

Saqib TA, Naqvi SN, Siddiqui PA, Azmi MA (2005) Detection of pesticide residues in muscles, liver and fat of 3 species of Labeo found in Kalri and Haleji lakes. J Environ Biol 26:433–438

Syed JH, Malik RN (2011) Occurrence and source identification of organochlorine pesticides in the surrounding surface soils of the Ittehad Chemical Industries Kalashah Kaku Pakistan. Environ Earth Sci 62:1311–1321

Tariq MI, Afzal S, Hussain I (2004) Pesticides in the shallow water table areas of Bhawalnagar, Muzafarghar D.G.Khan and Rajanpur Districts of Punjab. Environ Int 30:471–490

Tariq MI, Afzal S, Hussain I (2006) Degradation and persistence of cotton pesticides in sandy loam soils from Punjab, Pakistan. Environ Res 100:184–196

Tariq MI, Afzal S, Hussain I, Sultana N (2007) Pesticides exposure in Pakistan: a review. Environ Int 33:1107–1122

Tehseen WM, Hansen LG, Wood SG, Hanif M (1994) Assessment of chemical contaminants in water and sediment samples from Degh Nala in the province of Punjab, Pakistan. Arch Environ Contam Toxicol 26:79–89