Asian Journal of Water, Environment and Pollution, Vol. 6, No. 1, pp. 89-96.

Pesticide Pollution in Punjab: A Review

N.S. Tiwana, Neelima Jerath*, Gurharminder Singh and Ravleen Singh

Punjab State Council for Science & Technology MGSIPA Complex
Sector 26, Post Box 727, Chandigarh-160019, India
✉ neelimakj@yahoo.co.uk

Received July 21, 2006; revised and accepted November 12, 2007

Abstract: The use of chemical pesticides in the country has increased by more than seventeen times since 1955. The state of Punjab is one of the highest user of these pesticides especially after the ushering in of green revolution. Though the state has only 1.5% landmass of the country, it consumes about 17% of pesticides used in India. The per hectare pesticide use is highest in Punjab (923 g/ha) as compared to other agriculturally advanced states like Haryana, Andhra Pradesh, Tamil Nadu, Karnataka and Gujrat. Although the use of pesticides has helped to enhanced economic gains through crop protection yet they have had serious implications to human health and non-target plants and animals by accumulating in food and water. The present paper reviews various studies carried out in Punjab on the pesticide residues found in different food items (like wheat flour, human milk, vegetables, etc.) and their effect on human health.

Key words: Pesticides, residues, DDT, BHC/HCH, agriculture.

The application of increased amounts of pesticides has reached dangerous levels since the advent of green revolution in Punjab. The gains resulting from the use of chemical inputs, because of their ability to kill potential disease causing organisms and control insects, weeds, and other pests, however, have not been without their consequent environmental impacts. The excessive and non-judicious use of these chemicals (especially pesticides) has led to environment degradation through air, water and soil pollution.

Since pesticides/insecticides/herbicides are designed to kill or adversely affect living organisms, by their very nature, they pose risk to humans, non-target plants and animals. They not only contaminate the ecosystem but also bioaccumulate in the food chain and can be traced in plant and animal tissues causing serious health hazards. As per World Health Organization estimates pesticides lead to one million pesticide poisoning cases and 20,000 deaths every year globally.

*Corresponding Author

The broad classification of pesticides based on their composition is given in Figure 1. In India, the use of chemical pesticides is more prevalent.

Indian Scenario

Pesticide consumption in India has increased from 2353 MT in 1955 to 40,672 MT in 2005 for technical grade chemical pesticides. In March, 2005, 186 technical grade pesticides were registered in the country for use under section 9(3) of Insecticides Act, 1968. (Directorate of Plant Protection and Quarantine, Govt. of India). Indian pesticide industry has achieved the status of second largest basic pesticide manufacturer in Asia after Japan.

Interestingly, India's consumption of pesticides per hectare is low (0.5 kg/ha) when compared with world averages like those of Korea (6.60 kg/ha) and Japan (12.0 kg/ha).

According to the pesticide industry statistics, India spends only $3/ha on pesticides compared to $24/ha spent by the Philippines, $255/ha by South Korea and $633/ha by Japan (TERI, 2000). However, the contamination of

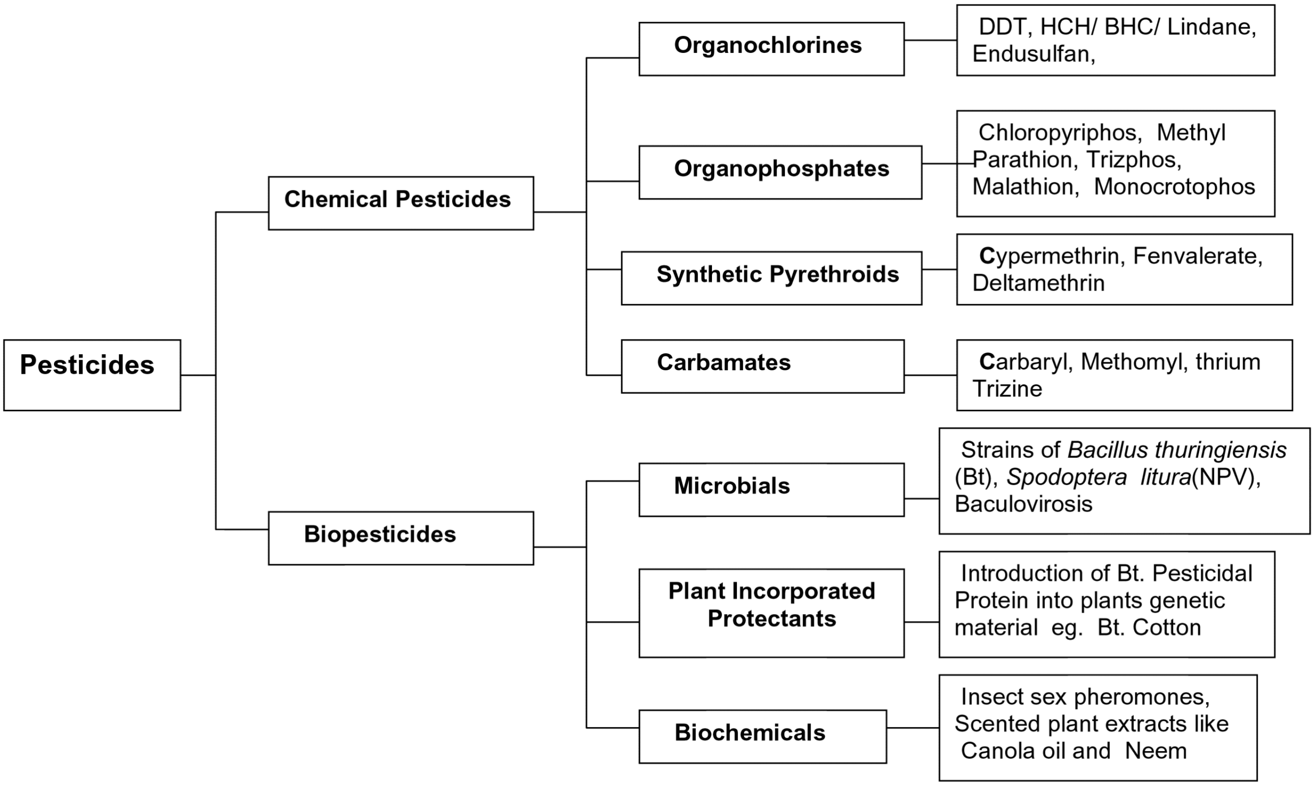

Figure 1: Classification of pesticides.

food products in the country is alarming. About 20% of Indian food products contain pesticide residues above tolerance level compared to only 2% globally (TERI, 2000). This is primarily due to their non-judicious use in certain areas/states, lack of awareness and inadequate information dissemination amongst the farming community.

Pesticide usage for cultivation of food crops amongst different states of India indicates a mixed pattern. The per hectare pesticide usage is highest in Punjab (923 g/ha) as compared to other agriculturally advanced states like Haryana (843 g/ha), Andhra Pradesh (548 g/ha), Tamil Nadu (410 g/ha), Karnataka (216 g/ha) and Gujarat (47 g/ha) (Agnihotri, 2000).

Punjab State Scenario

Punjab has made a commendable progress after Green Revolution. The food grain production has increased from 3.16 million tons in 1960-61 to 24.48 million tons in 2002-2003 (Deptt. of Agriculture, Govt. of India). Whereas the initial increase in production was mainly due to increase in the area under cultivation, a spectacular rise of 16.18 million tons from 1971 to 2003 can be largely attributed to intensive use of inputs like fertilizers, pesticides and mechanization of farming.

Though the state has only 1.5% landmass of the country, it consumes about 17% of pesticides used in India. Further, the consumption has increased from 3300 MT in 1975 to 6900 MT in 2005 for technical grade chemical pesticides (Figure 2). Out of these, >90% of the pesticide are being used in cultivation of cotton, rice and vegetables (Singh, 2002). The Malwa region (cotton belt) accounts for nearly 75% of pesticides used in the state.

Although pesticides have played a key role in making Punjab "the food bowl of the country", the ubiquitous presence of pesticide residues in the biotic and abiotic environment is a matter of serious concern.

Pesticide Residue Studies

In the 1960s, Rachel Carson's publication "*Silent Spring*" prompted worldwide concern about the damage caused by chemical pesticides on human life and on the environment (Carson, 1962). Since then several scientific studies have been conducted by various researchers, Government and Non-government organizations, on pesticide residues in the environment and food products.

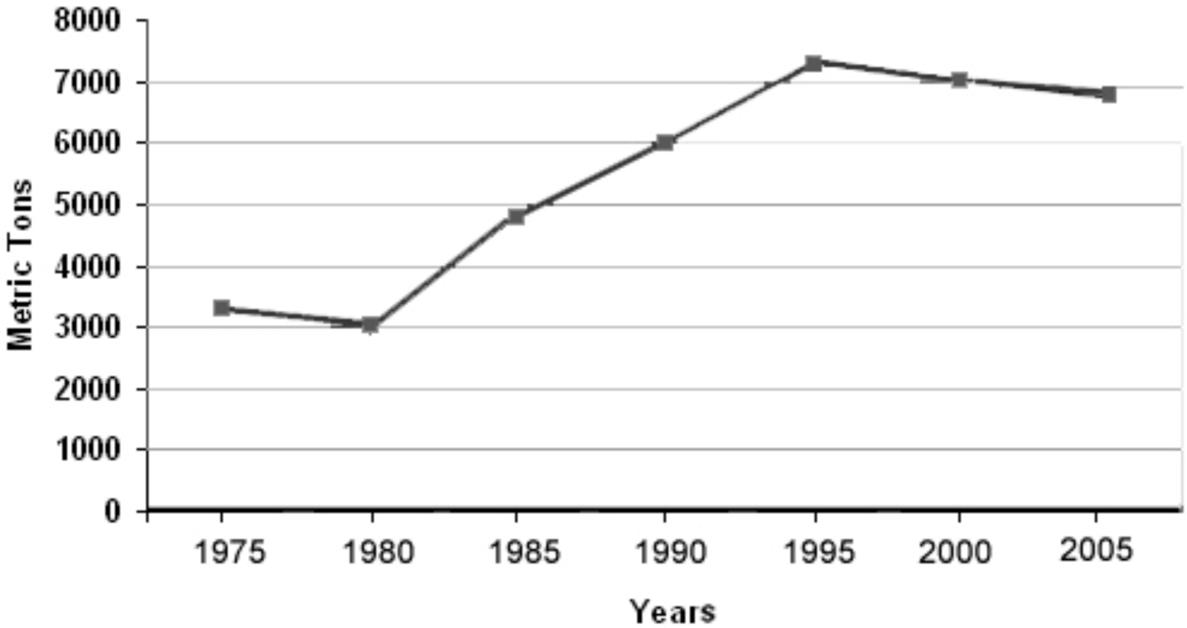

Figure 2: Consumption trend of pesticides in Punjab.
Source: Directorate of Plant Protection and Quarantine, Govt. of India.

Results indicate residues of chemical pesticides in human beings, milk, water, vegetables and other food products at levels, which are dangerous for human health. The results of the studies conducted within the Punjab state are briefly discussed below.

A study on "Residues of DDT and HCH/BHC in Wheat Flour in Punjab" was conducted during 1974-76 by Joia et al. (1978*),* who collected 140 samples of wheat flour from seven cities. Residues of DDT (*dichlorodiphenyltrichloroethane*) and HCH (*hexa-chlorocyclohexane*) were detected in 124 and 116 samples respectively and in most samples simultaneously. Twenty seven samples showed DDT residues (p,p′-DDT and o,p′ -DDT) >1 µg/gm (WHO permissible residue limit in cereals is 0.1 µg/gm). The maximum being 10 µg/gm in one sample from Jalandhar. However, the residues of HCH/BHC were found to be higher than DDT. The highest level (12 ppm) was found in a sample from Chandigarh (WHO permissible residue limit of HCH/ BHC in cereals is 0.1 µg/gm). The study indicated the possibility of DDT contamination of wheat through sources other than direct admixture with grains, whereas for HCH/BHC residues, it suggested mixing of HCH with wheat grains during storage as one of the main reasons. The investigators also calculated the daily intake of DDT and HCH/BHC for a man weighing 50 kg to be 120 µg DDT and 300 µg HCH/BHC respectively through the contaminated wheat flour. This alone constituted about 40% of the "Acceptable Daily Intake" (ADI) of 0.005 mg/kg/day of DDT (Anonymous, 1972). This was much higher than the total dietary intake of DDT in USA (55 µg), UK (34 µg) and Spain (78.4 µg) (No ADI value for BHC/HCH residues is available). Similarly the daily intake of HCH/BHC was found to be higher than in the UK (17 µg). The authors also reported that both these insecticides are persistent and get stored in the adipose tissues of the human beings. The body burden of these insecticides above certain level may be hazardous to human health. The study urged for serious efforts to check the contamination of wheat with these insecticides.

Battu et al., in 1978 assessed the status and magnitude of pesticidial contamination in vegetable oils and oil seed cakes in Punjab (Battu et al., 1980). Forty three samples of mustard, groundnut, coconut, rapeseed, cottonseed, sesame seed and rice bran oil were obtained from selected markets of Ludhiana, Muktsar, Ferozepur, Sangrur and Khanna and analyzed. Results indicated presence of HCH residues (HCH-T) in all samples (mainly consisting of alpha and gamma isomers) traces of beta and delta isomers were also detected. Further, 70% of the samples contained DDT residues (p,p′-DDT, p,p′-DDE, o,p′-DDT and p,p′-TDE). Despite the wide occurrence of DDT and HCH residues in vegetable oils, no sample of popular brands of hydrogenated vegetable oil analyzed showed their presence, probably due to effect of processing. Further, analysis of 23 samples of oilseed cake intended for use as animal feed revealed much lower level of contamination.

In 1980, Kalra and Chawla reported "Occurrence of DDT and BHC (benzenehexa chloride) residues in human milk in India". Human milk samples from 75 lactating women in Punjab were collected within a week after delivery. Analysis indicated the presence of DDT and BHC residues in all samples. This was the first report on DDT and BHC/HCH residues in human milk in India. The mean level of DDT residue (0.51 mg/l) in Punjab was more than the level reported from USA, Canada, Europe and Australia, though the highest concentration was reported in Guatemala (4.07 mg/l). BHC/HCH residues were also reported to be higher than other countries (except Japan). DDT present at an average level of 0.5 mg/l in milk indicated an intake of 0.09 mg/kg/day of DDT, which is 18 times the ADI of 0.005 mg/kg/day recommended by WHO.

Large scale use of pesticides has also resulted in the development of pesticide resistance in various insects and pests. Shiva (1989) has reported that DDT induced pest increase could range from 36-1200 times. The insect pests which were considered insignificant in Punjab before the green revolution became major pests later on, which could be due to destruction of their natural enemies. She also reported 40 new insect pests and 12 new diseases in rice monoculture since the ushering of the green revolution in Punjab. The rice leaf folder (C*naphalocrocis medinalis*) was first recorded as minor infestation in 1964. However, later it appeared in the all rice growing areas of the state as a major pest and caused heavy losses in 1983. Lately, American bollworm (*Helicoverpa armigera*) of cotton has developed resistance to all the major groups of conventional pesticides (Dhaliwal et al., 2000).

Based on scientific studies and feedback from national and international agencies several general chemical pesticides and insecticides were banned/restricted in the state for use in agriculture (Tables 1 and 2).

Table 1: List of pesticides banned (Yearwise) for use in agriculture

Sr. No.	*Name of pesticide*	*Sr. No.*	*Name of pesticide*
1.	Dibromochloropropane (DBCP) (1997)	13.	Calcium cyanide (1995)
2.	Endrin (1997)	14.	Copper acetoarsenite (1995)
3.	Pentachloronitrobenzene (PCNB) (1998)	15.	Ethyl mercury chloride (1995)
4.	Pentachlorophenol (PCP) (1998)	16.	Menazon (1995)
5.	Toxaphene (1998)	17.	Sodium methane arsonate (1995)
6.	Ethyl parathion (1997)	18.	BHC/HCH (1997)
7.	Chlordane (1997)	19.	Phenyl mercury acetate (PMA) (1997)
8.	Heptachlor (1996)	20.	Nichotine sulphate (1997)
9.	Aldrin (1996)	21.	DDT (1989)
10.	Paraquat-di-methyl sulphate (1997)	22.	Chlorobenzilate (2003)
11.	Nitrofen (1997)	23.	Nicotine sulphate (1997)
12.	Tetradifen (1997)	24.	Phenyl mercury acetate

Source: PAU, 2004 & Central Insecticide Board, Govt. of India

Table 2: List of Pesticides restricted for use in agriculture in India

Sr. No.	*Name*	*Status*
1.	Aluminium phosphide	To be sold only to Government undertakings/organizations and used under strict supervision
2.	Captafol	Shall be used only as seed dresser. Foliar spray is banned.
3.	Dieldrin	Restricted for locust control in desert areas.
4.	Ethylene dibromide (EDB)	Restricted as fumigant for foodgrains through Central/State organizations.
5.	Methyl bromide	Restriction similar to aluminium phosphide.
6.	Sodium cyanide	Restricted for fumigation of cotton bales by Plant Protection Adviser, GoI.
7.	Lindane (HCH/BHC)	Formulations generating smoke for indoor use is prohibited. Can be used for field crops.
8.	Methyl parathion	Use permitted only on crops where honey bees are not pollinators
9.	Carbaryl	Not to be sprayed at flowering stage of crops.

Source: PAU, 2004

From 1991 to 1995, Chattopadhyay studied "Insecticide and pesticide pollution of food stuffs and their toxic effect on man" (Chattopadhyay, 1998). He reported more than 40 pesticides in use in agriculture in various districts of Punjab. Experimental samples were prepared by spraying various vegetables like cabbage, cauliflower, brinjal, etc., with pesticides like quinalphos, malathion, methyl carbaryl, phosphamidon, dimethoate, dichlorovos and phorate and exposed to various environmental conditions to determine their degradation time. He observed that persistence of the insecticides was temperature dependent. Whereas residues of malathion and quinalphos were observed even after one week when the temperature ranged between 15°C and 22°C, phosphamidon, dimethoate and dichlorovos were detected only upto 4/5 days, when temperature range was 30.8° to 42.6°C. The investigator recommended atleast 10 days gap between last application of the pesticide on crop and its harvest. In the blood samples obtained from Patiala region, α and β isomers of BHC/HCH within ranges of 1.80-5.28 ppb and 1.28-3.12 ppb respectively, were detected. In the blood samples of people involved directly in spraying operations, pesticides residues were found in higher ranges eg. methyl parathion was detected in the range of 17.56-17.94 ppb, quinalphos at a level of 5.30 ppb and malathion at a level of 7.62 ppb.

Chahal et al. (1999) also investigated the levels of insecticide residue in vegetables from 1991 to 1997 in their study, "Monitoring of farmgate vegetables for insecticide residues in Punjab". They collected 197 samples of various vegetables from farmer fields when these were ready for transportation to the market. Fiftythree samples were collected during 1991-93, while 96 during 1994-96 and 48 during 1997-98. Results indicated that 45 out of 65 samples of Brinjal were contaminated with different insecticides and 24 of these contained residues above their maximum residue limits (MRLs). In case of cabbage, 25 samples were found to be contaminated with monocrotophos, methyl parathion, quinalphos, chloropyriphos, cypermethrin, fenvalerate, deltametrin and endosulfan. Out of these, 19 samples contained insecticides above MRL values. Seven out of 17 okra samples were contaminated with methyl parathion, quinalphos, monocrotophos, triazophos, chloropyriphos and fenvalerate, though none exceeded their respective MRLs. Three out of five samples of potato contained residues of dichlorovos above its MRLs of 0.5 mg/kg. Residues of phosphamidon in one and quinalphos in two samples of tomato out of 25 samples were found to exceed their respective MRLs. All the samples were also analysed for the presence of DDT and HCH/BHC residues; however, their residues were below the detection limit of 0.001 mg/kg during 1996-98. This may be attributed to their ban in agriculture. The study revealed that 70% of vegetables were contaminated with different insecticides and about 27% of samples contained residues above their respective MRLs. The authors observed that farmers were not adhering to recommendations of Punjab Agricultural University and suggested periodic monitoring of vegetables to ensure that timely preventive measures are adopted.

In 2002, Balwinder Singh compared pesticide residues in food products during 1976 -1996 with 1996-2001 in Punjab (Singh, 2002). The results are summarized in Tables 3 and 4. Data indicate that whereas between 1976 and 1996 major pesticide residues were DDT and BHC/HCH, the trend shifted to other organic pesticides thereafter, especially due to ban on use of DDT in agriculture. However, HCH/BHC was still used on cereals (with 97% rice samples indicating contamination). Further, the percent contaminated samples of fruits and vegetables also increased to 85% and 71% during 1996 to 2001 against 38.3% and 43.7% respectively during 1976 to 1996, indicating their higher use in perishable, ready to market food products. The number of samples with pesticides residues above tolerance limits has also increased, which is a cause of concern. However, the contamination of milk and butter with DDT has distinctly reduced.

The fact that pesticides are affecting public health in Punjab has also been brought out by a study conducted by Kumar in 2005 in cotton belt of Malwa region. The study compared cancer incidence in Talwandi Sabo block with that in Chamkaur Sahib block (control area) in Punjab. Since more than half of the pesticides manufactured in the country are estimated to be used on cotton crop, the study tried to find out if cotton cultivation could be linked to cancer. 39,732 families comprising 183,243 people were surveyed in 129 villages of both the blocks. The number of age adjusted confirmed cancer cases in Talwandi Sabo block were 103/lakh compared to 71/lakh at Chamkaur Sahib. Further, cancer deaths/lakh/year were 52 in Talwandi Sabo block verses 30 in Chamkaur Sahib. Several factors like age, sex, sources of drinking water, usage of pesticides, tobacco chewing, non-vegetarianism, alcohol and smoking, and jaundice incidence were taken into account. Water and vegetable samples were analyzed during March to May 2004 from the study and control area. Heptachlor and malathion levels, both in tap and ground water in Talwandi Sabo, were reported to be higher than the permissible limit of 0.00003 mg/l and 0.0005 mg/l, respectively. However, this pesticide was

Table 3: Insecticide residues in different food and feed commodities in Punjab during 1976-1996

Commodities	*Samples*			
	Analysed	*Insecticides detected*	*Contaminated (%)*	*Above tolerance limits (%)*
Cereals	1088	DDT	87.4	15.8
		HCH/BHC	67.6	1.9
Fruits & Vegetables	183	DDT	38.3	Nil
		HCH/BHC	43.7	Nil
Milk	1110	DDT	97.7	41.0
		HCH/BHC	100.0	40.0
Butter	283	DDT	100.0	71.0
		HCH/BHC	100.0	Nil
Infant formula	54	DDT	100.0	Nil
		HCH/BHC	86.0	Nil
Animal Feed	228	DDT	100.0	35.0
		HCH/BHC	100.0	32.0

Source: Singh, 2002

Table 4: Insecticides residues in different food and feed commodities in Punjab during 1996-2001

Commodities	*Samples*			
	Analysed	*Insecticides detected*	*Contaminated (%)*	*Above tolerance limits (%)*
Rice	99	HCH/BHC	97.0	9.0
Fruits	27	Phosphamidon Quinalphos	85.0	11.0
Vegetables	147	Endosulfan, Quinalphos Chloropyrisphos, M. Parathion, Monocrotophos	71.0	18.0
Milk	92	DDT	2.2	Nil
		Lindane/HCH	53..2	53..3
Butter	16	DDT	75..0	Nil
		Lindane/HCH	31..3	Nil
Animal Feed	31	DDT	22.5	10.0
		HCH/BHC	77.5	Nil
		Malathion	38.5	Nil

Source: Singh, 2002

found absent/within permissible limits in Chamkaur Sahib and levels of heptachlor endoepoxide, á-endosulfan, á-HCH/BHC, ethion and chloropyrifos were found to be more in vegetables grown in Talwandi Sabo as compared with vegetable samples from Chamkaur Sahib. Chloropyrifos and ethion pesticide levels were found to be above the permissible limits (0.01 µg/gm and 1.0 µg/gm) in fruit samples also. Heptachor, aldrin and endosulfan were detected in blood samples taken from cancer patients from Talwandi Sabo and Chamkaur Sahib. Based on the above data, the report observed that, though it was difficult to pinpoint a single cause for cancer, a multi-pronged strategy to provide safe water supply and discouraging indiscriminate pesticide use needs to be adopted.

As reported by Tiwana et al. in 2005, the Punjab Pollution Control Board has also initiated studies on estimation of pesticide in river water since 2002. The results confirmed presence of pesticide residues in water and sediments of river Sutlej, Beas and Ghagger probably due to run off. Further, though DDT is banned in agriculture, since, this water is used for agriculture and human and cattle use, it could cause adverse health impacts.

A study conducted by Mathure et al. in 2005 on "Analysis of pesticide residues in blood samples from villages of Punjab" has found very high levels of pesticide residues in human blood samples that were taken from four villages in Bhatinda district and one village in Ropar district. Twenty randomly selected blood samples were tested for organochlorine pesticides, which showed 15 to 605 times higher residues as compared to samples of people in the United States. Six to 12 types of pesticide residues were found. The average levels of monocrotophos in the blood samples (0.095 μg/gm) were found to be four times higher than the short-term exposure limit for humans set by WHO and FAO. The study calls for large scale biomonitoring.

Sharma et al. in 2005 conducted a study in Jalandhar and Moga districts in order to find out the "Awareness level of the farmers regarding the implications caused due to excessive use of pesticides". Results indicate that 28% of the respondents were not aware about instructions written on pesticide containers, 64.5% respondents were not aware about recommended dose of inputs, 48.5% respondents were unaware of the need to keep pesticides in original containers and 54% were careless about their safe storage. Majority of the farmers (75.5%) did not dispose off empty containers, rather they reused them in household activities. Though persistence of some pesticides was known to a majority of farmers (67%), only 36% respondents were aware about the hazardous effects of their excessive use on soil nutrients and bio control agents. About 54% of farmers were also unaware of the ill effects like respiratory and skin diseases and allergies caused by pesticides in human beings.

Conclusion

It is evident from the studies discussed above that as Punjab recovers from the ecstasy of the green revolution, it is now battling with residual effects of extensively used chemical pesticides in environment and food products. For the general population, diet has become a major exposure route for most known toxic contaminants. With the ban on highly persistent organochlorine pesticides in agriculture, there has been a decline in their residues in food. However, the incidence of contamination by less persistent but more toxic organophosphates and carbamate pesticides are on the rise in the state.

Therefore, there is an urgent need to find viable alternatives so that farmers do not depend on highly hazardous organochlorines, organophosphates and carbamates for pest control activities. The solution lies in promoting practices like Integrated Pest Management (IPM), organic farming, biopesticides and crop diversification. IPM employs control of pests with use of crop rotation, biopesticides and pesticides of plant-origin like Neem formulations. The Punjab Agricultural University, Ludhiana, has developed IPM technology for cotton growers. However, an evaluation undertaken in 1998 (Mangat, 1998) in five blocks of Faridkot district indicated that only 18.67% of the farmers showed high adoption status, 50.67% showed medium adoption status and 30.66% showed low adoption status for IPM technology. Organic farming is also gaining gradual momentum with growing demand of organic food due to increasing awareness of health and environment issues in agriculture. It has been initiated in 7200 acres in the state on a pilot basis. Regarding biopesticides, the most widely used are subspecies and strains of *Bacillus thuringiensis* (Bt). With introduction of Bt-cotton in Punjab, the area under cotton has increased from 4.49 lakh hectares in 2002-03 to 5.6 lakh hectares in 2005-06 and production of cotton has almost doubled from 10.83 lakh bales (170 kg each) to 22 lakh bales during the corresponding years (Deptt of Agriculture. Govt. of Punjab). Other biopesticides used in the state include neem and plant-based formulations like Repline, Neemark and Indene (Dhaliwal et al., 2000).

Further, to exit paddy-wheat cropping pattern and diversify into new areas like vegetables, fruits, oil seeds, pulses and allied fields, the Govt. of Punjab has launched a multi crop multi year contract farming scheme to give boost to crop diversification. So far more than seven lakh acres is covered under crops other than wheat and paddy. Agriculture Diversification Infrastructure Development fund has also been set up.

With popularization of some of the above practices, it is expected that the use of pesticides in the agriculture sector in Punjab will reduce and soil, ecosystem and human health will be restored.

References

Agnihotri, N.P. (2000). Pesticide consumption in agriculture in India: An update. *Pesticide Research Journal,* **12(1):** 150-155.

Anonymous (1972). Pesticide residues in food. World Health Organization. Technical Rep. Series, No. 502.

Battu, R.S., Chawla, R.P. and R.L. Kalra (1980). Insecticide residues in market samples of vegetables, oils and oilseeds cakes from selected area of Punjab. *Indian Journal of Ecology,* **7(1):** 1-8.

Carson, R. (1962). Silent Spring. Houghton Mifflin Publishers, USA.

Chahal, K.K., Singh, B., Battu, R.S. and B.K. Kang (1999). Monitoring of farmgate vegetables for insecticidal residues in Punjab. *Indian Journal of Ecology*, **26(1):** 50-55.

Chattopadhyay, P.K. (1998). Insecticide and pesticide pollution of food stuffs and their toxic effect on man. Project sponsored by. Punjab State Council for Science and Technology, Chandigarh.

Dhaliwal, G.S., Arora, R., Dhawan, A.K. and B. Singh (2000). Intensive agriculture and pest problems: A case study of Punjab. Indian Journal of Ecology, **27(2):** 109-130.

Joia, B.S., Chawla, R.P. and R.L. Kalra (1978). Residue of DDT and HCH in wheat flour in Punjab. Indian Journal of Ecology, **5(2):** 120-127.

Kalra, R.L. and R.P. Chawla (1980). Occurrence of DDT and BHC residues in human milk in India. Experientia, **37:** 404-405.

Kumar, R. (2005). An epidemiological study of cancer cases reported from villages of Talwandi Sabo block, District Bhatinda, Punjab. Post Graduate Institute of Medicinal Education and Research, Chandigarh & Punjab Pollution Control Board, Patiala.

Mangat, S., Arora, R. and K.S. Gill (1998). Adoption status of IPM in American cotton in Punjab. *Indian Journal of Ecology*, **25(1):** 50-54.

Mathure, H.B., Agarwal, H.C., Johson, S. and N. Saikia (2005). Analysis of pesticide residues in blood samples from villages of Punjab. Centre for Science & Environment, Tughlakabad, New Delhi.

PAU (2004). Package & Practices for crops of Punjab- Kharif. Punjab Agriculture University, Ludhiana, pp. 3-4.

Sharma, A., Khurana, G.S. and G.S. Dhaliwal (2005). Awareness of the farmers of Punjab state regarding environment implication caused due to excessive use of Pesticides. *Indian Journal of Ecology*, **32(1):** 76-78.

Shiva, V. (1989). The violence of green revolution. First Edition, p. 62.

Singh, B. (2002). Pesticidal contamination of the environment of Punjab. *Indian Journal of Ecology*, **29(2):** 189-198.

TERI (2000). Pestering Problem. The Energy & Resources Institute, New Delhi, Issue no. 31.

Tiwana, N.S., Jerath, N., Saxena, S.K., Nangia, P. and H.K. Parwana (2005). State of Environment: Punjab. Punjab State Council for Science & Technology, p. 315.