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CANCER: The Flip Side of the Green Revolution

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Abstract—*Malwa region of Punjab also known as the 'cancer belt' reports a number of cancer patients in the recent years. Besides other types of cancers, breast cancer is the most common among the women of Punjab. Excessive use of pesticides is the main reason for increase of breast cancer cases in the Malwa region. Organochlorine pesticides especially 1,1,1-Trichloro-2,2'bis(p-chlorophenyl)ethane (DDT) was widely used as an agricultural pesticide after the green revolution. Green Revolution techniques also rely on chemical fertilizers, pesticides and herbicides which no doubt increase the production rate by more than double but also give a scary by product in terms of several health disorder, which are faced by today's generation. Pesticides are potentially toxic, resistant to biodegradation and it readily accumulates in human body tissues, causing a variety of health problems. They are generally very stable compounds and can persist for long periods of time after their original use. This paper reviews the various studies encompassing the use of pesticides and their adverse effect on human health.*

1. INTRODUCTION

Punjab was selected by the Indian government to be the first for the Green Revolution in the late 60's. For increasing agriculture production, high amount of synthetic fertilizers, and pesticides were used by farmers. Green Revolution techniques also heavily rely on chemical fertilizers, pesticides and herbicides which no doubt increase the production rate by more than double but also give a scary by product in terms of several health disorders, which are faced by today's generation. Malwa region of Punjab also known as the **'cancer belt'** has reported number of cancer patients in the recent years. Organochlorine pesticides especially DDT was maximum used as an agricultural pesticide in Punjab after the green revolution [1]. These pesticides are potentially toxic, resistant to biodegradation and it readily accumulates in human body tissues, causing a variety of health problems. They are generally very stable compounds and can persist for long periods of time after their original use. Organochlorine compounds generally degrade slowly and are fat-soluble, meaning that they can accumulate in humans, animals and plants. *1,1,1-Trichloro-2,2'bis(p-chlorophenyl)ethane (DDT)* easily degrades into dichlorodiphenyldichloroethane (DDD) and dichlorodiphenyldichloroethylene (DDE), which are more persistent than the parent compound. The half-life of *p,p*'-DDE in humans has been estimated as more than 7 years [2]. They can bio-accumulate over time, with the concentrations of organochlorine compounds increasing in animals higher up in the food chain. Due to the lipophilic nature of DDT and its principal metabolite, dichlorodiphenyltrichloroethane (DDE), these compounds have been found in diverse human samples of serum, adipose tissue, and breast milk [3-5]. Cumulative exposure to pesticides may come from food, water, air, dust, soil etc. Pesticides can be absorbed through skin contact, inhalation or accidental ingestion. Recent studies reveal the presence of pesticides and heavy metal residues in food and fish [6, 7] from there they enters in the human body through the food chain. Farm workers come into direct contact with pesticides at work as well and are occupationally exposed to them. Many countries including India have banned certain organochlorine pesticides but agriculture uses continues in several parts of India in the other form of organochlorine i.e., gamexine [8, 5].

Besides other types of cancers, the women of Punjab are suffering from breast cancer. 1 in 15 women is expected to be diagnosed with this malignant disease in her lifetime [9]. Excessive use of pesticides is the main reason for increase of breast cancer cases in the malwa region. According to the data collected by cancer registry cell of Indian Council of Medical Research (ICMR) 70 deaths of cancer patients have been reported in mere 7 months. Amongst 700 cancer detection camps held by Roko cancer (U.K based organisation) in Punjab in the last 5 years, 16,000 women underwent mammography, 950 were found suffering from breast cancer [10]. Out of which 145 were from Ferozepur district and 106 from Faridkot. The emphasis of this paper is to show the association between organochlorine pesticides and breast cancer.

2. MALIGNANCY AND ITS RELATION WITH ORGANOCHLORINE PESTICIDES

Breast cancer is a malignant growth that begins in the tissue of the breast. Malignancy may be described in biological terms as the ability of a group of cells to divide progressively, free of homeostatic control, invade, form distant metastasis, and eventually kill the host. It is the most common cancer among women [11]. Breast cancer incidence is rising not only in western countries but now breast cancer epidemic has spread

to developing nations. Only about one-third of new cases of breast cancer are attributable to known risk factors, and much of the etiology remains unexplained [12, 13]. Therefore it has been hypothesized that environmental exposures may also contribute to breast cancer risk [14, 12].

In Indian females, the most frequently reported malignancies were breast (22.7%) followed by uterine cervix (17.5%) gallbladder (6.4%) and ovary (5.8%) as reported by the Kolkata cancer registry on the cancer profile in the Eastern India [15]. Breast cancer risk can be attributed to established risk factors including advancing age, early menarche, going through menopause later in life, having a first child late in life, not having any child, having mother or sister with breast cancer, past exposure of breasts to ionizing radiation or having certain types of benign breast disease. But these factors explain only about 25 to 50% of breast cancer cases. There is an increasing public interest to know the role of environmental contaminants in the etiology of breast cancer.

Due to the estrogenic activity of DDT [16], Since the 1940s, DDT has been widely used throughout the world to combat agricultural pests, indoor insects, and in sanitation campaigns against malaria. At present its use has been totally banned in developed countries due to its persistence (low biodegradability), accumulation and bio-concentration in lipid systems, including subcutaneous fat, breast tissue, brain, and adrenal glands [17, 18]. Pesticides especially organochlorine pesticides [19] have received the most attention because of their extensive use in agriculture and for control of malaria and typhus [20, 21]. The half-life of these pesticides is long so that they persist in the environment and are able to concentrate up in the food chain and continue to be detected in the food supply and breast milk [22-25]. They have the ability to be stored in the adipose tissue of humans as well as animals. Organochlorine pesticides like dichlorodiphenyltrichloroethane and their metabolites are not eliminated from our bodies after exposure, but remain stored in the fat of the body. These compounds mimic estrogenic activity and can act as tumor promoters [26]. Organochlorines have been studied with respect to breast cancer due to their potential to act as direct carcinogens or as indirect carcinogens by mimicking the action of estrogen, interfering with intracellular communication and disrupting immune functions [27-30]. It has been suggested that xenoestrogens may have a role in the etiology of breast cancer. Compounds that have been suggested to be xenoestrogens in common use are certain constituents of detergents, pesticides and plastics [31]. While the use of DDT is restricted to vector control programs, the annual production of γ-HCH (lindane) increased from 40 metric ton in 1996 - 1997 to 250 metric tons in 1997-1998 [32]. The current intakes of organochlorine insecticides in developing countries in Asia are up to 100 times greater than those on more developed countries. On the basis of occupational and environmental studies, organochlorine compounds play a potential role in the etiology of human cancer.

3. INTERNATIONAL AND NATIONAL POSITION OF THE PROBLEM

The research worldwide has shown that pesticides do produce the incidences of cancer and other diseases. A study from Ontario in which blood and adipose tissue and 52 blood samples from persons engaged in the agricultural application of DDT and 315 from residents were analyzed for total DDT. Mean value of total DDT for adipose tissue and blood were 5.83 and 0.032 ppm respectively and there was a statistically significant correlation between total DDT in lipid and blood [33]. Analysis of 27 samples of blood (19 males and 8 females from 21 to 57 year old) was done in Tokyo Metropolitan Research Laboratory of Public Health for polychlorinated terphenyls (PCTs), polychlorinated biphenyls (PCBs) and DDE showed a mean value of 3.2, 5.0 and 11.2 ppb respectively [34]. In 1986, a total of 41 samples of maternal blood, milk subcutaneous fat and umbilical cord blood were analysed from mothers in Nairobi [35]. The main contaminants found in all the samples were pp' –DDT (100%), pp' DDE (100%), op' DDT (59%), dieldrin (27%), transnonachlor (15%), β-HCH (12%) and lindane (2%). Blood samples were analysed for organochlorines which found very high amount of organochlorine pesticides residues [36, 37]. In Mexico, maternal adipose tissue and maternal blood serum from 64 mothers were analysed for organochlorine pesticide residues- HCB, α, β, γ, δ- HCH, aldrin, dieldrin, heptachlor, heptachlor epoxide, pp'-DDT, op'-DDT, pp'- DDD, α, β-endosulfan, endosulfan sulfate, chlordane, and methoxychlor [38]. Concentration of total HCH (t-HCH) in maternal adipose tissue, maternal serum was 0.17 and 0.22 mg/kg respectively, and total DDT (t-DDT) was 5.851, 5.226 mg/Kg. There was a strong association found between adipose tissue and serum residues according to the study done in belgium [39]. A survey of 577 whole blood samples from school children in Peninsular Malaysia, analysed for the residues of 11 organochlorine pesticides revealed the presence of pesticide residues in blood in nanogram per gram [40]. According to the reports, in Canada [41], USA [42], Mexico [43], Lowa, south Carolina [44], South Africa [45] and Hong Kong [46] the chemicals found in highest concentration in whole blood were organochlorines. One of the study from Chiapas, Mexico, strongly demonstrated the high level of p,p′-DDE due to extensive use of organochlorine pesticides for pest control in agriculture and against malaria [47].

Human blood samples have also been analysed in different part of India by many analysts for the pesticides residue determination. According to a study conducted in Delhi, blood samples from 182 people were examined for DDT residues showed that all except 8 contained DDT and its metabolites [48]. DDT and HCH residues were detected in all the 99 samples of blood and adipose tissue of normal and exposed persons from urban area of Lucknow [49] which found high concentration of organochlorine among children, females and males. A total of 340 biopsies of body fat and blood samples

from 162 males and 178 females collected from 3 government hospitals in Delhi showed high concentration of DDT and HCH [50]. A survey of blood samples of general population of occupationally unexposed population from Delhi showed levels of DDT several times higher than that from other countries [51, 52].

During Ardh Kumbh Congregation at Hardwar in April, 1992 samples were analysed for HCH and DDT contamination in whole blood from the occupationally exposed persons, involved in spraying operation of HCH and DDT for the control of mosquitoes and flies and it was found that the percentage was 3.1 times and 2.8 times more as compared to general population [53]. In a study from Ahemdabad, rural and urban areas blood samples were analysed for DDT, HCH, heptachlor, heptachlor epoxide, aldrin, oxychlordane, HCB and dieldrin in serum. All serum samples were contaminated by HCH and pp' DDE, op'- DDT, pp' DDD, pp' DDT and t-DDT [54, 55]. Contributions of DDT metabolites (DDT, DDD and DDE residues) were reported. And found that the DDT levels exceeded beyond the limit which thus caused acute biological impairments [56]. DDT and HCH residues in animal's and mother's milk of Paliakalan Kheeri, Uttar Pradesh were analysed and found the total concentrations of DDTs and HCHs in human breast milk were high than animal milk [5]. According to a study total content of HCH and DDT in whole blood samples from villagers of Punjab was 0.057 mg/l and 0.0652 mg/l respectively [57]. organochlorines (α-HCH, γ-HCH, δ-HCH, total-HCH, and p, p′-DDE) in the blood samples were analysed and found higher in children with aplastic anaemia than in those of controls, only α-HCH differed significantly ($P < 0.05$) [58]. Bedi in 2013 has also reported the Pesticide residues in human breast milk [4]. A total of 111 human blood samples were analyzed by gas chromatography and pesticide residues were detected in 35 % of the blood samples [59]. In which residues of α-HCH, β-HCH, p,p′ DDD, p,p′ DDE, p,p′ DDT, β-endosulfan, monocrotophos, profenophos and phosalone were found with mean levels of 1.11, 5.89, 0.51, 3.88, 0.39, 34.90, 0.79, 0.39 and 6.76 ng ml^{-1}, respectively. In one of the hospital based control study [60], of 50 women t- HCH and t-DDT levels were found higher in the blood of the study group (25 cases) than in those of the controls (25 cases) with only γ-HCH being significantly different ($P<0.05$).However, both t-HCH and t-DDT were higher in the tumor tissues of the controls than in those of the study group, γ-HCH was significantly different ($P<0.05$).The level of total HCH (α-HCH was significantly different, $P<0.05$) was higher in the breast adipose tissue of the study group, whereas total DDT was higher in the breast adipose tissue of the control group.

4. OVERALL DISCUSSION AND CONCLUSION

Malwa region is well known and important cotton belt in Punjab. About 54% of the total pesticides used in Indian agriculture are consumed on cotton alone for only 5% of the total cultivated area. Inspite of the recommended only seven sprays on cotton in six months farmers spray as many as 32 times [57]. Several studies have shown pesticide residues in breast milk, fruits and vegetables from Punjab and a few reports of high incidence of cancer have been coming from certain areas of Punjab. Studies indicate a strong linkage between pesticide exposure and chronic disease like cancer. Organochlorines are considered to be a possible cause for hormone dependent cancers like breast cancer, cervical and prostate [61]. The number of cancer patients has grown manifold in the recent years in the Punjab region.

Although there is ban on the use of certain hazardous organochlorine pesticides but still people are using them frequently. The incidence of pesticide toxicity is increased in the country especially in the state Punjab. There is an intense need to provide the other alternatives and awareness to the farmers so that they can improve their crop production without the use of these silent weapons against the humanity. Recently another adverse affect of the use of pesticides in terms of white fly attack on cotton plants has also been seen in the Punjab state which affected the farmers financially as well as mentally. The possibility that these flies may have developed immunity to the pesticides which are used for so long can't be ignored. Biopesticides like neem and plant-based formulations like Repline, Neemark and Indene [62] can be the good and healthy alternatives for these carcinogenic organochlorine pesticides.

Only with the proper knowledge and awareness programme regarding the use of pesticides and their alternatives, Punjab will be the "RANGLA PUNJAB" in the real sense.

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