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REVIEW ARTICLE

Use of pesticides in agriculture and livestock animals and its impact on environment of India

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SUMMARY : A vast majority of the population in India is engaged in agriculture and is therefore highly exposed to the pesticides used in agriculture. Exposure to pesticides both occupationally and environmentally causes a range of human health problems. Indiscriminate and repeated application of pesticides leads to loss of biodiversity, pest-resistance and other ecological imbalance. Many pesticides are not easily degradable, they persist in soil, leach to groundwater and surface water and contaminate wide environment. In India, the use of pesticides remains the cornerstone of controlling ticks, lice and other ecto-parasites from the livestock animals. In the absence of an effective alternative method of control, reliance on chemicals is bound to increase, which exerts selection pressure on the target organism resulting into the development of resistance. The persistence nature of pesticides led to their accumulation in animal tissues and subsequently causes human dietary exposure through consumption of animal products *viz.,* meat, milk, eggs and sea foods. Low dose but long term exposure of pesticides can cause serious health hazards to human health and environment as well. The reports on occurrence of pesticides residues in animal products manufactured in India are fragmentary, but provide confirmation to the fact that Indian consumers do get dietary exposure to these pesticides. Thus, the intensive pesticide application results in several adverse effects in the environment and human health that cannot be ignored.

Key Words :
Pesticides, Residues, Environment, Resistance

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The production of pesticides started in India in 1952 with the establishment of a plant for the production of BHC near Calcutta, and India is now the second largest manufacturer of pesticides in Asia after China and ranks twelfth globally for the consumption (Mathur, 1999). There has been a steady growth in the production of technical grade pesticides in India, from 5,000 metric tonnes in 1958 to 102,240 metric tonnes in 1998. In 1996-97 the demand for pesticides in terms of value was estimated to be around Rs. 22 billion (USD 0.5 billion), which is about 2% of the total world market. The pesticides cover a wide range of compounds including insecticides, fungicides, herbicides, rodenticides, molluscicides, nematicides, plant growth regulators and others. Among these, organochlorine (OC) insecticides, using successfully in controlling a number of diseases, such as malaria and typhus, were banned or restricted after the 1960s in most of the technologically advanced countries. The introduction of other synthetic insecticides – organophosphate (OP) insecticides in the 1960s, carbamates in 1970s and pyrethroids in 1980s and the introduction of herbicides and fungicides in the 1970s–1980s contributed greatly to pest control and agricultural output. The pesticide market of India in the world is with US$ 0.6 billion per annum, which is 1.6% of the global market (Hunda and Ananda, 2006). Although the pesticide consumption in India is still very low, there has been a widespread contamination of food commodities with pesticide residues basically due to these indiscriminate and non-judicious application. Despite a ban imposed by the World Health Organization (WHO) on use of certain organochlorine compounds, some of these chemicals are intensively used in limited quantity in many developing countries including India for agricultural, livestock and public health programmes.

Since pesticides 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 bio-accumulate in the food chain and can be traced in plant and animal tissues causing serious health hazards (Johan *et al.*, 2001). Animal husbandry is one of the most important areas of foreign exchange. To compete in the international markets, it is necessary that Indian products should be meant for exports of international standards. Therefore, it is necessary to strengthen quality competitive aspects of animal products. Feed and fodder offered to animals are often contaminated with pesticide residues (Sandhu, 1980), (Raikwar and Nag, 2003) and after feeding, these residues pass through the body systems (Prasad and Chhabra, 2001). Pesticide poisoning in human has been extensively studied (Hamilton *et al.*, 2004) and frequently reported in forensic medicine (Below and Lignitz, 2003). As per World Health Organization estimates, pesticides lead to one million pesticide poisoning cases and 20,000 deaths every year globally. Therefore, there is a need of discussion on causes of environmental contamination, pesticide residues in milk, meat and other dairy products, health hazards associated with dietary exposure of successful in meeting the goals of self-sufficiency in pesticides as well as prevention and control strategies for occurrence of pesticides in animal products in Indian scenario.

Types of chemical pesticides:

Organophosphate pesticides:

These pesticides affect the nervous system by disrupting the enzyme that regulates acetylcholine, a neurotransmitter. Most organophosphates are insecticides. They were developed during the early 19th century, but their effects on insects, which are similar to their effects on humans, were discovered in 1932. Some of the OP compounds are diazinon, malathion, coumaphos.

Carbamate pesticides:

These pesticides affect the nervous system by disrupting an enzyme that regulates acetylcholine, a neurotransmitter. The enzyme effects are usually reversible. There are several subgroups within the carbamates. Aldicarb, carbofuran, carbaryl, carbosulfan are the example of carbomates.

Organochlorine insecticides:

These were commonly used in the past, but many have been removed from the market due to their health and environmental effects and their persistence. DDT, chlordane, aldrin, dieldrin, heptachlor are the common OC compounds.

Pyrethroid pesticides:

These were developed as a synthetic version of the naturally occurring pesticide pyrethrin, which is found in chrysanthemums. They have been modified to increase their stability in the environment. Some synthetic pyrethroids are toxic to the nervous system. Deltamethrin, cypermethrin, permethrin are some of the commonly used pyrethroid.

Pesticide use in agriculture:

In the process of development of agriculture, pesticides have become an important tool as a plant protection agent to boost up food security as these chemicals play a significant role by keeping many dreadful diseases. A vast majority of the population in India (56.7%) is engaged in agriculture and is therefore exposed to the pesticides used in agriculture (Gupta, 2004), (Planing Commission of India, 2002-2007). Although Indian average consumption of pesticide is far lower than many other developed countries, the problem of pesticide residue is very high in India. Generally, pesticides are used in three sectors *viz.*, agriculture, public health and consumer use. The consumption of pesticide in India is about 600 g / hectare, whereas that of developed countries is touching 3000 g / hectare. Pesticides are found as common contaminants in soil, air, water and on non-target organisms in our urban landscapes. Once there, they can harm plants and animals ranging from beneficial soil microorganisms and insects, non-target plants, fish, birds, and other wildlife (USGS, 1995). Repeated and excessive use of pesticides in agriculture to the development of resistance in many insects/ pests. Residues in food for humans and feed for livestock can be a consequence of direct application of a chemical to the food source, by the presence of pollutants in the environment or by transfer and bio-magnification of the chemical along a food chain.

As it is clear from Fig.1, the consumption of chemical pesticides in India is gradually decreasing from 1994-2006. However, the Punjab and Haryana were the two states using the largest quantity of chemical pesticides during 1999-01 (Fig. 2).

The pattern of pesticide usage in India is different from that for the world in general. As can be seen in Fig.3, in India

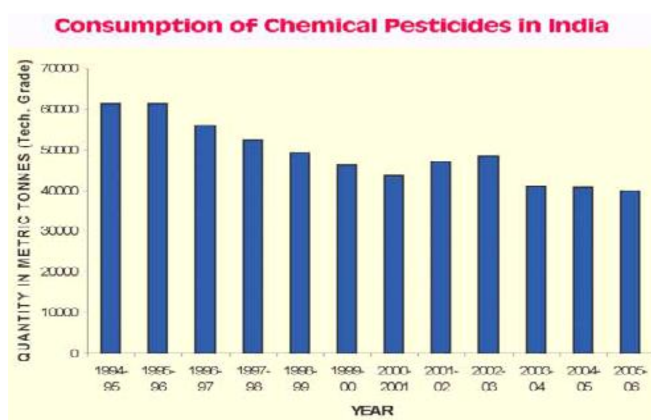

Fig. 1 : Consumption of different chemical pesticides in India

76% of the pesticide used is insecticide, as against 44% globally (Mathur, 1999). The use of herbicides and fungicides is correspondingly less heavy. The main use of pesticides in India is for cotton crops (45%), followed by paddy and wheat. Consumption of pesticides in Haryana in agriculture during 1999–2000 was 5,030 MT. This followed Uttar Pradesh (7,400 MT), Punjab (7,100 MT) and Andhra Pradesh (7,000 MT). However, the g/ha consumption in Haryana was 8,481 as compared to the average consumption of 288 g/ha in the country (Agnihotri, 2000).

Impacts on non – target organisms:

Pesticides are found as common contaminants in soil, air, water and on non-target organisms in our urban landscapes. These chemicals can harm plants and animals ranging from beneficial soil microorganisms and insects, non-target plants, fish, birds and other wildlife. Pesticides can kill birds in several ways, including direct effects of acute poisoning by ingestion of granules, baits, treated seeds, and direct exposure to sprays. Indirect death of birds may result from consumption of treated crops, contaminated water, or feeding on contaminated prey. Wildlife poisoning depends on a pesticide's toxicity and other properties (eg. water-soluble pesticides may pollute surface waters), the quantity applied, frequency, timing and method of spraying (eg. fine spray is prone to drift), weather, vegetation structure, and soil type. Insecticides, rodenticides, fungicides (for seed treatment) and the more toxic herbicides

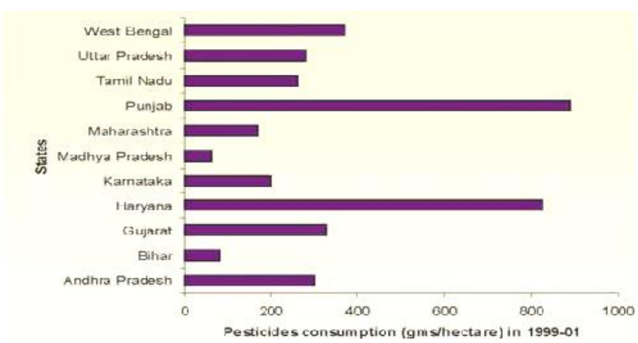

Fig. 2 : State-wise pesticides consumption in India

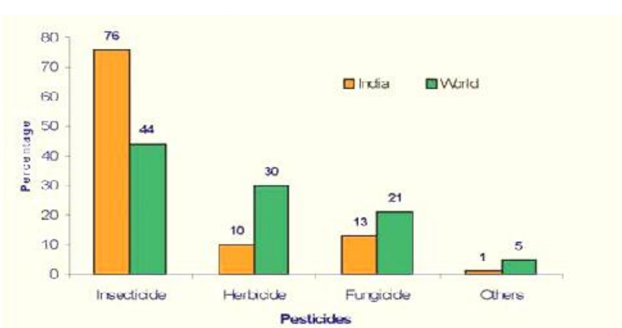

Fig. 3 : Consumption pattern of pesticides in India and the world

threaten exposed wildlife.

Impact on environment :

Pesticides present the only group of chemicals that are purposely applied to the environment with aim to suppress plant and animal pests and to protect agricultural and industrial products. Pesticides can contaminate soil, water, turf and other vegetation. In addition to killing insects or weeds, pesticides can be toxic to a host of other organisms including birds, fish and beneficial insects. However, majority of pesticides are not specifically targeting the pest only and during their application they also affect non-target plants and animals. Repeated application leads to loss of biodiversity. Many pesticides are not easily degradable, they persist in soil, leach to groundwater and surface water and contaminate wide environment. Depending on their chemical properties, they can enter the organism, bio-accumulate in food chains and consequently influence the environment.

Impacts on humans

Exposure to pesticides both occupationally and environmentally causes a range of human health problems. It has been observed that the pesticides exposures are increasingly linked to immune suppression, hormone disruption, diminished intelligence, reproductive abnormalities and cancer. There is now overwhelming evidence that some of these chemicals do pose a potential risk to humans and other life forms and unwanted side effects to the environment (Forget, 1993; Igbedioh, 1991; Jeyaratnam, 1985). No segment of the population is completely protected against exposure to pesticides and the potentially serious health effects, though a disproportionate burden is shouldered by the people of developing countries and by high risk groups in each country (WHO, 1990).

It is estimated that nearly 10,000 deaths annually to use of chemical pesticide worldwide, with about three-fourths of these occurring in developing countries (Horrigan *et al.*, 2002). Pesticides being used in agricultural tracts are released into the environment and come into human contact directly or indirectly affecting human life (Wadhwani and Lall, 1972; Kasyap and Gupta, 1973). Humans are exposed to pesticides found in environmental media (soil, water, air and food) by different routes of exposure such as inhalation, ingestion and dermal contact. Exposure to pesticides results in acute and chronic health problems (Hollingworth *et al.*, 1995; Hurley *et. al.*, 1998). The world-wide deaths and chronic diseases due to pesticide poisoning were numbered about 1 million per year (Environment Forum, 1999). Some of these are suicides, but most involve some form of accidental exposure to pesticides, particularly among farmers and spray operators in developing countries, who are careless in handling pesticides or wear insufficient protective clothing and equipment. Moreover, there have been major accidents involving pesticides that have led to the death or illness of many thousands. In India, the first report of pesticide poisoning was documented from Kerala in 1958, where more than 100 people died after consuming wheat flour contaminated with parathion. One instance occurred in Bhopal, where more than 5,000 deaths resulted from exposure to accidental emissions of methyl isocyanate from a pesticide factory.

There are two types of the pesticide effects on human health:

Chronic effects of pesticide exposure:

Chronic health problems linked to pesticides include adverse neurological effects such as a fourfold increased risk of early-onset Parkinson's disease, shortened attention span, memory disorders, and reduced coordination, reproductive problems including miscarriages, reduced infant development, birth defects, depression and cancer.

Acute effects of pesticide exposure:

Acute health problems which are sometimes misdiagnosed or not recognized as being associated with pesticide toxicity, include blurred vision, headaches, salivation, diarrhoea, nausea, vomiting, wheezing, eye problems, skin conditions, seizure, coma, and even death. Mild to moderate pesticide poisoning mimics intrinsic asthma, bronchitis, and gastroenteritis. Pesticides are especially harmful to children because of their developing physiology. And, relative to their size, they are exposed to higher amounts of pesticides.

Surface water contamination:

Pesticides can reach surface water through runoff from treated plants and soil. Contamination of water by pesticides is widespread. During a survey in India, 58% of drinking water samples drawn from various hand pumps and wells around were found contaminated. Maximum residue levels (or tolerances) have been established for pesticides in foodstuffs and drinking water in most countries to avoid any adverse impact on public health, and to insist on good agricultural practice. Residues of systemic herbicides in soil used in the previous season may influence the growing of succeeding crops. Residues of insecticides in surface water may cause adverse effects on aquatic organisms.

A number of researchers have reported pesticides and heavy metals in drinking and groundwater in different parts of India (Dikshit *et al.*, 1990; Kumar *et al.*, 1995; Bansal and Gupta, 2000). HCH and DDT were detected in different sources of water wells, hand pumps and ponds in Bhopal. Water samples of wells in Bhopal showed residues of total HCH (4640 μg/l) and total DDT (5794 μg/l) (Bouwer, 1989). Drinking water samples from Ahmedabad showed total HCH was 23.90-2488.70 nanogram/l and total DDT (p,p-DDE, o,p'-DDT and p,p'-DDT) in the range of 10.90-314.90 nanogram/l, respectively (Jani *et al.*, 1991). Organochlorine and organophosphorus pesticide residues were detected in groundwater samples from irrigation wells, domestic wells and canals used for irrigation and drinking purposes in Aligarh (Ray, 1992). The concentration of aldrin and dieldrin residues in water samples collected from different sites upstream and downstream sections of river Yamuna in Delhi ranged from 0.0005 - 0.05 μg/ml (upstream) and from 0.0001 - 0.1 μg/ml (downstream) respectively (Nair *et al.*, 1991). Once ground water is polluted with toxic chemicals, it may take many years for the contamination to dissipate or be cleaned up.

Impacts on livestock animals:

There is increasing anxiety about the importance of small residues of pesticides, often suspected of being carcinogens or disrupting endocrine activities, in drinking water and food. In spite of stringent regulations by international and national regulatory agencies, reports of pesticide residues in human foods, both imported and home-produced, are numerous. Pesticide residues in livestock generally accumulate by two ways either through direct application on animals or on agricultural crops and fodder (Poppenga, 1999). The livestock reared on pesticides contaminated soils, crops, and fodders may accumulate considerable residues in edible tissues. Furthermore, pesticide residues also accumulate on cropland soil (Jabbar *et al.*, 1993). Animals can accumulate these substances from contaminated feed and water. Also, due to the lipophilic nature of these pesticides, milk and other fat-rich substances are the key items for their accumulation (John *et al.*, 2001). Therefore, an indirect source of pesticides accumulation can be represented by animal-derived products.

A little work was carried out in Haryana on OCPs residues in milk (Chauhan *et al.*, 1982; Kathpal *et al.*, 1992; Kumari and Kathpal, 1995). However, endosulfan, an organo-chlorinated insecticide, is generally used in agriculture for the control of various pests in crops in India, as a result, it has been reported to be present as residues in different feed concentrates and green fodders up to a concentration of 6 ppm (Dikshit *et al.*, 1989; Prassad, 1998; Kang *et al.*, 2002; Imrankhan *et al.*, 2003; Deka *et al.*, 2004). It was however reported that unlike the other organochlorinated insecticides, endosulfan apparently does not pass into the milk of cattle when ingested in feed–even at a high concentration for a prolonged period of time.

Animal husbandry constitutes backbone of fish collected in river Yamuna in Delhi, which received discharges from a DDT factory, contained DDT at a mean concentration of 56 mcg/g (Aggarwal, 1986). Similarly, fish from rural ponds that million buffaloes, 185 million cattle, 120 million received agricultural runoff contained DDT and HCH goats, 62.5 million sheep, 14.3 million pigs and 430 at mean concentration of 7 and 6.3 mcg/g, respectively million chickens (FAO, 2005). Among several meat products, greatest contamination was observed in chicken muscle followed by goat and beef collected in Lucknow, India (Kaphalia and Seth, 1981). The increasing incidences of pesticide residues in the meat and milk are of a great concern for ensuring food safety and human health. Higher contents of organo-chlorine pesticide residues have been reported in meat (Nag *et al.,* 2005) and milk samples collected from different locations of the country (ICMR,1993). Agnihotri *et al.* (1974) reported that most of the milk samples from Delhi market contained DDT in levels higher than MRL fixed by FAO-WHO. Lakshminarayan and Menon (1995) made similar observation on milk samples from Hyderabad. Verma, (1990) found 17 and 12µ of Lindane/kg of buffalo and cow milk, respectively from Indore.

Development of pesticide resistance

This use of pesticides has led to appearance of pesticide resistance in 27 insect pests; 14 of public health importance, 7 of agricultural crops and 6 of stored grains and commodities. Chronologically, in India, the pesticide resistance appeared first in insect vectors of parasitic diseases in 1952, in agricultural pests in 1963 and in insect pests of stored grains and commodities in 1971 (Mehrotra, 1989). Insecticide resistance to representatives of commonly used insecticide groups (pyrethroids-cypermethrin, organophosphates-chlorpyriphos; cyclodienes-endosulfan) was determined in five major insect pests of cotton from the main cotton growing regions of India with emphasis on Andhra Pradesh and Maharashtra (Kranthi *et al.,* 2002).

In India, about 60% of livestock is reared by small and marginal farmers and use of OP compounds like diazinon and malathion is very common for the control of agricultural pests including livestock and poultry (Sharma, 2004; Ghosh *et al.,* 2006). Besides their applications against agriculturally important pests, OP compounds are also used for mass eradication of mosquito larvae in the breeding places (ICMR, 2002). Livestock is an integral part of the agricultural production system in India and plays an important role in national economy. However, almost of all dairy and meat animals are suffering from tick infestation (Ghosh *et al.,* 2006) and cause significant economic loss. Indiscriminate use of pesticides for the control of these ecto-parasites has resulted into development of large scale of diazinon and pyrethroid resistance in *R.(B.) microplus* collected from different agro-climatic regions of India (Kumar *et al.,* 2011; Sharma *et al.,* 2012).

Conclusion :

Pesticides are often considered a quick, easy and inexpensive solution for controlling weeds and insect pests in urban landscapes. Pesticides have contaminated almost every component of our environment. Pesticide residues are found in soil and air, and in surface and ground water across the nation, and urban pesticide uses contribute to the problem. Pesticide contamination poses significant risks to the environment and non-target organisms ranging from beneficial soil microorganisms, to insects, plants, fish, and birds. Contrary to common misconceptions, even herbicides can cause harm to the environment.

Depending on the chemical properties of synthetic insecticides, they can enter the organism, bio-accumulate in food chains and consequently influence also human health. Overall, intensive pesticide application results in several negative effects in the environment that cannot be ignored. For the general population, diet has become a major exposure route for most known toxic contaminants. 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. Organic farming is also gaining gradual momentum with growing demand of organic food due to increasing awareness of health and environment issues in agriculture. Neem and plant-based formulations like Repline, Neemark and Indene (Dhaliwal *et al.,* 2000) can be adopted routinely. 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 the country will reduce and soil, ecosystem and human health will be restored. Farmers are unlikely to change the way they manage their animals and parasite problems unless they see convincing evidence that a new approach will confer an economic advantage.

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REFERENCES

Aggarwal, H.C. (1986). DDT Residues in the river Jamuna in Delhi, India. *Water Air & Soil Pollution*, **28** : 89-104.

Agnihotri, N.P. (2000). Pesticide consumption in agriculture in India –an update. *Pesticide Res. J.*, **12**(1) : 150-155.

Agnihotri, N.P., Dewan, R.S., Jain, H.K. and Pandey, S.Y. (1974). Residues of insecticides in food commodities from Delhi: II. High fat content food materials. *Indian J. Entomol.,* **36**(3) : 203 -208.

Below, E. and Lignitz, E. (2003). Cases of fatal poisoning in post-mortem examinations at the Institute of Forensic Medicine in Greifswald—analysis of five decades of post-mortems *Forensic Sci. Int.,* **133** : 125–131.

Bansal, O.P. and Gupta, R. (2000). Groundwater Quality of Aligarh district of Uttar Pradesh. *Pesticide Res. J.*, **12** (2) : 188-194.

Chauhan, R., Singh, Z. and Dahiya, B. (1982). Organochlorine insecticides as food contaminants. In First International Conference on Food Science and Technology, May 23–26, 1982, Bangalore, Abstract. No. 9, Section II, p. 5.

Deka, S.C., Barman N. and Baruah, A.A.L.H. (2004). Monitoring of pesticide residues in feed, fodder and butter in Assam. *Pestic. Res. J.,* **16**(1) : 86–89.

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

Dikshit, T.S.S., Kumar, S.N., Raizada, R.B., Srivastava, M.K. (1989). Organochlorine insecticide residues in cattle feed. *Bull. Environ. Contam. Toxicol.*, **43** : 691–696.

Dikshit, T.S.S., Raizada, R.B., Kumar, S.N., Srivastava, M.K., Kulshreshta, S.K. and Adbolia, U.N. (1990). Residues of DDT and HCH in major sources of drinking water in Bhopal, India. *Bull. Environ. Contamn. Toxicol.,* **45** : 389-393.

Environews Forum, Killer environment (1999). *Environ. Health Perspect.*, 107 : A62.

Forget, G. (1993). Balancing the need for pesticides with the risk to human health. In: *Impact of pesticide use on health in developing countries*, (Eds.) G. Forget, T. Goodman and A. de Villiers, IDRC, Ottawa, p. 2.

Ghosh, S., Azhahianambi, P. and Fluente, J. de la (2006). Control of ticks of ruminants with special emphasis on livestock farming system in India—present and future possibilities for integrated control- a review. *Exp. Appl. Acarol.,* **40** : 49–66.

Gupta, P.K. (2004). Pesticide exposure – Indian scene, *Toxicology*, **198** : 83-90.

Hamilton, D., Ambrus, A., Dieterle, R., Felsot, A., Harris, C., Petersen, B., Racke, K., Wong, S.S., Gonzalez, R., Tanaka, K., Earl, M., Roberts G. and Bhula, R. (2004). Advisory Committee on Crop Protection Chemistry, Division of Chemistry and the Environment of the International Union of Pure and Applied Chemistry, Pesticide residues in food—acute dietary exposure, *Pest. Manage. Sci.*, **60** : 311–339.

Horrigan, L., Lawrence, R.S. and Walker, P. (2002). How sustainable agriculture can address the environmental and human heath harms of industrial agriculture. *Environ. Health Perspect*., **110**(5) : 445-456.

Hollingworth, R.M., Kurihara, N., Miyamoto, J., Otto, S. and Paulson, G.D. (1995). Detection and significance of active metabolites of agrochemicals and related xenobiotics in animals. *Pure Appl. Chem*., **67** : 1487-1532.

Hunda, B.S. and Anada, S.R. (2006). Pesticide marketing : The Indian scenario *ICFAI. J. Managerial Econ*., **4** (2) : 32-37.

Hurley, P.M., Hill, R.N. and Whiting, R.J. (1998). Mode of carcinogenic action of pesticides inducing thyroid follicular cell tumors in rodents, *Environ. Health. Perspect.,* **106** : 437.

H. Bouwer (1989). Agriculture and Ground water quality. *Civil Engg.,* **59** : 60-63.

ICMR Bulletin (1993). Surveillance of food contamination in India. *Indian Council of Medical Research*, New Delhi, 117 pp.

ICMR Bulletin (2002). Chemical insecticides in malaria vector control in India.

Igbedioh, S.O. (1991). Effects of agricultural pesticides on humans, animals and higher plants in developing countries. *Arch. Environ. Health*, **46** : 218.

Imrankhan, M., Barman, K. and Atreja, P.P. (2003). Pesticide residues in food chain: threats and solutions. *Indian Dairyman,* **55** : 61–66.

Jabbar, A., Masud, S.Z., Perveen, Z. and Mubarik, A. (1993). Pesticides residue in cropland soils and shallow groundwater in Punjab, Pakistan. *Bull. Environ. Contam. Toxicol.*, **51**(2) :112-118.

Jani, J.P., Raiyani, C.V., Mistry, J.S., Patel, J.S., Desai, N.M. and Kashyap, S.K. (1991). Residues of organochlorine pesticides and polycyclic aromatic hydrocarbons in drinking water of Ahemdabad city. *Bull. Environ. Contamn. Toxicol*., **47** : 381-385.

Jeyaratnam, J. (1985). Health problems of pesticide usage in the third world. *BMJ*, **42** : 505.

John, P.J., Bakore, N. and Bhantnagar, P. (2001). Assessment of organochlorine pesticides residue levels in dairy milk and buffalo milk from Jaipur city, Rajasthan, India, *Enviro. Internat.*, **26** : 231-236.

Kathpal, T.S., Singh, G., Yadav, G.S., Dhankar, J.S. and Singh, A. (1992). Monitoring of milk and milk products for DDT and HCH contamination. *Pesticide Res. J.*, **4**(2) : 123–131.

Kang, B.K., Singh, B., Chahal, K.K. and Battu, R.S. (2002). Contamination of feed concentrates and green fodder with pesticide residues. *Pestic. Res. J.,* **4**(2) : 308–312.

Kaphalia, B.S. and Seth, T.D. (1981). DDT and BHC residues in some body tissues of goats, buffalo and chickens from Lucknow, India. *Pestic. Monit. J.,* **15** : 103-106.

Kasyap, S.K. and Gupta, S.K. (1973). Review of pesticide toxicology in India. In: Proceedings of the symposium on, “Progress and problems in pesticide residue analysis”. Ludhiana, 18-19 Nov., 1973 pp. 1-44.

Kranthi, K.R.,Jadhav, D.R., Kranthi, S., Wanjari, R.R., Ali, S.S. and Russell, D.A. (2002). Insecticide resistance in five major insect pests of cotton in India. *Crop Protection*, **21**(2) : 449-460.

Kumari, B. and Kathpal, T.S. (1995). Level of contamination of milk with HCH and DDT in Haryana. *Indian J. Animal Sci.*, **65**(5) : 576–582.

Kumar, S., Paul, S., Sharma, A.K., Kumar, R. Tewari, S.S., Chaudhuri, P. Ray, D.D., Rawat, A.K.S. and Ghosh, S. (2011). Diazinon resistant status in *Rhipicephalus (Boophilus) microplus* collected from different agro-climatic zones of India. *Vet. Parasitol.*, **181** : 274-281.

Kumar, S., Singh, K.P. and Gopal, M. (1995). Organochorine residues in Rural drinking water sources of northern and north eastern India. *J. Environ. Sci. Health,* **A30** : 1211-1222.

Lakshminarayan, V. and Menon, P.K. (1975). Screening of Hyderabad market samples of food stuffs for organochlorine insecticide residues. *Indian J. Pl. Protect.*, **3** : 4-19.

Mathur, S.C. (1999). Future of Indian pesticides industry in next millennium, *Pesticide Information*, **24** (4) : 9-23.

Mehrotra, K.N. (1989). Pesticide resistance in insect-pests Indian Scenario. *Pesticide Res. J.*, **1**(2) : 95-103.

Nag, K.S., Raikwar, M.K., Mahanta, S.K. and Kundu, S.S. (2005). Pesticide residues in feeds. In: *Animal feed technology* (Eds. S. S. Kundu, S. K. Mahanta, Sultan Singh, P.S. Pathak). *Satish Serial* Publishing House, Delhi.

Nair, A., Dureja, P. and Pillai, M.K.K. (1991). Levels of aldrin and dieldrin in environmental samples from Delhi, India. *The Science of Total Environment*, **108** : 255-259.

Poppenga, R.H. (1999). Current environmental threats to animal health and productivity. *J. Nat. Toxins.,* **8**(1) : 47-55.

Prassad, K.S.N. (1998). Biodegradation of organochlorine pesticide residues in ruminants and measures to minimize their excretion in milk. Ph.D. Thesis, NDRI, Karnal (HARYANA) INDIA.

Prasad, K.S.N. and Chhabra, A. (2001). Organochlorine pesticide residues in animal feed and fodders, *Indian J. Animal Sci.*, **71**(12) : 1178–1180.

Planning Commission of India, New Delhi. (2001). Goverment of India, Tenth five-year plan (2002-2007), pp. 513–566.

Raikwar, M.K. and Nag, S.K. (2003). Organochlorine pesticide residues in animal feeds, In: Proceedings of 40th Annual Convention of Chemists, *Indian Chemical Society*, (4) 127.

Ray, P.K. (1992). Measurements on Ganga River Quality- heavy metals and pesticides. Project Report, Industrial Toxicology Research Center, Lucknow, India.

Sandhu, T.S. (1980). Pesticide residues in foods, *Indian Dairyman*, **32** : 61–63.

Sharma, B. (2004). Role of drug residue and drug resistant genes in livestock and their impact on human health and environment. In Agriculture and Environment. Gender Equity and Environment Division, Ministry of Agriculture and Cooperatives, Singh Dubar, Kathmandu.

Sharma, A.K., Kumar, R., Kumar, S., Nagar, G., Singh, N., Rawat, S.S., Dhakad, M.L., Rawat, A.K.S., Ray, D.D. and Ghosh, S. (2012). Deltamethrin and cypermethrin resistance status of *Rhipicephalus (Boophilus) microplus* collected from six agro-climatic regions of India. *Vet. Parasitol.*, **188** : 337– 345.

Verma, D.K. (1990). BHC residues in milk: A gas chromatographic investigation. *Internat. J. Environ. Analytical Chem.*, **42**:79-81.

WHO (1990). Public health impact of pesticides used in agriculture. *World Health Organization*, Geneva : p. 88.

Wadhawani, A.M. and Lall, I.J. (1972). Harmful effects of pesticides. Report of the special committee of ICAR. *Indian Council of Agricultural Research*, New Delhi : pp. 44.

WEBLOGRAPHY

FAO (2005). FAO statistics on livestock population in India. [Online] Available: *http://faostat.fao.org.*

USGS (1995). Pesticides in the atmosphere: current understanding of distribution and major influences. Fact Sheet FS- 152-95. *http://water.wr.usgs.gov/pnsp/atmos/*