Addressing the Challenges of Pesticide Residue: Impacts on Agriculture, Environment, and Public Health

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Abstract

The fields for agriculture is continuously decreasing due to many reasons like increase in residential areas in parallel to the continuous increase in world population, opening of new urban residential areas, establishment of factories, increase in the number of highways and vehicles. Since the area of the world is limited, opening new fields for agriculture is not possible in order to meet the requirement of increasing population. Pesticides come first among the inputs used to increase product amount to be obtained from unit of area. Pesticides are chemical compounds used with the aim of removing micro and macro pests in the agriculture. Use of pesticides in agricultural struggle applications appears the easiest and the cheapest method. This situation increases use of these compounds for long years. Increasing amount of pesticide using also creates a general and potential danger like use of other toxic materials. Three main problems determine the limits in continuous use of pesticides: Organisms become resistant against pesticides in time, Some pesticides do not undergo biodegradation easily, but remains resisting in the environment they are implemented or carried and They also harm some living things other than those targeted. In this paper, discussion is focused on the impact of pesticide residue in agricultural pollution and remediation options and strategies are considered in the following conclusions.

Keywords: Agriculture, Pesticide, Biodegradation, Pesticidal residue

Introduction

Environmental degradation is the deterioration of the environment through depletion of resources such as air, water and soil, the destruction of ecosystems and the extinction of wildlife. It is defined as any change or disturbance to the environment perceived to be deleterious or undesirable. Pollutions are the main cause for environmental degradation. Due to increase in human activity, green cover is reducing day by day.

India has been an agricultural based country since ancient time and today also, its economy is based on agriculture sector. A basic fact of green revolution in India, which convened a food deficient state to food surplus state, was the ability to control pests, weeds, insects and diseases by providing effective plant protection umbrella coupled with soil-water management and high yielding varieties. Today, farmers regard pesticides as an essential tool to ensure production of crops of quality and quantity to satisfy an increasing human population. Agricultural experts believe that these food and fiber needs can be met, but to do so will require the increased use of pesticides. Thus these are considered as an indispensable component in pest management strategies for food production and public health in today's context. Pesticides are designed to kill and because their mode of action is not specific to one species, they often kill or harm organisms other than pests, including humans. The application of pesticides is often not very precise and unintended exposures occur to other organisms in the general area where pesticides are applied. Regardless of the

method of application, pesticides ultimately reach the soil, which serves as a reservoir for these chemicals and in turn contaminate the environment.

A pesticide is any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest. Pests can be insects, mice and other animals, unwanted plants (weeds), fungi or microorganisms like bacteria and viruses. Though often misunderstood to refer only to insecticides, the term pesticide also applies to herbicides, weedicides, fungicides, and various other substances used to control pests (USEPA, 1997). Pesticides have made a phenomenal contribution worldwide towards the production and preservation of food, fiber and cash crops, as also the eradication of diseases and maintenance of public health.

Production and usage of pesticides in India

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 (Mathur, 1999). There has been a steady growth in the production of technical grade pesticides in India, from 5,000 metric tons in 1958 to 102,240 metric tons 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 pattern of pesticide usage in India is different from that for the world in general. 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.

Per capita consumption of pesticides in India is low in comparison to other countries. It is only 0.45 kg/ha as compared to 13.35 kg/ha in Italy, 9.18 kg/ha in Japan, 6.56 kg/ha in South Korea and 0.58 kg/ha in the United States. However, India ranks 12th in agro pesticides globally and second in Asia alone (Planning Commission, 2002-2007).

Routes by which pesticides contaminate the environment

- The environmental impact of pesticide use is related to several fundamental properties, essential to their effectiveness as pesticides.
- Firstly, pesticides are toxicants, capable of affecting all taxonomic groups of biota, including non-target organisms, to varying degrees depends on physiological and ecological factors.
- Since pesticides are offered for plant protection, there has been improvement in the control of pest population and spread of infection born disease vectors (Tulucc and Celik, 2002). Majority of chemicals arc beneficial when used judiciously.
- Secondly, many pesticides need to be resistant to environmental degradation so that they persist in treated areas and thus their effectiveness is enhanced. This property also promotes long-term effects in natural ecosystem (Christensen and Tucker, 1977).
- However, many chemicals at even relatively low dosages disturb the metabolism of biota by altering normal enzyme activity (Arslan et al., 1997).

Effects of pesticides on human health

a) Direct impact on humans

The World Health Organization (WHO) estimates that an estimated three million reported cases of pesticide associated acute poisoning occur annually, resulting in 220,000 deaths among which 99 per cent occur in the developing world, in spite of these countries accounting for only 20 per cent of global pesticide use. The true number of cases is likely to be considerably higher. In 1990, as per WHO report, an estimated 25

million agricultural workers are poisoned by pesticides every year. Up to date global estimates are lacking, but today there are 1.3 billion agricultural workers and it is likely that millions of pesticide poisoning cases still occur each year.

The potential adverse impact on human health from exposure to pesticides is likely to be higher in countries like India due to easy availability of highly hazardous products, and low risk awareness, especially among children and women. The general conditions of use in very hot climates where personal protection gear is not always used, increase the risks to health. Overexposure to pesticides can occur before spraying- because of easy access for children, lack of adequate labeling and during mixing - during spraying and alter spraying operations. Spray operators and bystanders can be affected. Particularly at risk are women at home who are generally in charge of washing the used clothes of the spray operator, and usually do not know about risks from pesticide-contaminated clothes. Pesticides can cause depression, insomnia, blindness, cancer, hyperflexia and other gastrointestinal problems. The chemicals can also mix with the ground water through seepage into the soil that may be consumed ultimately as drinking water. According to researchers from the National Institutes of Health (NIH), licensed pesticide applicators that used chlorinated pesticides on more than 100 days in their lifetime were at greater risk of diabetes. One study found that associations between specific pesticides and incident diabetes ranged from a 20 percent to a 200 percent increase in risk. New cases of diabetes were reported by 3.4 percent of those in the lowest pesticide use category compared with 4.6 percent of those in the highest category. Risks were greater when users of specific pesticides were compared with applicators who never applied that chemical.

Due to highly persistent nature of organochlorine pesticides, organophosphate pesticides have increased in use. These are associated with acute health problems for workers that handle the chemicals, such as abdominal pain, dizziness, headaches, nausea, vomiting, as well as skin and eye problems.

As pesticides are inherently toxic to living organisms hence are likely to affect the health of farmers and workers. Besides users, they can be dangerous to consumers, workers and close bystanders during manufacture, transport, or during and after use. The use of chemicals in farming and agriculture has resulted in an increased intake of chemicals by humans. This increased intake of chemicals has in turn resulted in many deleterious effects to the human body. The effects of chemicals on human health are very damaging. It can lead to a host of health problems that can even be fatal. Insecticides and pesticides used for agriculture can be eaten if the food especially vegetables and fruits are not thoroughly washed. Chemicals can also enter the human body through the skin, nose, eyes and mouth.

Pesticide-related health problems result from exposures, which occur chiefly via one or more of the following routes:

• Oral ingestion
• Inhalation
• Dermal (through the skin)

Within the body, pesticide is metabolized or stored in the fat or secreted unchanged, sometimes metabolism increases toxicity, e.g. the hydrolysis of carbosulfan and furathiocarb produces more toxic water soluble compound. carofuran. Some fat soluble substances are not metabolized readily, but stored in fatty tissues i.e. DDT and HCH. In time of poor nutrition these are released in to blood stream with the possibility of toxic effects if concentration reaches a high level.

b) Through pesticide residues in environment and food commodities

Before explaining the effects of residues, definition of pesticide residues is given below:

Pesticide Residues: Substances, which remain in or on a feed or food commodity, soil, air or water following use of a pesticide. For regulatory purposes it includes the parent compound and any specified

derivatives such as degradation and conversion products, metabolites and impurities considered to be of toxicological significance (FAO, 1986).

Environmental pollution by pesticide residues is a major environmental concern due to their extensive use in agriculture, animal husbandry and in public health programs (Waliszevski et al., 1996). It is estimated that often less than 0.1 percent of an applied pesticide reaches the target pest, leaving 99.9 percent as an unintended pollutant in the environment, including in soil, air, and water, or on nearby vegetation (Pimentel, 1995). Pesticides can also move from the site of application via drift, volatilization, leaching and runoff. Toxic effects of pesticides depend upon its toxicological properties, level of residues and degree of exposure to human beings to residues. The more presence of pesticide residues in food does not mean that it is hazardous. To be toxic the residues have to be present in quantities large enough to be considered unsafe or toxic (greater than MRL) which cause some disorder or disease in the body.

In India the first report of poisoning due to pesticides was from Kerala in 1958, where over 100 people died after consuming wheat flour contaminated with parathion (Karunakaran, 1958)**.** This prompted the Special Committee on Harmful Effects of Pesticides constituted by the ICAR to focus attention on the problem (Report of the Special Committee of ICAR, 1972). In a multi-centric study to assess the pesticide residues in selected food commodities collected from different states of the country (Surveillance of Food Contaminants in India, 1993), DDT residues were found in about 82% of the 2205 samples of bovine milk collected from 12 states. About 37% of the samples contained DDT residues above the tolerance limit of 0.05 mg/kg (whole milk basis). The highest level of DDT residues found was 2.2 mg/kg. The proportion of the samples with residues above the tolerance limit was highest in Maharashtra (74%), followed by Gujarat (70%), Andhra Pradesh (57%), Himachal Pradesh (56%), and Punjab (51%). In the remaining states, this proportion was less than 10%. Data on 186 samples of 20 commercial brands of infants formulae showed the presence of residues of DDT and HCH isomers in about 70 and 94% of the samples with their maximum level of 4.3 and 5.7 mg/kg (fat basis) respectively. Measurement of chemicals in the total diet provides the best estimates of human exposure and of the potential risk. The risk of consumers may then be evaluated by comparison with toxicologically acceptable intake levels. The average total DDT and BHC consumed by an adult were 19.24 mg/day and 77.15 mg/day respectively (Kashyap et al., 1994). Fatty food was the main source of these contaminants. In another study, the average daily intake of HCH and DDT by Indians was reported to be 115 and 48 mg per person respectively, which were higher than those observed in most of the developed countries (Kannan et al., 1992).

Contamination of environmental components and food commodities with pesticide residues

I. **Soil**: Overuse of pesticides can also result in serious environmental damage to surface water, groundwater, and air quality, which consequently harm birds, aquatic species, mammals, as well as beneficial insects (also called natural pest enemies).Finally, misuse of pesticides could harm the predator-prey balance and result in higher levels of pest infestation and disrupt the existing ecosystem balance. Ground water is a source of drinking water for as much as 95 % of the population in agricultural areas. Among the pesticides, most acutely dangerous to man are insecticides and rodenticides (Pimental and McLughlen 1991).Not every pesticide is acutely toxic to humans or other non target species. More than 50% of the pesticides reach to soil during the applications for plant protection, the related ecosystem comprising of soil and water bodies may get polluted (Awasthi et al., 2002). The persistence of toxic residues in soil and water adversely affects soil health (Kammenga et al., 2000). In a study, it has been found that soil samples under paddy-wheat, cotton-wheat and sugarcane fields have shown contamination with different groups of pesticides which is a matter of concern. In soil, pesticide residues from organochlorine group like HCH to the extent of 0.051 mg kg^{-1}. DDT 0.066 mg kg^{-1}, endosulfan 0.039 mg $kg^{-1}$and chlordane 0.019 mg kg^{-1} among synthetic pyrethroids. Cypermetethrin 0.035 mg $kg^{-1}$and fenvalerate 0.022 mg kg^{-1} from

organophosphates group chlorpyriphos 0.172 mg kg^{-1}, malathion 0.008 mg kg^{-1}, quinalphos 0.010 mg kg^{-1}. Dominant contaminants were DDT, cypennethrin and chlorpyriphos from the respective groups (Kumari et al.2008).

2. **Water**: Different categories of water analysed all over India during 1996 to 2001 has reveled wide spread contamination with DDT, HCH, lindane, chlorpyriphos and traces of herbicidal compounds. Contamination was up to 60% with HCH and 30% with DDT in addition to other pesticides. If judged on the basis of MRL values of EU, majority of the samples exceeded these limits (Annual Progress Report (2002).

3. **Fruits and vegetables:** Contamination of fruits like grapes, mangoes, apples, guava, ber, sapota etc. has decreased from 93% in 1986-98 to 47% in 2002.About 6% samples contained residues above MRLs which declined significantly to 1.5% during 2001-02. In fruits we find insecticides as well as fungicides residues. The probable cause of relatively less residues in fruits may be long maturation time of these fruits during which toxicants degrade to safe limits.

4. **Honey**: Monitoring studies conducted during 1974-1988 from Bombay & Punjab markets showed presence of OC insecticides in 62-100% samples, whereas samples processed from 1996 to 2002 showed 55 to 100% contamination with OC, OP, SP and carbamate insecticides which is because of change in usage pattern of plant protectants. As there are no MRLs fixed for honey, it is not possible to calculate the samples with residues above MRL values.

5. Milk:

(i) **Bovine milk**: DDT and HCH have been main pesticidal contaminants of' bovine milk throughout India till 2000 AD. Mostly 30-45% of total samples showed contamination with DDT above MRLs and 20 to 78% samples contained HCH above MRLs during 1990-2001. However, samples analysed during 1999-2000 revealed much less contamination as compared to earlier observation. DDT residues were found above MRL value in 11% and HCH above MRI. in 17% samples. Surprisingly endosufan, some organophosphates and synthetic pyrethroids were also detected in some of the samples.

(ii) **Human milk**: Samples analysed during 1981 to 2001 have constantly shown 100% contamination with DDT and HCH. By and large all samples exceeded MRL values. As observed in bovine samples, the human milk samples have been found to contain endosulfan in addition to DDT & HCH. Amount of residues is slightly on the decreasing side.

The toxic residues of the chemicals can affect the central nervous system, liver and respiratory organs. Indiscriminate and disproportionate use of pesticides is comparatively more in certain crops while in some it is negligible. The farmers use pesticides more frequently and in increased doses than the recommended doses or procedures. It leads to the presence of high amount of residues in food commodities. The pesticides are used disproportionately in India in relation to places and the amount of pesticides residue varies from one place to another. Tamil Nadu consumes 1.2-2.0 kg/ha of land followed by Andhra Pradesh and Punjab where 0.8-1.2 kg is the rate of consumption. Pesticide residues in the feed and fodder arc solely responsible for their accumulation in animal and poultry. The states like Tamilnadu, AP, Punjab, Haryana and Karnataka have highest use of pesticides in order to get more production while on the other hand the states like Bihar. West Bengal, North eastern states have lowest use of pesticides. It is because of illiteracy of farmers, poor economic conditions or due to lack of awareness. So the food commodities in high using states have more residues of pesticides.

Application and health effects of pesticides commonly used in India

- Besides causing acute and chronic toxicity, pesticides are affecting the immune system in general and other sensitive systems leading to immune suppression, immuno potentiation and hypersensitivity of the host against infectious and non infectious diseases as well as causing glomerulonephritis, rheumatoid

arthritis, carcinogenicity, reduced fertility, increased cholesterol, high infant mortality, varied metabolic and genetic disorders and reduced lifespan in humans and livestock populations in India (Singh, 2001).

- There is abundant evidence that many pesticides produce their acute toxic action by inhibiting enzymes. In addition, chemicals via food chain have banned physiological mechanisms in man.
- Tulucc and Celik, (2002) carried out a study on effect of pesticides on human and Bovine Erythrocyte Carbonic Anhydrase Enzymes and investigated that Deltamethrin. Pyrazophos. Chlorpyrifos-methyl, Dimethoat, Metamidophos, Dichlorvos, Diazinon, Captan and Malathion, which are pesticides cause inhibitory effect on human erythrocyte carbonic anhydrase (HCA) and bovine erythrocyte carbonic anhydrase (BCA). Deltamethrin was found to have the strongest inhibitor for both HCA and BCA.
- The incidence of cancer, asthma and diseases of kidney, skin and digestive tract has increased by 20-25% in Punjab. Youngsters at the age of 25-30 are suffering front heart ailments and male infertility. The food we eat, the water and milk we drink are contaminated with one or other chemicals. So much so the traces of BHC, endosulphan, DDT & HCH the banned pesticides have been found in the safest and sacred mother's milk in many cases in Haryana. Punjab and Himachal Pradesh.
- Large amounts of pestcides reach the soil, either as direct application, from fall-out, from aerial spraying in rain or dust or plant and animal remains which become incorporated with the soil. Thus, the soil is an Environmental reservoir for these residue from which they enter into the bodies of invertebrates, get transported into water or air and are broken down to innocuous substances.
- The use of pesticides leads to the destruction of non target flora-fauna thus, adversely affecting biodiversity and ecosystem stability. The Increased use of pesticides has also leaded to development of new crop pest which are resistant to existing pesticides (Kalra and Chawla, 1983).

How to minimize pesticidal contamination of food commodities and environment

There is no doubt that pesticides will, as they have done for the last 50 years, continue to play a significant role globally in increasing and stabilizing food supply in future also. The problem needs to be future strategies and suggestions

1. Given the challenges that are involved in the use of pesticides in general and risk perception by consumers in particular it is important that pesticides must be used at levels "as low as reasonably achievable". Consequently, the use of chemicals for crop protection should be part of an integrated crop protection system.
2. Specific targets should be designed at national levels to progressively achieve more stringent qualitative and quantitative reductions in the use of pesticides on specific crops and overall.
3. Principles for Good Agricultural practices (GAP) should be developed which specifically aim at reducing the dependency of agriculture on plant protection chemicals.
4. Least harmful (low risk) plant protection practices should be developed which specifically aim at reducing the dependency of agriculture on plant protection chemicals.
5. Regular surveillance of pesticidal residues in soil, water and food commodities as part of national programme should be carried out in different climate regions. The information thus generated will help the researchers and policy makers in future choice of safer pesticides. Additionally the information will give actual status of contamination to the consumers for avoiding exposure to toxic residues.
6. Education of farmers/users of pesticides is absolutely essential to cause awareness about hazards of pesticide residues and to bring down contamination of food commodities and environmental components.
7. Complete ban on use of hard pesticides like DDT, HCH and heptachlor, chlordane etc both in agriculture and public health sectors.
8. To achieve this aim all players in the chain should have appropriate knowledge about the responsible use of pesticides and ongoing training should take place.

Conclusion

The data on environmental and health risk assessment studies may be regarded as an aid towards a better understanding of the problem. Data on the occurrence of pesticide related illnesses among defined populations in developing countries are scanty. Generation of base-line descriptive epidemiological data based on area profiles, development of intervention strategies designed to lower the incidence of acute poisoning and periodic surveillance studies on high risk groups are needed. Our efforts should include investigations of outbreaks and accidental exposure to pesticides, correlation studies, cohort analyses, prospective studies and randomised trials of intervention procedures. Valuable information can be collected by monitoring the end product of human exposure in the form of residue levels in body fluids and tissues of the general population. The importance of education and training of workers as a major vehicle to ensure a safe use of pesticides is being increasingly recognised.

Pesticides are often considered a quick, easy, and inexpensive solution for controlling weeds and insect pests in urban landscapes. However, pesticide use comes at a significant cost. Pesticides have contaminated almost every part of our environment. Pesticide residues are found in soil and air, and in surface and ground water across the countries, and urban pesticide uses contribute to the problem. Pesticide contamination poses significant risks to the environment. The best way to reduce pesticide contamination in our environment is for all of us to do our part to use safer, non-chemical pest control methods.

There is a need to convey the message that prevention of adverse health effects and promotion of health are profitable investments for employers and employees as a support to a sustainable development of economics. To sum up, based on our limited knowledge of direct and inferential information, the domain of pesticides illustrates a certain ambiguity in situations in which people are undergoing life long exposure. There is thus every reason to develop health education packages based on knowledge, aptitude and practices and to disseminate them within the community in order to minimize human exposure to pesticides.

References

1. Anonymous 2002. Proceedings of the XII Workshop of All India Co-ordinated Research Project on Pesticide Residues. Feb.7-8, 2003. CCS Haryana Agricultural University. Hisar. PP 31-48.
2. Anonymous, 2010. Central Insecticide Board & Registration Committee. Ministry of Agriculture, India.
3. Arslan O. Sekeroglu, R. Celik, I. and. Tarakci, M 1997. The inhibition effects of some pesticides on the activity of five serum enzymes in vitro. J. Environ. Set. Health A. 32(2):361-365.
4. Awasthi, M.D., Sharma, Debi and Abuja. A.K. 2002. Monitoring of horticultural ecosystem: Orchard soil and water bodies for pesticide residues around North Bangalore. Pestic Res J 14(2): 286-291.
5. FAQ 1986. International Code of Conduct on the Distribution and Use of Pesticides. Food and Agriculture Organization of the United Nations. Rome. Italy: 31 pp.
6. Kalra and Chwala.1983. Studies on pesticides residues and monitoring of pesticides pollution, PL_480 project PAU. Ludhiana.
7. Kammenga, J.E., Dallinga, R.. Dunker. M.H., Kohler, H.R., Simonsen, V.,Triebskom, R. and Weeks, I.M. 2000. Biomarkers in terrestrial invertebrates for ecotoxicological soil risk assessment. Rev. Environ. Contain. Toxico/. 164: 93-147.
8. Kannan K, Tanabe S, Ramesh A, Subramanian AN and Tatsukawa R.(1992). Persistent organochlorine residues in foodstuffs from India and their implications on human dietary exposure. J AgricFood Chem **40**: 518–524.
9. Karunakaran. (1958). C.O. The Kerala food poisoning. J Indian Med Assoc **31**: 204.

10. Kashyap R, Iyer LR and Singh M.M. (1994). Evaluation of daily dietary intake of dichlorodiphenyltrichloroethene (DDT) and benzenehexachloride (BHC) in India. Arch Environ Health **49**: 63.
11. Mathur SC. (1999). Future of Indian pesticides industry in next millennium. Pesticide Information **24(4)**: 9–23.
12. Pimentel, D.1995. Amounts of pesticides reaching target pests: environmental impacts and ethics. J.Agric. and EnvirotkEthics. 8: I 7-29.
13. Pinientel, D.L.and MeLaughlen 1991. Environmental and economic impacts of reducing US agricultural pesticide use. CRC Handbook of Pest Management in Agriculture (2nd Ed. Vol I), (Ms, D.Pimentel and AA Hanson) CRC Press. Boca Raton. pp 679-718.
14. Planning Commission (2002-2007). Tenth five year plan. Pp. 697.
15. Report of the Special Committee of ICAR. (1972). (Ed) Wadhwani AM and Lall IJ. Harmful Effects of Pesticides Indian Council of Agricultural Research, New Delhi: 44
16. Singh, D.P. 2001.Pesticides pollution on veterinary public health and food safety in India. In: Livestock Community and Environment. Proceedings of the 10th Conference of the Association of Institutions for Tropical Veterinary Medicine. Copenhagen, Denmark.
17. Surveillance of Food Contaminants in India.1993.Report of an ICMR Task Force Study (Part 1). Eds. G.S. Toteja, J. Dasgupta, B.N. Saxena and R.L. Kalra. Indian Council of Medical Research, New Delhi.
18. Tulucc, Y., and Celik, 1.2002. Influence of some commercial pesticides on human and bovine erythrocyte carbonic anhydrase enzymes (in Vitro). 12(9:27-29.
19. USEPA 1997.USEI'A Office of Pesticide Programme, February 14, 1997, verified February, 2006.
20. Waliszevski, S.M., Pardio Sedus V.T. and Waliszevski, K.N. 19%. Detection of some organckchlorine pesticides in cow's milk. Fd. Addi. and Contaminants. 13(2):231-235.