

Pesticides and Health

" The most alarming of all man's assaults upon the environment is the contamination of air, earth, rivers and sea with dangerous and even lethal materials. This pollution is for the most part irrecoverable; the chain of evil it initiates not only in the world that must support life but in living tissues is for the most part irreversible. In this now universal contamination of the environment, chemicals are the sinister and little recognized partners of radiation in changing the very nature of the world - the very nature of its life."

Rachel Carson, author, Silent Spring

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Dr. SK Ghosh, Ex Dy Director

Address for correspondence

**ENVIS Centre,
National Institute of Occupational Health,**

Meghaninagar, Ahmedabad, India

Phone : 079 - 22682868

Fax : 079 - 22686110

Website : www.envisnioh.org

E-mail : nioh@envis.nic.in

Pesticides have become an area of intense research due to its diverse properties and related effects. The demand for pesticide products and the concentrations that they make towards agricultural efficiency are clear but the volume of production indicates that the potential for misapplication and accidental exposure is great. Besides being beneficial for increased crop yield as well as in vector control programme, it has resulted in the manifestation of several health-related problems. Unintended exposure to pesticides can occur during their manufacturing, formulation and application or from environmental residues after application. Pesticides have been an integral part of modern agriculture for a long time and until very recently, not much attention was given to the potential problem of environmental and groundwater contamination. Indiscriminate and injudicious use of chemical pesticides in agriculture has resulted in several associated adverse effects such as environmental pollution, ecological imbalances, pesticides residues in food, fruits and vegetables, fodder, soil and water, pest resurgence, human and animal health hazards, destruction of biocontrol agents, development of resistance in pests etc. Today synthetic chemical contamination is pervasive and global. There is no clean, uncontaminated place and no person untouched by this chemical legacy. It is rational to believe that pesticides, which are toxic to pests, might produce some adverse health effect. United Nations Environment Protection (UNEP) reported that nine of the twelve most unwanted persistent organic pollutants (POP's) are pesticides used in agriculture crops and for public health vector control programme. These twelve POP's have been identified by the UNEP as a powerful threat to the human and wildlife health on a global basis (Fisher, Environ Health Perspect 1999,107:18A,). Some of the pesticides are

DEFINITION AND CLASSIFICATION:

A pest has characteristics that are regarded by human as injurious or unwanted. The term pesticide covers a wide range of compounds including insecticides, fungicides, herbicides, rodenticides, molluscicides, nematocides, plant growth regulators and others. Ideally a pesticide must be lethal to the targeted pests, but not to non-target species, including man.

Pesticides can be classified on the basis of type of pest control, toxic property and chemical composition.

On the basis of pest control :

- Insecticides (against insect pest)
- Herbicides (for killing and controlling weeds)
- Fungicides (against fungal diseases)
- Others (e.g. molluscicides, nematocides, etc.)

On the basis of their acute toxicity (as classified by WHO)

- Class Ia: Extremely hazardous, **demarcated in red**
- Class Ib: Highly hazardous, symbolized by a yellow triangle
- Class II: Moderately hazardous, marked by a blue triangle
- Class III: Slightly hazardous

On the basis of chemical composition:

- Organophosphate compounds
- Organochlorines
- Synthetic pyrethroids
- Carbamates
- Biopesticides

PRODUCTION AND CONSUMPTION

According to the 1991 census, 66.8% of the entire economically active workforces -i.e. about 180 million people - were engaged in agriculture.

Sources: Employment Information: Indian Labour Statistics 1994. Chandigarh: Labour Bureau, Ministry of Labour, 1996.

Use of pesticides in India began in 1948 when DDT was imported for malaria control and BHC for locust control. India started pesticide production with manufacturing plant for DDT and benzene hexachloride (BHC) (HCH) in the year 1952.

Source: Gupta PK. Pesticide exposure--Indian scene. Toxicol. 2004;198:83

The introduction of other synthetic insecticides organo-phosphate (OP) insecticides in the 1960s, carbamates in 1970s and pyrethroids in 1980s and the introduction of herbicides and fungicides in 1970s - 1980s contributed greatly in pest control and agricultural output.

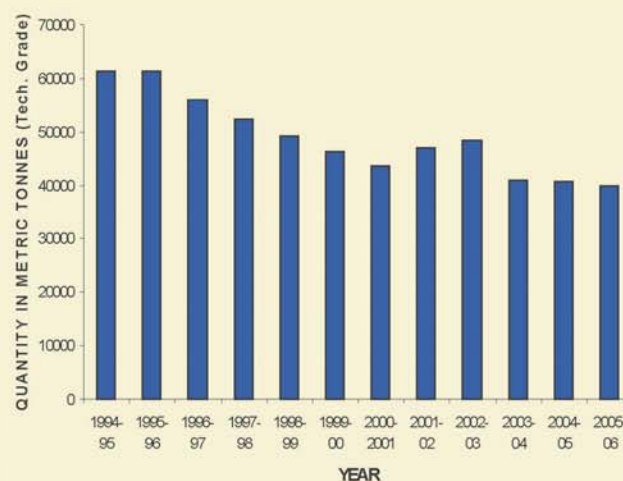
Source: Pesticide Pollution: Trends and Perspective, ICMR Bulletin,

2001, Vol.31, No.9.

The following working condition of farmers makes them susceptible to high exposure to pesticides:

- Safety gears costly and also not suitable for tropical climate.
- Practice Poor to dangerous
- Barefoot and barehanded, wearing minimum cloth, leaking spray tank etc
- Mixing of concentrated chemicals and refilling spraying tanks and spraying-even tasting the mixture.
- Multiple pesticides used mix and match; subsequent medical management difficult
- Unintended exposure of women & children to pesticides while mixing and spraying

Consumption of Chemical Pesticides in India



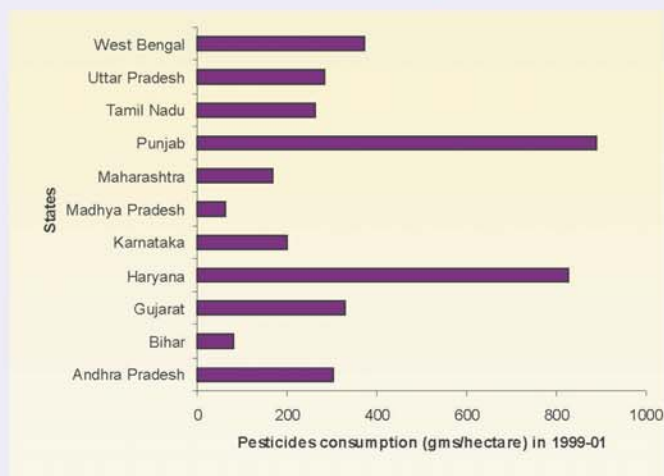
Sources: Adapted from http://dacnet.nic.in/ipmweb/ipmhome/lpmpest_main.htm

Consumption of Biopesticides/Neem based Pesticides

Year	Neem	Bacillus thuringiensis	Total
1994-95	83	40	123
1995-96	128	47	175
1996-97	186	33	219
1997-98	354	41	395
1998-99	411	71	482
1999-2000	739	135	874
2000-01	551	132	683
2001-02	736	166	902
2002-03	632	143	775
2003-04	824	157	981
2004-05	965	139	1104
2005-06	1717	203	1920

Sources: States/UTs Zonal Conferences on inputs.

Statewise Pesticides consumption in India



Source: Adapted from FAO stats <http://www.fao.org>

Pesticides restricted for use in India

S.No.	Name of Pesticides
1.	Aluminium Phosphide
2.	DDT
3.	Lindane
4.	Methyl Bromide
5.	Methyl Parathion
6.	Sodium Cyanide
7.	Methoxy Ethyl Mercuric Chloride (MEMC)
8.	Monocrotophos(ban for use on vegetables)
9.	Endosulfan(Banned in the state of Kerala)
10.	Fenitrothion

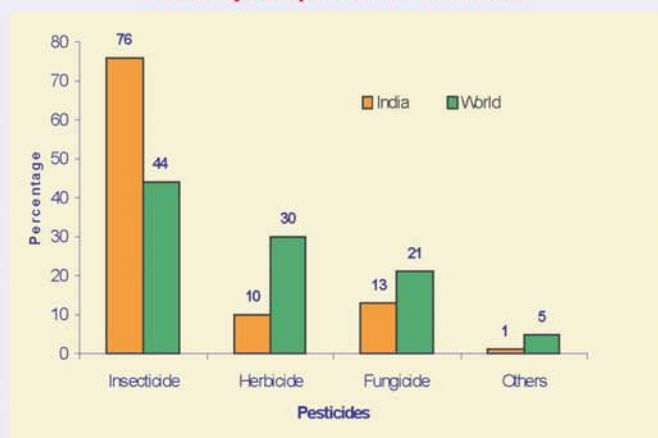
Source: http://cibrc.nic.in/list_pest_bann.htm

List of Pesticides / Pesticides formulations banned in India

Pesticides banned for manufacture, import and use	
1. Aldrin	2. Pentachloro Nitrobenzene
3. Benzene Hexachloride	4. Pentachlorophenol
5. Calcium Cyanide	6. Phenyl Mercury Acetate
7. Chlordane	8. Sodium Methane Arsonate
9. Copper Acetoarsenite	10. Tetradifon
11. Cibromochloropropane	12. Toxafen
13. Endrin	14. Aldicarb
15. Ethyl Mercury Chloride	16. Chlorobenzilate
17. Ethyl Parathion	18. Dieldrin
19. Heptachlor	20. Maleic Hydrazide
21. Menazone	22. Ethylene Dibromide
23. Nitrofen	24. TCA (Trichloro acetic acid)
25. Paraquat Dimethyl Sulphate	
Pesticide / Pesticide formulations banned for use but their manufacture is allowed for export	
1. Nicotin Sulfate	2. Captafol 80% Powder
Pesticide formulations banned for import, manufacture and use	
1. Methomyl 24% L	2. Phosphamidon 85% SL
3. Methomyl 12.5% L	4. Carbofuron 50% SP
Pesticide Withdrawn	
1. Dalapon	2. Paradichlorobenzene (PDCB)
3. Ferbam	4. Simazine
5. Formothion	6. Warfarin
7. Nickel Chloride	

Source: http://cibrc.nic.in/list_pest_bann.htm

Consumption pattern of Pesticides



Source: Mathur SC. Future of Indian pesticides industry in next millennium. Pesticide Information 1999;XXIV(4):9-23.

HEALTH EFFECTS

Organophosphorus insecticides

Organophosphorus insecticides are normally esters, amides, or thiol derivatives of phosphoric, phosphonic, phosphorothioic, or phosphonothioic acids. Most organophosphorus insecticides are more stable in the pH range that may be encountered in the environment (pH: 3- 6), than at neutral pH. Different climatic conditions, especially temperature and humidity, before, during, and after spraying may influence the survival time of insects markedly.

The metabolic fate of organophosphorus insecticides is basically the same in insects, animals, and plants. Uptake in animals and insects may occur through the skin, respiratory system, or gastrointestinal tract. Metabolism occurs principally by oxidation, hydrolysis or by conformational changes by transfer of a group of the molecule.

The signs and symptoms of acute organophosphate poisoning are an expression of the effects caused by excess acetylcholine (cholinergic syndrome). According to the degree of the severity of poisoning, the following signs and symptoms can occur:-

- Mild: anorexia, headache, dizziness, weakness, anxiety, substernal discomfort, fasciculations of the tongue and eyelids, miosis, and impairment of visual acuity.
- Moderate: nausea, salivation, bronchorrhoea, lacrimation, abdominal cramps, diarrhoea, vomiting, sweating, hypertension or hypotension, and muscular fasciculations.
- Severe: miosis or mydriasis, non-reactive pupils, dyspnoea, respiratory depression, pulmonary oedema, cyanosis, loss of sphincter control, convulsions, coma, bradycardia or tachycardia, cardiac ischaemia, cardiac dysrhythmias, hypokalaemia, and hyperglycaemia. Acute pancreatitis has also occurred. Muscular paralysis may involve the respiratory muscles. Some organophosphorus pesticides have caused delayed peripheral neuropathy.

Source: <http://www.inchem.org/documents/pims/chemical/pimg001.htm>

The Poison Information Centre in NIOH, Ahmedabad reported that OP compounds were responsible for the maximum number of poisoning (73 %) among all agricultural pesticides.

Source: Dewan A and Saiyed HN. In: WHO Workshop on Occupational Health Problems in Agriculture Sector. p. 136, 1998.

Organochlorines (OC)

Organochlorines are compounds that contain carbon, chlorine, and hydrogen. Their chlorine-carbon bonds are very strong which means that they do not break down easily. They are highly insoluble in water, but are lipophilic.

Source: <http://www.fws.gov/Pacific/ecoservices/envicon/pim/reports/contaminantinfo/contaminants.html>

The organochlorine compound exhibit an ability to resist degradation, associate with sediments and to accumulate in the tissue of invertebrates, fish and mammals. Most of the organochlorine compounds have properties that contribute to their ability to concentrate in biota and magnify in the foodchain.

Source: <http://www.epa.gov/region09/water/tmdl/nbay/tsdf0602.pdf>

Organochlorines contribute to many acute and chronic illnesses. Symptoms of acute poisoning can include tremors, headache, dermal irritation, respiratory problems, dizziness, nausea, and seizures. Organochlorines are also associated with many chronic diseases. Studies have found a correlation between organochlorine exposure and various types of cancer, neurological damage (several organochlorines are known neurotoxins), Parkinson's disease, birth defects, respiratory illness, and abnormal immune system function.

Many organochlorines are known or suspected hormone disruptors, and recent studies show that extremely low levels of exposure in the womb can cause irreversible damage to the reproductive and immune systems of the developing fetus.

Source: <http://www.chemicalbodyburden.org/aboutus.htm>

Carbamate

Carbamates, or urethanes, are a group of organic compounds sharing a common functional group with the general structure -NH(CO)O- . Carbamates are esters of carbamic acid, NH_2COOH , an unstable compound. These insecticides can cause cholinesterase inhibition poisoning by reversibly inactivating the enzyme acetylcholinesterase.

Source: <http://en.wikipedia.org/wiki/Carbamate>

Health hazards for man occur mainly from occupational over-exposure to carbamate insecticides resulting in poisoning characterized by cholinergic symptoms caused by inhibition of the enzyme AChE. The main routes of exposure are inhalation and skin. Apart from the symptoms indicative of ChE poisoning, other signs and symptoms induced by certain carbamates have been described, such as skin and eye irritation, hyperpigmentation, and influence on the function of testes (slight increase of sperm abnormalities). These signs and symptoms were found in a few studies and should be confirmed before it can be stated that they were induced by carbamates.

Source: <http://www.inchem.org/documents/ehc/ehc/ehc64.htm>

Pesticides as Endocrine disruptors :

An endocrine disruptor is an exogenous substance or mixture that alters function(s) of the endocrine system and consequently causes adverse health effects in an intact organism or its progeny or (sub) populations¹. Exposure to low doses of endocrine-disrupting chemicals may have little effect on the exposed adult organism, but the offspring of that organism may suffer drastic repercussions. Report indicates that newly hatched herring gull chicks collected in the lake Ontario area in Canada; a region highly contaminated with DDT, had altered reproductive system. Male chicks had gonads and oviducts resembling ovaries and oviduct system of female birds developed abnormally². Further, reduction in penis size and serum testosterone levels in juvenile alligator population of lake Apopka in Florida, USA, has also been attributed to the contamination of the lake by DDT-metabolite p, p' DDE and p,p' DDD³. Further, another group of pesticide i.e. pyrethroid compounds (sumithrin, fenvalerate and d-transallethrin) which are considered to be safe till recently as compared to organochlorine and organophosphate compounds have also been reported to be able to disrupt estrogen function *in vitro*⁴. However, very little is known about the estrogenic potential of these compounds *in vivo*.

Source:

- 1 IPCS "Global Assessment of the state-of-the-science of Endocrine disruptors", 2001.
- 2 Fox, In: Chemically induced Alterations in Sexual and functional, development: The Wildlife and human connection, pp.203 1992
- 3 Guillette et al. Gen. Comp. Endocrinol., 32, 1996
- 4 Go Vera et al. Environ Health Pers, 107, 173 1999

"Exposure to some of the pesticides during infancy, even at very low levels, can lead to serious life-long consequences if the pesticides disrupt hormone-driven development processes."

Charles M Benbrook

USEFUL WEBLINKS

" Until we have a more complete understanding of pesticide toxicity, the benefit of the doubt should be awarded to protecting the environment, the worker, and the consumer- this precautionary approach is necessary because the data on risk to human health from exposure to pesticides are incomplete."

British Medical Association

IndiapesticidesLtd
<http://www.indiapesticideslimited.com/>

Central Insecticides Board and Registration Committee
<http://cibrc.nic.in/>

Indian Chemical Council
<http://www.icmaindia.com/>

Information system for Integrated Pest Management
<http://dacnet.nic.in/ipmweb/iipm.htm>

Stockholm Convention on Persistent Organic Pollutants
<http://www.pops.int/>

US Environmental Protection Agency Pesticides
Programme

www.pesticideinfo.org
www.usda.gov
www.epa.gov

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MEGHANINAGAR,
AHMEDABAD-380016.
GUJARAT-INDIA

- Prepare only enough pesticide for the particular application, use all the prepared pesticide on the application site (but avoid excess application), and avoid using pesticides on windy days.
- Persistent organochlorine pesticides should be no longer permitted to use. Persistent organochlorine pesticides are broad spectrum pesticides. However, these chemicals are not readily broken down in the environment and accumulate in humans and animals. They therefore have the potential to harm human health and the environment many years after application and it is an offence to use them.
- Follow Pesticide 'NEVERS'
- NEVER store pesticides in non-pesticide containers, e.g. containers used or labelled for food and drink.
- NEVER re-use pesticide containers for any purpose other than to hold the original pesticide.
- NEVER dispose of pesticide wastes down drains, toilets, sinks, gully traps or into bodies of water (such as rivers, lakes, streams or dams).
- NEVER dispose of pesticide wastes or contaminated or uncleaned pesticide containers in public litter bins or private garbage bins, or leave them out for curbside collection.
- NEVER dispose of surplus pesticides in the garden.
- NEVER deliver used glass or plastic pesticide containers to bottle collection depots.
- NEVER burn pesticide wastes, including pesticide containers.

Source: <http://www.environment.nsw.gov.au/envirom/wastepest.htm>

First aid measures:

If pesticides are spilled on the skin:

- Follow the first-aid directions on the label - or immediately wash with soap and water.
- Remove pesticide-contaminated clothes immediately - wash them separately from other clothes.
- Monitor for symptoms of poisoning - if in any doubt, seek immediate medical attention.
- If pesticides come in contact with the eyes, wash with copious amounts of water.

Regulation of pesticide use:

Central Insecticides Act, 1968

The Central Insecticides Act 1968 [Act 46 of 1968. As amended by Acts 46 of 1972, 24 of 1977 and 23 of 2000]. This Act is made to regulate the import, manufacture, storage, transport, distribution and use of pesticides with a view to prevent risk to human beings, animals and the environment. It came into force with effect from 1st August, 1971. Through this Act, a Central Insecticides Board has been set up to advise the state and central governments on technical matters and for including insecticides into the Schedule of the Act.

Prevention of Food Adulteration [PFA] Act, 1954

This act governs the production and use of insecticides in India. This Act and its Rules lay down standards for different food articles as well as provisions for their storage, distribution and sale. The Maximum Residue Limits [MRLs] for different pesticides are regulated through this PFA Act.

Source: <http://ipu.ac.in/uslaw/journal/A13.pdf>

Use of biopesticides

Biopesticides are a group of pesticides derived from natural materials like animals, plants, bacteria, and certain minerals. For example, canola oil and baking soda have pesticidal applications and are considered biopesticides. At the end of 2001, there were approximately 195 registered biopesticide active ingredients and 780 products.

Biopesticides fall into three major classes:

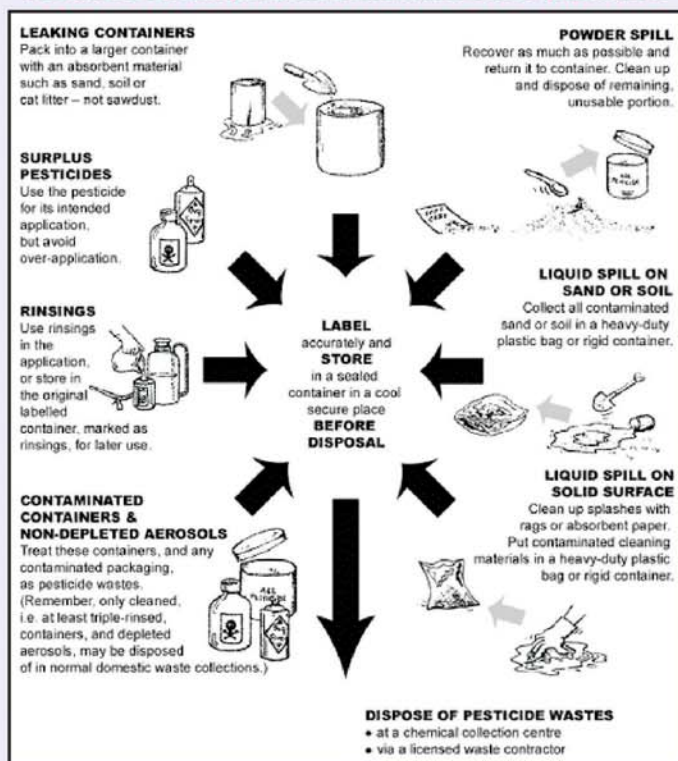
1. Microbial pesticides consist of a microorganism (e.g., a bacterium, fungus, virus or protozoan) as the active ingredient.
2. Plant-Incorporated-Protectants (PIPs) are pesticidal substances that plants produce from genetic material that has been added to the plant.
3. Biochemical pesticides are naturally occurring substances that control pests by non-toxic mechanisms.

Advantages:

- Biopesticides are usually inherently less toxic than conventional pesticides.
- Biopesticides generally affect only the target pest and closely related organisms, in contrast to broad spectrum, conventional pesticides that may affect a group of organisms such as birds, insects, and mammals.
- Biopesticides often are effective in very small quantities and often decompose quickly, thereby resulting in lower exposures and largely avoiding the pollution problems caused by conventional pesticides.

Source: <http://www.epa.gov/opp00001/biopesticides/whatarebiopesticides.htm>

Possible steps to prevent contamination of pesticides



Source: Adapted from <http://www.environment.nsw.gov.au/envirom/wastepest.htm>

Level of DDT and HCH in human biological samples in India

Levels of DDT and HCH residues in human milk samples in Indian population

City	Whole milk basis (ppm)	
	Total DDT	Total HCH
Ahmedabad	0.305	0.224
Bangalore	0.053	0.014
Bombay	0.224	0.053
Calcutta	0.114	0.031
Delhi	0.344	
Delhi		0.38
Lucknow	0.127	0.107
Ludhiana	0.51	0.195

Source: Pesticide Pollution: Trends And perspective, ICMR Bulletin, 2001, Vol.31, No.9.

Levels of DDT and HCH in blood samples of Indian population

City	Year	Total DDT (ppm)	Total HCH (ppm)
Lucknow	1980	0.02	0.022
Delhi	1982	0.71	0.49
Lucknow	1983	0.028	0.075
Delhi	1985	0.301	
Ahmedabad (rural)	1992	0.048	0.148
Ahmedabad (urban)	1997	0.032	0.039

Source: Pesticide Pollution: Trends And perspective, ICMR Bulletin, 2001, Vol.31, No.9.

Levels of DDT and HCH residues in fat samples in Indian population

City	Year	Total DDT (ppm)	Total HCH (ppm)
Delhi	1964	26.0	1.43
Delhi	1973	21.8	
Delhi	1976	4.7	
Chandigarh	1980	20.03	2.44
Agra	1980	12.02	2.0
Bombay	1980	6.15	
Calcutta	1980	6.5	1.61
Bhopal	1980	9.14	1.06
Ahmedabad	1980	21.81	3.87
Bangalore	1980	7.82	5.05
Meerut	1981	4.7	
Delhi	1984	22.25	16.85

Source: Pesticide Pollution: Trends And perspective, ICMR Bulletin, 2001, Vol.31, No.9.

PREVENTIVE MEASURES :

Integrated Pest Management:

Integrated Pest Management (IPM) as cardinal principle and main plan of plant protection in the overall Crop Production Programme since 1985. IPM is an eco-friendly approach, which encompasses cultural, mechanical, biological and need based chemical control measures. The IPM approach is being disseminated through various schemes/projects at national and state level with the following objectives:

- To maximize crop production with minimum input costs.
- To minimize environmental pollution in soil, water and air due to pesticides.
- To minimize occupational health hazards due to chemical pesticides.
- To preserve ecosystem and maintain ecological equilibrium.
- To no or less use of chemical pesticides for minimum pesticide residues.
- To improve farming systems.

Source: http://dacnet.nic.in/ipmweb/ipmhome/lpmpest_main.htm

Curtailing pesticide misuse:

The pesticide misuse should be minimized to reduce the exposure. The pesticide misuse includes:

- Failing to follow label or permit instructions
- Using pesticides in a way that is likely to injure people or damage property
- Harming a non-target plant or animal
- Using an unregistered pesticide or possessing one (and intending to use it)
- Storing pesticides in containers that do not have the approved label attached
- Disposing of a pesticide or its container illegally, e.g. pouring pesticide waste down a drain
- Spraying pesticides from an aircraft without a relevant license
- Spraying pesticide against the wind direction

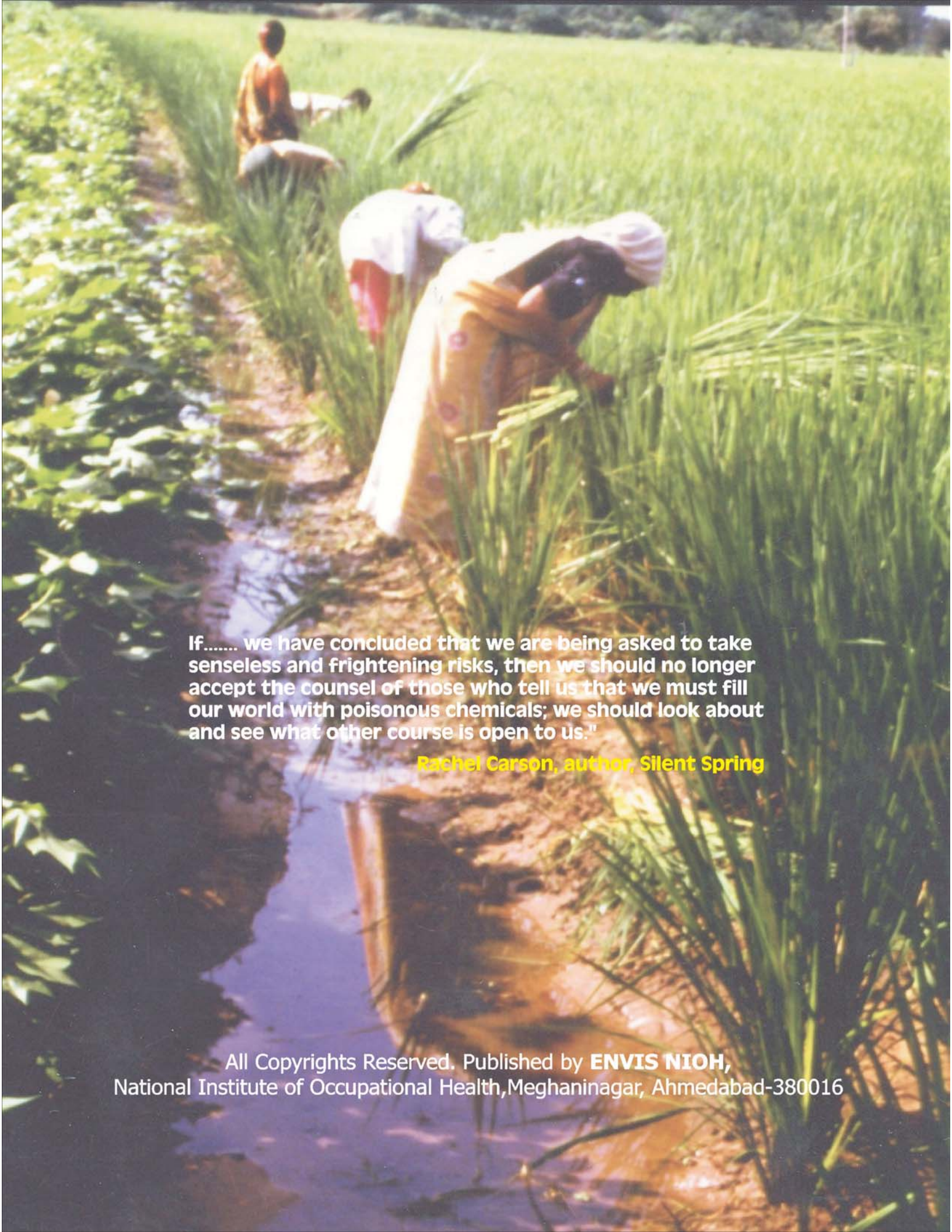
Source : <http://www.environment.nsw.gov.au/envirom/pestmisuse.htm>

Safety precautions

- When using pesticides always read the pesticide container label before use and strictly follow the directions for use provided by the manufacturer or supplier.
- Prepare pesticides in a well-ventilated area, wear appropriate protective clothing (such as gloves, facemask and goggles) and keep children and animals away from preparation and application areas.



Unsafe pesticide spraying practice



If..... we have concluded that we are being asked to take senseless and frightening risks, then we should no longer accept the counsel of those who tell us that we must fill our world with poisonous chemicals; we should look about and see what other course is open to us."

Rachel Carson, author, Silent Spring

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