The Integrated Pest Management (IPM) Approach as an Alternative Pesticide Use in Nepal

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Abstract

In the last four decades Nepal has introduced several categories of pesticides — including organochlorine, organophosphates, carbamates, and synthetic pyrethroids. Most of the insecticides used were broad in spectrum, causing tremendous damage to human health and the environment — including soil microbes and water biota. These toxic chemicals with high persistence in nature were chosen to control pests for a longer period by innocent and illiterate users in the past. Some of these biological toxicants are still used in Nepal. Target species were insect pests of agricultural crops within the agro-ecosystem, but beneficial natural enemies in the food chain have been victimised as well. The Ministry of Health has also used insecticides against vectors of malaria and *kalajar*. Insecticides have contaminated major portions of the environment, killing animals on the surface soil, while under the soil making their way to the water table and forming different metabolites. The biological magnification has been traced from dead animals — including fish from the lakes of the Pokhara Valley. A backlash has already been noticed: the overuse of insecticides has caused minor pests to become major ones after a short colonisation period. Almost all insecticides used in the past for three years have bred resistance among insects and produced biotypes. Even synthetic pyrethroids that were introduced during the 1980s have led to a 12- to 56-fold level of resistance among *Heliocoverpa armigera* in the western part of Nepal. The misuse of insecticides is reported to have killed fish in ponds, channels, canals, rivulets, and rivers. Due to lack of awareness among the users, insecticide-related poisoning and death are increasing in Nepal. The integrated pest management (IPM) is suggested here as an alternative approach to pesticide use for Nepal.

Introduction

One of the features of modern farming has been the introduction of agrochemicals and the dependency on importation they create. The use of pesticides in Nepal is very low compared to other countries in South Asia. But the trend towards importing them in recent years has clearly brought about an alarming and dangerous situation. The overuse and misuse of these toxic chemicals by illiterate farmers are primarily on cash crops. Target crops have been cotton, vegetables, and tea. Fish have also suffered. In the past two decades, cereal crops, such as rice, maize, and wheat, have also come under a growing threat from toxic chemicals. Pesticides are used widely by farmers and agricultural labourers under inadequate safety conditions. Large numbers of people are victimised by occupational intoxication. High persistence organochlorine insecticides are used widely in Nepal. There is lack of awareness about environmental pollution from pesticides (Giri 1990).

Pradhan (1978) reported the use of gammaxene dusts in agriculture during the 1970s. No other substitutes are available in terms of costs to poor farmers. Chemical pesticides include insecticides, rodenticides, fungicides, and weedicides. The use of insecticides has been over 70 per cent of the total chemical pesticides. Some nine insecticides, namely, parathion-ethyl, demeton-s-methyl, trichlorfon, fenitrothion, parathion-methyl, trichlorfon granules, chlordane 10 per cent, HCH 10 per cent, and malathion five per cent dusts, have been were marketed. Two insecticides, namely chlordane and HCH 10 per cent dusts, have major commercial niches. They are highly persistent in soil. Crops such as rice, maize, wheat, vegetables, and fruit trees are treated with chlorinated hydrocarbons, which not only pollute the agro-ecosystem but also produce biological magnification. They are transported under the soil through the water table towards rivers.

Pesticides in the Agro-ecosystem

Fishes in the lakes of the Pokhara Valley have died. Insecticide residue detected in fish flesh indicated the presence of BHC and DDT. The insecticides were used 20 to 30 years ago in the neighbouring villages against agricultural and household insect pests — including mosquito vectors. Pesticides are spilled, no matter whether they are used on crops or in the household. Over 90 per cent of pesticides fall on non-targeted areas, causing tremendous damage to the environment and health. These insecticides move along with rainwater above and under the soil surface and accumulate in lakes along with different metabolites. Joshi (1988) reported a 19 per cent reduction in DDT residue levels in food commodities from 1981 to 1988. Chlorinated hydrocarbon insecticides have a higher persistence compared to other chemical pesticides, and the reduction in toxicity as well as in the formation of different metabolites is very slow. Therefore, future research needs to focus on detection of residues or organic chlorine in the ecohydrology of the high mountain areas of Nepal where these pesticides are being used more and more frequently.

Organochlorine insecticides with high persistence accumulate in the food chain, resulting in biological magnification. Methodological problems are encountered in estimating the impact of pesticide exposure on the health of field workers in Nepal. Clinical signs of toxication, notably acetylcholinesterase depression, are not reported.

Reports from thirty-three different studies on the water quality of the Bagmati River at different locations in the valley are documented (EAST Consult 1994). The study mainly focussed on biological oxygen demand (BOD) and heavy metal deposits. No pesticide residue analysis work was reported. NEW ERA (1990) reported the use of DDT in the Trishuli Valley below 1,200m in elevation for the control of malaria-bearing mosquitoes. DDT is sprayed in houses and cattle sheds. The level and concentration of organic micro-pollutants and pesticides are not known. There is no analytical laboratory facility in Nepal capable of undertaking pesticide residue analysis. According to the District Agricultural Inputs' Corporation, the use of pesticides within the district was reported to be very low, except for DDT. The use of pesticides was limited within the study area. The water of the carp culture fish pond showed high BODs and faecal coliform content. The faecal coliforms were high in all locations sampled, except in the Ghekhu *Khola*, in which the water quality is comparatively better. From the human health hazard point of view, the water was considered highly polluted.

Development of Resistance in Insects

Nepal has been using chemical pesticides since 1955. In the beginning they were considered a boon to farmers. Crop yields increased dramatically. They were also useful in controlling serious tropical diseases like malaria.

However, it was known right from the beginning that pesticides were a potential threat to people using them. Later it was found that the new chemicals were also responsible for environmental damage. People were poisoned through land, water, and food crops. Indiscriminate use of pesticides was found to be responsible for creating a new biotype, 'super bugs'.

Pyrethroid, endosulfan, organophosphate, and carbamate insecticides created a resistance to them in the larvae of *Helicoverpa armigera* in Nepal (Table 1). Armes and Pandey (1995) reported that *H. armigera* strains from Pokhara showed a 12-fold resistance to pyrethroids in 1993 and a 56-fold one in 1994, while in Nepalganj the increase was 103-fold in 1995. Similarly, tolerance to endosulfan (2-3-fold) and methomyl (2-fold) rose in Pokhara in 1994 and that to methomyl 11-fold in Nepalganj in 1995. No indication of resistance to phosphate (monocrotophos) or phosphorothionate (quinalphos) organophosphate insecticides was found in Pokhara, but quinalphos showed a 4-fold increase in Nepalganj in 1995.

Table 1: Development of Resistance among Insects to Insecticides in Nepal, 1995

Resistance in *Helicoverpa armigera* (multiplicative increase)			
	Pokhara		Nepalgunj
	1993	(1994)	(1995)
Cypermethrin	12	56	103
Fenvalerate		53	126
Endosulfan	2	3	3
Quinalphos	1	0.8	4
Monocrotophos		0.8	0.4
Methomyl		2	11

Pesticide Poisoning and Deaths

Pesticide poisoning is reported to affect 750,000 people, the majority of whom are in the Third World (PAN 1986), each year. The World Health Organisation (WHO 1989) has published figures showing a million poisonings and 20,000 deaths a year. If recent Sri Lankan figures were applied globally, the numbers would be 2.9 million people hospitalised each year for acute poisoning, with 220,000 deaths (PAN 1986), while, in Nepal, poisoning and deaths due to pesticides are increasing (Fig. 1). Most of the poisoning cases in Nepal are due to insecticides and rodenticides.

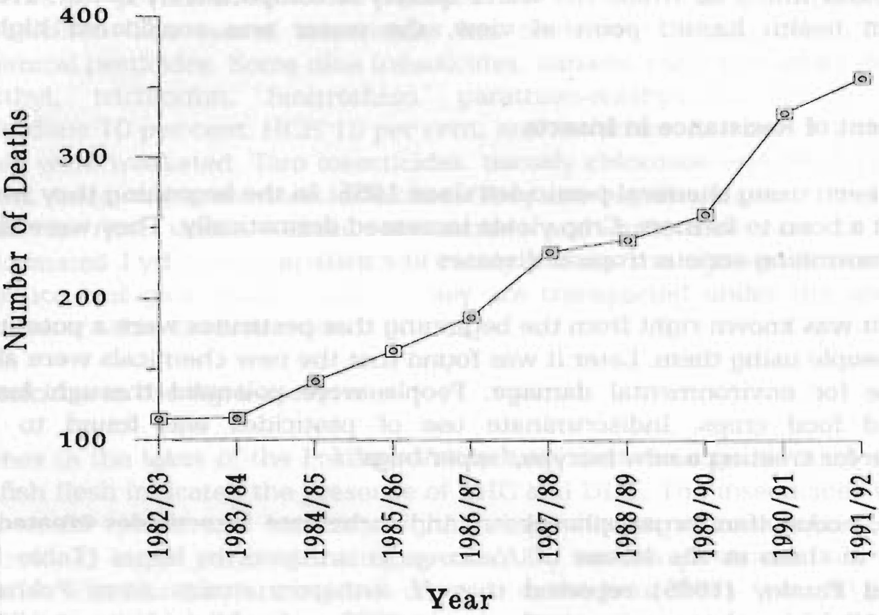

Figure 1: Deaths from Pesticide Poisoning in Nepal

Source: CBS, 1995

Some constraints on the accuracy of proper diagnosis are observed in Nepal. Misdiagnosis of poisoning is due to the absence of diagnostic tools, high patient-doctor ratio, unfamiliarity of health workers with the signs and symptoms of poisoning, and lack of access on the part of poor victims to the formal health care centres.

The Entomology Division of the Nepal Agricultural Research Council (NARC) is responsible for carrying out research on an integrated pest management (IPM) approach. NGOs are actively promoting safe pesticide use and management through IPM.

The predominant crops grown in the mid-hills of Nepal are rice, wheat, maize, millet, potatoes, tomatoes, and other vegetables. The use of pesticides in different crops against pests and their toxicity and hazards are given in Table 2. Currently Nepal is using small quantities of herbicides. This use is not expected to increase very much in the near future.

Table 2: Use of Pesticides in Nepal against Pests of Agricultural Importance together with Comparative Toxicity and Hazards

Pesticides	WHO (mg/kg) Class ADI Oral LD50	Pests				
		Rice	Maize	Wheat	Potatoes	Tomatoes and Other Vegetables
Insecticides						
Organochlorines						
Aldrin	Ib 0.0001 685		White ants		Red ants	Red ants
Lindane	II 0.01 88	Rice bugs	Borer complex	Stored Pests		
Chlordane	II 0.0005 460				Red ants	
DDT	II 0.02 113					
Endosulfan	II 0.006 80	Case worms	White ants			Caterpillars
Organophosphates						
Demeton-s-methyl	Ib 0.0003 40					
Dichlorvos	Ib 0.004 56	Rice bugs				Caterpillars
Dimethoate	II 0.01 150					
Fenitrothion	II 0.005 503	Case worms	Armyworm			
Malathion	III 0.02 100			Stored Pests		
Monocrotophos	Ib 0.0006 14	Stem borers				Aphids
Parathion methyl	Ia 0.02 14	Army worms	Wire worm			Caterpillars
Phosphamidon	Ia 7					Aphids
Carbamates						
Carbaryl	II 0.01 300	Stem borers		Army worm	Aphids	Caterpillars
Carbofuran	Ib 0.01 8	Seedbed beetles	Red ants	Stem borers	Red ants	Red ants
Methomyl	Ib 0.01 17		Red ants			DBM
Propoxur	II 0.02 95	Case worms			Aphids	Aphids
Pyrethroids						
Cypermethrin	II 0.05 250	Leaf folders				Caterpillar
Deltamethrin	II 0.01 135	Case worms	White grubs			DBM
Fenvalerate	II 0.02 450	Stem borers				Caterpillar
Fungicides						
Carbendazim	IV0.01 15000	Blasts			Late	Rot
Carboxin	IV 3820	Blasts		Rusts	blight	
Copper oxychloride	III 1440			Rusts	Wilt	
Edifenphos	Ib 0.003 150					
Mancozeb	IV 0.05 8000			Smuts		
Thiram	III 560				Late	Rot
Tridemorph	II 650				blight	
Herbicides						
2,4-D	II 0.3 375			Weeds		
atrazine	IV 2000			Weeds		
glyphosate	IV 0.3 4320	Weeds	Weeds			Weeds
isoproturon	III 1800					

Organochlorines were introduced in to Nepal during the 1950s (Baker and Gyawali 1994). Toxicity is high for humans due to high residues, and persistence in the food chain is also high. Hence health risks are very high (Table 3).

Table 3. Pesticides and Their Effects on Health

Insecticides	Effects
Organochlorines*	cause cancer, tumours, birth defects, mutations, blood disorders, spontaneous abortion, and damage to the brain, nerves, and kidneys**
Aldrin Class II, 100mg/kg	cumulative in animal tissue but rapidly eliminated when exposure is terminated, short-lived on foliage, half life in soil approx. 1-4 months, shorter in tropical conditions.
Lindane (gamma HCH, gamma BHC) Class II, 88mg/kg	stored in body fat
Chlordane Class II, Oral 460mg/kg	stored in body fat, highly residual, harmful to fish
DDT Class II , Oral 113mg/kg	stored in body fat, highly residual, harmful to fish
endosulfan Class II , Oral 80mg/kg,	not cumulative in body tissues, moderately persistent on foliage, 50 per cent residue is lost from plant tissue in 3-7 days.
Organophosphates	Build-up in humans with repeated exposure can cause irreversible nerve damage, loss of muscle function, spontaneous abortion, psychiatric disorders, and death. One teaspoonful of methyl parathion spilled on the skin can be fatal.
Demeton-s-methyl Class Ib, 65mg/kg	does not accumulate in the body tissue, relatively short-lived: 14-21 days.
Diazinon Class II, Oral 300mg/kg	Diazinon and its metabolites are rapidly excreted from the body, mainly in the urine, residue on foliage 5-10 days, and in the soil 2-3 weeks
Dichlorvos Class Ib, 56mg/kg	Non-cumulative in the body tissue
Dimethoate Class II, 150mg/kg	Not cumulative in body tissue, as it is rapidly excreted via the urine
Fenitrothion Class II, 500mg/kg	does not accumulate in body tissue
Malathion Class III, 2100mg/kg	does not accumulate in body fat, residual properties are moderate
Monocrotophos Class Ib, 14mg/kg	does not accumulate in body fat, persistence 7-14 days. Half life in soil 10-20 days
Parathion methyl Class Ib, 14mg/kg	does not accumulate in body tissue, non-persistent.
Phorate Class IB, 2mg/kg	does not accumulate in body fat, residues in the soil approximately 14 weeks
Phosphamidon Class IA, 7mg/kg	does not accumulate in body tissues, half life on plants about 2 days
Cabamates	cause nerve damage, spontaneous loss of muscle functions, and death
Carbaryl Class III, >300mg/kg	residue half-life 3-5 days
Carbofuran Class III, 8mg/kg	half-life in the soil, 30-60 days, metabolised in the liver
Pyrethroids	some effects on central nervous system
Cypermethrin Class III, >4,000mg/kg	does not accumulate in the tissues, residues on foliage 10-14 days but several weeks in the soil
Fenvalerate Class III, 3,200mg/kg	persistent in fat tissue but does accumulate, short residual life on foliage (10-14 days) but several weeks in the soil.
Copper oxychloride Class III, 1,440mg/kg	does not accumulate in animal tissues, relatively short life
Mancozeb Class II, 8,000mg/kg	does not accumulate in body fats, residual-moderately resistant
Tridemorph Class II, 650mg/kg	residual properties 20-28 days, does not accumulate in animal tissues
2,4-D Class II, Oral 375mg/kg (rats)	relatively short-lived dry residue, breaks down quite rapidly
Atrazine Class III, 7,500mg/kg	residue approximately 6-12 months in the soil depending on the soil type, slightly toxic to fish

Source: * ADB, 1987, ** ARSAP/CIARD, 1989

Organophosphates were introduced into Nepal during the 1960s. Toxicity is high for humans, and persistence in the food chain is moderate. Health risks are very high.

Cabamates were introduced into Nepal during the 1970s. Toxicity is high for humans. Persistence in the food chain is low, but health risks are very high.

Pyrethroids were introduced into Nepal during the 1980s. Toxicity to humans and persistence in the food chain are low. Health risks are low.

Fungicides: Most of the chemical fungicides are safe compared to the toxic insecticides commonly used in Nepal. However, their frequent use on crops and plants has caused environmental pollution.

Malaria remains a major problem in the *Terai*, and some pockets of the mid-hills, such as Panchkhal and the Pokhara Valley, have reported malaria victims. DDT was mainly used for the control of the malaria vector.

Some villages near lakes in the Pokhara Valley have used insecticides on agricultural crops and also against mosquitoes. The insecticides and their metabolites were detected in fish-skins and are listed in Table 4.

Table 4. Insecticides Detected in Three Samples Collected from Begnas *Tal*, Pokhara (May 18, 1994)

Compound Name	Fish	Fish	Fish
Organochlorines	1	2	3
a-BHC	27.0ppb	26.9ppb	<11.3ppb
Ronnel	24.0ppb	31.4ppb	<11.3ppb
p,p'-DDE	85.1ppb	51.4ppb	<11.3ppb
p,p'-DDD	17.0ppb	11.3ppb	<11.3ppb
Methoxychlor	55.2ppb	58.1ppb	<11.3ppb
Source: Anonymous 1994			

Small quantities of pesticide are used on animals, mainly for ectoparasite control. The pesticides involved are mostly Malathion and Lindane.

The IPM Approach as an Alternative to Safe Pesticide Use

Cramer (1967) reported the loss of up to 55.1 per cent of agricultural crops for reasons such as insect pests, diseases, and weeds. The loss of rice yield in the Chitwan Valley is 200kg/ha from the borer complex alone (Anonymous 1995). Results for rice and wheat show an average of 45 per cent pre-harvest and 11.6 per cent post-harvest losses of normal rice (Ali et al. 1993). In spite of several efforts to minimise crop loss from pests, several categories of toxic pesticide were introduced; positive yield results were not forthcoming. Klarman (1987) suggested that an improvement in pesticide use was required. Therefore, the IPM approach has been recommended for controlling pests of national significance, with a major emphasis on host plant resistance. IPM is ecologically sound, environmentally non-pollutive, and sustainable to the economies of poor nations. Biological, cultural, traditional, and chemical control methods are the components of IPM. It has received considerable backing in the Eighth Five-year Plan and the twenty-year Agricultural Perspective Plan (APP 1995) of His Majesty's Government of Nepal (HMG/N). The term 'integrated pest management'

(IPM) was originally proposed to describe the integration of biological controls into a cohesive pest management system (Barlett 1956, Stern et al. 1959). Smith (1978) defined IPM as a multidisciplinary ecological approach to the management of pest populations that uses a variety of compatible control methods in a single coordinated pest management system. It is a combination of natural botanical pest management techniques and cultural and biological methods (Hoper et al. 1993). IPM options as an alternative to the use of the 12 most hazardous pesticides, known as the 'Dirty Dozen,' are well documented (Gips 1987). IPM and traditional pesticides are suggested as an alternative to chemical pesticides (NECOS 1992).

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