

PESTICIDES — an overview with particular reference to Sri Lanka

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From the earliest beginnings of mankind, there were also other species of living organisms. Some of these were beneficial to man while there were others which caused harm. Man's competitors adapted quickly to human habitat. Many insects and other organisms found man's crops to their liking and his dwellings provided shelter for a host of his competitors. As man continued to modify his surroundings, the competition from other organisms became more intense. Soon organised patterns of pest control evolved. Light traps to remove insects and scarecrows to discourage birds were among the earliest such efforts. With increased incidence of pests and outbreak of disease it became almost a necessity to develop more efficient forms of control. Pest control and various forms of pesticides were further developed with advances in science and technology and today these pesticides are used on an extensive scale in agriculture, sanitation and domestic hygiene.

Types of Pesticides

Pesticides are classified as a group of agrochemicals which consist of fertilizers and growth regulatory substances used in agriculture. In general, pesticides are chemicals, mostly organic and are biologically active. These compounds interfere with one or more of the essential metabolic processes of the organism against which they are applied. Pesticides could be broadly categorised into Herbicides (weedicides), Insecticides, Fungicides, Nematocides, Rodenticides and Acaricides. (Herbicides: — These are the chemicals applied to control weeds, which tend to reduce yields of agricultural crops considerably. In rain-fed rice, failure to control weed growth during the first three weeks after seeding can reduce yields by as much as 75 per cent. In irrigated wetland rice, weeds

have been found to reduce yields by about 50 per cent. Weeds also cause an increase in incidence of pests and diseases as some pests use certain weeds as alternate hosts and so are some plant diseases. The use of herbicides extends back thousands of years, perhaps to the days of the Roman Empire, when ash, common salt, etc. were used to control weeds on roads. In 1896 Bonnet in France discovered that a solution of copper sulphate would kill Charlock (*Sinapsis arvensis*) growing with oats, without damage to the crop. Sixteen years later Rabate demonstrated that dilute sulphuric acid could also be used as a herbicide. In 1932, the use of 3:5 dintro-ortho-cresol to destroy weeds in cereals was discovered again in France. In 1941, Templeman in England found that one of the early plant growth regulating substances and naphthylacetic acid acts as a weedicide. This discovery together with important findings of Nutman, Thornton and Quastel at Rothamstead and studies of Zimmerman and

Hitchcock in the United States led to the commercial development of hormone type selective weed-killers such as 2,4-D (274-dichlorophenoxy acetic acid) and MCPA (2-Methyl 4-Chlorophenoxy acetic acid). Since the discovery of these compounds a large number of herbicides, nearly 150, have been developed. Some of the more common ones are indicated in Table 1.

Most of these herbicides have to be selective in action. Some herbicides are made selective by the mode of application. Toxicity of herbicides is due to different reasons. Some are inhibitors of cell divisions. eg. carbamates and thio-carbamates. Some such as Urea and triazine herbicides, paraquat, pheny carbamates inhibit photosynthesis. Hormone herbicides, influence protein synthesis in the susceptible plants. Benzoic acid herbicides are known to inhibit respiration.

Insecticides

A large number of insect pests cause a tremendous loss to agricultural production. It is estimated that the losses due to insect damage is around US \$ 10 billion per year.

In the early part of the century, mostly inorganic chemicals were used to control insect pests. Arsenates and flurides were commonly used. In addition naturally occurring insecticides such

Table 1
Some commonly used herbicides

Common name	Chemical name
2,4-D	2,4-dichlorophenoxy acetic acid
MCPA	2-methyl-4-Chlorophenoxy acetic acid
2,4,5-T	2,4,5-trichlorophenoxy acetic acid
Simazine	2, Chloro-4, 6-bis (ethylamino)-C triazine
Propanil	3,4 dichloropropionalide
Diuron	3-(3,4-dichlorophenyl)-1, 1-dimethyl urea
Monouron	3-(p-Chlorophenyl)-1, 1-dimethyl urea
Paraquat)	quarterly ammonium compounds
Diquat)	2, 2-dichloropropionic acid
Dalapon	2, -Chloro-2-6-diethyl-N-(methoxymethyl) acetanilide
Alachlor	2-Chloro-N-isopropyl acetanilide
Propachlor	3-sec.butyl-5 bromo-6 methyl-uracil
Bromacil	N-phosphonomethyl glycine
Glyphosate	3-(3,4-dichlorophenyl)-1-methoxy
Linuron	1 methyl urea
Metribuzin	4-amino-6-tert-butyl 1-3 (methylthio) triazine

as nicotine, pyrethrums and rotenone derived from certain plant species were also widely used. However, with the development of modern chemical based insecticides in the post 1945 era, inorganic and plant derived insecticides have been less in use.

DDT was one of these modern insecticides. Its insecticidal property was first discovered by Mueller in 1939 for which he was awarded the Nobel prize in 1948. Sir Winston Churchill hailed DDT as "that miraculous DDT powder" because of its effectiveness in controlling an outbreak of louse-borne typhus among allied troops in 1943.

Since the discovery of DDT, a large number of insecticides, mostly organic in nature have been developed. These could be broadly categorised as chlorinated organophosphorus and carbamate insecticides. All these compounds are toxic compounds. Their LD values vary from around 10 to 1,000 mg per kg. (LD 50 value indicates the lethal dosage necessary to kill 50% of a particular animal population). These compounds interfere with a physiological process in insects. For example, organophosphorus insecticides interfere with the cholinesterase activity, which is essential in normal reactions involved in the transmission of nerve impulses. Carbamate insecticides too act in this manner. Some of the more common insecticides and their LD 50 values are given in table 2.

Fungicides

Diseases caused by fungi in plants bring about considerable losses in yields. In US the loss from plant diseases has been estimated at nearly US \$ 4 billion a year. In more recent times many instances of the incidence of diseases which have had a considerable impact on the people and economies of countries have been reported. The famous Potato Blight of 1845 which devastated potato cultivation in Western Europe, and Ireland and the coffee rust disease which ruined coffee plantations, in 1869 in Ceylon are two such examples.

As in insecticides, inorganic materials particularly derivatives of heavy metals, were used to control fungi. Copper sulphate was first used as a fungicide in

Table 2

Some commonly used Insecticides and their LD 50 values

Insecticide	Ld to manual/kg
DDT	200 mg
Endrin	7 mg.
Chlorodane	400 mg.
Aldrin	50 mg.
Parathion	10 mg.
Malathion	2000 mg.
Fenitrothion	250-760 mg
Diazinon	600 mg.
Dichloroves	25-170 mg.
Carbasyl	300-900 mg.
Carbouran	8-14 mg.
Dimethoate	500 mg.
Endosulfan	75 mg.
Monocrotophos	20 mg.
Methomyl	20 mg.
Trichlorofon	450 mg.
Fenthion	250 mg.

1761. Mercury containing compounds were used at the beginning of this century to control plant diseases. However, with advances in Chemistry a number of organic substances were developed as fungicides.

All fungicides are toxic compounds and interfere with vital processes in living organisms. These compounds largely inactivate essential enzyme systems and cause lethal effects. Some of the more common fungicides and their LD 50 values are indicated in table 3. As seen from this table, most of the fungicides are of low mammalian toxicity.

Fumigants

These are compounds used to fumigate nurseries, and grain stores against harmful micro organisms. These are volatile at room temperature and hence persist for short periods. Hydrogen cyanide, methyl bromide, carbon disulphide are some commonly used fumigants.

Nematocides

Nematodes are important agricultural pests and their control is essential to the production of some crops in some areas. Methyl bromides, ethylene dibromide and chloropicrin are some effective nematocides.

Acaricides

Ticks and mites often cause damage to plants and animals. Some insecticides are effective in controlling these pests. Sulphur, binapacryl and some of the bis-dithiocarbamates are commonly used, and are called acaricides.

Molluscicides

Snails and slugs are often harmful in that these organisms damage seedlings and foliage. Also, some types of snails are vectors of diseases such as bilharzia. Methaldehyde is an effective molluscicide commonly used.

Table 3

Some commonly used Fungicides and their LD50 values

Common name	LD50 values per kg
Benomyl	10,000 mg
Captafol	5,000 mg
Captan	9,000 mg
Ceresan	30-200 mg
Phenylmercury acetate	30-200 mg
Ferban	1,700 mg
Folpet	10,000 mg
Zineb	5,200 mg
Maneb	6,750 mg
Mancozeb	78,000 mg
Mercury oxide	30-200 mg

The need to use pesticides

Pesticides are used in large amounts all over the world. In the United States as estimated 700,000 tons of pesticides are used every year in different agricultural operations. In Malaysia 96 tons of pesticides were manufactured in 1976. In Sri Lanka, around 700,000 kg. of pesticides are imported annually to be used in food production. Insects, fungi and other pests continue to affect food production in various ways and the most effective method of controlling these organisms is considered to be the use of pesticides. Increase in agricultural productivity during the last two decades in many countries is supposed to be partly attributed to the effective use of pesticides.

A few decades ago, the population was relatively low and hence the food requirement remained at a low level. Cultivation was done less intensively and usually cultivation was only during

* Toxicity is usually determined on the basis of the effect on test animals of an amount of pesticide entering the body by one of a number of routes - through the mouth (oral), the skin (dermal), or by inhalation. Oral and dermal toxicities are expressed by the term LD50. This is the dose which results in the death of 50% of the test animals, usually rats, and this dose is expressed in milligrammes per kilogram (mpk) of the animal's body weight.

one season. Monoculture was practised to a small extent. Mixed cultivation, where a number of different crops were cultivated on the same land, was more popular. Thus, crops such as kurukkan, gingelly and maize were grown in a few patches and chillies and vegetables were

example the modern rice-varieties such as BG 90-2 have high yield potentials around 150 bushels per acre while the rice varieties cultivated a few decades ago were able to yield only around 75 bushels per acre. The new varieties not only have a higher yield potential

bring about an increase in the pest population. This is often due to the effect on the parasitic or predatory population of the pest, disrupting the equilibrium that exists between the pest and its parasite or predator. Sudden increase in the brown-plank hopper population in some areas is an example. Long term factors are those evolutionary processes such as mutation and for natural selections which alter the nature of the pest so that it could exploit the host more efficiently.

Rapid development of agricultural technology has resulted in a substantial increase in food production. Further, the crops cultivated are of higher nutritive value and high yielding. These factors have resulted in an almost unlimited supply of food almost throughout the year for pests. Such a situation is extremely conducive to the rapid increase of pest populations. Removal of weeds, although advantageous in many ways destroys the requirements of many of the parasites and predators of pests resulting in a rapid increase in the pest population. Research also reveals that the pesticide explosion has had a built-in boomerang. "The overuse of hazardous pesticides has created a global race of insect pests that are resistant to pesticides. The number of known pesticide-resistant insect species doubled in just 12 years - from 182 in 1965 to 364 in 1977, according to the UN's Food and Agriculture Organization. So more and more pesticides - including new more potent ones - are needed every year just to maintain present yields state researchers David Weir and Mark Schapiro.

Deforestation, modern irrigation projects etc. which alter the environment also often result in organisms rising to pest population levels. In Egypt is one example where large scale irrigation works have resulted in certain organisms becoming pests. All the factors discussed above bring about an increase in the pest population levels making it necessary to apply pesticides.

Pesticides are used not only in crop production. In the control of a number of human diseases, these chemicals are of

Naturally Occuring Pesticides

When different species of plants and animals exist in the same habitat, a competition exists among these species for survival and there is always an equilibrium among them. Presence of chemicals in some of these organisms enable them to be immune to various pest attack and to survive. Some of the most toxic of known chemicals such as snake venom, strychnine etc. are of natural origin. A number of chemicals toxic to insects or fungi are known to occur in nature. It is interesting to note that a few decades ago the insecticides used were mainly of plant origin.

Nicotine is one such insecticide. It has been used since the 18th century to control insects, in the forms of tobacco. The smoke of this plant has been used to control aphids. Nicotine is usually formulated as its sulphate and has little residual effects. It is highly volatile and is a useful fumigant. However, it is highly toxic to mammals and has a low LD 50 value.

Pyrethrum is another insecticide obtained from plants. The extracts of flowers of *Chrysanthemum cinerariaefolium* contains this chemical and has been used widely for a long time. It has very little residual toxicity and its toxicity to mammals is also low.

Rotenone, an insecticide, had been used in the 19th century and is obtained from the roots of a leguminosae called *Derris elliptica* and *Derris malaccensis*. Rotenone occurs with some other related compounds with insecticidal activity. These compounds are effective in the control of aphids and lepidopterous larvae, and are of low toxicity to most mammals.

Recent studies indicate that the neem plant (*Azadirachta indica*) produces compounds of insecticidal properties. Extracts of neem seeds have been found to be capable of controlling some rice insect pests. A compound called azadirachtin, has been identified as the chemical responsible. Azadirachtin repels caterpillars and locusts from eating leaves or seeds of plants.

A number of naturally occurring chemicals appear to have high potential as fungicides. It is known that some species of higher plants are immune to certain parasitic fungi which attack related species. A special endogenous fungi-toxic chemical is considered to be responsible for this immunity. A number of compounds have been isolated from plants, which are capable of controlling jungle growth; for example, Wyerone from broad bean plants.

grown as mixed crops. Under such a system of cultivation, there was little possibility for pests to multiply and spread. Further, the varieties cultivated were well adapted to the environment and hence there was negligible pest attack.

With the increase in population, the demand for food increased and the degree of cultivation was intensified. More land was brought under the plough and there was year round cultivation which provided food almost throughout the year for pests. Development of plant-breeding techniques resulted in the production of new varieties with higher yield potentials and their natural pest resistance has been disappearing. For

but their nutritive requirements too are at a higher level. This necessitated the application of more fertilizer and along with this came an increase in weed growth. Associated with this was evolving of organisms as pests which hitherto were not harmful.

Out of the large number and varieties of organisms in existence, not more than a few thousand are pests. At the same time a vast population of organisms, which are parasites or predators of these pests also exist. Various factors cause the transition of populations of organisms from the innocuous state to harmful condition. These are both long and short term. Short-term factors such as changes in the environment sometimes

considerable value. In 1950's there were around 200 million people infected with malaria and DDT was successfully used in the control of this disease. Yellow fever, another disease transmitted by a mosquito and Trypanosomiasis (sleeping sickness) transmitted by tsetse fly are two more examples of human diseases controlled through the use of pesticides.

Economics of pesticide use

• Crop losses due to weeds, insects and diseases are enormous and worldwide are estimated to exceed \$ 14 billion annually. The more important aspect of this is the aggregate loss of more than one-third of all agricultural production, or food for about one billion people. Almost all cultivated crops are known to be attacked by a wider range of pests and diseases (table 5) and controlling these effectively is of paramount importance in the efforts to increase food production.

Table 4
Accepted Daily Intake (ADI)
values of some pesticides

Pesticide	ADI values mg/kg body weight
Aldrin	0.0001
Captafol	0.05
Captan	0.125
Carbyl	0.01
Chlorodane	0.001
2, 4-D	0.3
DDT	0.005
Diazinon	0.002
Deildrin	0.0001
Diquat	0.002
Dithiocarbomates	0.025
Endrin	0.0002
Fenitrothion	0.001
Ferbam	0.025
Hexachlorobenzene	0.0006
Lindane	0.0125
Maneb	0.025
Paraquat	0.0007
Parathion	0.005
Pyrethrins	0.04
Thiram	0.025

Use of pesticides has made possible an increase in per acre yields in many countries. Making a case for pesticide usage some economists have estimated that cessation of use of all pesticides in the USA would reduce total produc-

tion of all crops and livestock by 30 per cent. Studies conducted in many parts of the world have indicated similar economic advantages from pesticides use. However, the hazards of pesticide and the economic advantages attributed to such hazards should also be noted in this regard. (see feature article on methods of Pest Control).

Pesticides in soil

Pesticides are applied as emulsions, dusts or solutions to foliage or to other surfaces. Whatever the mode of application of these chemicals, the ultimate recipient of most of these pesticides is the soil.

Pesticides undergo a number of changes in the soil. Initially the organic molecules get adsorbed in the soils colloidal particles. Some of these, due to their low melting points, volatilize to the atmosphere. Molecules of some pesticides would get decomposed when exposed to sunlight, a process called photodecomposition. The molecules which escape all these changes may get decomposed by soil organisms. It has been shown that bacteria, fungi and other organisms in the soil use the pesticide molecules as sources of food. Various enzymes are produced by these organisms and the molecules get decomposed. However, some compounds are resistant to this process. These recalcitrant compounds, specially those with more chlorine atoms tend to remain in the soil for longer periods and may get leached down and enter water bodies such as rivers, lakes etc. Usually, pesticide molecules decompose to non-toxic or less toxic compounds but, there are some compounds which decompose to form more toxic compounds. Plants and other living organisms may also take up the pesticide molecules. The various processes these chemicals undergo are summarised in Fig. 1. on page 8.

Pesticides are toxic compounds and interfere with vital processes of living organisms. Hence these compounds affect the soil organisms too. Studies carried out in many parts of the world indicate that some of the important processes of soil organisms are retarded by some pesticides.

Pesticides in food

The problem of pesticides in food has become important more recently with the introduction of chlorinated hydrocarbons such as aldrin, endrin, DDT etc. as pesticides. Prior to this only mercury and arsenic were involved but only to a limited extent.

Food tends to get contaminated due to direct application, when pesticides are applied to food crops. However, most of these pesticides disappear within a short period, but some pesticides are recalcitrant and hence, tend to remain in foods over a longer period.

Food also get contaminated due to indirect effects. This could occur when crops receive drifts of pesticides applied to adjacent crops and also from atmosphere fallout. Contamination may also occur when crops are grown in soils containing residues of persistent pesticides. Most of the pesticides have an affinity for lipid materials and hence tend to accumulate in fatty tissues, when ingested with food. Thus, milk, liver tissues have been found to contain pesticides such as DDT in relatively larger amounts. The Food and Agriculture Organisation and the World Health Organisation have established Acceptable Daily Intake (ADI) values for a number of pesticides and the amounts reported to be present in most of these foods are well below the ADI value. The ADI values of some of the common pesticides are indicated in table 4.

Pesticides in water

Water gets contaminated by pesticides as a result of a number of processes such as:

- (a) international application of pesticides as in the case of mosquito control,
- (b) atmospheric fallout,
- (c) soil erosion,
- (d) effluents of pesticide industries,
- (e) sewage.

The insoluble organic pesticides which are resistant to hydrolysis and the inorganics such as arsenicals and mercurials tend to cause water to be unsuitable for use and may bring about undesirable effects. Among these are the harmful

people for whom fish represents an important source of protein and a means of livelihood. The presence of pesticides in food, water and in the environment could be expected to cause undesirable effects on animals, including man. This

aspect is dealt with in the medical perspective by Professor Kodagoda. Out of the commonly used pesticides, chlorinated insecticides have a relatively higher LD 50 value, compared to organophosphorus insecticides (table 2). Hence, the chances for pesticide poisoning are more with the latter type. The ratio of deaths due to organophosphorus insecticides and organochlorine insecticides is about 30:1 and about 75 per cent of all deaths due to pesticides are cases of suicide.

Table 5

Some common pests and diseases of the more important food crops cultivated in Sri Lanka

Crop	Diseases	Pests
1. Rice and other Cereals	Blast Brown spot Bacterial blight Foot rot Sheath blight	Stem borer leaf hoppers leaf eating caterpillars Brown plant hopper gall midge Thrips leaf rollers
2. Leguminous vegetables (Beans, soya beans etc.)	Rust Anthracnose leaf spot	Bean fly (agromyza fly) leaf eating caterpillars
3. Cucurbits (bitter gourd, snake gourd etc.)		Fruit fly beetle Aulacophora
4. Solanaceous crops (Chillies, potato, brinjals etc.)	Blight leaf curl Anthracnose Wilt	Fruit worm Borers Caterpillars
5. Cabbage, cauliflower etc.	leaf spot	leaf eating caterpillars

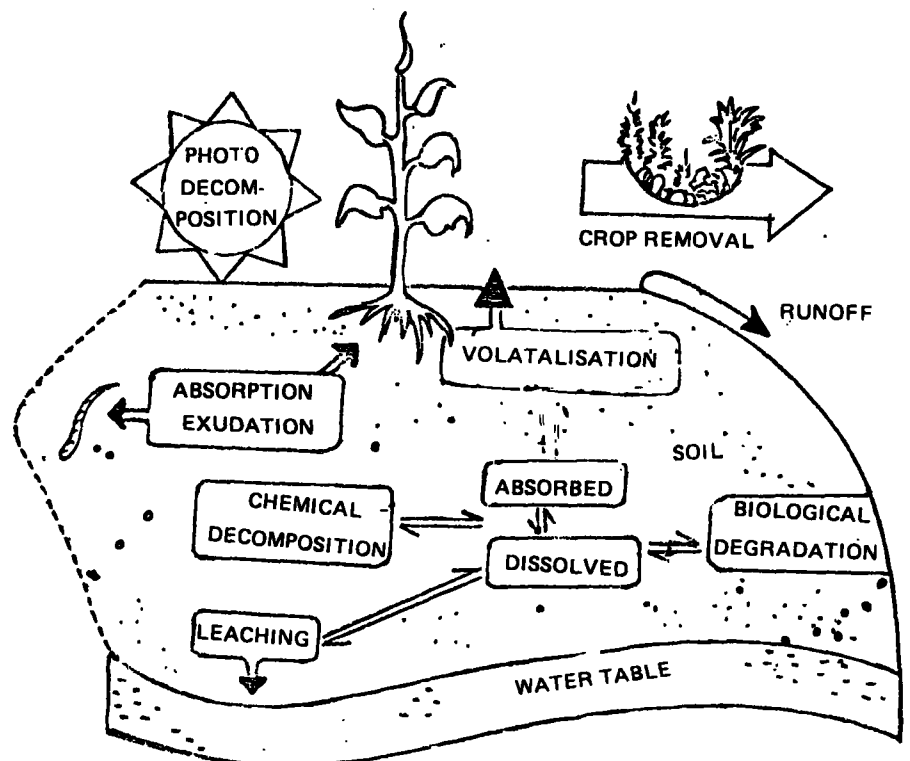
Chronic effects of pesticides on animals and human beings are due to the residues of pesticides in the environment. Out of the commonly used pesticides, DDT and other chlorinated insecticides appear to be most important with regard to accumulation in the body. Although no definite chronic effects have been reported due to exposure to these chemicals, high levels of DDT and other related insecticides have been reported in the fatty tissues of human beings. DDT values as high as 24 ppm have been reported in Texas, 2.9 ppm in Uganda, 6.5 ppm in Nigeria, 13.0 ppm in Thailand. Workers involved in the manufacture of DDT also had high levels of this compound in their fatty tissues,

results on aquatic organisms. The pesticide residues may have lethal or sub-lethal effects on fishes and other organisms which play major roles in food chains.

The easily decomposable compounds disappear within a short period. The rate of decomposition of these pesticides depend on the characteristics of water such as PH, chemical and biological composition and temperature.

Among the aquatic organisms affected by pesticide residues, fish are the most important. Studies carried out in the United States and Canada indicate that DDT is toxic to fish at concentrations as low as 0.5 ppb. Chlorinated compounds are generally more toxic. The effect of pesticides on fish, both fresh water and marine, especially in Asia are of significant importance to the

Fig. 1
The various processes pesticides undergo in the soil



though there was no conclusive evidence that these pesticide residues had any lethal or sub-lethal effects on man.

Problems of pesticides

The use of pesticides has its advantages as well as its disadvantages. The most important is the harmful effects of these on human beings as well as on many other animals, including beneficial insects, as a result of acute toxicity.

Handling poisonous chemicals involve considerable risks to many people. A number of pesticides banned in developed countries are imported to Third World countries in bulk.

Workers get exposed to these chemicals during repacking and others are affected during transport and storage. A number of incidents are reported in newspapers where people have died due to accidental pesticide poisoning. (See box on 'Occupational Hazards'). Farmers who ultimately handle these toxic chemicals get exposed to them and mishaps result frequently. Statistics of WHO indicate that nearly 500,000 people are poisoned by pesticides every year. According to the World Health Organisation, someone in the economically underdeveloped countries is poisoned by pesticides every minute. Further, a pesticide-caused death occurs about every 1 hour and 45 minutes, totalling at least 5,000 each year. (These two statistics are quoted from the proceedings of the US Strategy Conference on Pesticides Management, US State Rept. June 7-8 p.33). A large number of deaths due to pesticide poisoning have been reported more recently specially in the Third World.

Regular unintentional intake of small quantities of pesticides as residues in food and water cause accumulation of these substances in the body. (See Box on 'Pestilence of pesticides in Sri Lanka'). One of the harmful effects of pesticides is the damage it causes to the organisms of the environment which play important roles in maintaining the equilibrium in the eco-system. Among these are birds, fishes, reptiles etc. which are

PRECAUTIONS

*A typical dealer warning,
but how many users pay heed?*

1. All pesticides in the concentrated form are more or less strong poisons. All pesticides must be stored under lock and key beyond the reach of children and away from foodstuff, animal food and domestic pets. Insist on buying genuine packings only.
2. Use pesticides for recommended purposes and at recommended rates of application only. Misuse is dangerous and might be harmful.
3. Spray only with the wind and never against it so as to avoid spray drift settling on the body.
4. Avoid oral intake of any insecticide. Do not blow clogged nozzles with your mouth. Wash them with water and use a bristle of fibre for cleaning nozzles.
5. When preparing the spray solution, do not stir with the hands - use a rod or stick instead.
6. After handling the product, wash your hands and parts of the body on which the spray solution or concentrate may have splashed with soap and water.
7. Clean sprayers with water after the day's work is over.
8. Destroy all empty pesticide containers. Do not use them for any other purpose whatsoever.
9. Do not engage children for spraying purposes. Engage healthy adults, free of sores and wounds, for this purpose.
10. Do not drink, smoke, eat or chew beetle while spraying or preparing spray mixture.
11. Persons handling pesticides must wash their bodies and hands with soap and water before taking meals and after the day's work is over.
12. Spray only during the early hours of the morning or late in the evening and never during mid-day heat.
13. In the event of accidental poisoning, call a Doctor immediately.

seriously effected by the acute and chronic toxicity of pesticides. Biological magnification of recalcitrant pesticides also contribute to these harmful effects. This process refers to concentration of pesticide molecules in an organism, when one type of an organism feeds on another type which already has pesticide molecules in its tissues. Continuation of this process results in a progressive increase in the concentration of the pesticide. A number of examples could be given. Clear evidence of this process is found in the Dutch Elm disease control programme. In this DDT was applied as a 6 per cent suspension in water at a dosage of about 1.1 lb. per tree. Immediately after this treatment, the leaves were found to have a DDT + DDE (DDE is a decomposition product of DDT) concentration of 183 to 283 ppm. The soil under this tree had 1-8 ppm. Earthworms in the soil under the trees feeding on the fallen leaves had residues of 120 ppm. Birds dying from eating these earthworms had DDT residues as high as 342 ppm in the brain. This cycle could continue.

Another problem associated with the use of pesticides, referred to earlier is the appearance of new pests. This is

mainly due to the removal of all predators and parasites which normally hold a species under control. Use of pesticides often create conditions in which a previously minor pest can flourish. A clear example of such a process is seen in the red spider mite of fruit trees. Prior to the introduction of DDT red spider mite was only a minor pest as it was controlled by predators. DDT killed all its predators but not the mite. Thus the mite was able to increase its population and now it is a major pest to fruit growers. In such instances, the pesticide has altered drastically the natural balance between the pest and its predators.

Development of resistance to pesticides is another problem. In any species of a living organism, the individual susceptibility to poisonous substances vary and hence, in a large population of insects or any other pest, a proportion of individuals naturally resistant to a particular pesticide will survive. The resistant organisms will multiply rapidly due to less inter-specific competition and thus the pesticide will become less effective. Organisms with short generation periods

Selling Banned Pesticides in Third World Countries

David Weir and Mark Schapiro

A number of pesticides banned in the developed countries find a ready bulk market in the Third World countries. This issue has been investigated in-depth by two American researchers, David Weir and Mark Schapiro, and their findings published in "Circle of Poison - Pesticides and People in a Hungry World."

Giant multinational pesticides manufacturers using sophisticated marketing techniques and their world-wide network of subsidiaries and affiliates have created a global supermarket, its shelves stocked with products so dangerous they have been banned in the countries where they have been investigated". They emphasise that "the multinationals claim they sell pesticides overseas merely to supply a demand, a demand for their products to help feed a hungry world. But the fact is that multinational companies use sophisticated mass marketing techniques to create a demand in the Third World"

"To escape regulation in their home countries, the multinationals have discovered a clever strategy: they simply ship the separate chemical ingredients of a banned pesticide to a third world country, then manufacture it there in "formulation plants". From the third world country, the prepared pesticide can often be re-exported to any third country, free of regulation."

"Like many other Third World countries, Brazil offers special incentives to bring foreign chemical plants into the country: deferral of taxes, exemption from import duties, government-sponsored clearing of land for the plants. Shell has put £ 20 million to £ 30 million into new plants under these incentives over the past few years. Dow has a 2,4-D plant there. The Swiss firms Sandoz and Ciba Geigy set up a joint operation. And the largest pesticide company in the world—Bayer—has formulation plants in Brazil as well as in virtually every other country with market large enough to warrant one. In the Philippines are operating about 20 of the world's largest manufacturers, formulators and importers of pesticides.

"Formulation plants are spreading throughout Asia:

India. Many pesticides that have been banned or heavily restricted in the United States are produced in India, including BHC and DDT. Union Carbide, ICI, Bayer, and Hoechst have plants there.

Malaysia. Dow and Shell alone formulate one-quarter of all liquid pesticides here. Three organochlorines banned in the United States—Aldrin, DDT and BHC—constituted 730 of the 960 tons of pesticides manufactured in Malaysia in 1976.

Indonesia. Bayer, ICI, Dow, and Chevron dominate the local pesticide manufacturing industry, accounting for over 70 per cent of the total production in 1978.

will develop resistance more rapidly than those organisms with longer generation periods. Furthermore, experiments on organisms have clearly shown that some pesticides are definitely mutagenic, they produce irresistible change in genes. It has also been proved that pesticides can cause ill-effects on chromosomes, the carriers of the gene.

Pesticide Legislation

Legislation with regard to pesticides have been introduced in some countries with the following objectives.

- To protect people who may be exposed to risks during manufacture, packaging, transport and storage of pesticides,
- To protect people from direct or indirect contamination with pesticides
- To protect the buyer against the sale of low-quality or misleading products
- To ensure proper and correct application of pesticides so that there is no direct or indirect risk to the people.

To ensure that these objectives are met, all pesticides are registered with the authorities. The following details of the pesticides are normally obtained for registration purposes.

- Complete chemical and physical description of the pesticide
- Data as acute, sub-acute and chronic toxicity
- Metabolism and degradation studies
- Residues and the label.

Future of pesticides

Human population has increased steadily in the past and is likely to continue to increase although the amount of land available for crop production continues to decrease due to factors such as desertification, salinisation etc. In order to keep the levels of food production comparable to population, increasing agricultural productivity is of importance. Insects and other pests continue to harm crops and are a major obstacle in increasing production, and hence, effective measures to control these organisms is a sine qua non. As indicated elsewhere, use of chemicals to control pests has been found to be a very effective method and hence chemical pesticide will continue to be used in crop protection in the foreseeable future, in spite of the undesirable effects these compounds have on the environment.

In view of the undesirable effects of pesticides, studies are now being conducted in different parts of the world to develop more efficient and effective methods of pest control. In this regard, naturally occurring chemicals are investigated to determine the possibility of using them as pesticides (See box on 'Naturally occurring pesticides'). The fact that certain crops are not harmed by some insects or diseases indicated that these crops may be producing substances which distract the pests. Hence, the possibility of using these compounds as pesticides are being looked into.

Alternatives to chemical pesticides

The problem of crop protection and pest control has been with man ever since he began to practice agriculture in settled communities. Wherever a plant is growing in abundance, other forms of life are there to use it as a food. This is the main cause of crop damage in monoculture.

Man has attempted to use different methods of crop protection and pest control. Before advances in technology, non-technological methods were widely used. Even at present these methods could be used with a certain degree of success.

Use of other organisms to control pests on 'biological control' is one of the most effective alternatives to chemical pesticides. (See 'Biological Control'). In this method, a parasite or a predator of the pest is used to control the pest. Bacteria, fungi, viruses and nematodes have been successfully used to control certain pests. In Sri Lanka too this method was used in the control of the coconut caterpillar which caused considerable damage to coconut palms.

In the Autocidal method of pest control, the male insects are made sterile by various means. This will control the pest population and after a few generations, it may be reduced to negligible levels. A number of insect pests have been successfully controlled by this method. Several cultural methods and mechanical methods can effectively be used in the control of pest and weeds. (See box on "Mechanical and Cultural Methods").

Still another approach, which has been used with much success in the integrated approaches to pest and disease control

However, these varieties of crops were not high yielding. Many new high yielding varieties have lost their resistance to pests during its deve-

lopment by the plant breeders as characters such as yield are given priority. However, varieties with resistance to some major pests and high yielding property have been developed by the efforts of plant breeders and are of value in crop production programmes.

Using correct cultural methods in crop production is also of considerable value in crop protection and pest control programmes. Use of clean and disease free planting materials, correct timing of planting to minimize pest damage, uniformity of the area with regard to availability of the crops in the field, application of balanced fertilizers and control of weeds are some of the important cultural methods useful in pest control. Use of mechanical methods to control weeds is a cheap alternative to chemical methods of weed control. Light traps etc. could also be used to control certain insect pests.

Pesticide use in Sri Lanka

In Sri Lanka, pesticides were first used to control malaria in the 1940s. Since then various types of pesticides have been used. The gradual increase in the amounts of pesticides used in the country is shown in table 7. As shown in this table, there has been a

considerable increase in the use of pesticides in Sri Lanka, during the last few years. These compounds are available almost everywhere in the country. The more common types of pesticides marketed in Sri Lanka are indicated in tables 1, 2 and 3. With the increase in the use of these pesticides, deaths due to poisoning of pesticides has also increased during the last few years (table 8). Most of these deaths are due to acute poisoning.

While the benefits of pesticides cannot be ignored, very little attention appears to have been given to the harmful effects of pesticides. A number of these chemicals, banned in some countries like USA due to their toxic nature, are freely available in Sri Lanka. Highly toxic compounds could be bought without any restriction over the counter

although no hard drugs could be obtained from a pharmacy without a prescription from a recognised doctor. There appears to be no control over sales of pesticides and often they have been put up for sale in shops along with food items.

An Act of Parliament on control of pesticides, Act No. 33 of 1980, has been passed but no action appears to have been taken so far to implement the various measures in this act.

Table 6
Pesticides imported to Sri Lanka (in Thousands)

	1970		1972		1974		1976		1978		1979	
	kg	lit	Kg	lit	Kg	lit	Kg	lit	Kg	lit	Kg	lit
Insecticides	60	10	46	2	35	27	869	29	775	146	73	115
Herbicides	—	3	—	0.8	—	—	3.5	94	11	340	78	237
Fungicides	—	—	1.6	—	—	—	29	—	95	9	179	3
Other	49	15	—	9.5	—	—	—	22	—	7	4.5	7.4
Total	109	29	48	12	36	28	903	125	882	503	339	363
Value in Rs.	238.5		1381.8		1,009.9		21,573.3		23,733.1		37,906.6	

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Table 7
Deaths due to pesticides in Sri Lanka

District	1977	1978	1979	1980	1981
Amparai	—	—	—	29	18
Gampaha	8	24	53	17	30
Colombo	1	—	5	7	11
Kantalai	1	—	21	14	4
Ratnapura	17	1	15	21	25
Galle	25	5	43	23	13
Matara	—	6	20	100	70
Kandy	24	13	17	39	25
Puttalam	3	11	16	14	24
Metale	20	45	73	33	53
Kurunegala	8	4	26	122	111
Batticaloa	7	12	22	13	15
Anuradhapura	11	12	33	24	55
Jaffna	28	20	53	49	69
Vavuniya	1	—	10	24	37
Nuwara Eliya	—	45	22	62	63
Badulla	7	9	16	28	42
Sri Lanka	236	217	463	641	690

The figures given are deaths reported to hospitals

As shown in table 8 the cost of most of the pesticides have increased considerably during the last few years. This is likely to have contributed towards the high cost of farm products. Hence, while continuing to use these chemicals in the struggle to increase agricultural production, it is essential that cheaper

methods of pest control, which have less adverse effects on the environment are developed.

by specialist in their areas.

The papers that follow, deal in greater depth with specific aspects of pesticide use in Sri Lanka.

Table 8
Prices of some commonly used pesticides

Pesticide	Cost in 1980	Cost in March 1982
Insecticide		
Aldrin 450 ml.	35.00	52.00
BHC Dust 3 kg.	7.50	10.70
Carbaryl 500 g.	40.00	60.00
Carbofuran 2 kg.	30.00	42.50
Chlorodane 450 ml.	26.00	26.00
Diazinon 400 ml.	70.00	89.00
Parathion 450 ml.	36.00	40.00
Primiphos-methyl 450 ml.	98.00	134.00
Fungicides		
Benomyl 170 g.	78.50	78.00
Captan 500 g.	27.50	64.50
Copper oxychloride 500 g	18.00	18.00
Maneb 500 g.	27.20	50.00
Mercury oxide 4.5 litres	39.50	63.50
Sulphur ½ kg.	11.20	13.50
Thiran ¼ kg.	42.00	60.00
Herbicides		
Alachlor 450 ml.	60.00	94.00
Bromacil 4 lb.	256.90	279.20
Diuron 500 g.	85.00	129.00
MCPA 450 ml.	19.00	29.00
MCPA 450 ml.	18.00	30.80
Propanil 450 ml.	33.00	47.00
Simazine 500 g.	35.00	59.00

The Prices indicated are of the same pesticide from the same firm.