NATURE AND APPLICATION OF PESTICIDES

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As man continued to modify his environment, the competition from other organisms became more intense. An organized and settled form of agriculture brought about an increase in the pest population. Various systems of pest control evolved and the use of light traps, scarecrows, etc, were among the earliest of such efforts. With increased incidence of pests and diseases and the advancement of science and technology, the use of various types of chemicals to control pests became a common practice.

Pesticides are a group of chemical compounds mostly organic and biologically active. They interfere with one or more of the essential metabolic processes of the organism against which they are applied.

Pesticides used in the past were mainly inorganic simple compounds but those used at present are mostly complex organic compounds. These could be broadly categorised into various groups according to the type of pests they control. The types of pesticides commonly used are indicated below.

Type		Pests controlled
Acaricides	—	mites and ticks
Fungicides	—	fungi
Herbicides (weedicides)	—	weeds
Insecticides	—	insects
Molluscicides	—	molluscs such as slugs, snails
Nematocides	—	nematodes
Rodenticides	—	rodents (rats)

Of the above pesticides the more commonly used ones are fungicides, herbicides and insecticides.

1. **Fungicides** : These are used to control pathogenic fungi and could be categorised into the following broad groups.

   (i) **Systemic fungicides** - These are absorbed by plant roots and rapidly transported to the foliage and the apical point, eg. carboxin, benomyl.

   (ii) **Sulphur fungicides** - This is one of the first successful protective fungicides. It was used against powdery mildew. The main ingredient of this group is elemental sulphur as a wettable powder. Organic sulphur compounds are also used widely. These are the derivatives of dithiocarbamic acid. Dithiocarbamates of zinc, manganese, iron are commonly used as fungicides and these are less phytotoxic than elemental sulphur.

   (iii) **Copper fungicides** - Bordeaux mixture, and aqueous solution of copper sulphate and calcium hydroxide was one of the first few copper fungicides used. This has now been replaced by other copper compounds such as copper oxychloride, cuprous oxide.

   (iv) **Mercury fungicides** - Organomercury compounds are more commonly used and more toxic than the other fungicides. Due to their volatile nature these compounds are used for seed treatment. Widely used organomercury fungicides are ethylmercury chloride, phenylmercury acetate, phenylmercury chloride.

Most of the fungicides are complex organic compounds. Their mammalian toxicity is relatively low (see Table 1).

2. **Herbicides** : Most of the herbicides used at present to control weeds are organic compounds. However, a number of inorganic compounds such as ammonium sulphamate, ammonium thiocyanate, boron compounds, sodium arsenate are herbicides and were used in the past. With advances in science and technology, more effective compounds have been developed. Some of the more important groups of herbicides are indicated below.

(i) **Halogenated aliphatic acids**—eg. Trichloroacetic acid, Dalapon - 2,4, Dichloropropionic acid

(ii) Phenoxyaliphatic acids—eg. 2,4, - D (2,4—Dichlorophenoxy acetic acid), MCPA (2,Methyl—4—chloro—phenoxy acetic acid) 2,4,5—trichlorophenoxy-acetic acid, etc.

(iii) **Aromatic acids** —eg. 2,3,6 Trichloro-benzoic acid, Dicamba (2—methoxy — 3,6 dichlorobenzoic acid)

(vi) **Amides** —eg. Diphenamid (Dimethyl — 2—2—diphenyl acetamide) chlorthiamid (2,6—dichlorothiobenzamide)

(v) **Anilides** —eg. Propanil (3,4 — dichloro-phenyl—propanamide), propechlor (iso propyl — chloroacetanilide)

(iv) **Ureas** —eg. Diuron (3,4 — dichloro-phenyl dimethylurea)Fenuron (phenyl—dimethylurea), Monuron (4—chloro-phenyl dimethylurea)

(vii) **Carbamates** — eg. Chloropropham (iso-propyl—chlorophenyl—carbamate) Propham (isopropyl-phenyl carbamate)

(viii) **Triazines** — eg. Simazine (2—chloro—4,6—diethylamino—triazine), Atrazine (2—chloro—4—ethylamino, 6—isopropy-lamino—triazine)

(ix) **Pyridines** — eg. Paraquat, Diquat

(x) **Uracils** — eg. Amitrole (3—amino—1,2,4—triazole) Bromacil

As indicated above, most of the herbicides used are complex organic compounds. Some of these, such as ureas, carbamates and aliphatic acids are translocated. The mammalian toxicity of herbicides, indicated by LD_{50} values (see Table 1) is relatively low. Some herbicides are selective in action and hence could be effectively used to control weeds in crops. For, example, simazine could be used to control weeds in the maize crop. 2,4—Dichloropropionic acid kills weeds (broadleaved) in a rice crop. Selectivity is based on the physical nature of the plant or on the ability of the resistant plant to decompose the herbicide.

Herbicides in general tend to remain in the soil for a shorter period but there are persistent herbicides too. For example, 2,3,6 TBA, thiocarbamates, triazines are more persistent compared to others.

3. **Insecticides** : As in the case of herbicides, inorganic compounds were used as insecticides. Among these are copper sulphate, lime sulphur (Bordeaux mixture), etc. However, at present mainly synthetic organic compounds are used as insecticides although naturally occurring compounds are also used to a limited extent. The organic insecticides are of different types.

(i) Organochlorine compounds — These act as contact and stomach poisons. Most of them have residual effects and hence some are banned. Examples of organochlorine compounds are DDT, Aldrin, Chlorodane, Endrin, etc. All these are characterised by the presence of chlorine atom/s in the molecule. The mammalian toxicity of these compounds is relatively low. (Table 1).

(ii) Organophosphorus compounds — Organophosphorus compounds are contact or systemic poisons and interfere with the transmission of nerve impulses by inhibiting the activity of Cholinesterase, an enzyme. The residual toxicity of these compounds is relatively low in that they are decomposed rapidly. However, the mammalian toxicity of these compounds is generally high (Table 1). About 80 organophosphorus insecticides are available. Examples of these compounds are Malathion, parathion, fenitrothion, dimethoate, diazinon, monocrotophos, etc.

Table 1

LD_{50} values of some commonly used pesticides

Pesticide	Oral LD_{50} (mg/kg)
Herbicides	
2.4—D	300
MCPA	700
Diuron	3400
Monuron	3700
Dalapon	9300
Paraquat	141
Diquat	400
Simazine	> 5000
Fungicides	
Benomyl	>10,000
Captas	9000
Ceresan	200
Zineb	5200
Maneb	6750
Insecticides	
DDT	200
Endrin	7
Chlorodane	400
Aldrin	50
Parathion	10
Malathion	2000
Carbofuran	10
Monocrotophos	20
Trichlorofon	450
Fenthion	250
Diazinon	600

(iii) Carbamate compounds — These are closely related to organophosphorus compounds. They too have a low residual activity.
eg. Aminocarb, methrocarb, carbofuran.

(iv) pyrethroids — These are synthetic compounds but are related to naturally occurring pyrethrins which are insecticides of plant origin (Chrysanthemum). Pyrethroids are highly effective and are of low mammalian toxicity. They act as contact insecticides and have no systemic activity. Most pyrethroids are viscous liquids with low vapour pressures, but they are relatively costly.

Allethrin, permethrin and cismethrin are a few examples of these compounds.

(v) Botanical compounds — These are also called natural insecticides as they occur in plants. The mammalian toxicity of these compounds is low and have a very low residual toxicity. Nicotine (extracted from *Nicotiana tabacum)*, Rotenone (extracted from roots of *Derris* sp.), Pyrethrum (extracted from Chrysanthemum flowers) are a few examples of this group of insecticides.

Toxicity

Pesticides are toxic compounds, although their relative toxicities could vary. The LD_{50} values of pesticides indicate the dose of a pesticide which kills half of a population of test animals. This is expressed in milligrams of the toxic compound per kilogram of test animal (mg/kg).

The toxicity of pesticides generally decrease after application. This is mainly due to various physical and chemical changes in the molecule. However, some compounds tend to be stable and remain undecomposed for a longer period of time. Decomposition of compounds in contact with soil also takes place due to microbial activity. Some compounds are more resistant to microbial decomposition. In general chlorinated hydrocarbons such as DDT, Endrin, are recalcitrant.

Pesticide application

Pesticide compounds, manufactured as technical materials, have to be formulated so that it could be applied in the field. The active ingredient is blended with a number of inactive, inert ingredients.

A pesticide formulation has a number of ingredients. These are (i) the active ingredient (ii) solvents (iii) carriers (iv) surface active agents (v) special additives. These ingredients are added to make the pesticide more effective and applica-

tion efficient. These are various pesticide formulations.

(i) Water dispersable powders or wettable powders (WP)
(ii) Emulsifiable concentrates (EC)
(iii) Water soluble powders (WSP)
(iv) Granules (G)
(v) Dusts (D)
(vi) Controlled release formulations

Some of these formulations such as WPs, ECs or WSPs have to be diluted with water.

Application equipment

Various types of equipment are used to apply pesticides. Liquid — type pesticides are applied with sprayers. There are hand-operated knapsack sprayers, power sprayers. Mistblowers can also be used. Dusts are normally applied using hand-operated or power dusters.