Chemistry of pesticides

INTRODUCTION:

Hello dear students, I welcome you all for our lecture series on agrochemicals and pest control. The topic for today's discussion is Chemistry of pesticides.

Pesticides are defined as substances or mixtures of substances intended for controlling, preventing, destroying, repelling, or attracting any biological organism suppose to be a pest.

The term includes chemicals used as growth regulators, defoliants, desiccants, fruit thinning agents, or agents for preventing the premature fall of fruits, and substances applied to crops either before or after harvest to prevent deterioration during storage or transport. The term, however excludes such chemicals used as fertilizers, plant and animal nutrients, food additives and animal drugs. The term pesticide is also defined by FAO in collaboration with UNEP (1990) as chemicals designed to combat the attacks of various pests and vectors on agricultural crops, domestic animals and human beings. The definitions above imply that, pesticides are toxic chemical agents mainly organic compounds that are deliberately released into the environment to combat crop pests and disease vectors.

Today we are going to study this topic under the following captions. They are....

- **History of pesticides.**
- **Classification based on site of action**
- **Classification based on chemical nature**
- **Botanical pesticides**
- **Mineral-based pesticides**

First let us start with the historical background of pesticides

1. HISTORY OF PESTICIDES:

The practice of agriculture first began about 10,000 years ago in the Fertile Crescent of Mesopotamia where edible seeds were initially gathered by a population of hunter. Cultivation of wheat, barley, peas, lentils, chickpeas, bitter vetch and flax then followed as the population became more settled and farming became the way of life. Similarly, in China rice and millet were domesticated, while about 7,500 years ago rice and sorghum were farmed in the Sahel region of Africa.

It is clear that the farmed crops would suffer from pests and diseases causing a large loss in yield with the ever present possibility of famine for the population. Even today with advances in agricultural sciences losses due to pests and diseases range from 10-90%, with an average of 35 to 40%, for all potential food and fibre crops. There was thus a great incentive to find ways of overcoming the problems caused by pests and diseases. The first recorded use of insecticides is about 4500 years ago by Sumerians who used sulphur compounds to control insects and mites, while about 3200 years ago the Chinese were using mercury and arsenical compounds for controlling body lice.

Until the 1940s inorganic substances, such as sodium chlorate and sulphuric acid, or organic chemicals derived from natural sources were still widely used in pest control. However, some pesticides were by-products of coal gas production or other industrial processes. Thus early organics such as nitrophenols, chlorophenols, and naphthalene and petroleum oils were used for fungal and insect pests, whereas ammonium sulphate and sodium arsenate were used as herbicides.

Throughout most of the 1950s, consumers and most policy makers were not overly concerned about the potential health risks in using pesticides. Food was cheaper because of the new chemical formulations and with the new pesticides there were no documented cases of people dying or being seriously hurt by their "normal" use. There were some cases of harm from misuse of the chemicals.

Research into pesticides continued and the 1970s and 1980s saw the introduction of the world's greatest selling herbicide, glyphosate, the low use rate sulfonylurea and imidazolinone herbicides, as well as dinitroanilines and the aryloxyphenoxypropionate and cyclohexanedione families. This period also saw the introduction of the triazole, morpholine, imidazole, pyrimidine and dicarboxamide families of fungicides. As many of the agrochemicals introduced at this time had a single mode of action, thus making them more selective, problems with resistance occurred and management strategies were introduced to combat this negative effect.

In the 1990s research activities concentrated on finding new members of existing families which have greater selectivity and better environmental and toxicological profiles. In addition new families of agrochemicals have been introduced to the market such as the triazolopyrimidine, triketone and isoxazole herbicides, the strobilurin and azolone fungicides and chloronicotinyl, spinosyn, fiprole and diacylhydrazine insectides. Many of the new agrochemicals can be used at grams rather than the kilograms per hectare.

Today the pest management toolbox has expanded to include use of genetically engineered crops designed to produce their own insecticides or exhibit resistance to broad spectrum herbicide products or pests. These include herbicide tolerant crops like soybeans, corn, canola and cotton and varieties of corn and cotton resistant to corn borer and bollworm respectively. In addition the uses of Integrated Pest Management (IPM) systems which discourage the development of pest populations and reduce the use of agrochemicals have also become more widespread. These changes have altered the nature of pest control and have the potential to reduce and change the nature of agrochemicals used.

After studying brief history of pesticides, now we shall move on to classification of pesticides. In that first method of classification of pesticides is......

2. CLASSIFICATION BASED ON SITE OF ACTION:

Pesticides can be classified on the basis of their routes of entry into the body system of the target pest. They can be grouped as follows.

i) Stomach poisons.
ii) Contact poisons.
iii) Systemic poisons.
iv) Fumigants.

Stomach poisons: Stomach poisons enter the body of the pest through the mouth during feeding into the digestive tract from where these are absorbed into the systems. Stomach poisons are more effective against chewing insects and useful in controlling insects with siphoning or sponging types of mouth parts.
Examplesfor stomachpoisons includes dieldrin, sulphur and lead arsenate.

Next category is...
Contact poisons: These poisons enter the body directly through the cuticle by contact with the treated surface of the foliage, stem, etc. These poisons act on the nervous system of the pest. These may also be applied directly on to the body of the pest as a spray or dust. Examples: benzene hexachloride. dichloro diphenyl trichloro ethane, endrin, quinalphos and carbamates. Some of the known pesticides derived from plants also have contact action. Examples: pyrethrum, rotenone, sabadilla and nicotine.

Systemic poison: These poisons are applied on the plants' surface such as the foliage, green parts of the stem, and near the roots from where these are translocated into the plant tissues. Most of the systemic poisons act as stomach poisons, or both as stomach and contact poisons. The parts of the plant where these poisons have been translocated become lethal to the pests feeding on these parts of the plants. Systemic poisons are more effective against sucking pests. They have a selective action with little effect on the predators and parasites directly, unless acting through the food chain. Translocation of these poisons takes place mostly through xylem vessels. Examples for this section are demeton-o-methyl, phosphamidon, monocrotophos, phorate, carbofuran, dimethoate, mevinphos, aldicarb and so on.

The last type in this classification is....
Fumigants: Fumigants are volatile poisons and enter the body of the pests through the respiratory system. These are widely used in controlling stored grain pests. All types of pests can be killed by fumigants irrespective of the types of mouthparts provided a gas-tight atmosphere is ensured. Even for soil pests such as nematodes, fumigation is effective. Examples: dichlorvos, hydrogen cyanide, methyl bromide, paradichlorobenzene, ethylene dichloride, carbon tetrachloride, naphthalene, nemagon and aluminum phosphide.

Coming to the next method of classififaction i.e.,

3. Classification Based on Chemical Nature

Pesticides can be classified on the basis of their chemical nature. They can be grouped as Organochlorine Pesticides, Organophosphate Pesticides, Carbamates, Synthetic-pyrethroid, Microbial Insecticides and Insect Growth Regulators.

Organochlorine Pesticides: They are the synthetic organic pesticides that are earliest discovered and used. Their characteristics are broad-spectrum, long residual effect and relatively low toxicity. However, due to their stable chemical nature, they are hard to break down in the natural environment. Prolonged use in large quantities will easily lead to environmental pollution and accumulation in mammals, resulting in cumulative poisoning or damage. Organochlorine pesticides are therefore banned under general circumstances and gradually replaced by other pesticides.

Organophosphate Pesticides: Organophosphate pesticides are characterised by their multiple functions and the capacity of controlling a broad spectrum of pests. They are nerve poisons that can be used not only as stomach poison but also as contact poison and fumigant. These pesticides are also biodegradable, cause minimum environmental pollution and slow pest resistance. Temephos and F enitrothion are examples of organophosphate pesticides.

Carbamates: Carbamate pesticides work on the same principle as organophosphate pesticides by affecting the transmission of nerve signals resulting in the death of the pest by poisoning. They can be used as stomach and contact poisons as well as fumigant. Moreover, as their molecular structures are largely similar to that of natural organic substances, they can be degraded easily in a natural manner with minimum environmental pollution. Propoxur is an example of carbamate pesticides.

Synthetic-pyrethroid: Pesticides Synthetic-pyrethroid pesticides are a pesticide synthesized by imitating the structure of natural pyrethrins. They are comparatively more stable with longer residual effects than natural pyrethrins. Synthetic-pyrethroid pesticides are highly toxic to insects but of only slight toxicity to mammals. A llethrin and Permethrin are examples of synthetic-pyrethroid pesticides.

Microbial Insecticides: Microbial insecticides control pests by means of pathogenic micro-organisms including bacteria, fungus and viruses. *Bacillus thuringiensis israelensis* (B.t.i.) is an example of microbial insecticides.

Insect Growth Regulators: Insect growth regulators are compounds developed by copying insect juvenile hormone. The main functions are to interfere with the growth and hatching of larvae into adults, and to prevent the formation of exoskeleton so as to prohibit the growth of the insect. As its ability to live as a living organism is curtailed, the insect may die eventually as well as the whole insect population. Methoprene is an example of insect growth regulators.

Next Class of pesticides are......

4. **BOTANICAL PESTICIDES:**

Many plants and minerals have insecticidal properties; that is, they are toxic to insects. Btanical pesticides are naturally occurring chemicals extracted or derived from plants or minerals. They are called natural pesticides. In general, they act quickly, degrade rapidly and have, with a few exceptions low mammalian toxicity.

Some of the botanical pesticides are discussed here

Nicotine Sulphate: Nicotine is extracted from tobacco or related *Nicotiana* species and is one of the oldest botanical insecticides in use today. It is also one of the most toxic to warm-blooded animals and is readily absorbed through the skin. It breaks down quickly, so it is legally acceptable to use on organically grown crops.

Nicotine kills insects by interfering with the transmitter substance between nerves and muscles. It is commonly used to control aphids, thrips, spider mites and other sucking insecticides on most vegetables, some fruits, flowering plants and ornamental shrubs and trees. Roses are sensitive to nicotine.

Sabadilla: Sabadilla, another botanical insecticide, is derived from the seeds of the sabadilla lily. The active ingredient is an alkaloid known as veratrine. Sabadilla is considered among the least toxic of botanical insecticides, but its dust can be highly irritating to the eyes and can produce sneezing if inhaled. No residue is left after application of sabadilla because it breaks down rapidly in the sunlight.

Sold under the trade names Red Devil or Natural Guard, Sabadilla is effective against caterpillars, leaf hoppers, thrips, stink bugs and squash bugs.

Rotenone: Rotenone is a resinous compound produced by the roots of two members of the Leguminosae family. Its common use is to control various leaf-feeding caterpillars, beetles, aphids and thrips on a wide variety of vegetables and small fruits. A slow-acting chemical, rotenone requires several days to kill most susceptible insects, but insect feeding stops shortly after exposure.

Neem: Neem is a botanical pesticide derived from the neem tree, a native of India. This tree supplies at least two compounds, azadirachtin and salannin, that have insecticidal activity and other unknown compounds with fungicidal activity. The use of this compound is new in the United States, but neem has been used for more than 4,000 years for medicinal and pest control purposes in India and Africa. It is not highly toxic to mammals.

A neem-based pesticide, Margosan-O, has been shown to control gypsy moths, leaf miners, sweet potato whiteflies, western flower thrips, loopers, caterpillars and mealy bugs. This product is labelled for use on ornamentals, foliage plants, trees, shrubs and other non-food crops.

Pyrethrum/Pyrethrins: Pyrethrum is the most widely used botanical insecticide in the United States. The active ingredient, pyrethrin, is extracted from a chrysanthemum plant, grown primarily in Kenya, Rwanda, Tanzania and Ecuador.

Most insects are highly susceptible to pyrethrin at very low concentrations. The compound acts rapidly on insects, causing immediate knock down. Flying insects drop almost immediately after exposure.

Insect mortality is increased by mixing pyrethrins with a synergist, such as piperonyl butoxide (PBO) to create pyrethrum. PBO, however, is not certified to be used on organic crops. Growers, who want to meet organic certification standards, should consult with the Colorado Department of Agriculture before using pyrethrin products.

Pyrethrins are highly irritating to insects; as a result, they may be used as "flushing agents," causing insects to come out of hiding, a desirable circumstance when you need to identify an insect that is hiding in the turf grass such as grubs.

Pyrethrum is non-toxic to most mammals, making it among the safest insecticides in use. The Environmental Protection Agency has approved it for more uses than any other insecticide.

Pyrethroids are synthetic materials designed to imitate natural pyrethrum. They can be used on houseplants, but because they are synthetic, they aren't registered to use on organic crops.

Coming to the last category of pesticides, i.e.,

5. **MINERAL-BASED PESTICIDES:**

Sulphur: Sulphur probably is the oldest known pesticide in use. The Greek poet, Homer, described the benefits of "pest-averting sulphur" 3,000 years ago.

Sulphur can be used as a dust, wettable powder, paste or liquid. Its primary use is to control powdery mildews, certain rusts, leaf blights and fruit rots. Spider mites, psyllids and thrips also are susceptible to sulphur. Most pesticidal sulphur is labeled for vegetables such as beans, potatoes, tomatoes, peas and fruit crops such as grapes, apples, pears, cherries, peaches, plums and prunes.

Sulphur has the potential to cause plant injury in dry 90 degree-plus weather. It's also incompatible with other pesticides. Don't use sulphur on plants within 20-30 days of applying spray oils. Sulphur reacts with the oil to create phytotoxicity.

Lime Sulphur: Lime sulphur is made by boiling lime and sulphur together. The mixture is used as a dormant spray on fruit trees to control diseases such as blight anthracnose, powdery mildew and some insects including scales, thrips and eriophyid mites. Its drawbacks include its rotten-egg smell, its potential to burn exposed skin and eyes and to injure plants if applied when temperatures exceed 80 degrees F.

Bordeaux mixture: This is a natural-based pesticide, but it is not labelled for organic use.

Bordeaux mixture is produced by a reaction between copper sulphate and calcium hydroxide. It was used first in Bordeaux, France to control downy mildew.

Bordeaux mixture is primarily a fungicide that controls bacterial leaf spots, blights, anthracnose, downy mildews and cankers. It also repels many insects. The compound is labeled for use on many vegetables, tree fruits and nut crops.

Bordeaux, as with sulphur and lime sulphur, can be phytotoxic to plants. If applied in cool, wet weather, it may burn leaves or cause russeting of fruit.

ADVANTAGES AND DISADVANTAGES OF USING PESTICIDES:

The use of pesticides to control pests can cause concern to some people. People can become worried about the effects of the continued use of pesticide on the environment and its impact on human health There are good reasons for using pesticides and there are reasons for not using them.

Advantages of using pesticides are:

- Applying pesticides is not difficult, provided users are properly trained
- Modern pesticides are very effective. This means that nearly all the target pests which come in contact with these pesticides are killed
- Results are quick. This means the pests are killed within a very short time.
- Using pesticides can be an economical way of controlling pests. Pesticides can be applied quickly and there is not the high labour cost which might apply to other methods of control, such as removing weeds by hand.

Disadvantages of using pesticides are:

- If pesticides are not used correctly, they can affect human health or cause serious injury or death to the pesticide operator, other people or household pets.
- Pesticides can also directly affect other non-target animals. For example, a gardener spraying his garden to kill caterpillars will probably also kill harmless ladybird beetles and praying mantises.
- If pesticides are used incorrectly or applied wrongly, they may find their way into places where they are not wanted, for example, they might be washed into rivers or into the soil and also they can enter the food chain.

Now we can conclude our session. I conclude the session by saying that....

Conclusion:

Agriculture that protects people and the environment does not rely on toxic pesticides. On the contrary, diverse and healthy agricultural ecosystems, free of toxic chemicals, have a proven record of providing nutritious food and a safe environment.

So students I hope you have some useful information in this episode. Thank you so much for watching this session. Hope we will meet in the future episode. Until then take good care of yourself. Bye for now.