INTRODUCTION TO CHEMICAL CONTROL
Control of insects with chemicals is known as chemical control.

The term pesticide is used for those chemicals which kill pests and these pests may include insects, animals, mites, diseases or even weeds.

Chemicals which kill insects are called as insecticides.

Insecticide may be defined as a substance or mixture of substances intended to kill, repel, or otherwise prevent the insects.

Similarly

**Rodenticides** - Chemicals used to kill rats. Eg. Zinc phosphide

**Insecticides** - Chemicals used to kill insects. Eg. Malathion

**Acaricides** - Chemicals used to kill mites. Eg. Dicofol

**Avicides** - Chemicals used to kill birds. Eg. Anthroquinone

**Molluscicides** - Chemicals used to kill snails and slugs. Eg. Metaldehyde

**Nematicides** - Chemicals used to kill nematodes. Eg. Ethylene di bromide

**Fungicides** - Chemicals used to kill plant diseases. Eg. Thiram

**Herbicides** - Chemicals used to kill weeds. Eg. 2,4-D
Importance:
• Most powerful tools available for use in pest management.
• Highly effective, rapid in curative action, adoptable to most situations.
• Flexible in meeting changing agronomic and ecological conditions and economical.
• Reliable for emergency action when insect pest populations approach or exceed the ETL.
• There are many pest problems for which the use of chemicals provides the only acceptable solution.
• Their use is indispensable to modern society.

Properties of an ideal insecticide or pesticide:
• Freely available under different formulations
• Toxic and kill the pest required
• It should not be phytotoxic
• Non toxic to non target species
• Should not leave residues in crops like vegetables
• have wide range of compatibility
• Not be toxic to bees and fish and other beneficial organisms
• Have higher tolerance limits
• Possess quick known down effect
• Stable on application
• Should not possess tainting effects and should be free from offensive odour
• Should be cheaper
**Toxicity terms used to express the effect on mammals**

<table>
<thead>
<tr>
<th>Acute toxicity</th>
<th>Toxic effect produced by a single dose of a toxicant</th>
</tr>
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<tbody>
<tr>
<td>Chronic toxicity</td>
<td>Toxic effects produced by the accumulation of small amounts of the toxicant over a long period of time</td>
</tr>
<tr>
<td>Oral toxicity</td>
<td>Toxic effect produced by consumption of pesticide orally</td>
</tr>
<tr>
<td>Dermal toxicity</td>
<td>Toxic effect produced when insecticide enters through skin</td>
</tr>
<tr>
<td>Inhalation toxicity</td>
<td>Toxic effect produced when poisonous fumes of insecticide are inhaled (fumigants)</td>
</tr>
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</table>

**Different Classifications of Insecticides**

I. Based on the origin and source of supply

A. **Inorganic insecticides**: Comprise compounds of mineral origin and elemental sulphur. This group includes arsenate and fluorine compounds as insecticides. Sulphur as acaricides and Zinc phosphide as rodenticides.

B. **Organic Insecticides**:
   a. **Insecticides of animal origin**: Nereistoxin isolated from marine annelids, fish oil rosin soap from fishes etc.
   b. **Plant Origin insecticides or Botanical insecticides**: Nicotinoids, pyrethroids, Rotenoids etc.
   c. **Synthetic organic insecticides**: Organochlorines, Organophosphorous and Carbamate insecticides etc.,
   d. **Hydrocarbon oils**: Coal tar oil, mineral oils etc.
II. Based on the mode of entry of the insecticides into the body of the insect

a. **Contact poisons**: These insecticides are capable of gaining entry into the insect body either through spiracles and trachea or through the cuticle and kill them. Eg. Phosalone and HCH.

b. **Stomach poisons**: The poison or toxicant which enter the body of the insect through its food and kill it. Eg: *Bacillus thuringiensis*, Triazophos and Quinalphos.

c. **Fumigants**: A fumigant is a chemical substance which is volatile at ordinary temperatures and sufficiently toxic to the insects. Fumigation is the process of subjecting the infested material to the toxic fumes or vapours of chemicals or gases which have insecticidal properties. Chemical used in the fumigant and a reasonably airtight container or room is known as fumigation chamber or “Fumigatorium”. Fumigants mostly gain entry into the body of the insect through spiracles in the trachea.

**Commonly used Fumigants and their doses:**

a. Aluminium phosphide, marketed as Celphos tablets used against field rats, groundnut bruchids etc.

b. Carbon disulphide 8-20 lbs/1000ft^3 of food grains.

c. EDCT (Ethylene Dichloride Carbon Tetrachloride) 20-30 lbs/1000ft^3 of food grains.

d. EDB (Ethylene dibromide) 1 lb/1000ft^3 of food grains.

E. SO_2_: By burning Sulphur in godowns SO_2_ fumes are released.
d. Systemic insecticides
Chemicals that are capable of moving through the vascular systems of plants irrespective of site of application and poisoning insects that feed on the plants.
Ex: Methyl demeton, Phosphamidon and Acephate
‘Non systemic insecticides’ are not possessing systemic action are called non systemic insecticides. Some non systemic insecticides, however, have ability to move from one surface leaf to the other. They are called as ‘trans laminar insecticides’.
Eg. Malathion, Diazinon and Spinosad etc.
**An ideal systemic insecticide quality are**
- Should have high intrinsic pesticidal activity
- The toxicant must be adequately liposoluble for it to be absorbed by the plant system and water soluble for it to be translocated in the plant system.
- The toxicant or its metabolites should be stable for sufficiently long period to exercise residual effect.
- Should degrade to nontoxic form in reasonable time to avoid toxicity to consumer

- Systemic insecticides are applied as seed dressing, granular formulations, sprays etc.
- In the leaf, the entry of the toxicant are through stomata and cuticle.
- On stem the entry is through lenticels and cracks in the cuticle.
- In the seed it is through seed coat especially through the micropyle.
- Systemic insecticides are highly useful against sap sucking and vectors such as leafhoppers, whiteflies etc.
III. Based on mode of action:

- **Physical poisons**: Bring about the kill of insects by exerting a physical effect.  
  *e.g.* Heavy oils, tar oils etc. which cause death by asphyxiation. Inert dusts effect loss of body moisture by their abrasiveness as in Drie die and Activated Clay.

- **Protoplasmic poisons**: The poisons or toxicants which kill the insect by destruction of cellular protoplasm of the mid gut epithelium cells.  
  *e.g.* Arsenical compounds, Mercury and Copper.

- **Respiratory poisons**: The poisons or toxicants which block cellular respiration and inhibits the respiratory enzymes.  
  *e.g.* Hydrogen cyanide (HCN) and Carbon monoxide.

- **Nerve poisons**: The poisons or toxicants which block Acetyl cholinesterase (AChE) and effect the nervous system leading to death of the insects.  
  *e.g.* Organophosphorous and Carbamates.

- **Chitin inhibitors**: Chitin inhibitors interfere with process of synthesis of chitin due to which normal moulting and development is disrupted.  
  *e.g.* Novaluron, Diflubenzuran, Lufenuron and Buprofezin.

- **General Poisons**: Compounds which include neurotoxic symptoms after some period and do not belong to the above categories.  
  *e.g.* Chlordane, Toxaphene and Aldrin.
IV. Based on toxicity (Based on LD50):

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Generation</th>
<th>Category of insecticide</th>
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<tbody>
<tr>
<td>1</td>
<td>First generation</td>
<td>Inorganics and Botanicals</td>
</tr>
<tr>
<td>2</td>
<td>Second generation</td>
<td>Synthetic organics</td>
</tr>
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<td>3</td>
<td>Third Generation</td>
<td>IGRs like MH &amp; JH mimics</td>
</tr>
<tr>
<td>4</td>
<td>Fourth Generation</td>
<td>Anti JH, Synthetic pyrethroids</td>
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V. Based on stage specificity:
   a. Ovicides, Larvicides, Pupicides and Adulticides

VI. Generation wise:

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Toxicity evaluation of insecticides \( \text{LD}_{50} \) (Lethal Dose):

In 1952, Finney has given the computation methods.

\[ \text{LD}_{50} \text{ (Median Lethal Dose):} \]

It is the amount of toxicant required to kill 50% of the test population and is expressed in terms of milligrams of the substance of toxicant per kilogram body weight (\( \text{mg/kg} \)) of the test animal (usually rat, when treated orally).

- As the test animals usually rat and some times rabbit, it is also referred to as the mammalian toxicity. This forms the general criteria for acute toxicity and is also known \textbf{Acute oral LD}_{50}.
- In case of insects the \( \text{LD}_{50} \) (Median Lethal Dose) value is expressed in terms of micrograms of the toxicant per one gram body weight of the insect.
- The amount of toxicant required to be placed on the skin to cause death of 50% of test population is known as acute dermal \( \text{LD}_{50} \).
- It must be understood that higher the \( \text{LD}_{50} \) value lesser is the toxic nature of the chemical and vice-versa.

\[ \text{LC}_{50} \text{ (Median Lethal concentration):} \]

Defined as the concentration of insecticide required to kill 50% of the given organism or insect. This is used when the exact dose per insect is not known, but the concentration is known. It is usually determined by potters tower and probit analysis.

\( \text{LC}_{50} \) is expressed in PPM (1/1,000,000) or Percentage (1/100)

\[ \text{ED}_{50}/ \text{EC}_{50} \text{ (Effective Dose/Concentration 50):} \]

Chemicals that gives desirable effects (Sterility) in 50% of test animals. These terms are used to express the effectiveness of insect growth regulators (IGR)
LT<sub>50</sub> (Median Lethal time 50): LT<sub>50</sub> is defined as the time required to kill 50% of the population at a certain dose or concentration. LT<sub>50</sub> expressed in hours or minutes. LT<sub>50</sub> is used in field studies and also for testing insect viruses (NPV).

KD<sub>50</sub>/ KT<sub>50</sub> (Median Knock down Dose /Time 50): Dose / Time required for 50% of population having knockdown effect. KD<sub>50</sub> and KT<sub>50</sub> are used for evaluating synthetic pyrethroids against insects.

ID<sub>50</sub>/IC<sub>50</sub>: (Inhibition of metamorphosis)

Bioassay of insecticides (Bios-Life and Assay-Determination)

- Study of response of individual or group of organisms exposed to the toxicant is called ‘Bioassay’ or Any quantitative procedure used to determine the relationship between the amount (dose or concentration) of an insecticide administered and the magnitude of response in a living organism.
- Potter spraying tower apparatus is required for studying the biological effects of contact poisons on organisms. This air operated spraying apparatus applies an even deposit of spray over a circular area of 9 cm diameter.
- Suitable for studying the biological effects of chemicals, both when applied as direct spray on organisms or as a residual film.
- Bioassays are used for screening of potential insecticides, for determination of values of LD50 and LC 50, estimation of residues and quality testing of formulated insecticides.
The amount of initially laid down insecticidal chemical on the surface is **Deposit**.

Pest Residue: the amount of insecticide left over after a lapse of time. It is measured in ppm.

The time in which half of the amount of initial deposit is eliminated is **Half Life**

Insect pest receives as low as $10^{-6}$ to $10^{-1}$ per cent of pesticide applied.

The period for which the pesticides continue to remain toxic is called **Waiting Period**

**Acceptable Daily Intake (ADI):** It is the daily dose of a chemical which when given during an entire life time appears to be without appreciable risk on the basis of all facts known at that time.

**Maximum Residue Limit (MRL):** It is the concentration of a toxicant residue in or on the food when first offered for consumption.

$$\text{MRL} = \frac{\text{ADI/day/man}}{\text{Contaminated food in mg}}$$

**Vertebrate/Mammalian Selectivity Ratio (VSR or MSR)**

$$\text{VSR/MSR} = \frac{\text{Oral LD}_{50} \text{ of a mammal (Rat)}}{\text{Oral LD}_{50} \text{ of a insect}}$$
<table>
<thead>
<tr>
<th>CATEGORY OF INSECTICIDE</th>
<th>COLOUR OF LABEL</th>
<th>Oral LD$_{50}$ (mg/kg of body weight)</th>
<th>Dermal LD$_{50}$ (mg/kg of body weight)</th>
<th>TAG</th>
<th>SYMBOL AND SIGNAL WORD</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXTREMELY TOXIC</td>
<td>RED</td>
<td>&lt;50</td>
<td>&lt;200</td>
<td>&quot;KEEP OUT OF THE REACH OF CHILDREN&quot; &quot;IF SWALLOWED OR IF SYMPTOMS OF POISONING OCCUR CALL PHYSICIAN IMMEDIATELY&quot;</td>
<td>Skull and cross bones and the word “Fatal poison printed both in red colour”</td>
</tr>
<tr>
<td>HIGHLY TOXIC</td>
<td>ORANGE</td>
<td>51-500</td>
<td>201-1,000</td>
<td>&quot;KEEP OUT OF THE REACH OF CHILDREN&quot; &quot;IF SWALLOWED OR IF SYMPTOMS OF POISONING OCCUR CALL PHYSICIAN IMMEDIATELY&quot;</td>
<td>Skull &amp; cross bones printed in red colour and the word poison printed in red colour</td>
</tr>
<tr>
<td>MODERATELY TOXIC</td>
<td>YELLOW</td>
<td>501-1,000</td>
<td>1,001-1,500</td>
<td>&quot;KEEP OUT OF THE REACH OF CHILDREN&quot;</td>
<td>Poison printed in red</td>
</tr>
<tr>
<td>SLIGHTLY TOXIC</td>
<td>BLUE</td>
<td>1,001-5,000</td>
<td>1,501-2,000</td>
<td>&quot;KEEP OUT OF THE REACH OF CHILDREN&quot;</td>
<td>DANGER</td>
</tr>
<tr>
<td>UNLIKELY TOXIC</td>
<td>GREEN</td>
<td>&gt;5,000</td>
<td>&gt;2,000</td>
<td>&quot;KEEP OUT OF THE REACH OF CHILDREN&quot;</td>
<td>CAUTION</td>
</tr>
</tbody>
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