DIRECTORATE OF DISTANCE & CONTINUING EDUCATIONS

MANONMANIAM SUNDARANAR UNIVERSITY

TIRUNELVELI – 627012

OPEN AND DISTANCE LEARING(ODL) PROGRAMMES

(FOR THOSE WHO JOINED THE PROGRMMES FROM THE ACADEMIC YEAR 2023 – 2024)

B.Sc. CHEMISTRY
COURSE MATERIALS
SKIL ENHANCEMENT COURSE – V
PESTICIDE CHEMISTRY

By

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Unit I

Introduction: History of pesticides. Chemistry of Pesticides: Brief introduction to classes of pesticides (Chemical class, targets), structures, chemical names, physical and chemical properties. Toxicity of pesticides: Acute and chronic toxicity in mammals, birds, aquatic species etc. Methods of analysis of pesticides.

Insecticides: Classification and study of following insecticides with respect to structure, chemical name, physical properties, chemical properties, synthesis, degradation, metabolism, formulations, Mode of action, uses, toxicity.

Organophosphates and Phosphothionates: Acephate, Chlorpyriphos, Monocrotophos, and parathion-methyl. Organochlorine – Endosulfan, heptachlor; Carbamate: Cartap hydrochloride, Methomyl, Propoxur.

Unit II

Pesticides residues: Introduction- application of agrochemicals, dissemination pathways of pesticides, causes of pesticide residues, remedies. Pesticides residues in atmosphere-entry into atmosphere, action of pesticides, effects on environments. Pesticides residues in water - entry into water systems, action and effect in aquatic environment.

Pesticides residues in soil. entry into soil, absorption, retention and transport in soil, effects on microorganism, soil condition and fertility, decomposition and degradation by climatic factors and microorganism.

Pesticide Residues effect and analysis: Effects of pesticides residue on human life, birds and animals- routes for exposure to pesticides, action of pesticides on living system. Analysis of pesticides residues- sample preparation, extraction of pesticides residues (soil, water and vegetables/fruits) simple methods and schemes of analysis, multi-residue analysis

Unit III

Biopesticides: Pheromones, attractants, repellents – Introduction, types and application (8- Dodecen-1-ol, 10-cis-12-hexadecadienoic, Trimedlure, Cue-lure, methyl eugenol, N,N- Diethyl-m-toluamide, Dimethyl phthalate, Icaridin). Baits- Metaldehyde, Iron (II) phosphate, Indoxacarb, Zinc Phosphide, Bromadiolone.

Recommended Text

1. Handa SK. Principles of pesticide chemistry. Agrobios (India); 2012.
2. Matolcsy G, Nádasy M, Andriska V. Pesticide chemistry. Elsevier; 1989.
3. J. Miyamoto and P. C. Kearney Pesticide Chemistry Human Welfare and the Environment vol. IV Pesticide Residue and Formulation Chemistry, Pergamon press,1985.
4. R. Cremlyn: Pesticides, John Wiley.

Reference Books

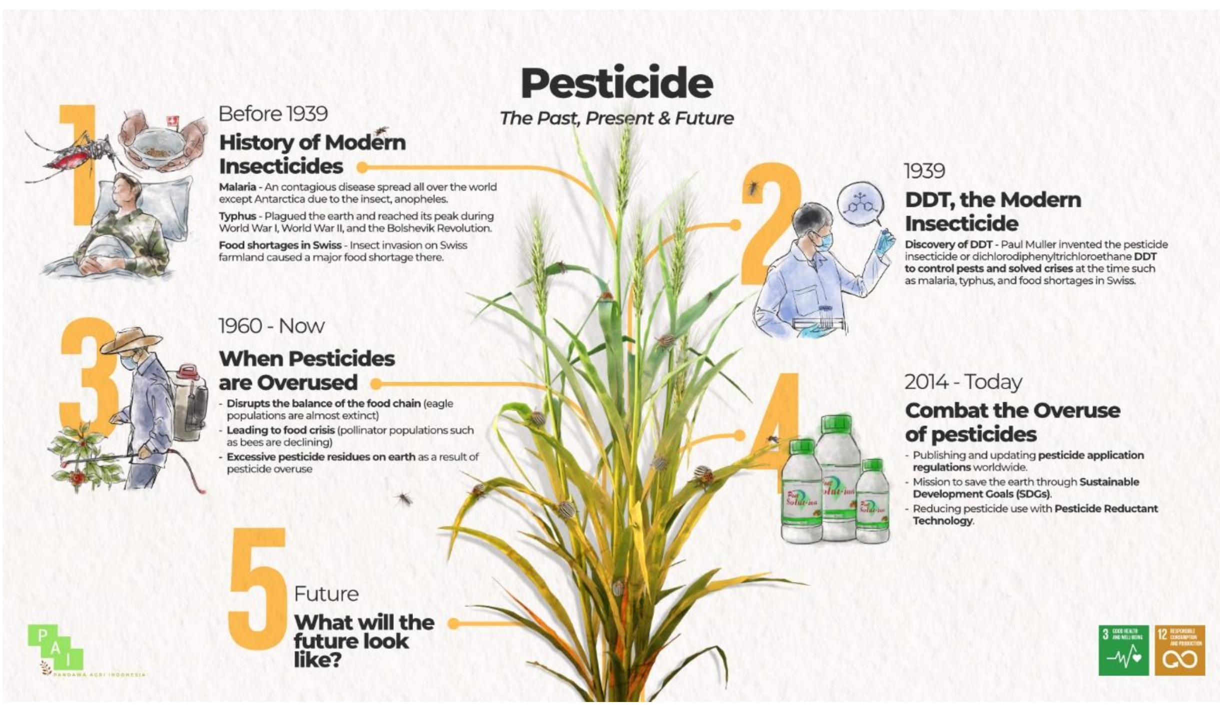
1. Roy N. K., Chemistry of Pesticides. CBS Publisher & Distributors P Ltd; 1st Ed. (2010).
2. Nollet L.M., Rathore H.S., Handbook of pesticides: methods of pesticide residues analysis. CRC press; 2016.
3. Ellerbrock R.H., Pesticide Residues: Significance, Management and Analysis, 2005

UNIT-I

Introduction:

History of pesticides:

The development of agriculture approximately 10,000 years ago, is limited to the evidence that has survived to the present day. Nevertheless, we know that more than 4,500 years ago the sumerians were using sulfur compounds to control insects and mites, that 3,200 years ago the chinese were using insecticides derived from plants and, by 2,500 years ago, had appreciated the role of natural enemies and the value of adjusting crop-planting times to avoid pest outbreaks, and that the Greeks and Romans understood the use of fumigants, mosquito nets, granaries on stilts, strictly bands on trees and pesticidal sprays and ointments although throughout this period and long beyond, such sophisticated practices were accompanied by widespread reliance on offerings to the gods and other superstitions. Use of pesticides in India began in 1948 when DDT was imported for malaria control and BHC for locust control. India started pesticide production with a manufacturing plant for DDT and benzene hexachloride in the year 1952. In 1958, India was producing over 5000 metric tonnes of pesticides.



Chemistry of pesticides:

Pesticides are chemical substances or mixtures of substances that are used to control, destroy, or repel pests. Pests can be organisms such as insects, rodents, fungi, slugs, snails, bird mites, and weeds that can destroy agricultural crops.

Classes of pesticides

Here is a brief introduction to classes of pesticides, including their chemical classes and targets.

Organophosphates:

Chemical class: Phosphoric acid esters Target: Insects

Examples: Malathion, Parathion, Diazinon

Pyrethroids:

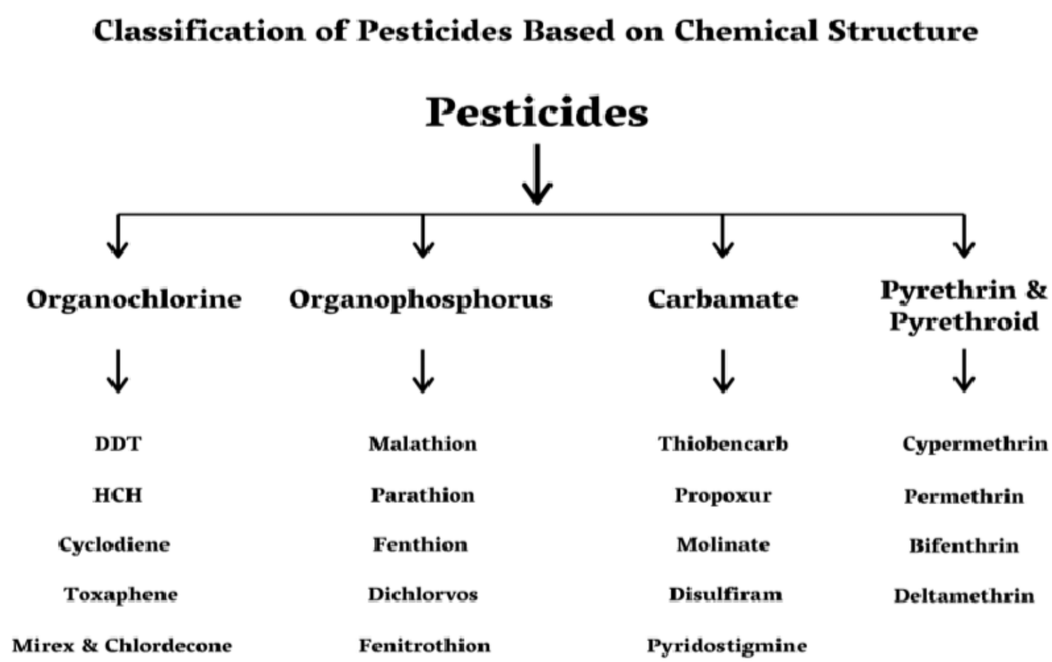
Chemical class: Synthetic pyrethrins Target: Insects

Examples: Permethrin, Deltamethrin, Cyfluthrin

Triazines

Chemical class: Triazinones Target: Weed

Examples: Atrazine, Simazine, Cyanazine



Azoles

Chemical class: Imidazoles and triazoles Target: Fungi

Examples: Clotrimazole, Propiconazole, Tebuconazole

Carbamates

Chemical class: Carbamic acid Target: Insects

Examples: Carbaryl, Methomyl, Aldicarb

Neonicotinoides:

Chemical class: Nitroguanidine and nitromethane Target: Insects

Example: Imidacloprid, Clothianidin, Thiamethoxam

Phenylpyrazoles:

Chemical class: Phenylpyrazole derivatives Target: Insects

Example: Fipronil, Ethiprole

Glyphosate:

Chemical class: Phosphonoglycine Target: Weed

Example: Glyphosate

Physical properties:

- Appearance and odor: Amber colored liquid with slight phenoxy odor.
- Density:9.0 pounds/gallon
- Boiling point :>212°F (>100°C)
- Freezing point:32°F (0°C)
- PH:8.0–9.0
- solubility: Soluble

Chemical properties:

- Solubility: Affects absorption and transport in plants and animals
- Stability: Affects persistence in the environment
- Reactivity: Affects interactions with targets and non-targets.
- Toxicity: Affects harmful effects on humans, animals, and the environment.

Toxicity of pesticides:

In Birds

Acute poisoning: Birds can be killed by pesticides that contaminate their food or the vegetation and insects they eat. Some pesticides that are lethal to birds include diazinon, phorate, carbofuran, monocrotophos, isofenphos, chlorpyrifos, aldicarb, azinphos-methyl, and parathion.

Chronic Toxicity:

- Reproductive issues: Pesticides can cause reduced fertility, decreased egg production, and thinner eggshells. They can also cause embryos to be deformed, or to have reduced hatchability.
- Behavioral changes: Birds exposed to pesticides may exhibit abnormal behaviors, such as singing less, failing to defend their territory, or providing less food for their chicks.
- Weight loss: Birds exposed to pesticides may lose weight and have a lack of appetite.
- Other health issues: Pesticides can cause birds to have a suppressed immune system response, and make them more vulnerable to predation. They can also cause impaired incubation and chick rearing behaviors.
- Lethal poisoning: Birds can be killed by pesticides that contaminate their food sources. Some pesticides that are known to be lethal to birds include diazinon, phorate, carbofuran, and monocrotophos.

In Animals,

Acute Toxicity:

- Respiratory tract irritation
- Sore throat and/or cough
- Eye and skin irritation
- Nausea, vomiting, diarrhea
- Headache, loss of consciousness
- Extreme weakness, seizures, and/or death.

Chronic Toxicity:

- Exposure to pesticides over an extended period of time can cause chronic poisoning. For example, DDT, an organochlorine insecticide, can cause chronic effects on the reproduction of certain birds of prey.

In Mammals,

- **Acute toxicity:** The effects of a single dose or short-term exposure to a pesticide. Acute toxicity is often the result of an accident, such as when mixing or applying pesticides. Acute toxicity is measured by LD50 and LC50 values.
- **Chronic toxicity:** The harmful effects of long-term exposure to a pesticide. Chronic toxicity is more difficult to determine than acute toxicity because it's gradual and can manifest in complex ways.

Methods of analysis of pesticide:

There are several approaches which vary in their degree of complexity, in the time, effort are analytical instrumentation required to complete them.

Multiresidue methods :-

It has been designed to detect band measure a multiplicity of residues in a range of foods. Multistep contains:Sample preparation⇒Extraction⇒Clean up⇒Chromatographic separation. Out of 10 MRMs currently used by FDA and USDA, *8 based on gas chromatography and the *2 based on HPLC. However, none of these MRMs procedures can detect all the residues on all crop types. In practice, they represent a compromise among the number of residues that can be detected, the range of food types that can be handled, and the levels of residues that can be measured. The principal advantage resides in the number of different residues that they can detected and determined.

Single residue methods :-

It has been designed to measure a single analyte and, often, its principal metabolites and transformation products of toxicological importance. Multistep contains:Sample preparation⇒Extraction⇒Clean up⇒Chromatographic separation. Each step is optimized for the analyte of interest. Generally, they are less time consuming to perform and often provide lower limits of detection than MRMs. However, they do vary in the level of validation to which they have been subjected volume 2 of the pesticides Analytical Manual (PAM 2) consists solely of SRMs. In PAM 2, those methods that have received EPA review are listed with Romain numerals, whereas methods that have not been reviewed are lettered.

Semi Quantitative and Qualitative methods :-

Semiquantitative and qualitative methods range widely in their abilities to estimate the level of particular pesticides residue in the sample. In general, they are capable of detecting a limited number of somewhat similar pesticides. Also called as screening methods as they are capable of assaying a large number of samples for the presence of limited number of pesticides residues in relatively short time. Additionally they are generally robust in character (i.e. less sensitive to small changes in the purity of reagents, quantities of reagent, time, temperature and environment conditions). Semiquantitative methods provide an estimate of the concentration ranges for detected residues, Qualitative methods will detect the pesticides if present above some predetermined level. The principal benefit of these methods are their low cost, relative speed, and simplicity. These methods use TLC, Enzyme inhibtion, and immunoassay.

Quantitative methods :-

The basic steps of a quantitative analytical method for pesticides residues include the following,

Sample preparation: the plant parts are separated into edible and non edible fractions followed chopping, grinding, or macerating of the sample.

Extraction: pesticides residues are removed from most of the samples other constituents by solubilizing them in a suitable solvent. This steps often involves blending the chopped sample with solvent in a homogenizer, followed by a filtration.

Clean up: The crude extract is purifies further by removing those co-extractives that can be interfere in the subsequent determined steps.

Detection and quantitation: A physical parameter of the seprated components in the mobile phase is measured as they passthrough a detector, this signal is then related to the quantity of analyte via a quantitation step.

Insecticides:

Structure of insecticide:

Insecticides are chemical substances used to kill or manage the population of insects. They come in various classes, each with distinct chemical structures. Below are examples of different types of insecticides, along with their structures.

• **Organophosphates**

Example: Malathion

Structure: Malathion has a core phosphorus atom double-bonded to a sulfur atom and bonded to two ethoxy groups, a methyl group,and a thioester group.

Chemical Formula: $C_{10}H_{19}O_6PS$

•**Pyrethroids**

Example: Permethrin

Structure: Permethrin features a cyclopropane ring attached to an ester group, with a dichlorovinyl group on one side and a phenoxy group on the other.

Chemical Formula: $C_{21}H_{20}Cl_2O_3$

•**Neonicotinoids**

Example: Imidacloprid

Structure: Imidacloprid contains a chloropyridine ring attached to an · an imidazolidinyl ring, with a nitroimine functional group.

Chemical Formula: $C_9H_{10}ClN_5O_2$

•**Organochlorines**

Example: DDT (Dichlorodiphenyltrichloroethane)

Structure: DDT consists of a central ethane structure with three chlorine atoms attached to one carbon and two benzene rings attached to the other carbon.

Chemical Formula: $C_{14}H_9Cl_5$

•**Carbamates**

Example: Carbaryl

Structure: Carbaryl has a carbamate functional group attached to a naphthyl ring, making it a naphthyl carbamates

Chemical Formula: $C_{12}H_{11}NO_2$

•**Phenylpyrazoles:**

Example: Fipronil

Structure: Fipronil features a pyrazole ring bonded to a trifluoromethyl sulfinyl group and a phenyl ring substituted with chlorine and fluorine atoms.

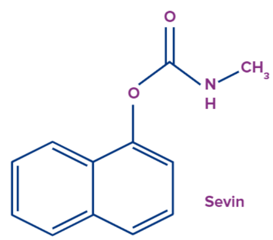
Chemical Formula: $C_{12}H_4Cl_2F_6N_4OS$

•**Biopesticides (Bacterial Derivatives):**

Example: Spinosad

Structure: Spinosad is a complex macrolide with a large lactone ring, several double bonds, oxygen-containing functional groups, and attached sugar moieties

Chemical Formula: $C_{41}H_{65}NO_{10}$



Chemical names of insecticides:

Insecticides come in various chemical formulations, and their chemical names vary depending on the active ingredient. Some common chemical names of insecticides include:

•Permethrin - A widely used synthetic pyrethroid.

•Malathion - An organophosphate insecticide.

•Chlorpyrifos - Another organophosphate, commonly used in agriculture.

•Imidacloprid - A neonicotinoid insecticide used to control sucking insects.

•Deltamethrin - Another synthetic pyrethroid with broad-spectrum activity.

•Carbaryl- A carbamate insecticide often used in gardens.

•Fipronil- A phenylpyrazole insecticide effective against a wide range of pests.

•Bifenthrin - A synthetic pyrethroid, commonly used in both agriculture and residential pest control

Physical and chemical properties of insecticide:

Physical Properties:

State: Insecticides can be solid (e.g., powders), liquid (e.g., emulsifiable concentrates), or gaseous (e.g., fumigants). Color: Often colorless, but can range from light yellow to brown depending on the compound and formulation.

Odour: Varies from odorless to having a distinct, often unpleasant smell. Solubility: The solubility of insecticides in water and organic solvents is critical. Many insecticides are soluble in organic solvents but have limited water solubility.

Melting Point: The melting point varies depending on the compound. For example, permethrin- has a melting point around 34-39°C.

Boiling Point: The boiling point also varies; Chlorpyrifos, for example, has a boiling point of about 160°C at low pressure.

Vapor Pressure: Indicates the tendency of the insecticide to evaporate. Lower vapor pressures mean the compound is less volatile (e.g., Deltamethrin has very low vapor pressure).

Chemical Properties:

Molecular Formula: The specific molecular structure of the active ingredient defines its chemical properties (e.g., Chlorpyrifos).

Reactivity: Some insecticides are chemically stable under normal conditions, while others may degrade when exposed to light, heat, or alkaline conditions. Carbaryl- can degrade in alkaline environments.

pH Stability: Insecticides may be stable or degrade at different pH levels. For instance, Malathion is more stable in acidic conditions.

Hydrolysis: Many insecticides undergo hydrolysis in the presence of water, which can lead to the formation of less toxic or inactive compounds.

Photodegradation: Exposure to sunlight can cause some insecticides to break down. Permethrin degrades relatively slowly under UV light.

Chemical Composition: Insecticides may contain carbon, hydrogen, oxygen, nitrogen, sulfur, phosphorus, and halogens, depending on the compound.

Synthesis:

Prothrin: A synthetic pyrethroid insecticide is synthesized from 5-(chloromethyl)furfural (CMF)in a six-step process.

Anthranilic diamide: A compound is synthesized by adding anhydrous ethanol and sodium ethanol to a reaction flask, then adding compound 1 and heating until reflux.

Novel compounds: A synthetic route is developed using alpha-amino acids as starting materials to construct amide bonds.

Pyrazole-5-carboxylic acid: A synthetic route is developed by reacting 2,3-dichloropyridine with hydrazine hydrate, then condensing diethyl maleate with hydrazine 2, and treating the resulting pyrazolidinone with phosphorus oxybromide.

Oxo Propyl Thiourea compounds: A reaction is performed between secondary amine and chloroacetyl chloride to give an intermediate, which is then reacted with ammonium thiocyanate.

Degradation:

Chemical degradation: The chemical and physical properties of the pesticide, as well as temperature, moisture, pH, and adsorption, determine the chemical reactions that occur and how quickly. Hydrolysis is a common reaction where the pesticide breaks down when it reacts with water.

Photodegradation: Degradation caused by sunlight.

Thermal degradation: Degradation caused by elevated temperatures.

Microbiological degradation: Degradation caused by microorganisms, such as white rot fungi, Rhizopus, and Aspergillus.

Mode of Action:

Neurotoxicity: Many insecticides target the nervous system of insects (e.g., Pyrethroids like Permethrin).

Enzyme Inhibition: Organophosphates and carbamates inhibit acetylcholinesterase, an enzyme critical for nerve function.

Growth Regulators: Some insecticides, such as Methoprene, act as insect growth regulators by mimicking juvenile hormones.

Metabolism:

Insecticides are metabolized by enzymes and undergo two phases of reactions:

Phase I

The primary reactions that decrease the biological activity of the toxicant. These reactions include oxidation, hydrolysis, and reduction.

Phase II

The secondary reactions that involve conjugating polar products with endogenous compounds such as sugars, sulfate, phosphate, amino acids, and glutathione. The polar products are then excreted.

Toxicity:

The toxicity of an insecticide to non-target organisms, including humans, is a critical factor. Fipronil- is highly toxic to aquatic life, while Imidacloprid is highly toxic to bees.

Uses:

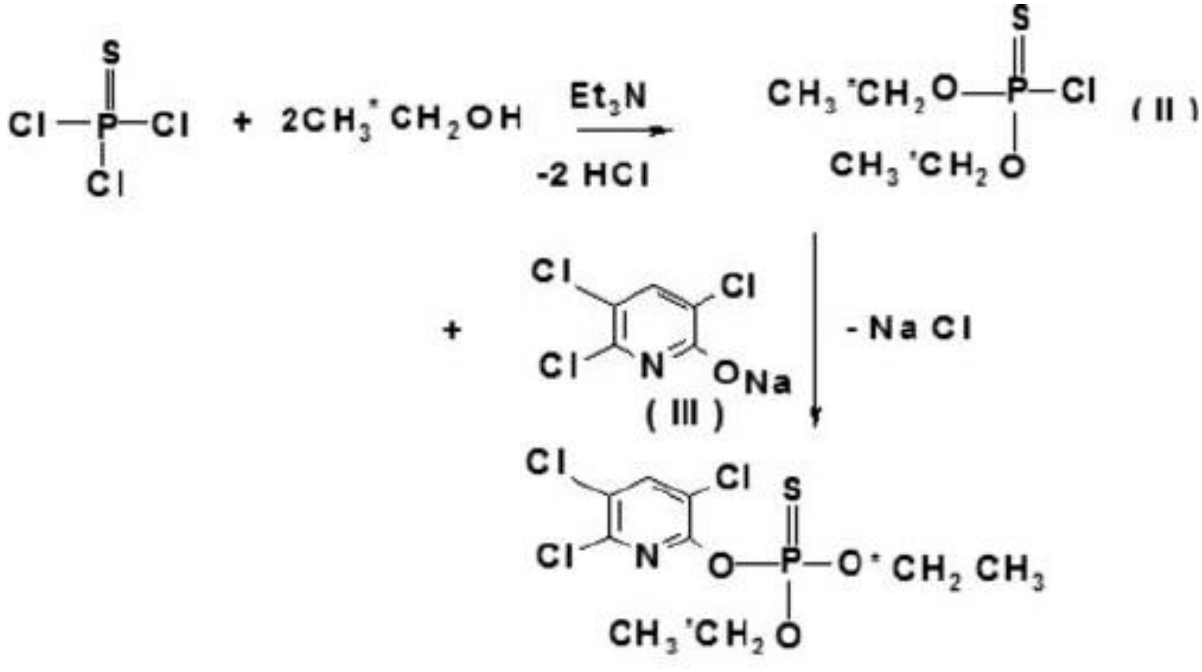
Insecticides are chemicals used to control insects that damage crops or spread disease:

Crop health: Insecticides help preserve crop health and control the spread of insect-borne diseases.

Increased yields: Insecticides can improve crop production and income.

Improved crop quality: Insecticides can ensure that crop quality isn't hampered by insects.

Quick pest control: Insecticides can reduce pests within hours.



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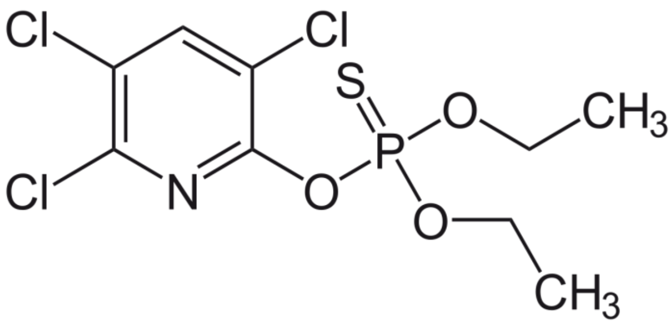
Chlorpyrifos:

Chlorpyrifos (CPS), also known as chlorpyrifos ethyl, is an organophosphate pesticide that has been used on crops, animals, and buildings, and in other settings, to kill several pests, including insects and worms. It acts on the nervous systems of insects by inhibiting the acetylcholinesterase enzyme. Chlorpyrifos was patented in 1966 by Dow Chemical Company. Chlorpyrifos is considered moderately hazardous to humans (Class II) by the World Health Organization based on acute toxicity information dating to 1999.Exposure surpassing recommended levels has been linked to neurological effects, persistent developmental disorders, and autoimmune disorders. Exposure during pregnancy may harm the mental development of children.

Structure of chlorpyrifos:



Production of chlorpyrifos:

The method comprises the following steps:

tetrachloropyridine, caustic soda, a catalyst and water are placed in a high pressure kettle according to a certain proportion for a pressurization alkaline hydrolysis reaction, then a material used for alkaline hydrolysis reaction is placed in a condensation kettle to carry out direct condensation reaction with O,O-diethyl chlorothiophosphate, the reaction is finished, an oil-water mixture containing chlorpyrifos is obtained, standing and layering are carried out to filter an oil layer, the oil layer is subjected to oxidation and decolouring by hydrogen peroxide, processes of washing for layering, dewatering and drying are carried out to obtain chlopyrifos crude oil with purity greater than 98%. The production method for synthesizing chlorpyrifos by taking tetrachloropyridine as the raw material avoids the usage of expensive 3,5,6-trichloropyridine-2-sodium alkoxide, tetrachloropyridine is directly taken as the raw material to synthesize chlopyrifos by a two-step reaction, so that the production cost and waste water discharge amount can be substantially reduced, the product purity and yield are high, and the method of the invention is suitable for large scale industrial production.

Properties of chlorpyrifos:

- Chlorpyrifos is a white or colorless crystalline solid with a mild, skunky odor. It has a molecular weight of 350.6 g/mol, a melting point of 108–110 °F, and a boiling point of 320 °F. It's corrosive to brass and copper, and decomposes at 160 °C, producing toxic and corrosive fumes.
- **Solubility:** Chlorpyrifos is practically insoluble in water, but soluble in most organic solvents.
- **Persistence:** Chlorpyrifos has short to moderate persistence in the environment, with a half-life of 2–1,575 days in soils.
- **Toxicity:** Chlorpyrifos is highly toxic to mammals, birds, fish, aquatic invertebrates, and honeybees. It's also a reproduction toxicant, acetylcholinesterase inhibitor, and neurotoxicant.
- **Exposure:** Chlorpyrifos can be absorbed through inhalation, ingestion, or dermal exposure. It can cause many diseases, including headache, rash, convulsions, coma, and death.
- **Application:** Chlorpyrifos is usually supplied as an emulsifiable concentrate that's mixed with water and applied as a spray. It can also be supplied as granules for direct application to soil.

Uses of chlorpyrifos:

Chlorpyrifos is an organophosphate insecticide widely used in agriculture to control a variety of pests.

Agricultural Pest Control:

Crops: Chlorpyrifos is used on a wide range of crops, including fruits (like citrus and apples)vegetables (such as corn and broccoli), nuts, and grains.

Soil Treatment: It is applied to the soil to control soil-borne pests like rootworms and termites.

Post-Harvest: Used on stored grain and other products to protect them from insects.

Non-agricultural Uses:

Turf and Golf Courses: Applied to manage insect pests in lawns, turf, and golf courses.

Ornamental Plants: Used to protect ornamental plants and trees from various pests.

Structural Pest Control: Employed in controlling termites and other wood-boring insects buildings.

Acephate:

Degradation : Acephate, an organophosphate pesticide used to control agricultural pests, can degrade in two main ways:

Methamidophos :

Acephate can partially self-degrade into methamidophos during crop cultivation. However, methamidophos is a toxic intermediate product, and some countries have partially restricted the use of acephate due to this.

O-methyl-N-acetylphosphoramidate: Acephate can also degrade through O-methyl-N-acetylphosphoramidate. Acephate can also degrade in the environment through hydrolysis, oxidation, and other factors:

Hydrolysis:

In water bodies, hydrolysis can be caused by water pH, microorganisms, and sunlight Bioaugmenting acephate-contaminated soils with microbial consortia like ZQ01 can increase the rate at which acephate is removed.

Metabolism :

Acephate, an organophosphate pesticide used in agriculture, breaks down in soil and water through a variety of pathways:

1. **Soil:**

Acephate breaks down quickly in soil, with half-lives ranging from 3–32 days depending on the soil type. Microorganisms degrade acephate primarily through aerobic metabolism, while photolysis also plays a role. The main metabolites in soil are methamidophos and carbon dioxide.Methamidophos is another organophosphate insecticide that can inhibit acetylcholinesterase (AChE).

2. **Water:**

Acephate hydrolyzes quickly in water. Microorganisms also degrade acephate in water, with carboxylesterase enzymes releasing acetate residues to form methamidophos. Phosphotriesterase (PTE) then catalyzes the hydrolysis of methamidophos to produce methyl dihydrogen phosphate, S-methyl dihydrogen thiophosphate, or O-methylphosphoramidate, which eventually leads to phosphoric acid.

Formulation :

Acephate is an insecticide that comes in various formulations, including dusts, granules, and soluble powders. These formulations allow for different application methods, such as foliar spray.

1. **Foiler spray:**

Dissolve the required amount of acephate in a small amount of water in a container. Stir the solution and then mix it with the remaining water. The amount of water needed depends on the crop stage, crop cover, the total area to be treated, and the type of sprayer used. Use a good quality sprayer with hollow cone nozzles to ensure thorough coverage of the crop.

2. Spray solution:

Empty the contents of the package into a spray tank that contains at least half of the total amount of water needed. Run the agitator and add the remaining water until the spray volume is reached. Don't add any liquid fertilizers, micronutrients, or adjuvants until the acephate has completely dissolved, which should take about five minutes. Cold water, lack of agitation, or water with high concentrations of boron or sulfur can slow down the dissolution rate. Acephate has contact and systemic action, which means it can eliminate insects directly on the surface of plants and be absorbed by the plants to target pests in different parts of the plant.

Mode of action :

- Acephate is an organophosphorus insecticide that controls biting and sucking insects by contact or ingestion
- It works by binding to and inhibiting the enzyme acetylcholinesterase (AChE) in the nervous system tissues of insects.
- This causes a buildup of the neurotransmitter acetylcholine, which overstimulates cholinergic receptors and activates the nerves, muscles, or brain.

Uses :

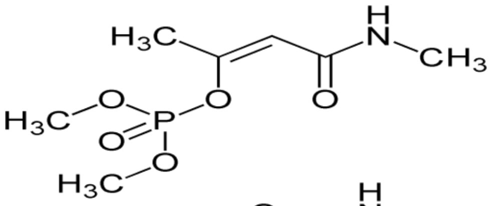
- Ornamental plants: Used in greenhouses and outdoors on plants like nonbearing fruit trees, Christmas trees, and cut flowers
- Food crops: Registered for use on field, fruit, and vegetable crops like cotton, tobacco, cranberries, and mint
- Food handling establishments: Used in these settings
- Seed treatment: Used as a seed treatment on cotton, peanuts, nonbearing crops like citrus, and tobacco.

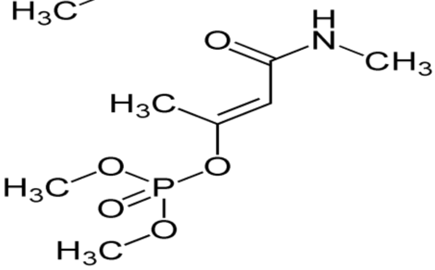
Toxicity :

- Acephate is moderately toxic to mammals, with an acute oral LD50 of 850–950 mg kg^{-1} in rats
- Methamidophos is an acetylcholinesterase (AChE) inhibitor that is highly toxic to mammals.
- Acephate can kill insects when they eat or touch it.
- At very high exposures, acephate can cause respiratory paralysis and death.
- Acephate can inhibit cholinesterase in humans, which can overstimulate the nervous system. Symptoms include nausea, dizziness, confusion.

Monocrotophos:

Monocrotophos is a synthetic organophosphate acetylcholinesterase and monoamine oxidase inhibitor that is used





as a pesticide.

Properties:

- Appearance: A reddish-brown crystalline solid with a mild ester odor
- Chemical name: Dimethyl (E)-1-methyl-2-(methylcarbamoyl)vinyl phosphate
- CAS number: 2157-98-4
- Molecular weight: 223.2
- Water solubility: Soluble in water
- Melting point: 54–55°C (131°F; 328 K)
- Density: 1.33 g/cm3

Synthesis:

The synthesis of monocrotophos typically involves the following steps:

1. Preparation of dimethyl phosphite: $(CH_3O)_2PHO + CH_3I \rightarrow (CH_3O)_3P + HI$
2. Reaction with N-methylhydroxylamine: $(CH_3O)_3P + NH_2OCH_3 \rightarrow (CH_3O)_2P(O)CH_3NH(O)$

$+ CH_3OH$

3. Chlorination: $(CH_3O)_2P(O)CH_3NH(O) + Cl_2 \rightarrow$

$(CH_3O)_2P(O)CH_3NCl(O) + HCl$

4. Reaction with dimethylamine: $(CH_3O)_2P(O)CH_3NCl(O) + (CH_3)_2NH \rightarrow (CH_3O)_2P(O)CH_3N(O)CH_3 + (CH_3)_2NH \cdot HCl$

Degradation:

Biodegradation: Enzymes like phosphatases and esterases break down monocrotophos into ammonia, carbon dioxide, and phosphates. The process involves the formation of intermediate compounds like acetic acid and valeric acid. The degraded metabolites are less toxic than the original monocrotophos.

Hydrolysis: The first step of monocrotophos degradation is hydrolysis, which produces N-methyl acetoacetamide and dimethyl phosphate.

Oxidation: Oxidation is a major factor in the rapid loss of monocrotophos residues.

Volatilization: Volatilization is another major factor in the rapid loss of monocrotophos residues.

Photocatalytic degradation: Photocatalytic degradation can be enhanced by doping TiO2 with tungsten trioxide (WO3) to increase the production of OH radicals. The calcination temperature of the catalyst also affects its photoactivity.

Bacterial degradation: Some bacterial strains can degrade monocrotophos, and some of these strains also promote plant growth.

Toxicity:

Humans: Exposure to monocrotophos can cause rapid organophosphate poisoning with symptoms including headache, dizziness, blurred vision, nausea, vomiting, diarrhea, muscle twitching, convulsions, coma, and death. Repeated exposure can cause personality changes such as depression, anxiety, or irritability.

Aquatic organisms: Monocrotophos is very toxic to aquatic organisms, including shrimps and crabs, and moderately toxic to fish.

Wildlife: Monocrotophos has been responsible for widespread bird kills, including a large kill of Swainson's Hawks in Argentina.

Ecosystem: Monocrotophos can leach into the soil and contaminate groundwater, causing harmful effects on non-targeted populations in the ecosystem.

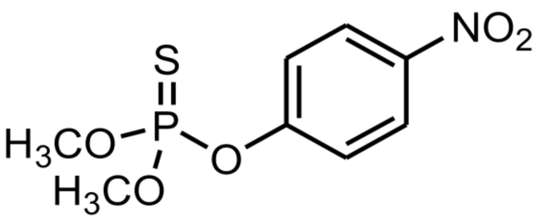
Uses:

Monocrotophos is a pesticide used to control pests on a variety of crops, including cotton, rice, sugarcane, peanuts, tobacco, and fruit crops. It's used to control a wide range of insects, such as aphids, caterpillars, mites, moths, locusts, and more.

Monocrotophos is a systemic insecticide that's highly toxic and can be absorbed through ingestion, inhalation, or skin contact. It's classified as a highly hazardous pesticide by the World Health Organization (WHO). Monocrotophos is harmful to other non-targeted populations in the ecosystem, including aquatic animals, birds, mammals, and humans.

Methyl-Parathion:

Parathion methyl, or methyl parathion, is an organophosphate insecticide, possessing an organothiophosphate group. It is



structurally very similar to parathion-ethyl.

Properties:

Appearance: Methyl parathion is a white crystalline solid. The commercial product is a tan liquid with a pungent odor.

Solubility: Methyl parathion is slightly soluble to insoluble in water.

Toxicity: Methyl parathion is an extremely toxic organophosphorus pesticide.

Toxicity mechanism: Methyl parathion's primary mechanism of toxicity is by inhibiting acetylcholinesterase in the central nervous system and at the neuromuscular junction.

Health effects: Exposure to methyl parathion can cause cardiovascular, gastrointestinal, reproductive, and respiratory effects:

Cardiovascular: Abnormalities in heart rate and electrocardiograms

Gastrointestinal: Nausea, vomiting, abdominal cramps, diarrhea, and fecal incontinence

Reproductive: Genetic damage in sperm and disruption of the blood-testis barrier

Respiratory: Pulmonary edema.

Degradation:

Biodegradation: The primary degradation process in soil, where microbes break down MP.

Hydrolysis: Occurs at higher temperatures.

Volatilization: Occurs in surface waters.

Photolysis: Occurs in surface waters, where MP is transformed into methyl paraoxon by oxidation with photochemically produced oxygen radicals.

Adsorption: MP can adsorb to soil and suspended matter, which can affect the degradation process.

Manganese dioxide: MP can be degraded by manganese dioxide (MnO2) in a reaction system with oxalic acid.

Copper(I) oxide nanoparticles: MP can be degraded by an aqueous suspension of copper(I) oxide nanoparticles (NPs).

Ultrasound: MP can be degraded to a limited extent by ultrasound induced cavitation.

Escherichia coli: MP can be degraded by an engineered strain of E. coli.

Toxicity:

Exposure to methyl parathion can cause rapid, fatal organophosphate poisoning. Symptoms include:

- Headache
- Dizziness
- Blurred vision
- Tightness in the chest
- Sweating
- Nausea and vomiting
- Diarrhea
- Muscle twitching
- Convulsions
- Coma

Organ systems: Methyl parathion can affect the cardiovascular, hematopoietic, reproductive, and nervous systems.

Health concerns: Methyl parathion can cause cardiovascular lesions, such as acute myocardial degeneration and vascular degeneration. It can also cause reproductive problems, such as placental morphology, fibrosis and hemorrhage, and inhibition of DNA synthesis in seminiferous tubules.

Regulatory actions: The U.S. government banned the indoor use of methyl parathion in 1998 to protect human health and the environment. The EPA has also restricted how methyl parathion can be used and applied.

Uses:

Parathion is an effective insecticide for a range of insect pests.

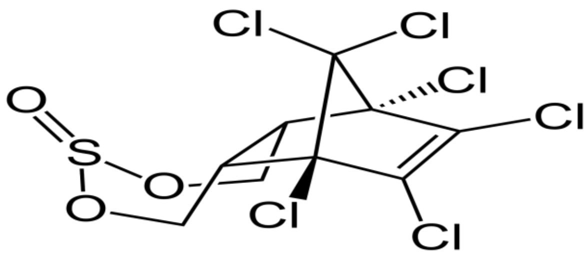
Methyl parathion is a chemical pesticide used to control insects on crops, especially cotton, soybeans, and vegetable,alfalfa, almonds, barley, beans, cabbage, canola, corn, cotton, hops, oats, onions, pecans, potatoes, rice, rye, sugar beets, sunflowers, walnuts, and wheat. Heptachlor

This chlorinated cyclodiene was used to kill soil and eusocial insects from the 1960s to the 1970s. It is toxic and carcinogenic to humans, and was banned in many developed countries in the 1970s.

Endosulfan

This OCP is used to control insects on food crops like fruits, vegetables, grains, and tea, as well as non-food crops like cotton and tobacco. It’s also used as a wood preservative and for public health applications, such as controlling the tsetse fly.

Aldrin: This synthetic OCP was used as a broad-spectrum soil insecticide to protect food crops and as a seed dressing to control pests like termites and ants. The US Environmental Protection Agency (USEPA) canceled all but three uses in 1972, and the manufacturer voluntarily canceled all uses in 1987. Aldrin has not



been imported since 1985 or produced domestically since 1974.

Properties:

Physical:

- Solids which possess low volatility
- Low solubility in water, high solubility in oils, fats,lipids etc., Not prone to environmental degradation.

Chemical:

- Isomerism is a common phenomenon, Ex. Gamma HCH Stable over a wide range of pH

Degradation:

Chemical reactions in air: Both α- and β-endosulfan can break down in the air through chemical reactions.

Sunlight: Endosulfan sulfate can break down in sunlight.

Biodegradation: Endosulfan can be biodegraded by bacteria. The optimal conditions for biodegradation are a pH of 8, a temperature of 30 °C, and an endosulfan concentration of 100 mg/L.

Hydrolysis: Endosulfan can be broken down into endosulfan diol through hydrolysis.

Oxidation: Endosulfan can be broken down into endosulfan sulfate through oxidation.

Toxicity:

Possess a high acute toxicity as well as chronic toxicity.

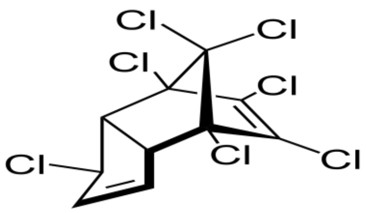
Compound.	LD50 (oral) mg/Kg
HCH.	1000
Dicofol.	684-809
Lindane.	88-91
Endosulfan.	70-110

- Insecticide: Endosulfan is used to control pests on crops, such as aphids, fruit worms, beetles, leafhoppers, moth larvae, and white flies. It can be applied to crops by aerial or ground-level foliar spray.
- Wood preservative: Endosulfan is used to protect wood from decay and insect attack.
- Tsetse fly control: Endosulfan is used to control the tsetse fly.
- Home garden pest control: Endosulfan is used to control pests in home gardens.

Heptachlor:

Heptachlor is an organochlorine cyclodiene insecticide, first isolated from technical chlordane in 1946. During the 1960s and 1970s, it was used primarily by farmers to kill termites, ants, and soil insects in seed grains and on crops, as well as by exterminators and home owners to kill termites.

Structure:



Properties:

Appearance: A white to light tan, waxy solid or powder

Odor: Camphor-like

Combustibility: Noncombustible, but can dissolve in flammable liquids

Solubility: Insoluble in water, but slightly more soluble than heptachlor epoxide

Molecular weight: 373.32

Specific gravity: 1.57 at 9°C

Boiling point: Decomposes at 145°C

Freezing/melting point: 95.5°C for pure heptachlor, 46–74°C for technical heptachlor.

Vapor pressure: 0.0004 mmHg, or 0.0003 mmHg at 25°C

Degradation:

1. **Soil:**

Heptachlor can degrade through volatilization, hydrolysis, epoxidation, and biodegradation:

Volatilization: Heptachlor can volatilize from soil surfaces, especially in moist soils.

Hydrolysis: Heptachlor can undergo hydrolysis in moist soils.

Epoxidation: Heptachlor can undergo epoxidation to produce heptachlor epoxide, which is more persistent.

Biodegradation: Heptachlor can undergo biodegradation by soil microorganisms.

1. **Water:** Heptachlor can degrade through hydrolysis in water, with a half-life of 1–3.5 days.

2. **Fresh water microorganisms:** Fresh water microorganisms can metabolize heptachlor to heptachlor epoxide and 1-hydroxychlordene.

Toxicity:

Toxicity to humans: Heptachlor can cause poisoning symptoms such as headache, dizziness, tremors, and seizures. Exposure to heptachlor can occur through the skin, mouth, or lungs. Children are especially sensitive to heptachlor's toxicity. Exposure during pregnancy or infancy can damage the nervous system and immune system. The EPA has classified heptachlor as a probable human carcinogen.

Toxicity to animals: Heptachlor is highly toxic to fish and freshwater invertebrates, and moderately toxic to mammals. Animals fed heptachlor throughout their lives had more liver tumors than animals that did not eat heptachlor.

Environmental toxicity: Heptachlor can bioaccumulate in fish and freshwater invertebrates.

Uses:

Agricultural use: Heptachlor was used on a wide variety of crops, especially corn, until the 1970s.

Nonagricultural use: Heptachlor was used in homes and gardens, for seed treatment, and to control termites.

Fire ant control: Heptachlor is still used to control fire ants in power transformers.

Cartap hydrochloride:

Cartap hydrochloride (C7H16ClN302S2) is a white crystalline solid with a slight odor and a molecular weight of 273.804

Properties:

Color: Colorless

Odor: Slight

Physical state: Solid

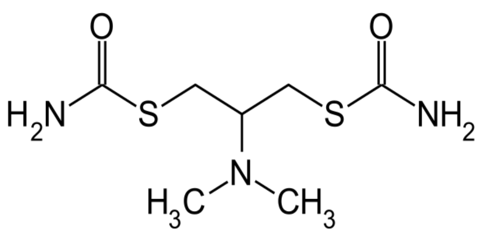
Melting point : 179-181˚C (decomposes)

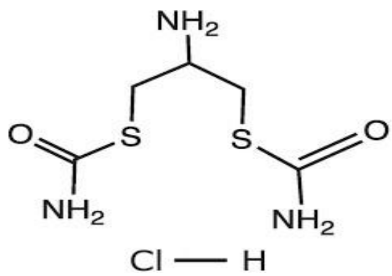
Solubility : About 200g/L in water at 25˚C, very slightly soluble in methanol and ethanol, insoluble in acetone, diethyl ether, ethyl acetate, chloroform, benzene and hexane.

Stability : Stable in acidic conditions, but hydrolyzed in neutral or alkaline medium

Cartap hydrochloride is a pesticide with the chemical name: S, S'- [2- (dimethylamino)- 1, 3- propanediyl] dicarbamothioate hydrochloride

Chemical structure:





Chemical properties:

Color : Colorless crystalline solid

Odor : slight

Melting point : 179- 181˚C with decomposition

Solubility : Approximately 200 grams per liter in water at 25˚C, and very slightly soluble in methanol and ethanol.

Vapor pressure : Negligible.

Stability : Stable, but incompatible with strong oxidizing agents

Synthesis: There are multiple matches for cartap hydrochloride synthesis methods, including a method that uses organic raw materials and a method that uses 1- N,N- dimethyl- 2,3- propylamine dihalide and thiocyanate as raw materials.

Organic raw materials: This method avoids using raw materials like sodium cyanide and sodium thio sulfate, which can create a lot of sewage containing sodium sulfite and sodium cyanide. This method can improve production efficiency and reduce production costs by increasing the reaction processes selectivity and conversion rate.

1-N,N- dimethyl- 2,3- propylamine dihalide and thiocyanate:

This method used 1- N,N- dimethyl- 2,3- propylamine dihalide and thiocyanate as raw materials to produce 2- N, N-dimethyl -1, 3- dithio-cyano propane and 3-N, N- dimethyl-1,2 dithio- cyano propane. The method then separates the mixture to produce 2-N,N-dimethyl-1, 3- dithio–cyano propane with a high content. This method can produce high yields, good product quality and small amounts of waste.

Methomyl:

Type:

It is a classification of carbamate insecticide.

Chemical name:

S-methyl N-methylcarbamoyloxy thioacetimidate.

Molecular formula:

$C_5H_{10}N_2O_2S$

Structure:

Metabolism and degradation of methomyl:

●It can be metabolized by enzymes like methomyl hydrolase, oxamyl hydrolase, and aldicarb hydrolase.

●The metabolic routes for methomyl include hydrolytic and oxidative route.

●The hydrolytic routes produces less toxic product than the parent compound, while the oxidative route produces sulfones via sulfoxide.

●Methomyl is a carbamate pesticide that can degrade in soil, water and sunlight.

Formulation:

●It is a white crystalline solid with a slight sulfurous odor and is highly toxic. Exposure to methomyl can occur through inhalation, ingestion, or contact.

●It is produced by the formal condensation of methylcarbamic acid with the hydroxy group.

●It is a water soluble and has a half life of about six weeks in soil.

Mode of action:

●Methomyl is a carbamate insecticide that works by inhibiting cholinesterase, an enzyme that's essential for the nervous system.

●This can overstimulate the nervous system, leading to symptoms of carbamate poisoning.

●Respiratory depression, Pulmonary edema, Muscle weakness, Dizziness, Sweating, Slight body discomfort, Headache, Salivation, Nausea, and Vomiting.

Toxicity:

Highly to moderately toxic.

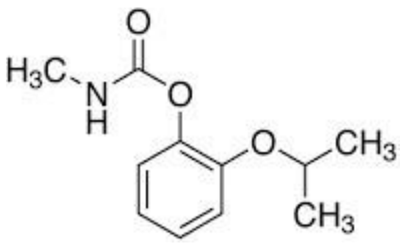
Methomyl is a cholinesterase inhibitor in humans via the oral dermal and inhalation routes of exposure.

Uses:

Insecticide Used in agriculture to control air borne and foliage insect pests on a variety of crops including fields , vegetables orchard crops and tobacco.

Propoxur:

Propoxur is a nonfood carbamate insecticide, marketed under the registered trademark name Baygon. It is. used to control cockroaches, flies, mosquitoes, and lawn and turf insects.



Propoxur has been used in malaria control activities and in flea collars for pets.

Properties:

● Appearance: White to cream-colored crystalline solid or powder

- Molecular weight: 209.2
- Melting point: 86–89°C for technical product, 91.5°C for pure propoxur
- Vapor pressure: 6.5 x 10 mHg at 20°C, 1 x 10 mHg at 12°C
- Specific gravity: D = 1.19
- Solubility: In water of 20°C, approximately 0.2%
- Chemical name: 2-isopropoxyphenyl methylcarbamate
- CAS Number: 114-26-1
- pH range: 4 to 7 (1% in water)

Synthesis:

1. carbonochloridic acid ester method, this method method flow are complicated
2. methylamino formyl chloride method, this method environmental pollution is more serious
3. methyl isocyanate method, though this method method flow is simple, the three wastes are few, reaction yield is generally below 90%.

Degradation:

- Hydrolysis: Propoxur's hydrolysis is dependent on pH and light intensity. For example, in Milli-Q water, the half-life of propoxur decreased from 327 to 161 hours when exposed to sunlight instead of darkness.
- Photocatalytic degradation:The amount of TiO2 loaded on Hβ zeolite affects the degradation of propoxur. Increasing the amount of TiO2 up to 7% increases the degradation, but then decreases as the loading increases.
- Biodegradation:Bacteria like Neisseria subflava and Staphylococcus aureus can biodegrade propoxur.
- Alkaline solution:Propoxur breaks down quickly in alkaline solution.

Toxicity:

Humans: Propoxur can cause severe carbamate poisoning if inhaled, ingested, or comes into contact with the skin or eyes. Symptoms include:

- Headache
- Sweating
- Nausea and vomiting
- Diarrhea
- Muscle twitching
- Loss of coordination
- Death
- Blurred vision
- Tachycardia
- Cholinergic crisis
- Atropine is the recommended antidote

Birds: Propoxur is highly toxic to many birds, including quail, mourning doves, and finches. Symptoms include tearing, salivation, muscle incoordination, diarrhea, and tremors. Death generally occurs rapidly (5–45 min).

Aquatic species: Propoxur is moderately to slightly toxic to aquatic species, such as trout and bluegill.

Honeybees: Propoxur is highly toxic to honeybees.

Formulations:

- Aerosols
- Baits
- Dusts and powders
- Emulsifiable concentrates
- Pet flea collars
- Pest strips
- Ready-to-use solutions

- Shelf paper
- Wettable powders

Uses:

Propoxur is used in and around residences, commercial food handling establishments, and industrial and commercial facilities. It's also used in long-lasting insecticidal nets (LLINs) and in- and outdoor residual spraying (ORS and IRS) programs. Propoxur works by inhibiting acetylcholinesterase (AChE), which causes a cholinergic crisis. Symptoms of a cholinergic crisis include: increased secretions, miosis, nausea and vomiting, bronchoconstriction, and muscle fasciculation. Atropine is the recommended antidote for propoxur poisoning.

UNIT-2

Pesticide residue is any substance that remains on or in food, the environment, or on vector control after pesticides are applied. It can also include derivatives of pesticides, such as conversion products, metabolites, reaction products, and impurities.

Pesticide residues can occur in a variety of ways, including:

Food crops:

Pesticides can be used in many ways during food production, and small amounts can remain on or in food after harvest or processing.

Contaminated soil:

Pesticides that are no longer used can persist in the environment and contaminate soil, which can then lead to pesticide residues in food grown on that soil.

Contaminated water:

Pesticides can also contaminate water, which can lead to pesticide residues in fish that live in that water. Pesticide residues are a concern for food safety, the environment, and the occupational health of field workers. Government organizations monitor and regulate pesticide residues to ensure food safety. Application of agrochemical dissemination pathways of pesticide:

Agrochemicals are chemical products used in agriculture to enhance crop growth, protect plants from pests and diseases, and improve crop yields. They include:

1. Fertilizers: Provide essential nutrients for plant growth.
2. Pesticides: Control pests, diseases, and weeds.
    - Insecticides: Control insects.
    - Herbicides: Control weeds.
    - Fungicides: Control fungal diseases.
    - Rodenticides: Control rodents.
3. Plant growth regulators: Manage plant growth and development.
4. Soil conditioners: Improve soil structure and fertility.
5. Irrigation chemicals: Manage water quality and usage.
6. Post-harvest chemicals: Extend shelf life and maintain quality during storage and transportation.

Agrochemicals can be synthetic or natural, and their use aims to:

- Increase crop yields
- Improve crop quality
- Reduce crop losses
- Enhance food security
- Support sustainable agriculture

However, agrochemicals can also have environmental and health impacts, such as:

- Water pollution
- Soil contamination
- Harm to beneficial organisms
- Human health risks

Responsible use, management, and regulation of agrochemicals are crucial to minimize their negative impacts.

Agrochemicals have various applications in agriculture and beyond:

1. Pest control: Insecticides, herbicides, and fungicides control pests, weeds, and diseases, protecting crops and improving yields.

2. Crop protection: Agrochemicals shield crops from abiotic stresses like drought, heat, and cold.

3. Soil management: Fertilizers and soil conditioners enhance soil fertility and structure.

4. Plant growth regulation: Plant growth regulators (PGRs) manage plant growth, development, and productivity.

5. Post-harvest management: Agrochemicals extend shelf life, prevent spoilage, and maintain quality during storage and transportation.

Key aspects:

- Benzyne intermediate: A highly reactive, short-lived species with a triple bond.
- Nucleophilic attack: Occurs at the benzyne intermediate, not the original aryl halide.
- Stereospecificity: The reaction is stereospecific, with the nucleophile attacking from the opposite side of the leaving group.

This mechanism is important in organic synthesis, allowing for the introduction of various functional groups into aromatic compounds.

Example: Chlorobenzene + NaNH2 → Aniline (via benzyne intermediate)

Note: This is a general mechanism, and specific conditions may vary depending on the reactants and catalysts used.

Causes of pesticide residue:

1. Agricultural Practices:

- Overuse or misuse of pesticides in agriculture, such as excessive application or spraying during inappropriate weather conditions, can lead to residues in the environment.

2. Pesticide Drift:

- Wind can carry sprayed pesticides to non- target areas, including water bodies, residential areas, and other unintended locations, contributing to environmental contamination.

3. Volatilization:

-Some pesticides can vaporize and enter the atmosphere, where they can be transported over long distances before settling in new locations.

4. Improper Disposal:

-Inadequate disposal of pesticide containers, excess pesticides, and contaminated equipment can lead to residues in the soil and water, eventually entering the atmosphere.

5. Persistent Chemicals:

-Some pesticides have long half-lives and can persist in the environment for extended periods, accumulating in soil, water, and air.

Remedies for Pesticide Residues:

1. Integrated Pest Management (IPM):

-Implementing IPM strategies can reduce reliance on chemical pesticides by using biological control, crop rotation, and other non-chemical methods.

2. Bioremediation:

-Utilizing microorganisms, plants, or fungi to break down or absorb pesticide residues in the soil and water.

3. Buffer Zones:

-Establishing buffer zones around agricultural fields to reduce pesticide drift and protect nearby ecosystems.

4. Use of Biopesticides:

-Switching to biopesticides, which are derived from natural sources and typically degrade more quickly in the environment.

5. Improved Application Techniques:

-Employing precision agriculture techniques, such as targeted spraying and the use of drones, to minimize pesticide use and reduce off-target contamination.

Pesticide residue in Atmosphere:

Pesticides are used in agriculture to control pests and increase crop production, but they can enter the environment and become residues in the air, water, and soil. These residues can have serious consequences for human health and the environment.

Entry into Atmosphere:

1. Volatilization from soil and water surfaces
2. Spraying and dusting during agricultural applications
3. Industrial emissions (manufacturing, formulation)
4. Atmospheric deposition (wet and dry)
5. Biomass burning (e.g., crop residues)

Action of Pesticides in Atmosphere:

1. Photolysis: breakdown by sunlight
2. Hydrolysis: reaction with water
3. Oxidation: reaction with atmospheric oxidants
4. Transport: wind-borne movement
5. Deposition: settling on surfaces

Effects on Environment:

Air:

1. Air pollution
2. Human exposure through inhalation
3. Impact on atmospheric chemistry

Water:

1. Contamination of surface and groundwater
2. Impact on aquatic life
3. Bioaccumulation in food chain

Soil:

1. Soil contamination
2. Impact on soil microorganisms
3. Effects on plant growth

Biota:

1. Toxicity to non-target organisms (bees, birds, beneficial insects)
2. Bioaccumulation and biomagnification
3. Disruption of ecosystems

Human Health:

1. Respiratory problems
2. Neurological effects
3. Cancer risk
4. Reproductive issues

Pesticide Residue Fate:

1. Degradation (chemical, biological)
2. Transport (atmospheric, water)
3. Accumulation (soil, biota)
4. Persistence (environmental half-life)

Mitigation Strategies:

1. Integrated Pest Management (IPM)
2. Alternative pest control methods
3. Pesticide formulation improvements
4. Regulatory measures (label restrictions)
5. Public awareness and education
6. Monitoring and analysis

Some key pesticide residues found in the atmosphere include:

1. Organophosphates (e.g., chlorpyrifos, malathion)
2. Pyrethroids (e.g., permethrin, cypermethrin)
3. Herbicides (e.g., glyphosate, atrazine)
4. Insecticides (e.g., neonicotinoids, DDT)

Pesticide residue in Water:

A direct movement of pesticides into groundwater is a common type of point source pollution, in which the pesticides enter the water wells result from pesticide spills and improper disposal of pesticides. Urban use of insecticide is considered as a point source pesticide in surface waters.

Entry into water system:

Pesticide residue in water is a major concern as they create harmful effects in living organisms. Pesticides can enter into water system by several pathways likes.

Agriculture runoff, spillage drifts industrial effluents, washing of spray equipmet, aerial sprays and transport from soils treated with pesticide.

Run off :

Pesticides from agriculture fields, gardens, and urban areas enter waterways through surface runoff.

Leaching:

Pesticides seep into groundwater contamination aquifers and wells.

Atmospheric Deposition:

Pesticides drift, volatilize, or settle on water surfaces.

Wastewater Effluent:

Treated wastewater containing pesticides enters waterways.

Actions:

1. Bioaccumulation: Pesticides accumulate in aquatic organisms, potentially harming humans consuming contaminated fish or shellfish.

2. Biomagnification: Pesticides concentrate up the food chain, amplifying their impact.

3. Alteration of Aquatic Habitats: Pesticides disrupt ecosystems, altering species composition and population dynamics.

4. Water Quality Changes: Pesticides affect water chemistry, potentially harming aquatic life.

Effects on Aquatic Environment:

Water pollution from pesticide residues can have far-reaching effects on the aquatic environment, including:

- Toxicity:Pesticides can harm or kill aquatic organisms, including fish, invertebrates, and algae.
- Bioaccumulation:Pesticides accumulate in aquatic organisms, potentially harming humans consuming contaminated fish or shellfish.
- Biomagnification:Pesticides concentrate up the food chain, amplifying their impact.
- Changes in species composition:Pesticides alter the balance of aquatic ecosystems.
- Disruption of nutrient cycling:Pesticides impact primary production and nutrient availability.
- Alteration of aquatic habitats:Pesticides disrupt ecosystems, leading to changes in population dynamics.
- Human health risks:Consuming contaminated water or aquatic organisms can harm humans.
- Economic impacts:Water pollution can affect fisheries, tourism, and other industries.
- Long-term ecosystem damage:Pesticide residues can persist in aquatic environments, causing prolonged harm water pollution from pesticide residues to protect aquatic ecosystems and human health.

Specific Effect:

- Fish:Bioaccumulation,biomagnification, reproductive issues
- Invertebrates:Toxicity, changes in population dynamics
- Algae:Changes in growth, composition, and primary production
- Microorganisms:Disruption of nutrient cycling, decomposition

Mitigation Strategies:

1. Integrated Pest Management (IPM): Reduce pesticide use through alternative methods
2. Pesticide-Free Zones:Establish buffer zones around waterways.
3. Water Treatment:Improve filtration and treatment systems
4. Monitoring and Regulation: Enhance pesticide residue monitoring

and enforcement

5. Public Education:Raise awareness about pesticide risks and responsible use.

Additional Measures:

Best Management Practices (BMPs) for agricultural runoff

- Pesticide registration and labeling requirements
- Water quality standards and guidelines
- Research and development of alternative pesticides

Pesticide Residue in Soil:

Pesticides and their byproducts can have harmful effects on soil and plants when they penetrate the roots and spread throughout the plant. These effects can include:DNA damage, Oxidative stress, Photosynthetic blockade, Necrosis, Chlorosis, Leaf curl, and Plant death.

Some examples of pesticides that can leave residues in soil include:

- DDT: This chlorine-based pesticide is stable and can accumulate in soil. It can also concentrate in the fatty tissue and internal organs of animals, and move quickly through the food chain, leading to biomagnification.
- Aldrin and dieldrin: These synthetic pesticides are commonly used in agriculture and are classified as persistent organic pollutants (POPs). Residues from these pesticides can contaminate water and crops grown in contaminated soil.
- Organochlorine pesticides: These synthetic chlorinated hydrocarbon derivatives are also POPs, and are highly toxic, persistent, and slow degrading.
- Carbamates: These pesticides are used for agricultural and non-agricultural purposes, and their residues have been found in soil, wastewater, surface water, drinking water, and food products.
- Chlordane: This organochlorine pesticide can leave toxic residues in soil that can harm soil organisms, especially earthworms and

indigenous soil microorganisms.

- Herbicides: These chemicals are designed to kill unwanted plants, and their residues can accumulate in soil.

Entry in soil:

Pesticides enter the soil through a variety of means, including:

- Spraying: Pesticides are sprayed directly onto the soil to control pests.
- Soil treatment: Pesticides are used to treat the soil during cultivation.
- Fumigation: Pesticides are used to fumigate during storage.
- Wind action: Pesticides can be released into the atmosphere and deposited on the soil by wind action.

Pesticides can remain in the soil for years, even after the last application. The amount of pesticide used, how it's used, and the properties of the pesticide itself all affect how much residue builds up.

Pesticides in soil can undergo adsorption, retention, and transport:

- Adsorption: Pesticides bind to soil particles through a physical process called adsorption. The strength of the bond depends on the pesticide’s chemical properties, soil pH, and the soil’s composition. Adsorption can occur because of the attraction between the pesticide and the soil particles, similar to how paper clips stick to a magnet.
- Transport: Pesticides can move through the environment in the form of air, water, or particles. They can reach the atmosphere, streams, or groundwater, and move through the hydrologic system depending on their chemical and physical properties.
- Retention: Soil retention is the process by which soil holds water in place. Cohesion and adhesion are the two main forces that cause water to be retained in soil. Cohesion is the attraction of molecules to each other, while adhesion is the attraction of water molecules to the soil's solid surface.

Toxicity:

- Pesticides can be toxic to microorganisms killing or inhibiting their growth and reproduction.
- pesticides have varying levels of toxicity to different microorganisms.
- Toxicity can depend on factors like pesticide concentration, exposure, duration and microorganism species.

Disruption of nutrient cycles:

- Pesticides can alter nutrient availability for microorganisms impacting their survival and function.
- Reduce nitrogen fixation by certain bacteria.

Inhibit decomposition processes leading to nutrient accumulation .

- Alter carbon cycling affects microbial communities.

Effects of microorganisms:

1. Soil microorganisms:

- Soil microorganisms have the ability to carry biochemical transformations of various elements like nitrogen(N),phosphorus(P),sulfur(S) and carbon(C).
- Pesticides may directly or indirectly affect the vital biochemical reactions such as mineralization of organic matter, nitrogen fixation, denitrification by deactivating specific soil microorganisms and enzymes.

2. Water microorganisms:

- Pesticides can contaminate drinking water supplies by entering surface water and groundwater system through runoff , spills, leaks, improper disposal.

3. Bioaccumulation:

- pesticides can also enter the food chain through a process known as bioaccumulation.
- Humans are the top of the food chain they consume plants and animals that have already accumulated pesticides so their bodies can contain high concentrations of these chemicals.

- Organophophates and carbamates affect the human nervous system.

4. Affects plant cell:

- Pesticide can interfere with photosynthesis process reducing plant growth.
- It can cause genetic mutations or damage DNA leading to changes in plant growth and development.
- Pesticide can distribute plant harmone balance and interfere the cell division process.

Soil condition:

- Soil contamination: Pesticides can persist in soil contaminating it for extended periods.
- Soil pH changes: Pesticides can alter soil pH affecting nutrient availability and microbial activity.
- Reduced soil fertility: Repeated pesticides use can reduce soil fertility requiring additional fertilizers.
- Increased soil salinity: Some pesticides can increase soil salinity affecting plant growth and microbial activity.
- Ecosystem affect: Prolonged pesticide use can lead to long term soil degredation affecting ecosystem services. Ex: carbamate
- Soil structure changes: Pesticides can affect soil structure leading to changes in water infiltration and erosion.
- Microbial community disruption: It can alter soil microbial communities, impacting decomposition, nutrient cycling and soil health.
- Hormonal distruption: some pesticides an interfere with plant harmones affecting plant growth and development.

Fertility:

- Microorganism affect: soil base microorganisms can die consuming these toxic chemicals. Ex: DDT , boric acid ,acephate.
- Nutrient imbalance: Pesticides can alter soil nutrient availability leading to deficiencies. Ex: carbamate, urea ,malathion…

- Soil structure changes: Pesticides can affect soil structure, impacting water infiltration and root growth. Ex:Triazine, Organophosphate….
- nitrogen fixation Reduced: Pesticides can inhibit nitrogen fixing bacteria reducing soil nitrogen availability.
- Long term soil degradation: Prolonged pesticide use can lead to long term soil degradation reducing fertility.

Decomposition:

Pesticide decomposition is the process by which pesticides transform into benign substances that are environmentally compatible with their application sites.

Persistence:

- Pesticides are designed not to persist significantly beyond their intended use period.
- Soil half-lives typically range from days to weeks.
- However, pesticide residues are still found ubiquitously in the environment, even in groundwater and potable water.
- About half of the detected substances are no longer in use, and some are stable transformation products.

Degradation Mechanisms:

- Biotic Transformation: Microorganisms mediate this process.
- Abiotic Transformation: Involves chemical and photochemical reactions. Environmental Conditions: Redox gradients, sunlight availability, and atmospheric photo transformation influence degradation.

Degradation:

Pesticides, widely used to control crop diseases and pests, unfortunately leave behind residues that can harm both human health and the environment. Understanding how these residues break down is crucial for environmental restoration.

Microbial Degradation:

- Microorganisms play a vital role in breaking down pesticide residues. Bacteria, fungi, actinomycetes, and viruses are key players.

- The structure of the pesticide influences its degradation. Microbes target various classes, including organochlorines, organophosphates, and carbamates.
- Biodegradation by microorganisms effectively removes pesticides from soil and water environments.

Factors Affecting Pesticide Degradation: Internal Factors:

- Pesticide Structure: Complex structures may hinder degradation.
- Intermediate Metabolites: During degradation, some pesticides produce, intermediate compounds (e.g., 3-phenoxy benzoic acid).

External Environmental Factors:

- Climate: Temperature, humidity, and sunlight impact degradation rates.
- Soil Properties: Soil type, pH, and organic matter affect microbial activity. Water Availability: Adequate moisture supports microbial degradation.
- Oxygen Levels: Aerobic conditions enhance microbial activity.
- Presence of Co-substrates: Some compounds aid degradation.
- Competition: Microbes compete for resources, affecting degradation efficiency.

Degradation Mechanisms:

- Biotic Transformation: Mediated by microorganisms.
- Abiotic Transformation: Involves chemical and photochemical reactions. Overall Degradation: A combination of microbial, chemical, and physical processes.

Effect of pesticide residue on human:

Pesticide residues can have significant effects on human health, particularly when exposure occurs over a long period or at high levels.Here's an overview of the potential impacts:

1. Acute Health Effects:

- Poisoning: High levels of pesticide exposure, typically from accidental ingestion, inhalation, or skin contact, can lead to acute poisoning. Symptoms may include nausea, vomiting, dizziness, headaches, respiratory difficulties, and in severe cases, seizures or death.

- Allergic Reactions: Some individuals may experience allergic reactions, such as skin rashes, eye irritation, or respiratory problems, upon exposure to certain pesticides.

2. Chronic Health Effects:

- Cancer: Prolonged exposure to certain pesticides has been linked to an increased risk of various cancers, including non- Hodgkin lymphoma, leukemia, prostate cancer, and breast cancer. Chemicals like organochlorines (e.g., DDT) and organophosphates are of particular concern.
- Neurological Effects: Long-term exposure to pesticides, especially those affecting the nervous system (like organophosphates and carbamates), can lead to neurological problems. This includes memory loss, cognitive decline, Parkinson's disease, and other neurodegenerative conditions.
- Reproductive and Developmental Toxicity: Pesticide exposure has been linked to reproductive issues such as reduced fertility, birth defects, and developmental delays in children. Pregnant women and children are particularly vulnerable to the effects of pesticide residues.

2. Impact on Vulnerable Populations:

- Children: Children are more susceptible to the harmful effects of pesticides due to their developing bodies and behaviors, such as hand-to-mouth activities. Pesticide exposure in early life is associated with developmental issues, learning disabilities, and behavioral problems.
- Pregnant Women: Pesticides can cross the placenta and affect the developing fetus, leading to potential birth defects, low birth weight, and other developmental issues.
- Elderly: Older adults may be more vulnerable to the effects of

pesticides due to weakened immune systems and pre-existing health conditions.

Effects of pesticide residue on birds:

Pesticide residues can have serious and often detrimental effects on bird populations. Here's an overview of the potential impacts:

1. Acute Toxicity:

- Direct Poisoning: Birds can suffer from acute poisoning when they ingest pesticide laden food, drink contaminated water, or encounter pesticide-treated surfaces. This can lead to rapid onset of symptoms such as convulsions, paralysis, respiratory distress, and often death.
- Secondary Poisoning: Birds that are predators or scavengers can be poisoned by consuming prey that has ingested pesticides. For example, a bird of prey might eat a rodent that has consumed pesticide-laced bait, leading to secondary poisoning.

2. Reproductive Issues:

- Eggshell Thinning: Certain pesticides, particularly organochlorines like DDT, cause eggshell thinning in birds. This makes eggs more likely to break before hatching, leading to a decline in bird populations. This phenomenon was famously observed in birds of prey such as eagles, falcons, and ospreys.
- Reduced Fertility: Pesticide exposure can reduce fertility in birds, affecting their ability to reproduce. This can manifest as fewer eggs laid, lower hatchability, or the production of infertile eggs.
- Embryonic Development: Pesticides can disrupt the normal development of bird embryos, leading to birth defects, developmental abnormalities, or the death of the embryo before hatching.

3. Behavioral Changes:

- Altered Feeding Behavior: Pesticides can affect the nervous system of birds, leading to disorientation, lack of coordination, and altered feeding behaviors. This can impair a bird's ability to forage for food, leading to starvation.

- Disrupted Mating Rituals: Behavioral changes due to pesticide exposure can interfere with mating rituals, which are often complex in birds. This can reduce successful mating and ultimately impact population levels.
- Nesting Behavior: Pesticides may cause changes in nesting behavior, such as abandonment of nests or reduced care for offspring, which can decrease chick survival rates.

Effects of pesticide residue on animals:

Pesticide residues can have a range of harmful effects on animals, depending on the type of pesticide, the level of exposure, and the species affected. These effects can be direct, such as poisoning, or indirect, through impacts on ecosystems and food sources. Here's an overview of the potential impacts:

1. Acute Toxicity:

-Direct Poisoning: Animals, particularly mammals, reptiles, amphibians, and aquatic species, can suffer acute poisoning after direct exposure to pesticides. This can happen through ingestion of contaminated food or water, inhalation of pesticide sprays, or skin contact with pesticide-treated surfaces. Symptoms of acute poisoning may include vomiting, diarrhea, seizures, respiratory distress, and in severe cases, death.

-Secondary Poisoning: Predatory and scavenging animals are at risk of secondary poisoning when they consume prey that has been exposed to or killed by pesticides. For example, a predator might eat a rodent that has ingested rodenticide, leading to the predator's poisoning.

2. Chronic Health Effects:

- Cancer: Long-term exposure to certain pesticides can increase the risk of cancer in animals. For example, herbivores grazing on pesticide-treated plants may ingest carcinogenic residues over time, leading to an increased incidence of tumors.
- Endocrine Disruption: Some pesticides are known to disrupt

endocrine systems, leading to hormonal imbalances in animals. This can result in reproductive issues, developmental abnormalities, and other chronic health problems.

- Neurological Damage: Pesticides that affect the nervous system, such as organophosphates, can cause long-term neurological damage in animals, including cognitive impairment, loss of motor control, and behavioral changes.

3. Reproductive and Developmental Effects:

- Infertility: Pesticides can affect the reproductive systems of animals, leading to reduced fertility, fewer offspring, or birth defects. This can have significant impacts on animal populations, particularly for species with low reproductive rates.
- Developmental Abnormalities: Pesticides can interfere with the normal development of embryos and young animals, leading to birth defects, delayed growth, and other developmental issues. These effects can be particularly severe in species with sensitive developmental stages, such as amphibians and reptiles.

1. Behavioral Changes:

- Altered Feeding Behavior: Pesticides can affect the central nervous system of animals, leading to changes in feeding behavior. For example, animals may become disoriented or lose their appetite, which can lead to malnutrition or starvation.
- Disrupted Mating Rituals: Behavioral changes caused by pesticide exposure can interfere with the mating rituals of animals, reducing successful reproduction and affecting population dynamics.

Routes of Exposure to Pesticides:

Pesticides can enter living organisms through various routes, each with its own set of risks and implications. The major routes of exposure include:

a. Dermal Exposure

The skin is the most common route of pesticide exposure, especially for individuals who handle these chemicals directly, such as farmers, pesticide applicators, and industrial workers. Pesticides can be absorbed through the skin when they come into contact with contaminated surfaces, clothing, or directly during the mixing, loading, and application processes. The extent of dermal absorption depends on the chemical properties of the pesticide, the concentration, the duration of exposure, and the condition of the skin.

b. Inhalation Exposure

Inhalation of pesticide vapors, aerosols, or dust particles can occur during the application of sprays, fumigants, or powders. This route of exposure is particularly concerning in enclosed spaces or when protective equipment is not used. Inhalation can lead to the rapid absorption of pesticides into the bloodstream through the lungs, potentially causing immediate or long-term respiratory and systemic effects.

c. Oral Exposure

Oral exposure to pesticides can occur through the ingestion of contaminated food,water, or soil. This route is particularly relevant for the general population, including children who might accidentally ingest pesticides or pesticide residues. Oral exposure is also a risk for agricultural workers who eat or drink without properly washing their hands after handling pesticides. Once ingested, pesticides can be absorbed through the gastrointestinal tract, leading to various toxic effects depending on the dose and the type of pesticide.

d. Ocular Exposure

Although less common, ocular exposure can occur when pesticides come into contact with the eyes, either through direct splashing or from airborne particles. This route of exposure can lead to irritation, inflammation, or more severe damage to the eyes and surrounding tissues, depending on the toxicity of the pesticide.

Action of Pesticides on Living Systems:

The impact of pesticides on living systems varies depending on the chemical nature of the pesticide, the organism being targeted, and the level of exposure. The actions of pesticides can be categorized based on their mode of action:

a. Neurotoxic Effects

Many pesticides, particularly organophosphates, carbamates, and pyrethroids, act on the nervous system of pests. These chemicals interfere with the normal functioning of neurotransmitters, leading to overstimulation of nerve cells, paralysis, and eventually, death. However, these neurotoxic effects are not exclusive to pests; they can also affect non-target organisms, including humans, leading to symptoms such as headaches, dizziness, respiratory distress, and in severe cases, neurological damage.

b. Endocrine Disruption

Some pesticides, like certain insecticides and herbicides, are known to interfere with the endocrine system, which regulates hormones in living organisms. These endocrine disruptors can mimic or block hormones, leading to developmental, reproductive, and immune system problems. For instance, exposure to endocrine-disrupting pesticides has been linked to birth defects, infertility, and increased cancer risk in both humans and wildlife.

c. Cytotoxic Effects

Pesticides can also exert cytotoxic effects, causing direct damage to cells by disrupting cellular membranes, inhibiting vital enzymes, or inducing oxidative stress. This can lead to cell death, tissue damage, and long-term health issues such as cancer. For example, herbicides like glyphosate are believed to induce oxidative stress in cells, contributing to chronic diseases.

d. Carcinogenic and Mutagenic Effects

Certain pesticides have been classified as carcinogens or mutagens, meaning they have the potential to cause cancer or genetic mutations. Prolonged exposure to these chemicals, even at low levels, can increase the risk of developing cancer, particularly in organs that metabolize or store the chemicals, such as the liver or kidneys. The mutagenic effects of some pesticides can also lead to genetic mutations that may be passed onto future generations.

Impact of Pesticides on Non-Target Species;

While pesticides are designed to target specific pests, their effects often extend to non-target species, including beneficial insects, birds, aquatic organisms, and mammals. The impact on non-target species can disrupt ecosystems, reduce biodiversity, and lead to unintended consequences such as pest resistance. For example, the widespread use of neonicotinoid pesticides has been linked to the decline in bee populations, which are essential for pollination and the health of many ecosystems.

Analysis of pesticide residue:

pesticide residue analysis is specialized field of analytical chemistry that involves identifying and measuring the amount of pesticide residue in food products. This process usually involves:

1. Extraction: Extracting the residues from the sample into acetonitrile, and then partitioning them into petroleum ether
2. Clean-up: Removing other components using florisil or alumina columns.
3. Analysis: Using analytical procedures to identify and measure the pesticide residue.these procedures may include

- Gas chromatography: mass spectroscopy (GC-MS): used for volatile compounds in complex samples
- Liquid chromatography: mass spectrometry (LC-MS): used for non-volatile compounds, such as thermally unstable molecules.
- MS/MS mode: can improve detectability and specificity but requires careful optimization of parameters for all analytes. pesticide residue analysis helps food manufactures and procedures ensure the safety of their products. For example, one study found that 53% of randomly collected food samples were residue-free, 45% contained residues below or equal to permitted levels, and 2% contained residues above the legal limit.

Sample preparation:

- Soil:

1. Collection: soil samples are taken before soil preparation and fertilization. The goal is to collect samples that represent the crop's nutrient status, or the problem being diagnosed.
2. Sieving: a 6 mm sieve or garden soil sieve can help homogenize the soil and remove stones and plant debris without damaging the sample. Gently rub handfuls of soil through the screen.
3. Mixing: place the dried, sieved sample on cloth and roll it to thoroughly mix it. Hold the cloth's four corners, then alternate between lifting one corner up and lowering the other corner down across the sample. Repeat the process in the opposite direction to roll soil from one corner to another.
4. Storing: store the soil in a paper carton or soil sample box with a polythene bag lining. label the carton with the cultivator's name, plot number, sampling date, and initials.
5. Air-drying: air -drying is a common way to preserve soil samples for days or decades without needing a constant energy supply to prevent evaporation. If the samples are intended for micronutrient analysis, it's important to avoid contaminating them with iron, zinc and copper. to do this, avoid brass sieves and use stainless steel or polythene materials for collection, processing, and storage.

- Water:

1) Wash your hands
2) Choose a container: use a clean, sterile glass or plastic bottle. If the water is chlorinated, add sodium thiosulfate to the bottle to stop the disinfectant from working.
3) Collect the sample: if you're collecting a sample from a faucet, don't run the water before you start. remove the bottle cap, place the bottle under the faucet, and collect the first water that comes out in the morning. fill the bottle to just below the shoulder. If you're collecting a sample from a water course or reservoir, you can submerge the bottle about 30 centimeters below the surface,

with the mouth facing slightly upward. if there’s a current, you can face the bottle’s mouth toward the current.

4) Note the time: immediately after filling the bottle, write down any relevant information about the water.
5) Refrigerate: if you’re not ready to send the sample to a lab right away, you can reirrigate it.
6) Document the chain of custody: this documentation tracks who has handled the sample, from the time it was collected until it’s. Analyzed, reported on, and disposed of. It’s especially important if the sample will be used in legal proceedings, or if you think it might be tempered with.

- Fruits:

1. Selection of fruits: choose a representative sample of fruits, such as apples, bananas, grapes, or any other fruit of interest
2. Washing: rinse the fruits with distilled water to remove any surface dirt or contaminants.
3. Peeling (optional): if necessary, peel the fruits to analyse the pulp or flesh separately.
4. Chopping: cut the fruits into small pieces or chop them into a uniform size to ensure representative sampling.
5. Homogenization: blend the chopped fruits into a homogenous mixture using a blender or food processor.
6. Extraction: extract the pesticide residues from the fruit mixture using a suitable solvent, such as acetonitrile or ethyl acetate.
7. Filtration: filter the extract to remove any solid particles or impurities.
8. Concentration: concentrate the extract using techniques like rotary evaporation or nitrogen blowdown.
9. Cleanup: perform clean up procedures, such as solid -phase extraction (SPE) or gel permeation chromatography (GPC), to remove co-extractives and interfering compounds.
10. Analysis: analyze the prepared sample using techniques like

gas chromatography – tandem mass spectrometry (LC-MS/MS) to detect and quantify pesticide residues.

- Vegetables:

Sample preparation can involve treating vegetables to make them ready for analysis by analytical equipment. for example, you can prepare vegetables for analysis by blanching them

1. Blanch: plunge vegetables into boiling water for 1-3 minutes.
2. Stop the cooking process: quickly transfer the vegetables to ice water to stop the cooking process. Blanching inactivates enzymes that can cause discoloration and off-flavors and aromas. It also reduces the number of microorganisms and makes vegetables limp, which makes them easier to pack into containers.

Extraction of pesticide residue:

- Soil extraction:

- Sample preparation: Soil samples are usually air-dried, ground, and sieved to obtain a uniform particle size.
- Extraction techniques:
- Solid-liquid extraction (SLE): involves mixing the soil with an appropriate solvent (like acetone, acetonitrile, or methanol) and agitating it to extract pesticides.
- Soxhlet extraction: a continuous extraction process using an organic solvent that is boiled, condensed, and then passed through the soil.
- Accelerated solvent extraction (ASE): Ases high temperature and pressure to improve extraction efficiency with solvents.

- Water extraction:

- Sample collection: Water samples are typically filtered to remove particulate matter before extraction.
- Extraction techniques:
- Liquid-liquid extraction (LLE): the water sample is mixed with an immiscible organic solvent, and the pesticides partition into the solvent.

- Solid-phase extraction (SPE): involves passing the water sample through a column containing a sorbent material that traps pesticides, followed by elution with a solvent.

-Solid-phase microextraction (SPME): a fiber coated with an extracting phase is exposed to the water sample, absorbing the pesticides directly from the water.

- Extraction of vegetables and fruits:

- Sample preparation: the sample is homogenized, often using a blender or food processor, to create a uniform matrix.
- Extraction techniques:
- Quenchers method (quick, easy, cheap, effective, rugged, and safe): a popular method involving extraction with acetonitrile, followed by a salting-out step and cleanup with dispersive SPE.
- Blender extraction: the sample is blended with an organic solvent, such as acetone or acetonitrile, to extract pesticides.
- soxhlet or ASE: similar to soil extraction but applied to the homogenized fruit or vegetable sample.

Simple methods for analysis:

Some methods used to analyze pesticides:

1. Gas chromatography (GC):

- A widely used technique that can separate pesticides well and quickly. GC can be used with various detectors, including halogen specific detector (XSD), flame photometric detector (FPD), and mass selective detector (MSD)

2. Liquid chromatography:

- Can be used to separate pesticides from mixtures
- LC can also be coupled with mass spectrometry (MS) to identify specific pesticides.

3. Gas chromatography–mass spectrometry (GC–MS):

- A common method for analyzing pesticide residues, especially volatile compounds in complex samples.
- GC–MS has become more widely available in recent years due to

inexpensive bench-top instruments.

1. Liquid chromatography–mass spectrometry (LC–MS):

- used to analyze non-volatile compounds, such as thermally unstable molecules.

Other methods used to analyze pesticides include:

- Electrochemical techniques, Spectrophotometric techniques, Chemiluminescence and fluorescence methods, and Biochemical assays

Schemes of analysis :

schemes of analysis used in pesticide chemistry:

1. Gas chromatography-mass spectrometry coupled (GC-MS):

- Used to analyze volatile compounds in complex samples

2. Liquid chromatography-mass spectrometry coupled (LC-MS):

- Used to analyze non-volatile compounds, like thermally unstable molecules.

3. GC-halogen specific detector (XSD):

- Used for pesticide analysis.

4. GC-flame photometric detector (FPD):

- Used for pesticide analysis.

5. GC-mass selective detector (MSD):

- Used for pesticide analysis.

6. GC-mass spectrometer (MS) ion trap:

- Used for pesticide analysis.

7. LC-tandem mass spectrometer (MS-MS):

- Used for pesticide analysis.

Multi residue analysis:

Multi-residue analysis (MRA) is a method that can be used to determine the levels of pesticides in foods, agricultural commodities, and other samples.

- MRA can be used to assess health risks and can be applied to a variety of substances, including:

- Benzene, toluene, ethyl benzene, and xylenes (BTEX)
- Other volatile organic chemicals (VOCs)
- Nonsteroidal anti-inflammatory drugs
- Pesticides

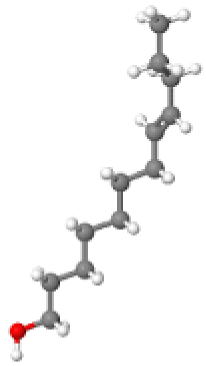
MRA involves validated methods, such as sampling, storage and transport, and processing and analysis. The analysis process may include:

1. Sample preparation: For example, Quenchers can be used to extract pesticides from soil samples.
2. Sample cleanup: Dispersive solid-phase extraction can be used to clean the extract.
3. Analysis: The extract can be analyzed using liquid chromatography coupled to tandem mass spectrometry (LC-ESI-MS/MS), capillary gas chromatography time of flight mass spectrometry (GC/TOFMS), or gas chromatography tandem mass spectrometry (GC/MSMS).
4. Identification, confirmation, and quantification: These steps can be performed using both technologies, and sample extracts can be compared against a matrix-matched standard.
5. MRA can be used to study pesticide dissipation rates and pre-harvest intervals in crops, or to analyze pesticide residues in animal-origin foods like chicken muscle

UNIT-3

8-Dodecen-1-ol:

8-Dodecen-1-ol is a chemical compound with the molecular formula $C_{12}H_{24}O$. It is a member of the dodecanol family, which are a type of organic compound known as fatty alcohols.



Introduction:

- Chemical name: 8-Dodecen-1-ol
- Molecular formula: C12H24O
- Molecular weight: 184.32 g/mol
- CAS number: 3391-86-4
- Appearance: Colorless to pale yellow liquid
- Odor: Mild, pleasant
- Boiling point: 248-250°C (478-482°F)
- Solubility: Soluble in alcohol, ether, and other organic solvents; insoluble in water

Types:

8-Dodecen-1-ol can be classified into various types based on their structural characteristics, production methods, and applications.

Here are some types of 8-Dodecen-1-ol:

- Cis-8-dodecen-1-ol has a cis configuration, meaning the double bond between the 8th and 9th carbon atoms is on the same side.
- Trans-8-dodecen-1-ol has a trans configuration, meaning the double bond between the 8th and 9th carbon atoms is on opposite sides.
- Natural 8-dodecen-1-ol derived from natural sources, such as plants or animals.
- Synthetic 8-dodecen-1-ol produced through chemical synthesis.
- Racemic 8-dodecen-1-ol a mixture of equal parts cis and trans isomers.

- Enantiomerically pure 8-dodecen-1-ol contains only one enantiomer (either cis or trans).
- Stabilized 8-dodecen-1-ol may contain additives or stabilizers to enhance shelf life or performance.
- Pharmaceutical grade 8-dodecen-1-ol meets pharmaceutical standards for purity and quality.
- Cosmetic grade 8-dodecen-1-ol suitable for use in personal care products.
- Industrial grade 8-dodecen-1-ol used in various industrial applications.

Please note that these types might not be mutually exclusive, and some 8-Dodecen-1-ol products may overlap between categories.

Applications:

8-Dodecen-1-ol has a wide range of applications due to its unique chemical properties. Here are some of the most common applications:

- Fragrances: Used in perfumes, colognes, and other scented products due to its pleasant odor.
- Flavorings: Used as a flavoring agent in food and beverages, especially in citrus and fruit flavors.
- Cosmetics: Used in skincare products, such as creams, lotions, and shampoos, due to its moisturizing and emollient properties.
- Pharmaceuticals: Used as an intermediate in the synthesis of various pharmaceuticals.
- Agricultural chemicals: Used in the production of pesticides, herbicides, and fungicides.
- Lubricants: Used as a lubricant in various industrial applications due to its high viscosity index.
- Solvents: Used as a solvent in paints, coatings, and other industrial applications.
- Polymers: Used as a monomer in the production of various polymers.

- Surfactants: Used as a surfactant in detergents, emulsifiers, and wetting agents.
- Biodegradable products: Used in the production of biodegradable plastics, lubricants, and other products.
- Personal care products: Used in soaps, lotions, creams, and other personal care products.
- Textile finishing: Used in textile finishing applications, such as fabric softeners and wrinkle resistors.
- Leather processing: Used in leather processing applications, such as leather softeners and conditioners.
- Paper processing: Used in paper processing applications, such as paper coatings and sizing agents.

10-cis-12-hexadecadienoic:

10-cis-12-hexadecadienoic acid is a type of fatty acid that belongs to the family of unsaturated fatty acids.

Introduction:

- Chemical name: 10-cis-12-hexadecadienoic acid
- Molecular formula: $C_{16}H_{28}O_2$
- Molecular weight: 240.40 g/mol
- Chemical structure: $CH_3(CH_2)_4CH=CHCH_2CH=CH(CH_2)_7COOH$
- Physical state: Liquid at room temperature
- Color: Colorless to pale yellow
- Odor: Mild, pleasant
- Solubility: Soluble in organic solvents, insoluble in water. This compound is a cis-unsaturated fatty acid, meaning that it has two double bonds in the cis configuration. The double bonds are located at the 10th and 12th carbon atoms in the chain. 10-cis-12-hexadecadienoic acid is found in various natural sources, including:
- Vegetable oils (e.g., soybean oil, canola oil)

- Animal fats (e.g., pork fat, beef tallow)
- Fatty fish (e.g., salmon, tuna) Types:
- Cis-10, cis-12-hexadecadienoic acid: This is the most common form, where both double bonds are in the cis configuration.
- Trans-10, cis-12-hexadecadienoic acid: This form has one trans and one cis double bond.
- Cis-10, trans-12-hexadecadienoic acid: This form has one cis and one trans double bond.
- Trans-10, trans-12-hexadecadienoic acid: This form has both double bonds in the trans configuration.
- Conjugated 10-cis-12-hexadecadienoic acid: This form has conjugated double bonds, which means that they are alternating between cis and trans configurations. Non-conjugated 10-cis-12-hexadecadienoic acid: This form has
- Non-conjugated double bonds, which means that they are not alternating between cis and trans configurations.

Racemic mixture: A mixture of both cis and trans isomers.

Enantiomerically pure: A single enantiomer (either cis or trans) in high purity.

Applications:

- Biofuel production: As a feedstock for biodiesel production due to its high energy content and renewability.
- Cosmetics: In skincare products and cosmetics due to its moisturizing and emollient properties.
- Food industry: As a food additive, flavoring agent, or nutritional supplement.
- Pharmaceuticals: As a building block for drug synthesis or as an active pharmaceutical ingredient.
- Polymer synthesis: As a monomer for producing biodegradable polymers.
- Lubricants: As a biodegradable lubricant base stock.
- Coatings: In paint, coatings, and adhesives due to its adhesive and

binding properties.

- Agricultural chemicals: As a component in pesticides, herbicides, or fungicides.
- Bioplastics: As a renewable resource for producing biodegradable plastics.
- Research and development: In various scientific studies and research applications.

Trimedlure (TML) :

Trimedlure (TML) is a synthetic chemical attractant primarily used in agricultural pest control, particularly for monitoring and managing populations of Mediterranean fruit flies (Ceratitis capitata).Trimedlure mimics the natural pheromones emitted by female fruit flies, attracting males and thereby allowing for population monitoring and control strategies.

Introduction:

Trimedlure is a synthetic pheromone, specifically a sex attractant, used to manage Mediterranean fruit fly (Ceratitis capitata) populations.

- Chemical Structure:Trimedlure's chemical structure is 10-cis-12-hexadecadienoic acid.
- Color and State:Colorless liquid
- Solubility:Insoluble in water, soluble in organic solvents
- Boiling point: 180-200°C
- Melting point: 30-40°C

Types:

- Trimedlure-A (TML-A.
- Trimedlure-C (TML-C.
- Controlled-Release Formulations.
- Advanced Isomeric Formulations.
- Trimedlure-A (TML-A): The original formulation, which is a racemic mixture of several stereoisomers. It has been widely used due to its effectiveness in attracting male Mediterranean fruit flies.

- Trimedlure-C (TML-C): A modified formulation designed to increase the efficiency of the lure. It generally contains a higher concentration of the more active isomers, leading to better attraction and lower application rates.
- Controlled-Release Formulations: These formulations are designed to release the active ingredients over a longer period. This can include gels, solid matrices, or impregnated fibers, which reduce the need for frequent reapplication.
- Advanced Isomeric Formulations: These are more refined versions of Trimedlure that focus on using the most effective stereoisomer (or a combination) for better performance and environmental impact.

Applications:

- Pest Monitoring: Trimedlure is most commonly used in traps to monitor Mediterranean fruit fly populations. By attracting and capturing male flies, farmers and pest control authorities can assess the population levels and identify areas of infestation.
- Mass Trapping: In some cases, Trimedlure is used in mass trapping strategies, where a large number of traps are deployed to significantly reduce the male fly population, thereby decreasing the chances of mating and reducing the overall population.
- Sterile Insect Technique (SIT): Trimedlure is often used alongside SIT programs. In SIT, sterile male flies are released into the environment to mate with wild females, leading to a decrease in the population. Trimedlure helps in assessing the success of these programs by monitoring the remaining male population.
- Eradication Programs: In regions where Mediterranean fruit fly infestations are severe, Trimedlure is used in eradication programs. It helps in detecting residual populations after large-scale control measures, ensuring that no breeding populations remain.
- Border and Quarantine Monitoring: Trimedlure is used in traps at borders and quarantine areas to prevent the introduction of

Mediterranean fruit flies into non-infested regions. This application is crucial for maintaining pest-free zones, especially in areas where the agricultural industry is vital.

Cue-lure:

Cue-lure is a chemical attractant commonly used in the monitoring and management of fruit fly populations, particularly in agricultural settings. It is a synthetic compound that mimics the natural attractants produced by certain fruits and flowers, specifically targeting male fruit flies of certain species, such as the Queensland fruit fly (Bactrocera tryoni) and other Bactrocera species.

Introduction:

Cue-lure is a synthetic pheromone, specifically a male sex attractant, used to manage various fruit fly species.

- Chemical Structure: Cue-lure's chemical structure is 4-(p-acetoxyphenyl)-2-butanone.
- State and Color: Colorless liquid
- Solubility: Insoluble in water, soluble in organic solvents
- Boiling point: 140-150°C
- Melting point: 20-30°C

Types:

Cue-lure itself refers to a specific type of chemical compound used as an attractant, but it can come in different forms or variations depending on how it's formulated or used. Here are the main types or forms of cue-lure that you might encounter:

- Pure Cue-Lure (Liquid Form):

- This is the pure chemical attractant, often available in liquid form. It can be directly applied to traps or other substrates.
- It may require mixing with a solvent or carrier substance before use.

- Impregnated Mat or Plug:

- In this form, cue-lure is impregnated into a solid material, such as a mat, plug, or block, which gradually releases the attractant over time.

- This form is convenient for long-term monitoring as it provides a steady release of the lure over several weeks or months.

● Cue-Lure Plus Insecticide:

- This is a combination product where cue- lure is mixed with an insecticide. When male fruit flies are attracted to the lure, they meet the insecticide and are killed.
- This type is particularly useful for mass trapping or in "male annihilation technique" (MAT) strategies.

Application:

Cue-lure is widely used in agricultural and horticultural settings to manage and monitor fruit fly populations. Here are the primary applications of cue-lure:

● Monitoring Fruit Fly Populations:

-Surveillance Traps: Cue-lure is used in traps to monitor the presence and population density of fruit flies, particularly Bactrocera species. Farmers and pest control professionals use these traps to detect early infestations, allowing for timely interventions.

-Surveying New Areas: In regions where fruit flies are not yet established,

cue-lure traps help in detecting any new incursions. This is crucial for preventing the spread of fruit flies to new areas.

● Mass Trapping:

-Male Annihilation Technique (MAT): Cue- lure is used in conjunction with an insecticide to attract and kill male fruit flies. This method significantly reduces the male population, leading to a decrease in reproduction rates and overall population control.

-High-Density Trapping: In areas with heavy fruit fly infestations, large numbers of traps baited with cue-lure are deployed to capture as many male flies as possible,helping to manage the pest population.

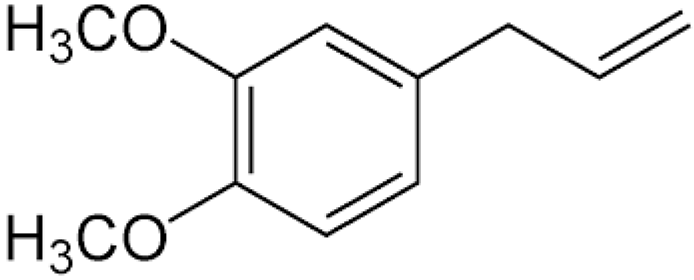
- Integrated Pest Management (IPM)

- Pest Control Strategy: Cue-lure is an integral part of IPM programs, where it is used alongside other methods such as biological control, cultural practices, and selective use of insecticides. This holistic approach reduces reliance on chemical insecticides and promotes sustainable pest management.

-Area-Wide Management Programs: In large-scale pest management programs, cue-lure is used to control fruit fly populations across wide areas, often as part of coordinated efforts between multiple farms or regions.

Methyleugenol:

Methyl eugenol is a naturally occurring organic compound found in various essential oils, such as those extracted from basil, clove, and nutmeg. It is a type of phenylpropene with the chemical formula $C_{10}H_{12}O_2$. Known for its sweet, spicy, and clove-like aroma, methyl eugenol plays a significant role in the fragrance and flavor industries. Additionally, it has applications in agriculture, particularly in pest control, and is studied for its potential therapeutic properties. However, due to safety concerns, its use is regulated in food, cosmetics, and pharmaceuticals.



Introduction:

Methyl eugenol is a synthetic pheromone, specifically a male attractant, used to manage various fruit fly species.

- Chemical Structure: Methyl eugenol's chemical structure is 4-allyl-1-methoxy-3-prop-2-enyl benzene.
- Color and State: Colorless liquid
- Solubility: Insoluble in water, soluble in organic solvents

- Boiling point: 255-260°C
- Melting point: 10-15°C

Types:

Methyl eugenol generally comes in two main forms based on its origin and production method:

- Natural Methyl Eugenol: This form is extracted from essential oils found in plants such as basil,clove, nutmeg, and bay. It is used in natural product formulations for fragrances, flavorings, and some other applications
- Synthetic Methyl Eugenol: This is produced through chemical synthesis, which allows for a controlled and consistent concentration of the compound. Synthetic methyl eugenol is used in industrial applications where specific quantities and purity are required, such as in perfumes, flavorings, and agricultural pest control products.

Applications:

Methyl eugenol is used in various fields due to its distinctive aroma and properties. Here are its primary applications:

- Fragrance Industry: It is used in perfumes, colognes, and other scented products to provide a sweet, spicy, and clove-like aroma.
- Flavor Industry: Methyl eugenol is employed as a flavoring agent in foods and beverages, particularly in spice blends and imitation vanilla flavoring.
- Agriculture: It acts as an attractant in traps for fruit flies, particularly the Oriental fruit fly (Bactrocera dorsalis), helping manage and control pest populations.
- Pharmaceuticals: Although less common, it has been investigated for potential antimicrobial, antifungal, and anti-inflammatory properties.
- Aromatherapy: In some cases, it is used in aromatherapy, though usage is cautious due to potential toxicity concerns.

Chemical properties:

- Structure: It is a phenylpropene, featuring a benzene ring (phenyl group) with a propene side chain. The structure includes a methoxy group (– OCH_3) and an allyl group (–$CH_2CH=CH_2$) attached to the benzene ring.
- Reactivity:
- Electrophilic Substitution: The aromatic ring in methyl eugenol can undergo electrophilic aromatic substitution reactions, such as nitration, sulfonation, and halogenation, though these are not typically the primary focus for this compound.
- Oxidation: Methyl eugenol can be oxidized under certain conditions to form products such as eugenol and other derivatives.
- Solubility: Methyl eugenol is soluble in organic solvents like ethanol, ether, and chloroform, but is only slightly soluble in water.
- Stability: It is relatively stable under normal conditions but can degrade upon exposure to light, air, or heat. Proper storage in a cool, dark place can help maintain its stability.
- Volatility: It is a volatile compound, which contributes to its effectiveness in fragrance and flavor applications as it can easily evaporate and diffuse into the air.

These chemical properties make methyl eugenol versatile in its applications, though its reactivity and stability must be managed to ensure optimal performance in its intended uses.

Physical properties:

- Appearance: It is a clear, colorless to pale yellow liquid.
- Odor: It has a distinctive sweet, spicy, and clove- like aroma.
- Boiling Point: Approximately 254°C (489°F).
- Melting Point:Methyl eugenol is a liquid at room temperature, so it does not have a melting point in the conventional sense.
- Density: Its density is around 1.058 g/cm^3.
- Solubility: It is slightly soluble in water but readily soluble in organic solvents like ethanol, ether, and chloroform.
- Refractive Index: The refractive index is approximately 1.542.

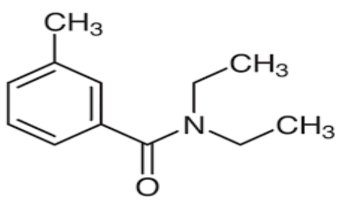
N, N-diethyl-m-toluamide:

N,N-Diethyl-m-toluamide known as DEET, is a chemical compound used as an active ingredient in insect repellents. DEET is a synthetic oil that repels insects, particularly mosquitoes, ticks, and flies. It's a topical application that works by interfering with insects' sense of smell and taste, preventing them from being attracted to humans.DEET was first developed in the 1940s by the US Department of Agriculture and was initially used for military purposes. It became widely available for civilian use in the 1950s. The chemical structure of N,N-Diethyl-m-toluamide(DEET) is $C_{12}H_{17}NO$

Molecular structure:

- Benzene ring (C_6H_5) with a methyl group (CH_3) attached to the meta position (m- toluamide)
- Two ethyl groups (C_2H_5) attached to the nitrogen atom (N)
- Amide group (CON) linking the benzene ring to the nitrogen atom Structure of formula:$C_6H_5CH_3CON(C_2H_5)_2$
- Ball-and-stick model:A benzene ring with a methyl group attached, connected to an amide group, which is linked to two ethyl groups.
- This structure is responsible for DEET's properties and effectiveness as an insect repellent.

Note: The "N,N-Diethyl" part of the name refers to the two ethyl groups attached to the nitrogen atom, and "m-toluamide" refers to the methyl group attached to the benzene ring in the meta position.



Types:

- Low-concentration (5-20%):

Low-concentration N,N-Diethyl-m-toluamide (DEET) refers to products containing 5-20% DEET. These are suitable for:

1. Children (above 2 months old)
2. People with sensitive skin
3. Short-duration outdoor activities (e.g., walking, gardening)
4. Low-risk areas (e.g., urban, suburban)

Examples of low-concentration DEET products:

1. Baby-friendly insect repellents
2. Gentle skin sprays
3. Wipes or sticks for skin application

- Medium-concentration (20-30%):

Medium-concentration N,N-Diethyl-m-toluamide (DEET) refers to products containing 20- 30% DEET. These are suitable for:

1. General-purpose use
2. Outdoor activities like hiking, camping, and gardening
3. Protection against mosquitoes, ticks, and flies for several hours
4. Moderate-risk areas (e.g., wooded, rural, or tropical environments)

Examples of medium-concentration DEET products:

1. Standard insect repellent sprays
2. Lotions and sticks for skin application
3. Outdoor worker sprays
4. General-purpose insect repellents

- High-concentration (30-50%):

High-concentration N,N-Diethyl-m-toluamide (DEET) refers to products containing 30-50% DEET. These are suitable for:

1. Extended protection (up to 12 hours) in high-risk areas
2. Tropical or jungle environments
3. Outdoor activities like backpacking, hunting, or fishing
4. Protection against aggressive or disease-carrying insects

Examples of high-concentration DEET products:

1. Heavy-duty insect repellents
2. Outdoor gear treatments (e.g., clothing, tents)
3. High-risk area sprays
4. Extended-duration insect repellents

- Ultra-high concentration (98%) :

Ultra-high concentration N,N-Diethyl-m-toluamide (DEET) refers to products containing 98% DEET. These are suitable for:

1. Extreme conditions (e.g., jungle, tropical, or desert environments)
2. High-risk activities (e.g., military, expedition, or search and rescue)
3. Prolonged exposure (up to 24 hours) to aggressive or disease-carrying insects
4. Treating outdoor gear and equipment for long-term protection

Examples of ultra-high concentration DEET products:

1. Specialized insect repellents for extreme conditions
2. Military-grade insect repellent
3. Expedition and outdoor gear treatments
4. High-risk area sprays.

Applications of N N-diethyl-m-toluamide:

N,N-Diethyl-m-toluamide (DEET) has various applications due to its effective insect- repelling properties:

- Insect Repellents: DEET is used in sprays, lotions, sticks, and wipes to repel mosquitoes, ticks, flies, and other insects.
- Outdoor Gear Treatment: DEET is used to treat clothing, tents, netting, and other outdoor gear to repel insects.
- Military and Tactical: DEET is used by military personnel and outdoor enthusiasts to protect against insect-borne diseases.
- Public Health: DEET is used in vector control programs to prevent the spread of diseases like malaria, dengue fever, and Zika virus.
- Agriculture: DEET is used to protect livestock and crops from insect damage.

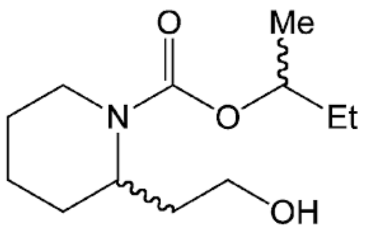
- Veterinary: DEET is used to repel insects on pets and livestock.
- Entomological Research: DEET is used to collect and study insects.
- First Aid and Emergency Kits: DEET is included in some first aid and emergency kits to prevent insect-borne illnesses.
- Travel and Adventure: DEET is used by travelers and adventure seekers to protect against insects in remote or high-risk areas.
- Industrial and Occupational: DEET is used in industries like forestry, construction, and landscaping to protect workers from insect bites.

Properties:

- Chemical formula: C12H17NO
- Molecular weight: 191.28 g/mol
- Appearance: Colorless to pale yellow liquid
- Solubility: Insoluble in water, soluble in ethanol and acetone Uses:
- Insect repellent for skin and clothing
- Outdoor gear treatment (e.g., tents, netting)
- Military and outdoor applications Benefits
- Effective against a wide range of insects
- Long-lasting protection (up to 12 hours)
- Available in various concentrations (5-98%) Precautions
- Use according to product instructions
- Avoid applying on damaged skin or near eyes
- Wash hands after application
- Use in well-ventilated areas to avoid inhalation

Introduction:

Icaridin (Picardin) is a Synthetic insect repllent used to prevent bites from mosquitoes, ticks, flies and other biting insects. It is a colorless liquid with a mild pleasant odour.



Chemical name:2-(2-hydroxyethyl)-1 piperidine carboxylic acid 1-methyl propyl ester Icaridin

Icardin was developed in the 1980s by the German chemical company, Bayer. It was designed to be a safer and more effective alternative to DEET

(N,N-Diethyl-meta-toluamide), a common insect repellant.

Types:

- Concentrated liquid
- Ready-to-use sprays
- Lotions
- Sticks
- Wipes
- Pump sprays
- Aerosol sprays Applications:
- Skin Application: Apply to exposed skin and clothing to repel insects.
- Clothing Application: Spray or apply to outer layers of clothing to repel insects
- Gear application: Apply to backpacks, tents and other outdoor gear to repel insects.
- Wipe application: Wipe on skin and clothing to repel insects.

Concentrations:

- 5% Icaridin
- 10% icaridin
- 15% icaridin
- 20% icaridin

- Icaridin is considered a safer and more effective alternative to DEET and DMP.
- Gentle on skin and clothing
- Long –lasting (up to 12 hours)
- Effective against mosquitoes, ticks, Flies and chiggers.
- Approval by the US Environment protection Agency (EPA) and registred in many countries.

Benefits:

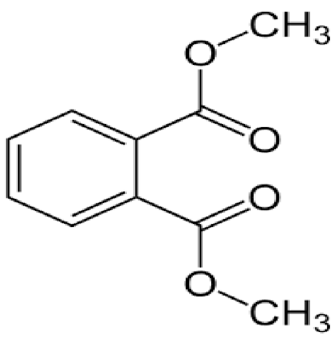
- Long-lasting protection (UP to 12 hours)
- Gentle on skin and clothing
- Not greasy or sticky
- Effective against mosquitoes, ticks, flies and chiggers.

Uses:

- Insect repellents for skin and clothing.
- Sprays, lotions, sticks, and wipes.
- Outdoor activities.
- Travel to areas with high insect borne disease risk.

Dimethyl phthalate:

Dimethyl phthalate is used as effective mosquito repellent. The disadvantage of this repellant is that it causes irritation to the eyes and mucous membranes. Its LD50 value is 8200 mg/kg.



Introduction:

Dimethyl phthalate (DMP) is a synthetic insect repellent used to prevent bites from mosquitoes, flies, and other biting insects. It is a clear, colorless liquid with a mild, slightly sweet odor.

Types:

- Types based on purity:

1. Technical grade DMP (90-95% purity)
2. Pharmaceutical grade DMP (99%+ purity)
3. Analytical grade DMP (99.9%+ purity)

- Types based on applications:

1. Plasticizer DMP (for plastics, PVC)
2. Pesticide DMP (insect repellent, insecticide)
3. Fragrance DMP (fixative in perfumes)
4. Medical DMP (pharmaceutical applications)

- Types based on formulations:

1. Liquid DMP
2. Solid DMP (flakes, pellets)
3. Emulsifiable DMP (for water-based applications)

- Types based on modifications:

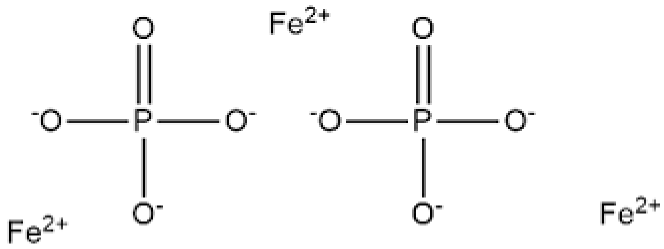
1. Linear DMP
2. Branched DMP
3. Cyclic DMP Applications:

- Skin application: Apply to exposed skin and clothing to repel insects.
- Clothing application: spray or apply to outer layers of clothing to repel insects.
- Gear application: Apply to backpacks, tents, and other outdoor gear to repel insects .
- Wipe application: wipe on skin and clothing to repel insects.

Iron(II)phosphate

Introduction :

Iron(II) Phosphate also known as ferrous Phosphate is a brown powder that is made from iron, phosphate and oxygen. Its chemical formula is $Fe_3(PO_4)_2$, Which is formed by combining three iron atoms with two phosphoric acid molecules. Iron(II)Phosphate is an ionic compound made up of an iron(II)ion (Fe^{2+}) and a polyatomic Phosphate anion. It is an iron salt of phosphoric acid .



Iron II phosphate

Types:

Here are some common types of iron(II) phosphate (also known as ferrous phosphate) used in pesticides:

- Mono Ferric Phosphate ($FeHPO_4$): Used as an insecticide and molluscicide.
- Diferric Phosphate (Fe_2HPO_4):Used to control slugs, snails, and insects.
- Tetra Ferric Phosphate ($Fe_4H_2P_2O_8$):Used as a molluscicide and insecticide.
- Iron(II) Phosphate Heptahydrate ($FeHPO_4 \cdot 7H_2O$):Used to control insects and slugs in agricultural and horticultural settings.
- Ferrous Phosphate Dihydrate ($FeHPO_4 \cdot 2H_2O$): Used as an insecticide and molluscicide.
- Ferrous Orthophosphate ($Fe_3(PO_4)_2 \cdot 8H_2O$): Used to control slugs, snails, and insects.
- Ferrous Ammonium Phosphate: A dual-purpose fertilizer and pesticide controlling insects and diseases.
- Iron(II) Phosphate -based granules: used to control pests like ants, cockroaches and crickets.
- Ferrous phosphate based wettable powder:used to control fungal disease in plants.

These formulations may vary in their composition, concentration and application methods, but they utilise Iron(II) Phosphate as the primary active ingredient.

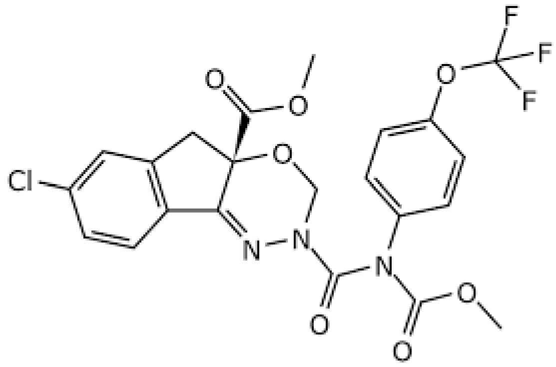
Applications:

- Used in food and feed. Supplements (Particularly in bread) in Fertilizers, and as a pesticide for control of snails and Slugs.
- Used as a trace mineral added to animal feeds.
- They are commonly used in Preparation for Painting or Powder coating, in order to increase adhesion to the Steel Substrate and Prevent corrosion, which Can Cause Premature failure of Subsequent coating Processes..
- It is one of the few molluscicides approved for use in the Practice of organic farming. Pesticide Pellets contain iron Phosphate Plus a Chelating agent Such as EDTA.
- Iron phosphate is used to make lithium iron phosphate, the cathode in lithium iron phosphate batteries.
- It can also be used for bonding fabrics, wool and other material to iron or Steel Surfaces.

Indoxacarb:

Introduction:

Indoxacarb is a broad-spectrum insecticide that's used to control certain pests, such as the beet armyworm, Colorado potato beetle, potato learn opper, moth fruit worm, cotton bollworm, and native budworm. Its part of the oxadiazine class of insecticides .and it's considered a 'reduced-risk pesticide by the EPA. Indoxacarb is a voltage-dependent sodium channel blocker that works by preventing sodium depend action potentials insect motor nerves. it's often used in commercial and farm planning. Indoxacarb poisoning can cause methemoglobinemia, which can lead to symptoms like cyanosis, dyspnea, headache, lightheadedness, fatigue, irritability and lethanary. In services cases it can be lead to shock. Services respiratory depression, or neurologist deterioration. Methemoglobinemia is a medical emergency.



Application:

Indoxacarb is used for control of certain lepidopteran pests including the beet armyworm.

FOLIAR Application: 201g water do not exceed 4 applications per season. including application made with these products against American bollworm bee safety. HARVEST indoxacarb blog is safe for bees, but do not apply directly into foraging bees.

Types:

Indoxacarb is an oxidation insecticide that comes in different types including isomers, enantiomers, and formulations.

- Isomers:

I do a car but can come in a mixture of S and R isomers or just S isomer the R isomer is the active compound.

- Enantiomers:

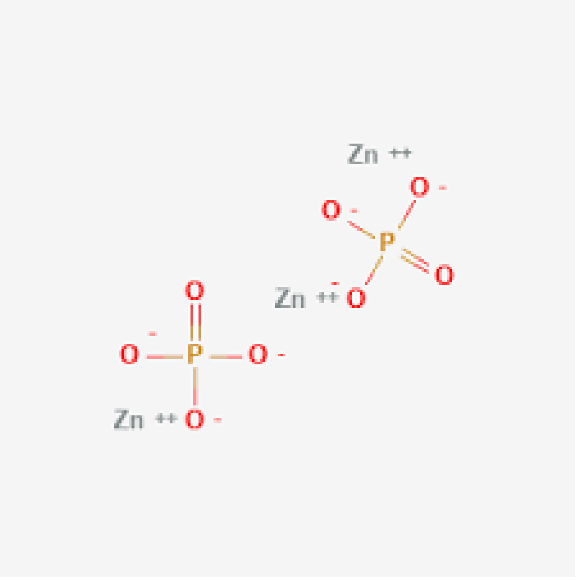
Indoxacarb can come in different enantiomers such as PPX-JW062, Which is Called ‘racemic Indoxacarb’, and DPX-MP062, Which is called ‘Indoxacarb 357 IR’.

Formulations:

Indoxacarb can come in different formulations Such as Emulible Concentrate (EC),Suspension Concentrate(SC) and Water Dispersible granule (WG).

Zinc phosphate:

Zinc phosphate is a chemical compound that comes in several forms, each with is own unique properties and applications.



Types:

Here are some common types of zinc phosphate:

- Ortho Zinc phosphate (Zn3(PO4)2): This is the most common form of zinc phosphate, used in ceramics, glass, and dental cements.
- Hopeite (Zn3(PO4)2.4H2O): A hydrated form of zinc phosphate, often used in the production of zinc phosphate pigments.
- Para Hopeite(Zn3(PO4)2.4H2O): Another hydrated form, similar to hopeite, but with a different crystal structure.
- Zinc phosphate tribasic (Zn3(PO4)2.xH2o): A mixture of ortho zinc phosphate and hopeite, used in corrosion-resistant coatings.
- Zinc phosphate monobasic (ZnH4PO4): Used in fertilizers, animal feed, and as a flux in soldering.
- Zinc phosphate dibasic(Zn2HPO4): Used in ceramics, glass, and as a catalyst in chemical reactions,

Applications:

Zinc phosphate has a wide range of applications across various industries due to its unique properties. Here are some of the main applications:

- Corrosion-resistant coatings: Zinc phosphate is used as a conversion coating for steel, aluminum, and other metals to protect against corrosion.

- Ceramics and glass: Used as a flux, opacifier, and stabilizer in ceramic and glass production.
- Dental cements: Zinc phosphate is a key component in dental cements, providing strength and durability.
- Fertilizers and animal feed: Zinc phosphate is used as a micronutrient in fertilizers and animal feed due to its high zinc content.
- Pigments and coatings: Used in the production of zinc phosphate pigments for paints, coatings, and plastics.
- Soldering fluxes: Zinc phosphate is used as a flux in soldering processes to promote wetting and bonding.
- Metal treatment: Used to treat metal surfaces, removing impurities and promoting adhesion.
- Pharmaceuticals: Zinc phosphate is used as an excipient in some pharmaceutical applications.
- Agriculture: Used as a soil amendment to provide zinc micronutrients for crops.
- Water treatment: Zinc phosphate can be used to remove impurities and contaminants from water.

Bromadiolone:

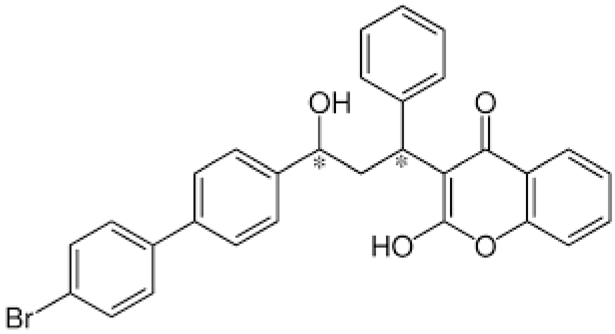
Introduction:

Bromadiolone is a rodenticide used to kill rats and mice around buildings and in transport vehicles. It's a second-generation anticoagulant that prevents blood from clotting by disrupting the recycling of vitamin K. Bromadiolone is highly toxic to all mammals and can be lethal to rats and mice after just one day of feeding. Signs of poisoning may be delayed for several days as the body runs out of vitamin K, which can pose a risk to wildlife predators that eat poisoned rodents. Bromadiolone is intended for sale to professionals only because of its potential risks to children and wildlife.

Bromadiolone was patented in 1967 to control rats, mice, voles, and water voles, including those that are resistant to warfarin and first-generation anticoagulants. It's formulated as a cereal or paraffin-based bait that contains 0.005% bromadiolone and is ready to use. Bromadiolone is an odorless, white to yellow powder that has a half-life of weeks to months, which is up to 60 times longer than warfarin. It's a member of the superwarfarin group of compounds, which are more potent and persistent than

first-generation anticoagulants.

The antidote for bromadiolone is vitamin K1, which can be given orally to adults in doses of 15–25 mg, or to children in doses of 5–10 mg, 2–4 times per day, until prothrombin time normalizes.



Applications:

- Bromadiolone is a rodenticide used to control rats and mice in and around buildings and transport vehicles. It's a second-generation anticoagulant that prevents blood from clotting by disrupting the recycling of vitamin K. Bromadiolone is highly toxic to all mammals and can be lethal to rats and mice after just one day of feeding. It's also effective against warfarin-resistant Norway rats, roof rats, and voles.
- Bromadiolone is applied in baits and bait packs. For commensal rats, you can use 16 ounces of bait per 15 foot interval, and for house mice, you can use 2 ounces of bait per 8 foot interval. Bromadiolone products can only be applied indoors in nonurban areas.

Types:

Bromadiolone is a rodenticide that's used to control rodent populations in both domestic and industrial settings. It's a powerful anticoagulant that's known for its potency and long-lasting effects. Bromadiolone is the active ingredient in many products, including:

- Contrac Blox: A product manufactured by Bell Labs that contains bromadiolone as its key ingredient
- Resolv Soft Bait: A soft bait rodenticide that contains bromadiolone and is designed to encourage feeding with its aroma.
- Contrac Bulk Pellets: A rodenticide bait that comes in a pellet form and contains bromadiolone.

Bromadiolone is highly toxic in acute toxicity studies and has been reported to cause hematoma, hematuria, and hemorrhage in chronic studies in rodents. It's also highly to moderately toxic to freshwater fish and birds. Environmental concerns include wildlife directly ingesting the baits or predators and scavengers being secondarily poisoned.

Metaldehyde:

Metaldehyde is a chemical compound primarily used as a pesticide to control slugs and snails in agricultural and horticultural settings. It is commonly found in pellet form and is favored for its effectiveness in protecting crops and plants from these pests.

Key Points About Metaldehyde:

- Chemical Structure: Metaldehyde is an organic compound with the molecular formula $C_8H_{16}O_4$. It is a cyclic tetramer of acetaldehyde.
- Usage: It is widely used in gardens, fields, and greenhouses to control slugs and snails, which can cause significant damage to crop and ornamental plants.
- Mode of Action: Metaldehyde works by disrupting the mucus production in slugs and snails, leading to dehydration and ultimately their death.
- Application: It is typically applied as bait pellets, which attract slugs and snails. These pellets are often spread around plants,

creating a barrier that the pests cannot cross without coming into contact with the chemical.

- Environmental and Health Concerns: Metaldehyde can be toxic to pets, wildlife, and humans if ingested. There are concerns about its environmental impact, particularly regarding water contamination, as it is persistent in the environment and can be washed into watercourses.
- Regulations: Due to its toxicity and environmental impact, the use of metaldehyde is regulated in many countries. Some regions have implemented restrictions or bans on its use, encouraging the adoption of alternative pest control methods.

Types:

Metaldehyde itself is a single chemical compound, but it is available in various formulations and products designed for specific uses. Here are the common types or forms in which metaldehyde is found:

1. Pellets or Granules:Description:

- The most common form of metaldehyde used for controlling slugs and snails. These pellets or granules are often colored (typically blue) to make them visible and less attractive to birds and other non- target animals.
- Use: Scattered around gardens, greenhouses, and crop fields to create a barrier against slugs and snails.

1. Liquid Formulations:

- Description: Metaldehyde can also be formulated as a liquid, often mixed with other chemicals to improve its effectiveness or stability.
- Use: Applied directly to plants or soil, although less common than pellets due to the difficulty of controlling the area of application.

2. Powder:

- Description: Metaldehyde is sometimes available in a powdered form.

- Use: Can be used similarly to pellets but may be more difficult to control and apply evenly.

3. Gels:

- Description: Some formulations of metaldehyde are available as gels, which can be applied directly to areas where slugs and snails are likely to travel.
- Use: Effective in small, specific areas, such as in potted plants or along garden borders.

4. Slug Baits with Metaldehyde:

- Ascription: Commercial slug baits often combine metaldehyde with other attractants to increase the effectiveness of the bait in drawing in slugs and snails.
- Use: Used similarly to pellets but often formulated to be more appealing to pests, sometimes combined with bittering agents to deter consumption by pets and other animals.

Applications:

Metaldehyde is primarily used as a molluscicide to control slugs and snails in various settings. Its application is essential in protecting crops, ornamental plants, and gardens from these pests. Below are the typical applications of metaldehyde:

1. Agricultural Use:

- Crops: Metaldehyde is commonly applied in agricultural fields to protect a wide range of crops, including vegetables, cereals, and fruits. Slugs and snails can cause significant damage to these crops by feeding on leaves, stems, and roots.
- Application Method: Farmers often scatter metaldehyde pellets or granules around the base of plants or in rows along crops. This creates a barrier that slugs and snails must cross, resulting in their ingestion of the pesticide.

2. Horticultural Use:

- Gardens and Greenhouses: In gardens and greenhouses, metaldehyde is used to protect ornamental plants, flowers, and small vegetable gardens from slug and snail infestations.

- Application Method: Gardeners typically apply metaldehyde pellets or gel formulations around the perimeter of the garden or directly around plants. It is also used in potted plants to prevent snails and slugs from reaching the plants.

1. Residential Use:

- Home Gardens: Homeowners often use metaldehyde in their gardens to protect plants from slugs and snails. It is especially useful for protecting delicate plants like lettuce, host as, and other leafy greens that are particularly attractive to these pests.
- Application Method: Metaldehyde is applied in the form of pellets or granules, spread evenly around garden beds, flowerbeds, or specific plants at risk of slug or snail damage.

2. Commercial Landscapes:

- Public Parks and Golf Courses: Metaldehyde is used in larger commercial landscapes, such as parks, golf courses, and other public green spaces, to manage slug and snail populations that could damage turf, ornamental plants, and landscaping features.
- Application Method: Groundskeepers apply metaldehyde in targeted areas where slug and snail activity are prevalent, usually in pellet form.

3. Alternative Applications:

- Industrial Use: In some cases, metaldehyde may be used in non-agricultural settings, such as around industrial sites where vegetation needs to be protected from mollusk damage.
- Application Method: Similar to agricultural use, metaldehyde is applied in areas where vegetation needs protection, often in granule or pellet form.