

CHEMICAL GROUPS AND MODES OF ACTION OF PESTICIDES

A. APPLICATORS

Subject A: Should know how pesticides are named.

B. SUPERVISORS, SANITARIANS, AND AGRICULTURAL EXTENSION OFFICERS:

Subject A: Should know how pesticides are named, their mode of action in general, and the significance of mixtures, manufactured and in the field.

Subjects B,C, & D: Should know the modes of action of those pesticides which they use or might be used in their area in the immediate future, and the approved and trade names of these pesticides.

C. OTHER HEALTH AND MEDICAL PERSONNEL:

Subject A: Should know how pesticides are named, and their mode of action in general. May need to know the significance of mixtures.

Subjects B,C, & D: Should know the chemical groups of pesticide, and their modes of action. Should know the approved and trade names of pesticides in use or otherwise available in the area that they work.

D. PESTICIDE REGISTRATION PERSONNEL:

Subject A: Should know how pesticides are named, their mode of action in general, and the significance of mixtures, manufactured and in the field.

Subject B,C, & D: Should know the outline of the mode of action of all chemical groups. May need to know the approved and trade names of the products registered in the country.

Section: V Chemical groups and modes of action of pesticides
Subject: A General points
Number: 1 Names of pesticides

Main points:

A REGISTERED PESTICIDE HAS TWO NAMES.

**THE COMMON OR APPROVED NAME IS A NAME GIVEN TO IT BY
THE INTERNATIONAL (OR A NATIONAL) STANDARDS ORGANIZATION.**

**THE PROPRIETARY NAME IS THE NAME GIVEN TO IT BY THE MANUFACTURER.
THIS IS ALSO KNOWN AS THE TRADE NAME**

**BOTH NAMES MUST APPEAR ON THE LABEL,
BUT THE PROPRIETARY NAME IS USUALLY MORE PROMINENT.
NEVERTHELESS, IT IS THE COMMON OR APPROVED NAME THAT IS IMPORTANT,
ESPECIALLY WHEN POISONING OCCURS, AS IT GIVES CLUES AS TO THE
CHEMICAL GROUP TO WHICH THE COMPOUND BELONGS, AND THESE INDICATE
THE TREATMENT NEEDED.**

Examples: Reldan is chlorpyrifos-methyl
Sevin is carbaryl.
Tomorin and Raitilan are coumachlor.

Subsidiary points:

1. Proprietary names are written with a capital first letter as in the examples above. Common or approved names are written with a small first letter.
2. Common or approved names always refer to the same chemical compound, except for some minor national differences. Proprietary names for the same compound may differ between countries. Some refer to mixtures in which the constituents may change, or they may be reallocated to a pesticide replacing another that has become obsolete.

For discussion:

Are there labels available? Can the proprietary and common or approved names be found?

Other information: Apart from the examples given above, only common or approved names are used in this course.

Suggested visual aid: Examples of local labels.

Section: V Chemical groups and modes of action of pesticides
Subject: A General points
Number: 2 Modes of action of pesticides

Main points:

1. **A GREAT NUMBER OF DIFFERENT BODY SYSTEMS ARE NECESSARY FOR LIFE. SOME ARE SHARED BETWEEN ALL SPECIES, BUT OTHERS VARY WITH THE CLASS OF ANIMALS OR PLANTS, OR BETWEEN SPECIES IN A SINGLE CLASS.**

PESTS INCLUDE ORGANISMS FROM MANY CLASSES, SUCH AS PLANTS, GERMS, MOULDS, INSECTS, SPIDERS, MITES, WORMS, FISH, BIRDS AND MAMMALS.

PESTICIDES KILL BY INTERFERING WITH ONE OR MORE ESSENTIAL BODY SYSTEMS IN THE PEST.

THE MORE THAT THESE SYSTEMS ARE SHARED BY MAN, THE GREATER IS THE HAZARD OF THE PESTICIDE TO MAN.

2. **MOST PESTICIDES BELONG TO A FEW CHEMICAL GROUPS, EACH OF WHICH HAS ITS OWN EFFECTS ON CERTAIN BODY SYSTEMS.**

SMALL CHANGES IN THE CHEMICAL STRUCTURE OF COMPOUNDS IN A GROUP RESULT IN SOME SPECIES BEING AFFECTED MORE BY THOSE CHEMICALS THAN BY OTHERS IN THE SAME GROUP.

This is why some chemicals are more selective than others
in their action on certain pests.

For discussion: What animal pests are most likely to share essential body systems with man?

Suggested visual aid: No special aid needed.

Section: V Chemical groups and modes of action of pesticides
Subject: A General points
Number: 3 Mixtures of pesticides in the field

Main points:

DO NOT MIX TWO OR MORE FORMULATIONS IN THE FIELD UNLESS THE LABELS OF EACH STATE CLEARLY THAT THEY ARE COMPATIBLE.

THE MIXING OF TWO ACTIVE INGREDIENTS OF THE SAME CHEMICAL GROUP IS UNLIKELY TO INCREASE THE EFFICACY OF THE MORE POTENT COMPOUND.

THE TOXICITY IS LIKELY TO BE AT LEAST ADDITIVE.

WHILE SYNERGISM BETWEEN ACTIVE OR OTHER INGREDIENTS IS UNLIKELY, THERE IS A THEORETICAL CHANCE THAT IT MAY OCCUR.

Subsidiary point:

If the toxicity of a mixture of two or more active ingredients is not known, the hazard is also unknown. Therefore, if such home-made mixtures must be used, the precautions to be taken should be those needed for a hazard one class higher than the hazard class of the more hazardous active ingredient.

For discussion:

Are any mixtures made in the field locally?

Other information:

This practice is prohibited in some countries.

Suggested visual aid: None indicated.

Section: V Chemical groups and modes of action of pesticides
Subject: A General points
Number: 4 Manufactured mixtures of pesticides.

Main points:

Mixtures made by formulators are of two types:

- mixtures of chemicals, one of which will be the active ingredient in a formulation containing non-pesticidal synergists, such as piperonyl butoxide, and
- mixtures of two or more active ingredients in a formulation.

IN THE FIRST TYPE, THE SYNERGIST IS INCLUDED TO INCREASE THE TOXICITY OF THE ACTIVE INGREDIENT FOR THE TARGET SPECIES.

IN THE SECOND TYPE, IF THE ACTIVE INGREDIENTS BELONG TO THE SAME CHEMICAL CLASS, THE TOXICITY WILL USUALLY BE ADDITIVE. IF THE ACTIVE INGREDIENTS BELONG TO DIFFERENT CHEMICAL CLASSES, EACH WILL EXERT ITS OWN EFFECTS, AND THE RESULTING TOXICITY OF THE MIXTURE IS LIKELY TO BE THAT OF THE MORE TOXIC CONSTITUENT.

WHILE UNINTENDED SYNERGISM BETWEEN ACTIVE AND OTHER INGREDIENTS IS A THEORETICAL POSSIBILITY, THERE HAVE BEEN FEW STUDIES OR REPORTS OF THIS OCCURRING TO ANY EXTENT.

HOWEVER, MANUFACTURERS SHOULD ALWAYS CONFIRM THAT THIS IS NOT OCCURRING, AND SHOULD CARRY OUT A FULL RANGE OF ACUTE TOXICITY TESTS ON ALL MIXTURES OF BOTH TYPES.

REGISTRATION AUTHORITIES SHOULD INSIST ON THE PRODUCTION OF THIS DATA, AND FORMULATORS SHOULD NOT BE ALLOWED TO CHANGE THE COMPOSITION OF MIXTURES WITHOUT THE PERMISSION OF THE REGISTRATION AUTHORITY.

Suggested visual aid: None indicated.

Section: V Chemical groups and modes of action of pesticides
Subject: B Insecticides
Number: 1 Organophosphorous compounds

Main points:

**THE MAIN TARGET OF ORGANOPHOSPHORUS COMPOUNDS
IN THE BODY IS THE ENZYME CHOLINESTERASE.
THIS ENZYME IS ESSENTIAL FOR THE
PASSAGE OF NERVE IMPULSES BETWEEN CELLS.**

ORGANOPHOSPHORUS COMPOUNDS ARE NOT STORED IN THE BODY FOR LONG PERIODS, BUT THEIR EFFECTS CAN ACCUMULATE OVER A PERIOD OF WEEKS.

Examples with hazard class of technical product:

| | | |
|-----------------|-------------------|---------------------------|
| parathion (Ia) | diazinon (II) | malathion (III) |
| dichlorvos (Ib) | fenitrothion (II) | chlorpyrifos methyl (III) |
| fenthion (Ib) | bromophos (III) | temephos (Table 5) |

Level: ADVANCED

Subsidiary points:

1. The degree of inhibition of red cell or whole blood cholinesterase indicates the possibility of the onset of symptoms and the outcome. Inhibition of plasma cholinesterase is only an indication of exposure to an inhibitor.
2. Inhibition of the enzyme may be fully reversible, partially reversible, or irreversible. The rate and degree of spontaneous reactivation depends on the nature of the compound.
3. Reactivation of red cell or whole blood cholinesterase is usually slow without treatment, and therefore the effects of small exposures resulting in a degree of inhibition can accumulate until symptoms can occur after a relatively minor exposure.

For discussion:

What are the common or approved and trade names of the chemicals most commonly used by the group?

Other information:

1. In this and the following modules, only a selection of pesticides can be given, and these should be modified to accord with local use.
2. The information on hazard classes in this section is to enable the toxicological 'scatter' of the chemical groups to be compared but does not give any information as to the hazard of formulations as this depends on concentration. (For definitions of classes, see module I B 2.)

Suggested visual aid: List of local common or approved names with trade names.

Section: V Chemical groups and modes of action of pesticides
Subject: B Insecticides
Number: 2 Carbamates

Main points:

**CARBAMATE COMPOUNDS
ACT IN A SIMILAR WAY TO ORGANOPHOSPHOROUS COMPOUNDS
BY INHIBITING CHOLINESTERASE IN THE BODY.
CHOLINESTERASE IS ESSENTIAL FOR THE PASSAGE OF
NERVE IMPULSES BETWEEN CELLS.
THE INHIBITION MAY BE FASTER BUT IS USUALLY OF SHORT DURATION.
EVEN IF NO TREATMENT IS GIVEN, THE CHOLINESTERASE IS REACTIVATED
WITHIN MINUTES OR HOURS.
CARBAMATES ARE NOT STORED IN THE BODY,
AND ACCUMULATION OF EFFECT DOES NOT OCCUR.**

Examples with hazard class of technical product:

| | | |
|---------------|-----------------|--------------------|
| aldicarb (Ia) | bendiocarb (II) | propoxur (II) |
| methomyl (Ib) | carbaryl (II) | fenthioncarb (III) |

Subsidiary points:

The effect of carbamates on red cell cholinesterase is transient and inhibition is difficult to measure. The level in a blood sample can change, even while the blood sample is being processed.

For discussion:

What are the common or approved and trade names of the carbamates most commonly used by the group?

Other information:

Carbamate insecticides must not be confused with thio-dithiocarbamate compounds. These do not inhibit cholinesterase.

Suggested visual aid: List of local common or approved names with trade names.

Section: V Chemical groups and modes of action of pesticides
Subject: B Insecticides
Number: 3 Organochlorine compounds

Main points:

ORGANOCHLORINE COMPOUNDS STIMULATE THE NERVOUS SYSTEM IN THE BRAIN. LARGE DOSES OVER A LONG PERIOD MAY AFFECT THE FUNCTION OF THE LIVER. THESE COMPOUNDS ARE STORED IN BODY FAT.

MOST COMPOUNDS ARE ALSO PERSISTENT IN NATURE AND HAVE EFFECTS ON NON-TARGET WILDLIFE THAT ARE NOT SEEN IN HUMANS. FOR THIS REASON, USE OF SOME COMPOUNDS IS RESTRICTED OR BANNED IN MANY COUNTRIES.

Examples with hazard class of technical product:

| | | |
|---------------|-------------------|------------------------|
| aldrin (Ib) | chlordan (II) | endosulfan (II) |
| dieldrin (Ib) | DDT (II) | heptachlor (II) |
| endrin (Ib) | HCH (ex BHC) (II) | methoxychlor (Table 5) |

Level: ADVANCED

Subsidiary points:

1. Stimulation of the central nervous system accounts for all the acute symptoms, and determines the treatment. Induction of liver enzymes in humans only occurs after very heavy continuous exposure.
2. Levels in human fat are related to intake, and are of little significance.
3. DDT has caused liver cancer in one species of mouse, but not in other animals. It is not thought by most experts to be carcinogenic for humans.

For discussion:

What are the common or approved and trade names of organochlorines permitted to be used in the country?

Other information:

1. The banning of these compounds has been due to their persistence in the food chain, and to some special effects, such as the thinning of bird egg shells. DDT has an outstanding safety record for man as it is very weakly absorbed through the skin except in oily solution.
2. The reference to table 5 in the examples above refers to Table 5 in the WHO Recommended Classification of Pesticides by Hazard, a list of active ingredients unlikely to give rise to hazard to humans in normal use.

Suggested visual aid: List of common or approved and trade names of compounds locally permitted for use.

Section: V Chemical groups and modes of action of pesticides
Subject: B Insecticides
Number: 4 Pyrethroid compounds

Main points:

**PYRETHROID COMPOUNDS ACT ON NERVES, PROLONGING ANY STIMULATION.
THEY PASS EASILY THROUGH THE CUTICLE OF INSECTS.**

**THEY ARE HIGHLY BIOACTIVE AND USED IN HIGH DILUTION.
THEREFORE THE HAZARD OF FORMULATIONS TO HUMANS IS LOW.**

**PYRETHROIDS ARE RAPIDLY BROKEN DOWN AND EXCRETED FROM THE BODY.
THEY ARE NOT STORED IN THE BODY, AND THEIR EFFECTS DO NOT
ACCUMULATE.**

Examples with hazard class of technical product:

| | | |
|-------------------|-------------------|-------------------------|
| bioallethrin (II) | deltamethrin (II) | allethrin (III) |
| cyhalothrin (II) | fenvalerate (II) | resmethrin (III) |
| cypermethrin (II) | permethrin (II) | bioresmethrin (Table 5) |

Level: ADVANCED

Subsidiary points:

1. Very few accidental poisoning cases have been reported in humans, after very high exposure.
2. In rats, the toxicity is high only on parenteral application
3. The paraesthesia (a feeling of tingling or burning in the skin) reported after exposure to some pyrethroids is due to lengthening of the refractory period of dermal nerve endings. It remits spontaneously after a few hours.

For discussion:

What are the common or approved and trade names of pyrethroids used by the group?

Other information:

1. These compounds are chemical developments of the insecticidal chemical found in the pyrethrum plant.
2. The reference to table 5 in the examples above refers to Table 5 in the WHO Recommended Classification of Pesticides by Hazard, a list of active ingredients unlikely to give rise to hazard to humans in normal use.

Suggested visual aid: List of local common or approved compounds with trade names.

Section: V Chemical groups and modes of action of pesticides
Subject: C Rodenticides
Number: 1 Warfarin

Main points:

**WARFARIN PREVENTS VITAMIN K PRODUCTION IN THE BODY
AND DECREASES PRODUCTION IN THE LIVER OF A CHEMICAL, PROTHROMBIN.
THIS IS ESSENTIAL FOR THE CLOTTING OF BLOOD.**

THIS CAUSES BLEEDING INTO THE SKIN AND OTHER PARTS OF THE BODY.

Warfarin is used as a drug for man to reduce the clotting power
of the blood and thus prevent heart attacks.
The dosage has to be carefully controlled.

Subsidiary points:

1. Warfarin does not act immediately. It is usually eliminated quickly, although its effect lasts longer. Several doses are needed to kill a rat. The hazard for humans or other large animals who might accidentally eat a single dose, is very small.
2. Rats in many places have developed a genetic resistance to warfarin.

For discussion:

Under what trade names is warfarin sold in this country?

Other information:

Since rodenticides have to be highly toxic to mammals if they are to be effective pesticides, their hazard to man is high. Warfarin is in class Ib, although the need for multiple dosage reduces its hazard in practice. This safety factor does not apply to other rodenticides with a similar action.

Suggested visual aid: List of local trade names.

Section: V Chemical groups and modes of action of pesticides
Subject: C Rodenticides
Number: 2 Warfarin derivatives

Main points:

Warfarin derivatives were developed to counteract
the genetic resistance to warfarin in rats.

**THESE COMPOUNDS HAVE THE SAME ANTICOAGULANT ACTION AS WARFARIN,
BUT REQUIRE ONLY A SINGLE DOSE TO KILL A RAT.**

**AS THEY ALSO INHIBIT VITAMIN K PRODUCTION
AND AFFECT THE CLOTTING FACTORS FOR BLOOD,
THEY ARE THEREFORE MORE HAZARDOUS THAN WARFARIN TO HUMANS
AND OTHER ANIMALS IF ACCIDENTALLY EATEN.**

Examples:

coumafuryl (Ia)
diphacinone (Ia)

brodifacoum (Ia)
chlorphacinone (Ia)

difenacoum (Ia)

Subsidiary points:

Although there is a specific antidote, the hazard class of these compounds indicates the care with which they must be handled.

For discussion:

Under what trade names are these compounds sold in this country?

Suggested visual aid: List of local trade names.

Section: V Chemical groups and modes of action of pesticides
Subject: D Other pesticides
Number: 1 Paraquat and diquat

Main points:

**THESE BIPYRIDYL DERIVATIVES ARE HERBICIDES
WHICH ARE INACTIVATED ON CONTACT WITH SOIL.**

**THEY ARE WEAKLY CORROSIVE TO THE EYES AND LOCALLY PROLONGED OR
REPEATED CONTACT CAN AFFECT THE SKIN, FINGERNAILS, AND THE LINING
OF THE NOSE, CAUSING BLEEDING.**

**THEY ARE ABSORBED THROUGH THE SKIN WHEN CONTACT IS PROLONGED.
IN NORMAL USE THEY ARE OF MODERATE OR SLIGHT HAZARD,
THE TECHNICAL PRODUCTS BEING IN HAZARD CLASS II.**

**HOWEVER, IF TAKEN BY MOUTH, THE OESOPHAGUS AND STOMACH MAY BE
AFFECTED BY THE CORROSIVITY, AND KIDNEY AND LIVER FAILURE MAY
OCCUR RAPIDLY. IF THIS IS SURVIVED, PARAQUAT AFFECTS THE LUNGS.
THIS IS USUALLY FATAL WITHIN A FEW WEEKS.**

Subsidiary point:

Paraquat reacts biochemically in the body, and the molecule exerts a toxic action on cells at the reaction sites.

For discussion:

Under what trade names are these compounds available in this country?

Other information:

Paraquat has caused few problems occupationally, but there have been many instances of the compound being taken deliberately by mouth in attempted (and usually successful) suicide attempts. Diquat does not present the same problems. Its effects on the liver and kidneys are similar, but no late effect is seen on the lungs.

Suggested visual aid : List of local trade names.

Section: V Chemical groups and modes of action of pesticides
Subject: D Other pesticides
Number: 2 Pentachlorophenol and related compounds

Main points:

**THESE FUNGICIDES AND HERBICIDES ACT BY STIMULATING METABOLISM IN
MAMMALS.**

**THIS RESULTS IN AN INCREASE IN THE RATE OF BREATHING,
AND A RISE IN BODY TEMPERATURE TO HIGH LEVELS.**

CONTACT WITH THE SKIN CAN CAUSE CHLORACNE.

**THE COMPOUNDS ARE VERY SLOWLY EXCRETED IN URINE
OVER A PERIOD OF ABOUT ONE WEEK,
AND THEREFORE THERE IS A TENDENCY TOWARDS ACCUMULATION
IN THE BODY ON REPEATED EXPOSURE.**

Examples:

pentachlorophenol (Ib)
dinoseb (Ib)

dinoterb (Ib)
medinoterb (Ib)

DNOC (Ib)
dinocap (III)

For discussion:

Under what trade names are these compounds available in this country?

Suggested visual aid: List of local trade names.

Section: V Chemical groups and modes of action of pesticides
Subject: D Other pesticides
Number: 3 Metals

Main points:

Several metals are or have been used as pesticides.
Modes of action of metals are to be found in textbooks of industrial toxicology.

1. **ARSENIC SALTS HAVE BEEN USED AS RODENTICIDES, HERBICIDES AND LARVICIDES. INORGANIC ARSENICALS ARE HIGHLY TOXIC AND PROBABLY CARCINOGENIC FOR MAN. THEY SHOULD NOT BE USED.**

Examples:

| | | |
|-----------------------|--|------------------------|
| arsenous oxide (Ia) | lead arsenate (Ib) | dimethyl arsinic acid |
| calcium arsenate (Ia) | cupric arsenoarsenite (Paris Green) (Ib) | (cacodylic acid) (III) |

INORGANIC ARSENICALS ARE HIGHLY TOXIC AND PROBABLY CARCINOGENIC FOR MAN. THEY SHOULD NOT BE USED.

2. **ORGANIC MERCURY SALTS ARE USED AS A FUNGICIDE ON SEEDS.**

Examples: phenyl mercury acetate and nitrate (Ia)

**THESE AND SIMILAR COMPOUNDS ARE HIGHLY TOXIC,
AND CAUSE LASTING DAMAGE TO THE NERVOUS SYSTEM.**

THEY SHOULD ONLY BE USED IF THERE IS NO OTHER POSSIBLE SUBSTITUTE.

3. **ORGANIC TIN COMPOUNDS ARE ACTIVE AGAINST SNAILS AT VERY LOW CONCENTRATIONS IN WATER.**

Examples:

| | | |
|------------------------------|-----------------------------------|----------------------|
| azocyclotin (Ib) | fentin acetate and hydroxide (II) | cyhexatin (III) |
| bis-(tributyl)tin oxide (Ib) | | fenbutatin (Table 5) |

4. **COPPER SALTS HAVE FUNGICIDAL ACTION.**

Examples:

| | | |
|--------------------|----------------------|--------------------------|
| cuprous oxide (Ib) | copper sulphate (II) | copper oxychloride (III) |
| | | oxine-copper (Table 5) |

Subsidiary points:

1. Thallium sulphate and zinc phosphide, are rodenticides.
2. Aluminium phosphide is a fumigant. It reacts in the same way as zinc phosphide.

For discussion: Under what trade names are metals marketed as pesticides in this country?

Suggested visual aid: List of local trade names.