

# 1. WHAT PESTICIDES ARE AND HOW THEY ARE CLASSIFIED

## 1.1 What are pesticides?

Pesticides are substances or preparations used to prevent, control or eliminate organisms considered harmful to crops, animals, materials or human health.

Their use is particularly widespread in agriculture, where they help protect crops against insects, fungi, weeds and other organisms that may compromise harvest yields or quality.

The term pesticide actually encompasses two broad categories: plant protection products, used mainly to protect plants, and biocidal products, used in other contexts, such as disinfecting environments or controlling pests.

This guide focuses primarily on plant protection products, because they represent one of the main potential sources of pesticide residues in food.

## 1.2 What are pesticides made of?

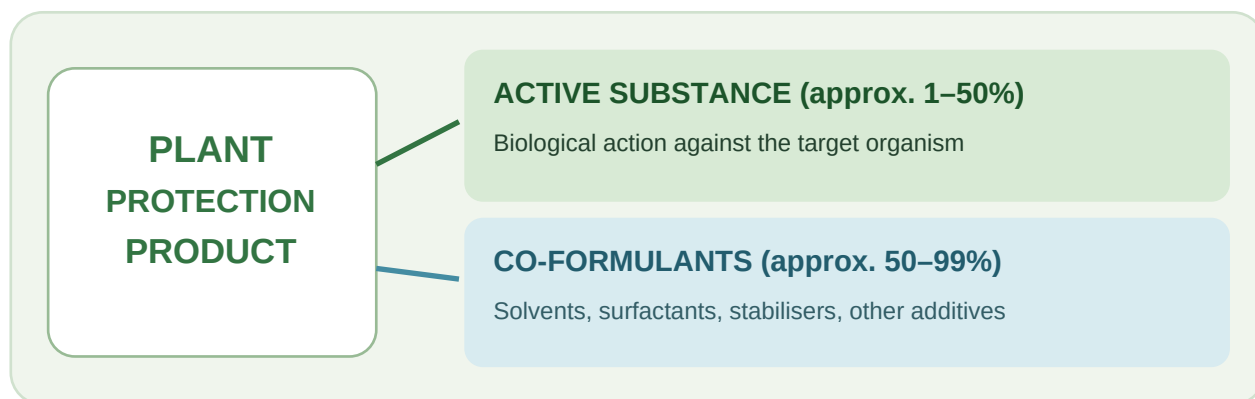
A plant protection product is generally a formulation consisting of one or more active substances and other ingredients, known as co-formulants.

The active substance is responsible for the product's biological action: it may kill a harmful organism, inhibit its development or interfere with specific physiological processes.

Co-formulants, by contrast, may improve the formulation's stability, facilitate application to crops, or promote adhesion and uptake of the active substance.

Active substances are not necessarily synthetic chemicals: they may also be naturally derived substances or microorganisms, including bacteria, fungi and viruses.

### Plant protection product: an illustrative formulation



Illustrative formulation. Actual composition varies by product; active substances and co-formulants have different functions.

## 1.3 Main categories of pesticides

Pesticides can be classified according to the organisms they are intended to control.

| Category                | Function                                       |
|-------------------------|------------------------------------------------|
| Herbicides              | Control weeds                                  |
| Insecticides            | Control harmful insects                        |
| Fungicides              | Combat diseases caused by fungi                |
| Acaricides              | Control mites and related organisms            |
| Nematicides             | Control nematodes                              |
| Molluscicides           | Control slugs, snails and other molluscs       |
| Rodenticides            | Control rodents                                |
| Plant growth regulators | Modify specific processes of plant development |

This classification describes the products' function, but neither their chemical composition nor their hazard. Two insecticides, for example, may belong to completely different chemical families, operate through different biological mechanisms and have very different toxicological properties.

#### 1.4 Why are pesticides used in agriculture?

Crops are continually exposed to organisms capable of reducing yields and compromising harvest quality.

Insects may damage plants directly or transmit diseases. Fungi may cause rot, deterioration and crop losses. Weeds compete with cultivated plants for water, nutrients and light.

Plant protection products are one of the tools available to control these problems.

However, crop protection does not depend exclusively on pesticides. Agronomic, biological, mechanical and preventive approaches can also reduce the need for them.

Integrated pest management relies on combining these tools and, wherever possible, giving preference to solutions that pose lower risks to health and the environment.

#### 1.5 The issue of selectivity

A fundamental consideration is whether a pesticide can act on its target organism without harming other organisms. This property is known as selectivity.

Selectivity, however, is not necessarily absolute. A substance developed to control one species may also interfere with other organisms, particularly when they share similar biological processes.

This is why the scientific assessment of pesticides addresses not only their effectiveness but also their potential effects on humans, animals and the environment.

#### 1.6 Chemical classification of pesticides

In addition to classification by function, pesticides can be grouped according to their chemical structure, origin and mechanism of action.

This distinction matters because substances used against the same organism can have very different chemical properties, environmental behaviour and toxicological effects.

Knowing the chemical family to which a pesticide belongs can help explain its persistence in the environment, potential for degradation, behaviour in living organisms and possible health effects.

There is therefore no single risk category that applies to all pesticides. Each substance must be assessed in light of its specific characteristics and the conditions of exposure.

## **Organophosphates**

Organophosphates are a family of phosphorus-containing compounds historically used mainly as insecticides.

Many act by inhibiting acetylcholinesterase, an enzyme essential for proper nervous-system function. This inhibition leads to an accumulation of acetylcholine, a substance involved in transmitting nerve impulses.

The mechanism is effective against insects, but it can also affect the nervous systems of mammals, including humans.

Well-known examples include chlorpyrifos, malathion and dimethoate.

Organophosphates include substances with widely differing properties, but some have been subject to major restrictions or withdrawals of authorisation because of toxicological concerns.

## **Carbamates**

Carbamates include substances used as insecticides, fungicides and herbicides.

Some insecticidal carbamates act on acetylcholinesterase, as organophosphates do, but generally through reversible inhibition.

Historically well-known examples include carbaryl and carbofuran.

However, belonging to the carbamate family does not mean that all substances share the same mechanism of action or toxicity.

## **Pyrethroids**

Pyrethroids are synthetic insecticides developed from knowledge of pyrethrins, naturally occurring insecticidal substances found in certain chrysanthemum species.

They primarily act by altering the operation of sodium channels in the membranes of insect nerve cells.

They have been widely used in agriculture and other sectors because they are effective against many insects.

Active substances in this family include permethrin, deltamethrin and cypermethrin.

Pyrethroids are generally less persistent in the environment than many older organochlorine insecticides, but some can be particularly toxic to aquatic organisms.

## **Neonicotinoids**

Neonicotinoids are a family of insecticides that act on nicotinic acetylcholine receptors in the insect nervous system.

Some have systemic behaviour: they can be absorbed by a plant and distributed through its tissues.

This property also allows them to act against insects feeding on sap or other parts of the plant.

Examples include imidacloprid, thiamethoxam, clothianidin and acetamiprid.

The use of several neonicotinoids has been heavily restricted in the European Union, particularly because of identified risks to bees and other pollinators. However, authorisation conditions vary with the active substance.

## **Organochlorines**

Organochlorines include numerous pesticides used historically, often characterised by the presence of several chlorine atoms in their molecular structure.

Some have properties of particular environmental significance: high persistence, affinity for fats and the ability to accumulate in living organisms.

DDT is probably the best-known example. Other compounds include aldrin, dieldrin and lindane.

Many organochlorine pesticides have been banned or severely restricted in numerous countries.

They remain scientifically important because some of these substances, or their degradation products, may persist in the environment for decades and continue to be detected in food chains.

## **Triazoles and other fungicides**

Triazoles are an important family of fungicides used to control various fungal diseases of crops.

Many act by interfering with the synthesis of ergosterol, an essential component of fungal cell membranes.

Examples include tebuconazole, difenoconazole and propiconazole.

There are also many other fungicide families, such as strobilurins and dithiocarbamates, characterised by different chemical structures and mechanisms of action.

Repeated use of fungicides with the same mechanism of action may favour the selection of resistant fungal populations, making some treatments progressively less effective.

## **Herbicides: glyphosate, triazines and other families**

Herbicides include chemically diverse substances intended to control weeds.

Glyphosate, one of the best-known herbicides, belongs to the organophosphonate family and works by inhibiting an enzyme involved in the synthesis of certain amino acids in plants.

Triazines include herbicides such as atrazine, which interfere with photosynthesis.

Other families include sulfonylureas, dinitroanilines and phenoxyacetic acid herbicides.

Here too, differences in chemical structure produce very different properties in terms of soil mobility, degradation, behaviour in water and potential effects on non-target organisms.

## **Biological and naturally derived pesticides**

Not all pesticides are derived from industrial chemical synthesis.

Some products use naturally derived substances, plant extracts or microorganisms capable of acting against harmful organisms.

One example is the bacterium *Bacillus thuringiensis*, used for its insecticidal activity against certain groups of insects.

Other examples include formulations based on natural pyrethrins, azadirachtin extracted from neem, and microorganisms that antagonise plant pathogens.

It is important to emphasise that natural origin does not automatically imply an absence of toxicity.

Natural substances can also cause unwanted effects in non-target organisms and must undergo appropriate safety assessments.

### **A fundamental distinction**

Chemical classification is useful for understanding the general characteristics of pesticides, but it is not sufficient on its own to establish the risk associated with a substance's presence in food.

At least three aspects must be distinguished: the substance's intrinsic hazard, the amount to which an organism is exposed, and the duration and route of exposure.

These considerations form the basis of pesticide toxicological risk assessment and will be explored in subsequent chapters.

Ultimately, speaking of pesticides as though they were a single entity means grouping together hundreds of profoundly different substances. To understand their presence in food, we must know not only their function but also their chemical nature, environmental behaviour and biological effects.

### **Reference sources: EFSA / US EPA**

<https://www.efsa.europa.eu/en/topics/pesticide-active-substances>

<https://www.epa.gov/expobox/exposure-assessment-tools-chemical-classes-pesticides>