3) Carbamate pesticides

Carbamates were introduced as pesticides in the early 1950s and are still used extensively in pest control due to their effectiveness and broad spectrum of biological activity (insecticides, fungicides, herbicides).

Chemically, the carbamate pesticides are esters of carbamates and organic compounds derived from carbamic acid. characteristics of carbamate pesticides are high polarity and solubility in water, thermal instability and high acute toxicity.

Microbial degradation of carbamate pesticides

Carbofuran is one of the pesticides belonging to the *N*-methylcarbamate class used extensively in agriculture, a number of bacteria capable of degrading carbofuran from the environment (*Pseudomonas*, *Flavobacterium*, *Achromobacterium*, *Sphingomonas*, *Arthrobacter*).

4) Biological pesticides

biopesticides are defined as naturally occurring pest control substances. They are classified into three groups:

a) Microbial pesticides: in which a microbial living organisms (bacteria, fungi, viruses, protozoans) is the active control agent

b) Plant pesticides: pesticidal substances produced by plants from introduced genetic material (plant incorporated protectants)

c) Biochemical pesticides: naturally occurring substances that control pests by nontoxic mechanisms. These include substances that interfere with growth or mating such as pheromones.

Microbiological control is supported by beneficial interactions resulting from competition, antagonism and parasitism of microorganisms against plant pathogens, insects and weeds.

Microorganisms are able to suppress pests by producing a toxin, causing a disease or preventing the establishment of other organisms. Currently, several microorganisms involved in such processes are the active ingredient of microbial pesticides.

a) Bacteria

The majority of commercial microbial insecticides are preparations based on strains of *Bacillus thuringiensis* (Bt) that produces a crystalline inclusion body during sporulation.

The crystal proteins (Cry proteins) are toxic to many insects and are defined as endotoxins (Bt toxin) that are generally encoded by bacterial plasmids

Cry proteins are produced as protoxins that are proteolytically converted into a combination of up to four smaller toxins upon ingestion.

These proteins bind to specific receptors in the larval midgut epithelium causing the formation of large cation-selective pores that increase the water permeability of the cell membrane.

A large uptake of water then causes cell swelling and rupture of the midgut. Poisoned insects can die quickly from the toxin activity or may die within 2-3 days from septicemia due to the entering of gut contents into the bloodstream.

Bacteria belonging to other genera such as *Pseudomonas fluorescens*, *P. putida*, *P. Chlororaphis* and *Burkholderia cepacia* have also been used as biopesticides

b) Fungi

Fungi often act as important natural control agents against insects, pathogenic fungi, nematodes and as herbicide. Many fungi utilized as biopesticides are pathogenic to insect.

Fungi can act as insecticide by two ways:

a) Infection: most of the fungi species cause death to the insect through spores called conidia.

b) Mycotoxins: another fungi mode can cause death of the host by the production of mycotoxins, which can interfere in the nervous system of insects.

c) Viruses

Virus-based biopesticides have been used as insect control agents. Baculoviruses are a large virus group belonging to the family *Baculoviridae* and can infect different insect orders, particularly Lepidoptera and Diptera. The commercial formulations that have been used include Granulosis virus

d) Protozoa

Some protozoan pathogens can kill insect hosts. One important consequence of protozoan infection is the reduction in the number of offsprings by the infected insects. Species of the genera *Nosema sp*. offer the greatest biopesticide potential.