

PESTICIDE DEGRADATION¹

by J. M. Vargas, Jr.

Abstract

Pesticide degradation is the breaking down of toxic pesticides into a nontoxic compounds and, in some cases, down to the original elements from which they were derived. The most common type of degradation is carried out in the soil by microorganisms, especially the fungi and bacteria. Pesticides which are rapidly degraded are called non-persistent while those which resist degradation are termed persistent. The degradation of methyl-bromide and dalapon along with the degradation and resynthesis of chloroneb is explained. The advantages and disadvantages of persistent pesticides are discussed.

Degradation of pesticides is the breaking down of toxic chemicals into nontoxic compounds and, in some cases, back into their original elements. The degradation or breakdown of pesticides can occur in plants, animals, and in the soil and water; or it can take place upon exposure to ultra-violet (UV) radiation. There are some strictly chemical reactions which take place in soil that aid in degradation, however, the most common type of degradation there occurs through the activity of microorganisms, especially the fungi and bacteria. There is nothing mysterious about microbial degradation of pesticides. Microorganisms simply supply a medium and an energy source for rather simple chemical reactions to take place. They, in return, obtain food, essential elements, or energy to carry on their life functions.

The soil fumigant methyl bromide, the herbicide dalapon, and the fungicide chloroneb are examples of pesticides which are degraded by microorganisms. The degradation of CH₃Br (methyl bromide) is a simple process involving the liberation of methane gas (CH₄) leaving the bromine behind to be bound to soil particles or to become part of some new compound.

A second example, dalapon, is a more complicated compound, but its detoxification still

involves simple chemical reactions. Dalapon (2,2-dichloropropionic acid) can be detoxified by the removal of the chlorine molecules to leave pyruvate or pyruvic acid. Pyruvate can be 1) aminated into amino acid, which in turn can be converted into protein, 2) it can be decarboxylated and be utilized in the formation of lipids or 3) it can enter the Krebs Cycle and become part of this energy producing cycle. Another possibility is the complete degradation of dalapon into CO₂ and CH₄, two gases which occur naturally in the environment.

The third reaction involves a fungicide chloroneb, which is less well known, but it's the only pesticide for which both degradation and resynthesis by microorganisms has been shown. It should be pointed out that chloroneb is structurally similar to two more popular pesticides; the herbicide dicamba and the insecticide methoxychlor. Chloroneb (1,4-dichloro-2,5-dimethoxybenzene) is broken down (demethylated) by microorganisms to 2,5-dichloro-4-methoxyphenol (DCMP). Other microorganisms, including some of the same ones responsible for degradation, are able to resynthesize chloroneb by remethylating DCMP. Fortunately, less than 20% of the DCMP is converted back to chloroneb. It does illustrate that degradation can be a simple chemical reaction (demethylation) and that the reverse process (methylation) can also take place.

Pesticides which are readily degraded in the environment are called non-persistent in comparison with those which are not readily degraded, which are called persistent. It is these two general categories to which I would now like to direct my remarks.

Below is a list of persistent and non-persistent

1. Presented at the International Shade Tree Conference in Detroit, Michigan in August, 1975.

tent pesticides:

	Persistent	Non-persistent
<i>Insecticides</i>	DDT Aldrin Dieldrin Chlordane	Methoxychlor Sevin (carbaryl) Malathion Lindane
<i>Herbicides</i>	Simazine Turbacil Tordon	Paraquat Dalapon Dacthal Treflan
<i>Fungicides</i>	PMAS Calo-Clor Cadmium compounds	Benlate Mancozeb Zineb Captan

The advantage of persistent pesticides is their long term effectiveness in pest control. It could be season-long weed control with simazine, weeks of disease control with mercury fungicide, or seasons of insect control with chlordane. However, the persistent pesticides have an obvious draw back; they contaminate the environment for long periods of time. There are also other disadvantages to persistent pesticides. Resistance to persistent insecticides has occurred much more frequently than to non-persistent insecticides. The housefly's resistance to DDT and the Japanese beetle grub's resistance to chlordane are two examples. Persistent herbicides have caused problems where overdoses have been applied because immedi-

ate re-establishment of desirable species is not possible; or where sensitive non-pest species have been introduced into an area once treated with a persistent herbicide. Where non-persistent herbicides have been used, replanting or crop rotation after an overdose is not a serious problem.

Persistent fungicides like the mercuries appear to have the least serious side effects, from a practical point of view, of any of the persistent pesticides. But what effect does building up a layer of mercury in the soil from continual use of mercury have on plant growth? Or more important, since mercury is not readily removed from the human body, what effect is continual exposure having on you?

My personal philosophy is that we are in the business of maintaining healthy plants, and if it takes a persistent pesticide to accomplish this, then that is what should be used. On the other hand, if a non-persistent pesticide is available which will do the same job, even if more applications are required, then I think we ought to be using it. For it is not only the responsibility of the "other guy" to protect and improve the environment around him, it is everyones duty, and it is especially the duty of those of us who are involved in making this a more enjoyable world to live in by protecting the plants we grow. For as Will Rogers once said about the land we live on, "They don't make that stuff any more"!

*Department of Botany and Plant Pathology
Michigan State University
East Lansing, Michigan
Department of Botany and Plant Pathology*