CHAPTER 5

Metabolism of Insecticides by Microorganisms

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1 Introduction

During the past 40 years the use of agrochemicals including pesticides has contributed to a significant increase in major crop production. According to an EPA report prepared by Lawless et al. (1975), there are at least 550 different pesticide chemicals commercially available in the United States alone. Moreover, about 8000 different pesticide "formulations" are sold on the market and over 500 of these products contain two or more "active ingredients". Pesticide usage over recent years has also increased dramatically, from $1.1 \times 10^9$ lb yr$^{-1}$ in 1971 to $1.5 \times 10^9$ lbs at the end of the decade (Storck 1980). A recent prediction shows that the worldwide expenditure on pesticides will steadily increase from U.S. $11.5$ billion in 1980 to $14.3$ billion in 1985. The United States alone will be spending nearly $4.5$ billion on pesticides by the year 1985 (Farm Chemicals 1981). Thus our environment will remain under continuous pressure from the intensive applications of massive quantities of these toxic chemicals.

Pesticides reaching the soil, sediment or water ecosystems can be degraded by chemical or biological agents (Fig. 1). Biological and chemical decomposition of xenobiotic compounds in such environments are always influenced by the changes of many physicochemical forces such as pH, temperature, ion concentration and redox potential. Consequently, these toxic compounds are decomposed through photometabolism, oxidation, reduction, and hydrolysis: the sum total mechanism of both chemical and biological phenomena. However, it is difficult to differentiate these processes under natural environments unless supported by model laboratory studies.

For many years the fate and metabolism of pesticides in the environment were considered as a natural phenomenon, and only when their long-term presence led to many chronic toxicity problems and affected the food chain system was more extensive research directed to study the pathways of degradation under natural and laboratory conditions. Microorganisms are now believed to be the principal agents which can cleave and modify the complex lipophylic pesticide molecules, once considered recalcitrant to simple water-soluble products. This process has been shown to reduce the toxicity of the xenobiotics from 2 to 800 times (Munnecke et al. 1982). These water-soluble intermediates are usually attacked by primary or secondary group(s) of organisms to form inorganic end-products resulting in complete biode-

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1 Chemical names of pesticides mentioned in the text are indicated in the Appendix.

Microorganisms first attack these organic chemicals by the enzymatic apparatus acquired during the course of enrichment when they are exposed to these specific or structurally related compounds. Presence of these chemicals in the environment either induces or derepresses the enzymatic function of a microorganism (Dagley 1978). This capability largely depends upon the selective microbial community as well as on the structural and functional groups of the xenobiotic compounds. In many instances, when these parameters were carefully considered, novel microbial cultures were isolated for future industrial application.

The intent of this paper is to discuss the major microorganisms isolated and their involvement in insecticide metabolism in natural habitats and/or under laboratory studies. More emphasis will be given to the most commonly used organophosphates,