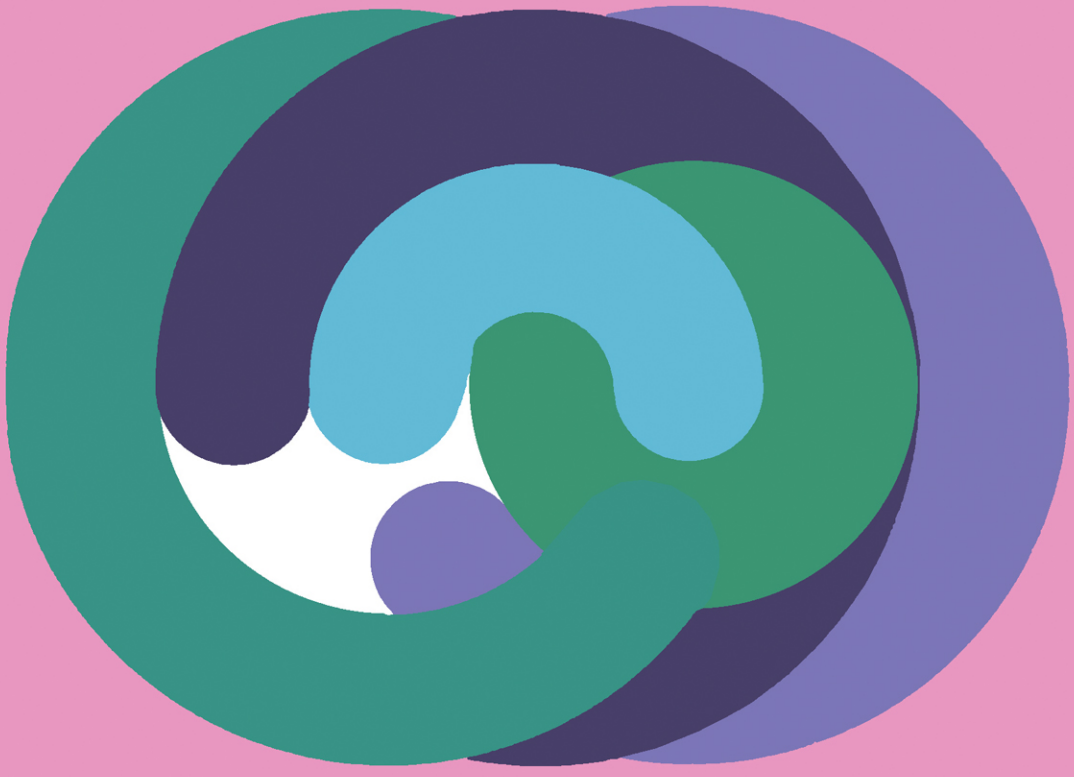
Fundamental aspects of pollution control and environmental science 5

PESTICIDES IN THE SOIL ENVIRONMENT

SHAHAMAT U. KHAN



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SHAHAMAT U. KHAN
Chemistry and Biology Research Institute
Research Branch, Agriculture Canada
Ottawa, Ont., Canada

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PREFACE

Chemicals for crop protection and pest control - known collectively as pesticides - are being increasingly used to ensure the production of adequate supplies of food and fiber. Some of these pesticides find their way into soils as a result of direct application or through indirect means. With the discovery that chlorinated hydrocarbon insecticides persist for years in soil, all pesticides are now being viewed with suspicion and concern by people interested in protecting our agricultural land from widespread pollution.

The extent and seriousness of the contamination of soils by pesticides still remains to be determined. Some environmentalists take the view that use of pesticides on agricultural soils should be reduced or banned because of the risk of uptake of these chemicals by crops and their subsequent incorporation into the food chain. On the other hand, agriculturalists and others argue that continued use of large quantities of pesticides is essential to the achievement of maximum yields. A reasonable alternative to these extreme views would be to first gain a better understanding of the behavior of pesticides in soils from the standpoint of the processes affecting these chemicals, and the implication of these processes on persistence, bioactivity and plant uptake. With this knowledge, the environmental impact of using a pesticide in agriculture could be assessed more accurately. This book, *Pesticides in the Soil Environment*, is an attempt to provide this kind of information by bringing together the available data on many aspects of the behavior and fate of pesticides in soils. It is hoped that it will serve as a text book for advanced courses, a reference volume for research workers and a source of detailed information for those who seek knowledge on the topic.

I will make no effort to acknowledge individually the many people who assisted me in proof reading, in the preparation of illustrations and the compilation of the indexes. To them I am grateful. I do wish, however, to express my appreciation to Mrs. Anneth Martin for her painstaking efforts in the final typing of the manuscript. My sincere gratitude is also expressed to the Chemistry and Biology Research Institute, Research Branch, Agriculture Canada, for providing opportunity and facilities to produce this book.

Finally, I must convey my deepest affection and appreciation to my wife Nighat and to my children, Saira and Zia, for their keen sense of understanding during the preparation of this book.

Ottawa, Ontario
December, 1979

Shahamat U. Khan

THE AUTHOR

SHAHAMAT U. KHAN is a Senior Research Scientist at the Chemistry and Biology Research Institute, Research Branch, Agriculture Canada, Ottawa. His research is concerned with the fate of pesticides in the environment.

He obtained a B.Sc. in Pure Science from Agra University, India, an M.Sc. in Chemistry from Aligarh University, India, and an M.Sc. and a Ph.D. in Soil Chemistry, both from the University of Alberta, Edmonton, Canada.

Dr. Khan belongs to numerous scientific societies and is a Fellow of the Chemical Institute of Canada and a Fellow of the Royal Institute of Chemistry (London). He is the Editor of the *Journal of Environmental Science and Health, Part B.*

He is the author or coauthor of more than 80 scientific research publications and has coauthored a previous book, *Humic Substances in the Environment* (1972) and coedited another book *Soil Organic Matter* (1978). In addition he has written a number of chapters in edited books and several review articles.

CONTENTS

Chapter 1

INTRODUCTION

Man has practiced some form of pest control since the beginning of agricultural times. The principles of seed treatment, fumigation and the use of certain preparations to kill unwanted pests were known to the ancient agriculturalists. Only in the last thirty years, however, has the use of chemical agents produced substantial benefits for mankind. Pesticides have controlled weeds, pests infesting economically important crops, vectors of human and animal diseases and have protected structures from damage. As the world's population increases so does the need for food and fiber production. Crop protection and pest control should therefore be continued and intensified.

Chemicals classified as pesticides have been used to some extent since ancient times. Arsenic was used by the Chinese in A.D. 900 to control garden insects. During the 17th century arsenic and tobacco were used as insecticides in the Western world. Beginning about 1870 the number of compounds available for use as pesticides increased gradually and equipment for applying these chemicals began to be developed. A recognizable acceleration in the rate of the introduction of pesticides began in 1924 with a still further increase in 1946. Some important insecticides were discovered during World War II, but these discoveries had far less to do with the war *per se* than is commonly assumed. Over the past three decades, increases in crop yields have largely been due to the production and use of enormous quantities of pesticides each year. The development of chemicals for crop protection can be attributed almost entirely to the pesticide industry. The phenomenal growth rate of the world pesticide industry over the past three decades is illustrated in Fig. 1.1. The value of pesticides produced in the world in 1974 is shown in Fig. 1.2 (Green et al., 1977). In 1971 $3.4 billion worth (retail) of chemical pesticides was applied on a world wide basis for agricultural (including forestry), industrial, and household use

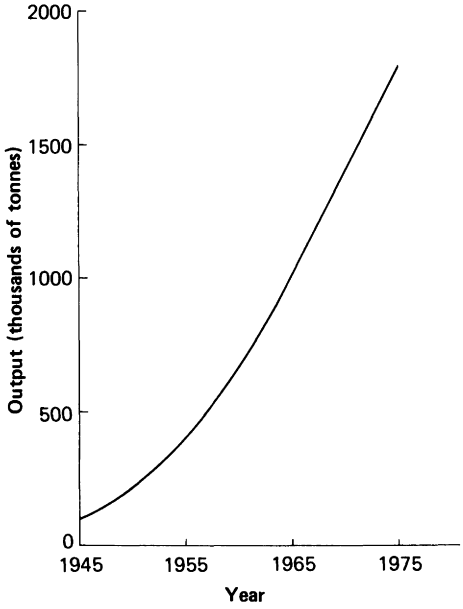

Fig. 1.1. Growth of world pesticide industry.

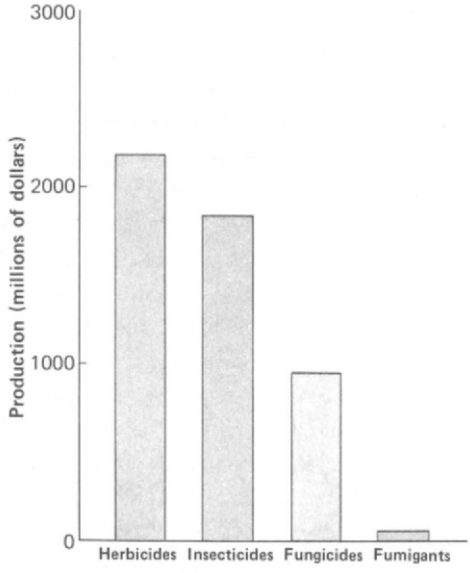

Fig. 1.2. Value of pesticides produced in the world in 1974.

(Anon., 1973). About half was used in the United States, where pesticide consumption has upsurged notably in the past 30 years. It is certain that the demand for pesticides will increase as the human population and its food and fiber requirements continue to grow. Table 1.1 shows the projected world demand and market forecast for pesticides based on price levels of the year 1975 (Green et al., 1977).

TABLE 1.1

Forecasts of world demand for pesticides

Chemical	Millions of dollars		
	1975	1980	1990
Herbicides	2300	3450	7700
Insecticides	1910	2390	3700
Fungicides	1035	1345	1880
Total	5245	7185	13280

In recent years the use of pesticides has grown impressively despite rising prices. For instance, in the United States the average value of all chemicals classified as pesticides increased at an average annual rate of 15.9% for the five year period 1972 to 1977, while sales of pesticides rose at an average annual rate of 26.3% for the same period (U.S. Dept. Agric., 1977). It is apparent that, in spite of increases in price, the use of pesticides can be expected to grow as an economic necessity. Pimental (1973) estimated that a $10 billion average loss in the United States in 1960 would have increased to $12 billion had pesticides not been applied. The cost of such pesticides, in 1966 for example, was $0.56 billion. Including application, the total cost was about $0.75 billion, representing nearly $3 saved for every $1 spent.

Despite the widespread use of pesticides, the U.S. Department of Agriculture estimated that in 1971, the agriculture industry in the United States alone, absorbed a loss of $10 billion annually owing to insects, weeds, plant diseases and nematodes. On the world level the losses to pest, plant diseases and weeds were estimated to exceed $70 billion (Marmet, 1977). Crop losses in less developed countries are judged to be greater than those in

the industrialized nations. Almost one half of the potential food production of the less developed countries in the tropics is lost due to the ravages of insects, plant disease organisms, weeds, rodents, birds, nematodes and others (Table 1.2). It has been estimated that cessation in the use of all pesticides in the United States would reduce total production of all crops and livestock by 40% and increase the price of farm products to the consumer by 50 to 70%.

TABLE 1.2

Losses of potential crop production by region (Glass, 1976)

Regions	% losses due to			Value of lost production $ millions
	Insect pests	Diseases	Weeds	
North and Central America	9.4	11.3	8.0	9837
South America	10.0	15.2	7.8	4561
Europe	5.1	13.1	6.8	11927
Africa	13.0	12.9	15.7	7735
Asia	20.7	11.3	11.3	27290
Oceania	7.0	12.6	8.3	476
USSR and People's Republic of China	10.5	9.1	10.1	8521

According to the census of Agriculture in the United States for 1974, the average cost of controlling pathogens was $20.03 per treated acre; nematodes, $16.50; insects in crops other than hay, $10.87; weeds in crops, $7.08; weeds in pasture, $3.17; insects in hay, $5.82; and for plant defoliation, $6.65 (U.S. Dept. Agric., 1977). Many farmers have been willing to spend money on pesticides because the investment has been profitable for them. It has been estimated that each dollar spent on pesticides in the United States produces an average of about $4 additional income for the farmer. It is, however, not possible to predict the value of the use of pesticides to individual farmers because of wide variations in types of crops, geographical locations, climatic conditions and the skill with which the chemicals are used. An optimistic view is that the increased use of pesticides will