Book review

Pesticide Chemistry and Bioscience: The Food-Environment Challenge:

The book is based on plenary and symposia lectures delivered during the IUPAC sponsored congress on Pesticide Chemistry in 1998 on the theme of ‘The Food-Environment Challenge’. The volume is sectioned into eight main topics covering chemical synthesis, mode of action, environmental fate and residues, risk assessment and regulatory aspects.

The first two chapters are the plenary lectures dealing with broader issues of food-environment challenge and essentially set the scene for the remaining sections of the book. The first paper deals with the question: How can technology feed the world safely and sustainably? Two aspects are discussed in detail: technological feasibility to feed the growing world population, and the impacts of political choices on adoption of technology. The paper highlights the challenges posed by the population growth, reaching 10 billion by 2040, requiring food production to increase three-fold. The author predicts, on the basis of advances in technology and especially biotechnology, namely availability of diverse range of chemistry for screens, combinatorial chemistry and high throughput screening capacity of agrochemical companies, that we shall meet the challenges of the future. Assuming, however, political will and adoption of new technologies such as genetically modified food and organisms.

The second plenary paper deals with the aspects of ensuring safety through regulatory perspective. The authors emphasizes that while caution and precautions are needed in evaluation and use of pesticides, the regulations should be formulated giving adequate consideration to the cost benefit analyses, as regulation does not necessarily generate safety. This very well written and witty paper cites examples where the public perception is not based on facts. The author makes a strong point that despite several cases of serious consequences of natural chemicals, the public appears to prefer ‘natural toxicity to synthetic safety’.

The next three chapters written by experts in synthetic chemistry deal with technological development of new pesticides, based on structure-activity relationship, essentially gazing into crystal ball and describing the type of chemistry which will be harnessed by industry to develop new more specific and environmentally friendly chemicals of the 21st century. Chirality and structure-guided pesticide design using combinatorial chemistry are discussed in detail in two separate papers. Both of these aspects are predicted to underpin the design of future pesticide molecules. The paper on chirality gives an elaborate account of the topic giving some 18 schemes of synthetic methodology. The paper on combinatorial chemistry points out ‘the revolution sweeping through pharmaceutical industry’ for drug design driven by genomics, high throughput screening and use of combinatorial chemistry. The authors argue strongly the need of adoption of this paradigm by agrochemical industry. Another paper sandwiched between these two does essentially the crystal-ball-gazing to predict the herbicide discovery in 21st century. The use of transgenic herbicide resistant crops, use of natural products, combinatorial chemistry, biological weed control is predicted to increase in future. In my opinion this paper would have been better placed after the earlier mentioned two on this aspect.

The third section of the book has four papers devoted to pesticide delivery. The aspects discussed in
this section include impact of biotechnology, innovations in spray technology, formulations for modern agriculture and optimisation of delivery through better understanding of foliar penetration of pesticides. The paper on impact of biotechnology gives a comprehensive overview of use of recombinant plants as delivery systems of pest control. It not only discusses the plants for delivering insecticide proteins, herbicide resistance, antiviral, antifungal, antinematode compounds, but also covers the concerns over transgenics. In addition to plants, insecticidal baculoviruses are given a good coverage in this paper. The second paper in this section deals with state of the art plant protection equipment employed in field for tall growing crops, such as fruit crops. The paper deals with technological advances in sprayers and nozzles and highlights the need for standardization and testing and certification of plant protection equipment. There is some very useful data on spray drifts included in this paper, which will be valuable for those trying to minimise with spray drift. The future product forms of pesticides are discussed in the third paper in the section. It discusses traditional, current and emerging technology in product forms. It forecasts increased use of plants as delivery systems, impregnated biodegradable carriers (polymers), novel structured fluids (reversible gels) and triggered (by temperature, humidity at right time) release products in future. The fourth paper demonstrates how modeling can help optimise the penetration of pesticides through cuticular membranes by choosing right adjuvants.

Natural products as pesticides are the focus of the next section in the book. Spinosyns (macrocyclic lactones produced by actinomycetes); synthons (enzyme inhibitors from carbohydrate chemistry), antimicrobial compounds from genetically modified bacteria, and phytoalexin (antimicrobial compounds in the defence force of plants) are four group of natural products deal separately in four different chapters in this book. These papers show how nature’s own rich sources can be used to provide us pesticides of future. It would be interesting to know how the public will view such ‘natural and therefore safe’ chemicals in comparison to ‘synthetic, more specific and effective chemicals’ of the future.

The herbicide and insecticide resistance and the need of new compounds to deal with this issue are covered in the book by four papers in the section on mode of action and resistance. The first paper in this section presents a prognosis for discovering new herbicide site of actions. To manage resistance, new sites of action (SOA) are needed. Apparently, out of some thousands of possible enzyme targets only 11 have been discovered so far. The tools of ‘chemical revolution’ described earlier should facilitate search of new SOAs. The next paper in this section also deals with potential target sites, specifically ABC transporter proteins (that help protect plant or other organisms against toxic compounds), which can play an important role in plant pathogenesis and fungicide sensitivity and can lead to discovery of new pesticides. Another paper in this section deals with insecticide resistance and focuses on resistance due to reduced target site sensitivity and its relationship to mode of action and new product discovery. Molecular approaches to discover new fungicides acting on the infection process of fungi is covered in the final paper of this section. Molecular and genetic studies of plant fungal pathogenicity together with high throughput screening is likely to lead new discoveries in this area.

The section on metabolism of pesticides in plant and animals discusses integrated pathways of herbicide detoxification with a paper focussing on role of cytochrome P450s and other enzymes in metabolism of xenobiotics. Need of understanding of enzymology and genetic manipulation of plant herbicide metabolisms has been highlighted. One paper discusses the metabolism of azoxystrobin fungicide in plants, animals and its fate in soil, which is important from the standpoint of its environmental impact.

After the first six sections largely devoted directly or indirectly to the discovery of new safer pesticides of future, the book contains three sections dealing with environmental fate, residues in food and environment and regulation and risk assessment aspects. In the environmental fate section, leaching, landscape level environmental modelling and how to integrate the information on fate and effects of pesticide on environment for risk assessment have been discussed. Commonality in these three papers is the description of processes governing the environmental fate and modeling of these processes. A short account of (and the references to) the activities on coordination of pesticide fate models and their use in European Union (FOCUS) and in USA (ECOFARM) will be most useful for any model user. It is good to see
the importance of probability modeling and need for uncertainty analysis highlighted through an example. New approaches of ecological risk assessment based on probabilistic methods to characterize exposure and effects are discussed nicely with some good illustrations in a separate paper. This paper also points out the need of collection of environment chemistry data differently. Slightly different in nature, the final paper in this section presents an Australian perspective of environmental fate. Two case studies (cotton and forestry) on better management of pesticide use to minimise off-site impacts has been discussed in this section. The only criticism of this section is that surface water transport pathways and their modeling, despite their importance, have not been received same degree of attention as leaching aspects.

The issues of residues in food and water, monitoring, methodology and QA/QC aspects have been covered in a separate section based on five papers. The first paper in this section provides a comprehensive treatment of QA/QC requirements for reliable analysis, including quality guidelines (ISO and EN) and standards (CODEX), good laboratory practices (OECD GLP) principles, and total quality management. Importance of sampling methods, sample preparation, calibration curves and recovery analysis in producing reliable and defensible residue data is highlighted. This paper provides most practical and useful information for analysts and laboratory managers, as well as those dealing with pesticide residue issues. Advances in pesticide residue analytical methodology is the topic of another paper, in which extraction, separation and detection of residues by liquid and gas chromatography as well as immuno-chemical techniques have been described. The analytical methods employed by European Countries for residue monitoring of priority pesticides is something that can serve as a useful guide. A subsection in the paper deals with treatment processes for removal of residues from water. An area of great economic and environmental importance, i.e. residues detected in food exports from developing countries, has been reviewed in another paper. The review list pesticides which have commonly been detected in exported food originating from different regions. It contains a list of pesticides with major risk in international trade. The review is most relevant, as the real ‘Food and Environment Challenge’ facing us indeed exists in developing countries. In a separate paper in this section, the link between pesticide residues and consumer has been explored. The last section of the book contains three papers on benefit cost, risk and risk management aspects. In the first paper the benefits of pesticides have been described in the light of losses due to different pests in different regions, providing tabular data on losses. The risk management issue has been discussed in another paper, especially in the light of Food Quality Protection Act 1996 in USA and the directions USEPA is taking in managing the risk. Key issues facing risk managers have been identified. Last paper in this section and indeed of the book is on ‘Pesticides in Food’. Public concerns, perceptions and relative risk due to pesticide residues in food have been discussed. Several tables in this chapter contain data on detection and violation of maximum residue levels (MRLs) due to pesticide residues in EU, USA and also developing countries. Included in this are examples from the UK where monitoring programs have shown residue problem. A more appropriate place for the paper was perhaps in the section dealing with residues in food and environment.

In summary, the book covers comprehensively the issue: ‘Food-Environment Challenge’. The major emphasis of the book is on synthesis of new chemicals and, as we enter new millennium, equipped with biotechnological tools and capacities to screen hundreds of thousands of chemicals in a year. After reading the book, I felt a lot more optimistic about the potential discovery of new pesticide chemicals, possibly natural compounds, with new sites and mode of actions, formulated in innovative ways not only to minimize the adverse impact on food and environment but also in a cost effective way. It is carefully organized, very well produced (except in the copy I have the print quality of last paper was slightly inferior to others) and is free from errors. The comprehensive index makes it easier to find information of interest.

A range of issues covered in the book and a wealth of information presented has a wide appeal and would prove to be a useful resource for not only IUPAC clientele but also for anyone interested in pesticide issues in food and environment.

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