INTERNATIONAL PERSPECTIVES FOR THE SAFETY EVALUATION OF PESTICIDE RESIDUES IN FOOD: TOXICOLOGICAL EVALUATION AND DIETARY EXPOSURE

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INTRODUCTION

Pesticide chemicals resemble human and veterinary drugs in many respects. In the first place, like most human and veterinary drugs, they are xenobiotic, i. e. chemical entities that are foreign to living organisms. Secondly, they are designed to protect the life of animals and plants, including humans.

Likewise, there is a close similarity between the toxicity involving human and veterinary drugs and that involving pesticide chemicals. A real difference among these chemicals is only semantic, that is to say: if a drug elicits untoward effects, the term of choice is generally overdosing or side-effect, if, instead, the same happens with a pesticide the preferred words are intoxication or contamitation.

Toxicologically there is no dissimilarity between drugs and pesticides. The variance consists in the different applications and targets.

With the increasing popularization of science and technology and the worldwide employment of synthetic chemicals in every instance of modern life, many of the fundamental concepts involving safety and risk tend to go astray in the mind of the learned as well the unlearned. The results of this situation are suspicion, fear and confusion from the part of the unlearned, and easy generalizations and ambiguities from the part of the learned.

The ubiquitousness of the word "contamination" is a representative example of this state of affairs. Everyone is using the term but nobody ever

attempted to arrive at one satisfactory definition. In particular when the word is used in connection with "toxicological aspects" of pesticide residues there is certainly a need to well characterize its meaning.

Since the problems entailing pesticide safety and toxicology are much the same all over the world, in dealing with human health and pesticide residues in food crops this paper will be internationally oriented.

BACKGROUND

At the beginning of the Twentieth Century, the major causes of mortality and morbidity in all countries of the world were infectious diseases. Scientific advances and the improvement of socioeconomic factors -such as better nutrition and sanitary conditions and immunization- have reduced the incidence of serious infectious diseases to the point that today the major health concerns in industrialized and many developing countries have shifted to chronic, degenerative diseases of complex etiology such as cardiovascular diseases and cancer. With this change in emphasis, increasing concern is being raised about the role to chemicals in the food supply in causin these degenerative diseases.

The individual person has only a limited capability of controlling his or her exposure to chemicals. For this reason governments, public health institutions, pesticide, drug and food producers must take suitable measures to ensure that their products are safe and wholesome at the proposed level of use. Such assurance is dependent upon knowledge of the toxicological and other effects of individual substances added to or found in food. This entails the development and interpretation of scientific data in order to create a logical platform for administrative and legal decision. A necessary condition for the protection of a country's consumers is that a regulatory framework is in place that converts risk assessment into sound public health policy.

The matter becomes complex when these concepts are put in the practice and institutions are created to carry out these tasks. In some countries, risk assessment and risk management are kept within the same institutional system; in others, they are scattered throughout two or more systems. The final outcome often results in an array of divergent national approaches that are difficult to apply in situations affecting the safety of pesticide residues in food. Harmonization is by and large lacking.

PESTICIDE RESIDUES IN FOOD SHOULD BE CONSIDERED CONTAMINANTS?

The most obvious interpretation for what is meant by "contamination" is when someone finds that something undesirable is where it shouldn't be, and he wonders where it may come from. Answering these questions is a first step. Technically, it should not be difficult to qualitatively solve problems of "contamination" to everybody satisfaction: analytical chemistry and elementary biology may suffice. If dioxins are found in milk stored in paper containers and the paper containers are produced by paper-mills that still use outdated water chlorination processes it should not be hard to determine where the "contamination" originated. If a watersoluble fungicide used on crops seeps into nearby drinking water supplies it should likewise be easy to detect and identify the "contamination" source. If a canned soup contains botulism toxins, the instance may be traced back to faulty food processing. Knowledge and know-how are available.

The subsequent step of combining analytical results with toxicological knowledge in order to define potential human and environmental health significance of "contamination" events may prove to be more arduous. At this point the obvious questions may be as follows: What is the toxicological significance for instance, of 3 ppt dioxins found in milk? or what is the toxicological significance of traces of a fungicide found in drinking water?. The "contamination" findings will become real problems of contamination only when there are convincing supporting toxicological and exposure data that permit to conclude so. When toxicological knowledge on the agent in question is just not available, then the exercise turns into a guessing game in which politics, not science, may play a role.

How many of these considerations related to common food contaminants can be applied to pesticide residues in food crops?

In a sense, all of them can be applied, with the overall appreciation that pesticide residues are not by definition common food contaminants even if there are situations in which they may be so considered. If a residue is the result of a direct use of a chemical for plant protection or other related purposes the tendency is not to call it a food contaminant. In the worse of cases it could be considered as an unavoidable food contaminant.

Contamination related to chemical entities must be identified, quantified and toxicologically assessed. As indicated, identification and quantification are relatively easy to establish while risk assessments very often leave margins of uncertainties. Consequently, diverging national "safe" and legal limits exist for same chemicals that may be potential agents of contamination (including pesticides) in air, food, water and the environment. Divergent national limits (generally expressed in part per million, ppm) have caused and still cause serious international and inter-country problems inclusive the hampering of worldwide food trade.

Historically, these problems have triggered the initiation of a trend toward harmonization.

Many countries, after a period of frustration and disillusionment in which their efforts were wasted to construct feeble bilateral agreement, decided to address the issue in a wider and more fundamental way. To this end, during the past 30 years they have turned their attention toward already-existing international organizations whose mandate included the promotion of human health, nutrition, agriculture, food production, chemical safety and environmental protection, namely the World Health Organization (WHO) and the Food And Agriculture Organization of the United Nations (FAO).

During this period important international programs and activities on the safety of air, water, food and environment have been initiated and keenly supoorted by FAO and WHO Member States. Among them there are the Joint FAO/WHO Expert Committee on Food Additives (JECFA) (1.955-1.991), the Joint FAO/WHO Meeting on Pesticide Residues (JMPR) (1.961-1.991), the Joint FAO/WHO Food Standards Programme (1.963-1.991), the IARC Program to Evaluate the Carcinogenic Riks of Chemicals to Humans (1.969-1.991) the UNEP International Register of Potentially Toxic Chemicals (IRPTC) (1.974-1.991) and the Joint ILO/UNEP/WHO International Program on Chemical Safety (IPCS) (1.980-1.991).

These international programs are responsible for developing the necessary sound technical support in preventing and solving problems that may arise from chemical contamination of food, air, water and environment.

TECHNICAL SUPPORT FOR ASSESSING AND CONTROL OF RESIDUES

Pesticide residues in food and the environment have been in the focus of international attention for many years. The JMPR has been meeting yearly to provide advice to FAO and WHO Member States and to the Codex Alimentarius Commission (CAC), primarily through the Codex Committee on Pesticide Residues (CCPR). The FAO Panel of Experts on Pesticide Residues in Food and the Environment review pesticide use patterns (good agricultural practices), data on the chemistry and composition of pesticides, and methods of analysis for pesticide residues and estimates the maximun residues levels (MRLs) that might occur on food commodities as a result of the use of pesticide according to good agricultural practices. The WHO Expert Group on Pesticide Residues review and evaluate the toxicological and related data and estimates, when possible, acceptable daily intakes (ADIs) for the pesticides on their yearly agenda. The FAO Panel of Experts and the WHO Expert Group meet separately during most of the Meetings to review and evaluate their respective data; they meet in plenary sessions to resolve common problems and to produce the joint report. During the nearly 30 years that JMPR has been meeting, most of the commonly used pesticides have been toxicologically evaluated.

The results of the evaluations carried out by the JMPR are contained in about 60 FAO/WHO publications (see APPENDIX I).

In addition to this extensive international information on pesticide residues in food developed by the JMPR together with an internationally-reputed safety and toxicological assessment of pesticides most commonly used, the ILO/UNEP/WHO International Program on Chemical Safety (IPCS) has generated a series of *Environmental Health Criteria (EHC) documents and Health and Safety Guides-on* a variety of chemicals including some pesticides used in public health and agriculture (see APPENDIX II).

The Environmental Health Criteria (EHC) documents produced by the IPCS include an assessment of the effects on the environment and on human health from exposure to a chemical or combination of chemicals, or physical or biological agents. They also provide guidelines for setting exposure limits. On the other hand, the *Healt and Safety Guides* has the purpose of facilitating the application of these guidelines in national chemical safety programs. The

first theree sections of a *Health and Safety Guide highlight the relevant technical information in the corresponding EHC.* Section 4 includes advice on preventive and protective measures and emergency action. The target readership includes people in the occupational health services, ministries, government agencies, industry, and trade unions, who deal with the safe use of chemicals (including pesticides) and the prevention of environmental health hazards, and those workers who want more information on this topic. An attemps has been made by the IPCS to use only terms that will be familiar to the intended user. However, sections 1 and 2 inevitably contain some technical terms. A bibliography has been included for readers who world like to have further background information.

Furthermore, IPCS has recently updated a comprehensive classification of pesticides by hazard (WHO/IPCS, 1.990) and a special review of the principles for the safety assessment of pesticide residues in food (WHO/ IPCS, 1.990a). In turn, the UNEP International Register of Potentially Toxic Chemical maintains and updates information on the current national regulatory status of pesticides in its Legal File and data-base.

The International Agency for Research on Cancer (IARC) occasionally publishes monographs dealing with the evaluation of the carcinogenic risk of some pesticides (see APPENDIX III).

As previously noted, the toxicological evaluation and safety assessment of chemicals of social, economic and commercial importance (such as pesticides) represent the most critical contributions for the prevention of human health and for the control of chemical contamination.

To ignore the results of these international contributions and their impact on a system of pesticide management for which internationally agreed actions are required to coordinate regional, national and international activities in this field would be a serious mistake. On the other hand, a proper familiarity with them will be of great benefit to all the sectors involved, regulators, producers, users and consumers.

Since the international conclusions and recommendations in this field are based on the concept and praxis of toxicological and safety evaluations it would be expedient to know more about them.

TOXICOLOGICAL AND SAFETY EVALUATION OF PESTICIDES

The development of modern toxicology has brought about a bagful of new words and expressions. Many of these are completely new. For instance the term "xenobiotic" has only recently found its place in dictionaries. Others, for example "safety evaluation" or "toxicological evaluation", are expressions made up of words but whose semantics go beyond the conceptual meaning of the individual words. For reason of convenience and clarity many treatises and books dealing with subjects in modern toxicology contain a special section called "glossary of terms" in which the expressions and words used in the context of the book are explained. "Safety" and "toxicological evaluations" are key expressions of modern pesticide toxicology and they deserve a special explanatory treatment.

Among the known chemicals there are substances that are found naturally and substances that are man-made. No matter if a substance is found naturally or it is man-made, under the point of view of human, animal, environmental health, they may or not be xenobiotic, i.e. they may be part of or utilized by the human and living organisms or they may be totally extraneous to them (xenobiotics). The fact of a susbstance (as most pesticides) being a xenobiotic should not be taken as if the substance is potentially harmful to human, animal or environmental health or welfare.

There are practically no arguments on the above overall views of moderns toxicology since there is an elegant sufficiency of data supporting these opinions. There is, however, a remarkably important point not to be missed on the subject of natural, man-made, xenobiotic, dangerous or beneficial chemicals. This point is typified by the *amounts* of the chemical that come into contact with the living organism and by the ability of the organism to cope with them. To cite an instance, the ingestion of exaggerated quantities of vitamin A over a prolonged period of time may be more dangerous to the human organism than the occasional ingestion of small amounts of methyl mercury contained in certain fish served at the restaurant table. In other words, too much of a "good thing" may be riskier to the health of the consumer than small quantities of "bad things", will all due attention to the relative length of exposure.

In order to understand which substances are potentially good or bad, and to advise on the necessary acceptable and tolerable amounts of exposure

to humans, animal and other living organisms, safety and toxicological evaluations are carried out.

Evaluations of this type are designed to proceed step-wise. The first essential step involves the production of adequate experimental and epidemiological data that will ensure the development of basic knowledge on the chemical and biological characteristics, as well as toxicological behavior of the chemical. Ideally, these data should be able to answer questions such as: 1) is the substance under study an essential component of living organisms; 2) is it transformed by the intermediary metabolism into a substance which can be utilized or easily disposed off by a living organism; 3) does it show any structural similarity with other substances whose toxic potencial has already been clarified; 4) is there any comparable situation with the metabolism of the test system and that of humans; 5) what is the substance target organ; 6) is the substance mutagenic, teratogenic, carcinogenic, neurotoxic, nephrotoxic, etc. to the test system; if yes, at which dose level; 7) are the observed effects reversible or not; 8) are the effects observed when the substance is ingested, inhaled or absorbed through the skin? The list of questions may proceed to zed when human data are to be required or when target organisms others than the human are taken into consideration or environmental aspects are at stake. The substance may be proved to be an essential element, an essential nutrient, a xenobiotic, an inert entity, a mutagen, a teratogen, a carcinogen, a neurotoxic... anything. Then further development of scientific data should be able to tell at which *amount(s)* the substance is able to elicit its effects. When this is possible, the process of data generation should be considered as having done its job, that is to say, it has been able to generate the necessary information for establishing a "no-effect level" or, in its absence, for the recommending further research, or, again, for recommending the discharging of the substance altogether.

The second step of the procedure is represented by a judgmental exercise. It implies the operation of examining if the data developed are valid in terms of methodology and good scientific practice, the interpretation of the data on all counts and, finally, the reaching of conclusion on the "safe level(s)" at which the substance is essential for, or, acceptable or tolerable by the human and other living organisms (toxicological evaluation). This second step may go further since it may be necessary to recommend amounts of the substance which can be allowed or tolerated in the enrironment at large - food, water, air and soil - on the basis of predicted exposure (safety evaluation).

Science stops here. From this point onward, the societal fate and approval destiny of the substance will be in the hands of public perception, often expressed in terms of politics, legislation, enforcement, or consumers' whims.

Toxicological and safety evaluations of chemicals in general, and pesticide chemicals in particular, requiere the sustaining efforts of a large number and variety of specialists in the toxicological disciplines. Internationally, this task was and is carried out by a selected group of experts who act in a personal capacity giving free of their time and effort to protect human and environmental health and to foster international agreement under the aegis of international organizations such as FAO, ILO, UNEP, WHO technically and financially supported by their Member States.

PESTICIDES AND ENVIRONMENTAL RISK

The Codex Alimentarius Commissions does not consider pesticide residues in food crops as food contaminants when their levels are within the maximum recommended level. There are several reasons for this position. In the firts place, pesticides are necessary in food production and secondly, they should be applied according to good agricultural practice. It follows that pesticides are potential contaminants only when they are being misused. The same concept, of course, could be applied to human and animal drugs. Why, then, whenever an environmental problem arises such as mass avian mortality, pesticides are the first causes to be pointed at?. The answer to this question goes beyond the scope of this paper. However, it should be helpful to interpret the notes of Peter Sandman on environmental risk communication published by the U.S. Environmental Protection Agency (US/EPA, 1.986) where he/she may find enough thoughts to come to their own conclusions. The notes have to do with communication systems. Here are the headings of Sandman's main ideas: a) environmental risk is not a big story; b) politics is more newsworthy than science; c) *repoters* covers viewpoints, not "truths"; d) the risk story is simplified to a dichotomy; e) *reporters* try to personalized the risk story; f) claims of risk are ussually more newsworthy than claims of safety; g) *reporters* do their jobs with limited expertise and time; h) risk perception is a lot more than mortality statistics; i) moral categories mean more than risk data; j) policy decisions are seen as either risky or safe; k) equity and control issues underlie most risk controversies; l) explaining risk

information is difficult but not impossible, if motivation is there; and m) risk communication is easier when are seen as legitimate.

The only remark to these notes is that, in view of the polarization of today science, the name *reporters* can be in many instances replaced by that of *science operators.*

DIETARY EXPOSURE TO PESTICIDE RESIDUES

National authorities have the responsibility and obligation to ensure that toxic chemicals, such as pesticides, are not present in food at levels that may adversely affect the health of consumers. Countries may set legal limits for pesticide residues in food and monitor compliance with such limits. This type of monitoring and food control is essential for consumer protection.

At the same time, government need to assess public health risks arising from the presence of toxic chemicals in food consumed in their countries.

To ascertain whether a consumer is at risk or not, it is necessary to estimate the actual dietary intake of a contaminant for comparison with Acceptable Daily Intakes (ADIs). Obtaining such an estimate is also important in determining whether there is a relationship between any observed effects in humans and the intake of a particular contaminant. The estimation of the actual dietary intake of pesticide residues in food as a measure of exposure is thus indispensable for risk assessment.

Pesticide residues intake estimates are equally critical for making sound decisions in the regulation of pesticides and food safety. If the actual intake of a toxic pesticide is found to approach or exceed the ADI, national authorities should evaluate whether the use of the pesticide may be to be restricted or eliminated. Dietary intake studies will provide the information that will indicate whether existing limits for pesticide residues in foods should be reviewed. If periodic estimates of actual exposure to pesticide residues are found to be below the ADI, health authorities and the citizens of the country are assured of the safety of the current food supply with respect to these substances. The basic, practical approaches for carrying out dietary intake studies are described in the FAO/UNEP/WHO Guidelines for the Study of Dietary Intakes of Chemical Contaminants (FAO/UNEP/WHO, 1.985).

Similarly, dietary pesticide residues intake estimates are necessary for reaching a conclusion as to acceptability of Maximun Residue Limits (MRLs) established by national or international control authorities. The approaches used internationally to this purpose are described in the FAO/UNEP/WHO Guidelines for Predicting Dietary Intake of Pesticide Residues (FAO/WHO/ UNEP, 1.989) The options for the prediction of dietary intake of pesticides residues are shown in Fig 1. They are as follows:

THEORETICAL MAXIMUM DAILY INTAKE (TMDI)

The TMDI is a prediction of the maximum daily intake of a pesticide residue, based on the assumption of MRL levels of residues in food and average daily food consumption per person. The TMDI is expressed in milligrams of residue per person.

ESTIMATED MAXIMUN DAILY INTAKE (EMDI)

The EMDI is a prediction of the maximun daily intake of a pesticide residue based on the assumption of average daily food consumption per person and maximun residues in edible portion of a commodity, corrected for the reduction or increase in residues resulting from preparation, cooking, or commercial processing. The EMDI is expressed in milligrams of the residue per person.

ESTIMATED DAILY INTAKE (EDI)

The EDI is a prediction on the daily intake of a pesticide residue based on the most realistic estimation of residue levels in food and the best available food consumption data for a specific population. The residue levels are estimated taking into account known uses of a pesticide, the range of contaminated commodities, the proportion of a commodity treated, and the quantity of contaminated home-grown or imported commodities. The EDI is expressed in milligrams of the residue per person.

The procedures described start with the most exaggerate and proceed towards more and more realistic intake predictions. Is should be noted that the less realistic predictions, which are relatively straightforward to carry out, give an overestimate of the true pesticide intake. By starting with the most exaggerated prediction, it is therefore possible to eliminate at an early

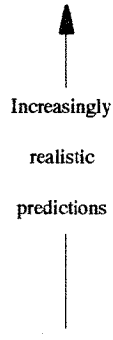
stage pesticides whose intake is clearly unlikely to exceed the ADI. More realistic predictions using refined data then make it possible to climinate other pesticides from further consideration.

Such an approach would facilitate acceptance Codex Alimentarius MRLs for the majority of pesticides and allow the national authority concerned to direct its attention to those most likely to be of public health concern.

Table 1 supplies an example for calculating TMDI, and Table 2 gives an example of calculation of EMDI. Fig. 2 depicts how predictions could be used to assess the safety of pesticide residues by comparison with ADI and to gauge the acceptability of Codex Alimentarius MRLs.

FIGURE 1

Options for the prediction of dietary intake of pesticide residues



1	Measured pesticide residue intake
2	"Best estimate" - estimate daily intake (EDI)
3	"Intermediate" - estimated maximum daily intake (EMDI)
4	"Crude estimate" - theoretical maximum daily intake (TMDI)

FIGURE 2

Schematic representation of the relationships between relevant factors used in the guidelines

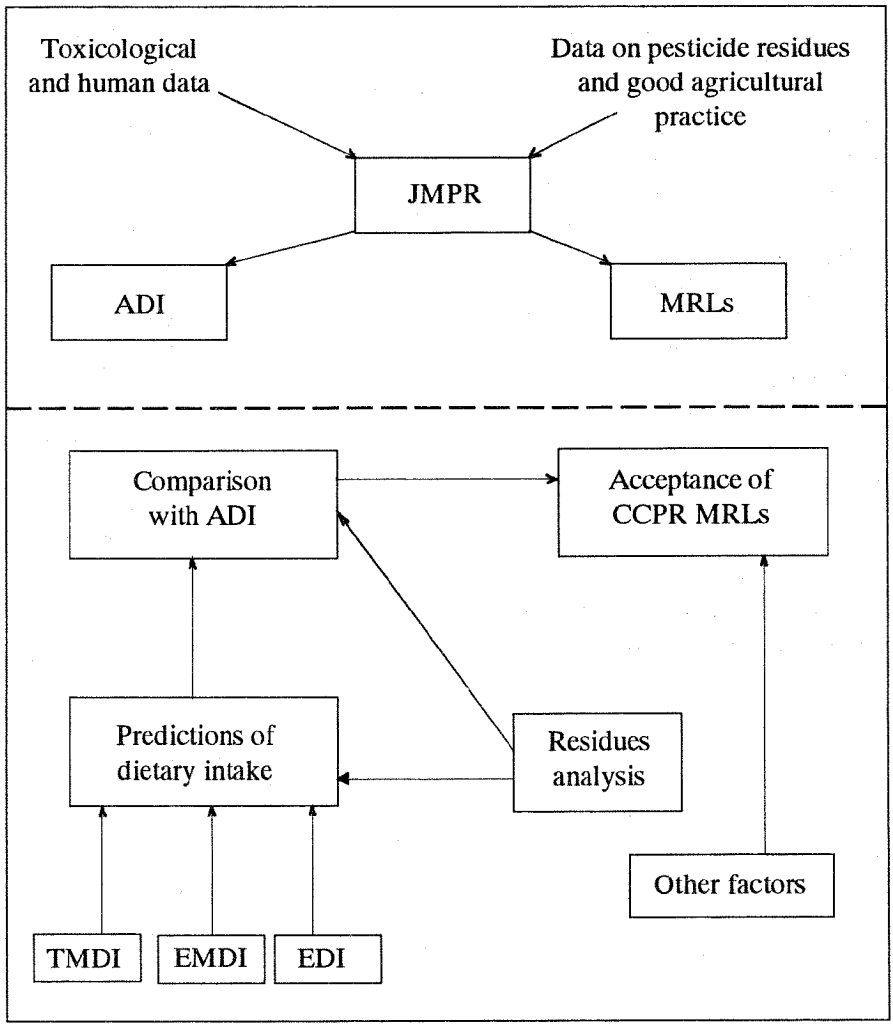


TABLE 1

Calculation of TMDI (ADI for pesticide X= 0.02 mg /kg of body weight)

Commodity	*Food consumption (kg per person per day)*	*MRL (mg/kg)*	*TMDI (mg/ person)*
Wheat	0.11	5	0.55
Rice	0.22	5	1.10
Apples	0.04	2	0.08
Bananas	0.08	1	0.08
Citrus fruits	0.03	5	0.15
Cabbage	0.10	0.5	0.05
Lettuce	0.02	0.5	0.01
Potatoes	0.40	0.2	0.08
Cattle meat	0.20	0.05[a]	-
Milk	0.30	0.01[a]	-
Total			2.10 (0.035 mg/kg body weight)[b]

a At or about the limit of determination.
b Equivalent to 175 % of the hypothetical ADI.

TABLE 2

Calculation of EMDI (ADI for pesticide X= 0.02 mg/kg of body weight)

Commodity	*Processed commodity*	*Food consumption (kg per person per day)*	*Residue level (mg/kg)*	*Processing factor*	*Cooking factor*	*EMDI (mg/person)*
Wheat	Bread	0.11	5	0.16	0.038	0.003
Rice	-	0.22	5	1	0.14	0.154
Apples	-	0.04	2	1	1	0.080
Bananas	Edible flesh	0.08	0.05	1	1	0.004
Citrus fruits	Edible flesh	0.03	0.1	1	1	0.003
Cabbage	-	0.10	0.5	1	0.5	0.025
Lettuce	-	0.02	0.5	1	1	0.01
Potatoes	-	0.40	0.2	1	0.5	0.04
Cattle meat	-	0.20	0.05[a]	-	-	-
Milk	-	0.30	0.01[a]	-	-	-
Total						0.319 (0.005 mg/kg body weight)[b]

a At or about the limit of determination.
b Equivalent to 25 % of the hypothetical ADI.

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APPENDIX I
LIST OF JMPR DOCUMENTS

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FAO/WHO (1.975a). Pesticide residues in food. Report of the 1.974 Joint Meeting of the FAO Working Party of Experts on Pesticide Residues and the WHO Expert Committee on Pesticide Residues. FAO Agricultural Studies, No. 97; WHO Technical Report Series, No. 574.

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FAO/WHO (1.983a).Pesticide residues in food - 1.982. Report of Joint Meeting of the FAO Panel of Experts on Pesticide Residues and the Environment and the WHO Expert Group on Pesticide Residues. FAO Plant Production Paper, No. 46.

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FAO/WHO (1.984). Pesticide residues in food - 1.983. Report of Joint Meeting of the FAO Panel of Experts on Pesticide Residues and the Environment and the WHO Expert Group on Pesticide Residues. FAO Plant Production and Protection Paper, No. 56.

FAO/WHO (1.985a). Pesticide residues in food: 1.983 evaluations. FAO Plant Production and Protection Paper 61.

FAO/WHO (1.985b). Pesticide residues in food - 1.984 Report of Joint Meeting of the FAO Panel of Experts on Pesticide Residues and the Environment and the WHO Expert Group on Pesticide Residues. FAO Plant Production and Protection Paper, No. 62.

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FAO/WHO (1.986a). Pesticide residues in food - 1.985. Report of Joint Meeting of the FAO Panel of Experts on Pesticide Residues and the Environment and the WHO Expert Group on Pesticide Residues. FAO Plant Production and Protection Paper, No. 68.

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FAO/WHO (1.986e). Pesticide residues in food: 1.986 evaluations. Part I - Residues. FAO Plant Production and Protection Paper 78.

FAO/WHO (1.987a). Pesticide residues in food: 1.986 evaluations. Par II - Toxicology. FAO Plant Production and Protection Paper 78/2.

FAO/WHO (1.987b). Pesticide residues in food - 1.987. Report of Joint Meeting of the FAO Panel of Experts on Pesticide Residues and the Environment and the WHO Expert Group on Pesticide Residues. FAO Plant Production and Protection Paper, No. 84.

FAO/WHO (1.988a). Pesticide residues in food: 1.987 evaluations. Part I - Residues. FAO Plant Production and Protection Paper 86/1.

FAO/WHO (1.988b). Pesticide residues in food: 1.987 evaluations. Part II - Toxicology. FAO Plant Production and Protection Paper 86/2.

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FAO/WHO (1.988d). Pesticide residues in food: 1.988 evaluations. Part I - Residues. FAO Plant Production and Protection Paper 93/1.

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FAO/WHO (1.990a). Pesticide residues in food: 1.989 evaluations. Part I - Residues. FAO Plant Production and Protection Paper 100.

FAO/WHO (1.990b). Pesticide residues in food: 1.989 evaluations. Part II - Toxicology. FAO Plant Production and Protection Paper 100/2.

FAO/WHO (1.990c). Pesticide residues in food - 1.990. Report of Joint Meeting of the FAO Panel of Experts on Pesticide Residues and the Environment and the WHO Expert Group on Pesticide Residues. FAO Plant Production and Protection Paper, No. 102.

APPENDIX II
LIST OF IPCS PUBLICATIONS ON PESTICIDE CHEMICALS

ACRYLONITRILE
WHO/IPCS (1.983) Acrylonitrile. Environmental Health Criteria No. 28. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

ALDICARB
WHO/IPCS (1.991) Aldicarb. Environmental Health Criteria No. 121. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

ALDRIN AND DIELDRIN
WHO/IPCS (1.989) Aldrin and dieldrin Environmental Health Criteria No. 91. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

ALLETHRINS
WHO/IPCS (1.989) Allethrins. Environmental Health Criteria No. 87. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

CAMPHECHLOR
WHO/IPCS (1.984) Camphechlor. Environmental Health Criteria No. 45. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

CARBAMATE PESTICIDES
WHO/IPCS (1.986). Carbamate pesticides. A general introduction. Environmental Health Criteria No. 64. International programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

CARBON DISULFIDE
WHO/IPCS (1.979). Carbon disulfide. Environmental Health Criteria No. 10. International Programme on Chemical Safety. World Health Organization, Geveva, Switzerland.

CHLORDANE
WHO/IPCS (1.984). Chlordane. Environmental Health Criteria No. 34. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

CHLORDECONE
WHO/IPCS (1.984). Chlordecone. Environmental Health Criteria No. 43. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

CHLOROPHENOLS
WHO/IPCS (1.989). Chlorophenols. Environmental Health Criteria No. 93. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

CYHALOTHRIN
WHO/IPCS (1.990). Cyhalothrin. Environmental Health Criteria No. 99. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

CYPERMETHRIN
WHO/IPCS (1.989). Cypermethrin. Environmental Health Criteria No. 82. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

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WHO/IPCS (1.984). 2,4-D-. Environmental Health Criteria No. 29. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.
WHO/IPCS (1.989). 2,4-D-. Environmental Health Criteria No. 84. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

DDT AID ITS DERIVATIVES
WHO/IPCS (1.979). DDT and its derivatives. Environmental Health Criteria No. 9. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.
WHO/IPCS (1.989). DDT and its derivatives. Environmental Health Criteria No. 83. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

DELTAMETHRIN
WHO/IPCS (1.990). Deltamethrin. Environmental Health Criteria No. 97. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

1,2.DICHLOROETHANE
WHO/IPCS (1.987). 1,2-dichloroethane.Environmental Health Criteria No. 62. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

DICHLORVOS
WHO/IPCS (1.989). Dichlorvos. Environmental Health Criteria No. 79. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

DIMETHOATE
WHO/IPCS (1.989). Dimethoate. Environmental Health Criteria No. 90. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

DITHIOCARBAMATES
WHO/IPCS (1.988). Dithiocarbamates.Environmental Health Criteria No. 78. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

ENDOSULFAN
WHO/IPCS (1.984). Endosulfan. Environmental Health Criteria No. 40. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

ETHYLENE OXIDE
WHO/IPCS (1.985). Ethylene oxide. Environmental Health Criteria No. 55. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

FENVALERATE
WHO/IPCS (1.990). Fenvalerate. Environmental Health Criteria No. 95. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

HEPTACHLOR
WHO/IPCS (1.984). Heptachlor. Environmental Health Criteria No. 38. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

KELEVAN
WHO/IPCS (1.986). Kelevan. Environmental Health Criteria No. 66. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

MIREX
WHO/IPCS (1.984). Mirex. Environmental Health Criteria No. 44. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

ORGANOPHOSPHORUS INSECTICIDES
WHO/IPCS (1.989). Organophosphorus insecticides - A general introduction. Environmental Health Criteria No. 63. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

PARAQUAT AND DIQUAT
WHO/IPCS (1.984). Paraquat and diquat. Environmental Health Criteria No. 39. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

PENTACHLOROPHENOL
WHO/IPCS (1.984). Pentachlorophenol. Environmental Health Criteria No. 71. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

PERMETHRIN
WHO/IPCS (1.989). Permethrin. Environmental Health Criteria No. 94. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

d-PHENOTHRIN
WHO/IPCS (1.990). d-Phenothrin. Environmental Health Criteria No. 96. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

PHOSPHINE
WHO/IPCS (1.988). Phosphine. Environmental Health Criteria No. 73. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

QUINTOZENE
WHO/IPCS (1.984). Quintozene. Environmental Health Criteria No. 41. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

RESMETHRIN
WHO/IPCS (1.990). Resmethrin. Environmental Health Criteria No. 92. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

TECNAZENE
WHO/IPCS (1.984). Tecnazene. Environmental Health Criteria No. 42. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

TETRADIFON
WHO/IPCS (1.986). Tetradifon. Environmental Health Criteria No. 67. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

TETRAMETHRIN
WHO/IPCS (1.990). Tetramethrin. Environmental Health Criteria No. 98. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

THIOCARBAMATE PESTICIDES
WHO/IPCS (1.988). Thiocarbamate pesticide. Environmental Health Criteria No. 76. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

TRIBUTYLTIN COMPOUNDS
WHO/IPCS (1.990). Tributyltin compounds. Environmental Health Criteria No. 116. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

TRICHLOROETHYLENE
WHO/IPCS (1.985). Trichloroethylene.Environmental Health Criteria No. 50. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

APPENDIX III
LIST OF IARC MONOGRAPHS ON PESTICIDE CHEMICALS

ACRYLONITRILE
IARC (1.979). IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Vol. 19, Lyon, p.73.
IARC (1.987). IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Suppl.7,Lyon, p.79.

ALDRIN
IARC (1.974). IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Vol. 5, Lyon, p.25.
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CARBON TETRACHLORIDE
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IARC (1.979). IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Vol. 20, Lyon, p.371.
IARC (1.987). IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Suppl. 7, Lyon, p.143.

CHLORDANE
IARC (1.979). IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Vol. 20, Lyon, p.45.
IARC (1.987). IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Vol. 42, Lyon, p.258.

CHLORDANE/HEPTACHLOR
IARC (1.987). IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Suppl. 7, Lyon, p.146.

CHLORDECONE (KEPONE)
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