PAN Germany

Beyond POPs

Evaluation of the UNEP Chemical Substitutes of the POPs Pesticides Regarding Their Human and Environmental Toxicity

Hamburg, April 2001

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Pesticide Action Network

Founded in 1982, Pesticide Action Network is an international coalition of over 400 citizen groups in more than 60 countries working to oppose the misuse of pesticides and to promote sustainable agriculture and ecologically sound pest management.

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1 Summary and Prospects

International attention is focusing on Persistent Organic Pollutants (POPs), some of the most unwanted chemicals in the world. POPs are toxic, bioaccumulative, highly persistent and pose a global threat to all living beings. Negotiations on an international legally binding instrument, a POPs convention came to an end in December 2000.

Nine of the chemicals initially targeted by the POPs convention, are pesticides which are mainly still in use in developing countries.

In 1997 the Governing Council of UNEP requested to improve the availability of information and expertise on alternatives to POPs. One outcome of this request is the UNEP "POPs Database on Alternatives". This database contains:

- 12 POPs initially targeted by the POPs convention
- 119 "Specific Uses and Applications" of the nine POPs pesticides and
- 84 chemicals/chemical classes, mechanical methods, botanical pesticides, microbial and predatory organisms as 'Alternatives' to the nine POPs pesticides.

When the "POPs Database on Alternatives" was made public in 1999 concerns emerged that POPs pesticides could possibly be replaced by other toxic pesticides.

Goal of this study is therefore, to evaluate the "Chemical Substitutes" of the nine POPs pesticides listed in the POPs database regarding their environmental and human toxicity.

Certain substances, techniques and not-specified substitutes were excluded from the evaluation. The evaluation was conducted utilizing widely accepted classifications on the human and environmental toxicity of the remaining 60 chemical substitutes. A rank-order system was applied to combine the different classifications and to evaluate the chemical substitutes within the existing list of the 60 pesticides.

Attention was paid to the fact that the use of those chemical substitutes listed in UNEP's "POPs Database on Alternatives" will take place under conditions of poverty - under conditions where a safe use of pesticides cannot be ensured.

The results of the evaluation show that the CHEMICAL SUBSTITUTES of the POPs pesticides are dangerous to human health and the environment and that they cannot be seen as sustainable alternatives. For example, thirty-three of the 60 evaluated chemical substitutes have been classified for their acute toxicity as "extremely hazardous" or "highly hazardous" and/or "very toxic" or "toxic" by the World Health Organisation and/or by the European Union, respectively. Thirty-eight of the evaluated chemical substitute have been classified as "Dangerous for the Environment" by the European Union and assigned with the symbol "N".

As a conclusion of the evaluation, PAN Germany does not recommend the use of any of the 60 pesticides as 'Alternatives' for the nine POPs pesticides.

A closer look at the use of the chemical substitutes by crop and commodity shows that the 'alternatives' are used for a broad variety of purposes. A list of especially critical crops and commodities was composed. This list can be seen as a starting point for further research to support non-toxic pest management.

Sustainable non-chemical solutions for environmentally sound pest management practices are needed as alternatives to the POPs pesticides. According to the UNEP: "*Non-chemical alter-*

natives have a number of advantages over chemical methods for the following reasons: non-chemical treatments are generally non-toxic and safer for farm workers and local communities; they do not leave undesirable residues in food, soil, plants and water; consumers strongly prefer products grown through non-chemical methods; many supermarkets and food manufacturers are encouraging farmers to reduce reliance on pesticides because of commercial risks; most non-chemical treatments do not require expensive and time-consuming registration by pesticide authorities."[1]

Within this study it was not possible to go more into detail about useful approaches to avoid that toxic pesticides are going be replaced by other toxic pesticides on field level. To achieve crop specific approaches to sustainable alternative, further work needs to be done. PAN Germany strongly recommends a follow-up study, which is pesticides AND crop specific.

One possible approach could be the utilisation of the results of the rank-order system in order to develop sustainable alternatives for specific crops. For example, *parathion* is number two in the results of the rank-order. *Parathion* is listed for 7 commodities in the POPs database: ants control and specific pests of castor, groundnuts, mangos, peas and peaches. These uses of *parathion* could be a starting point for research on crop and commodity specific non-chemical, sustainable solutions.

1 United Nations Environment Programme, (2000): Case Studies on Alternatives to Methyl Bromide, Technologies with low environmental impact, pg. 10, UNEP, France

2 Introduction

"Toxic and very long-lasting, persistent organic pollutants endanger the well-being of our planet and all living beings, (...)

Only decades ago, most of the 12 POPs targeted for international action under the treaty being negotiated did not exist, and now they are in the air, water,soil around the planet and in us all, and they last for generations,.... [2]

(Klaus Töpfer, Executive Director of UNEP)

With these words Klaus Töpfer, the Executive Director of the United Nations Environment Programme (UNEP), addressed a problem of global dimension, which demands urgent international action to protect the well being of humans and the environment.

Persistent Organic Pollutants (POPs) are man-made toxic chemical substances which are highly persistent and bioaccumulative. They have been released into the environment on a large scale since the 50ties. Due to their chemical properties POPs pose a global threat to human health and the environment.

In 1992 the United Nations Conference on Environment and Development in Rio de Janeiro agreed to address the problem of persistent organic pollutants. Six years later, in early 1998 an Intergovernmental Negotiating Committee (INC) started to prepare for an international legally binding instrument for implementing international action on POPs. Final result of the negotiations is a POPs Convention, initially dealing with 12 POPs.

Since the beginning of the negotiations, NGOs from all over the world were involved. Coordinated by the International POPs Elimination Network (IPEN), some 290 NGOs - including all five PAN Regional Centres in North America, Latin America, Africa, Asia & the Pacific and Europe - were engaged to make public interests part of the intergovernmental negotiations.

The strong involvement of the Pesticide Action Network is due to the fact that 9 of the initially targeted 12 POP chemicals are pesticides. The history of pesticide use presents numerous examples of replacing dangerous pesticide with 'alternative' pesticides, which turned out to be also dangerous. To disrupt this replacement-chain the international PAN has always focused on sustainable non-chemical alternatives to POPs.

In 1997 the Governing Council of UNEP requested who to improve the availability of information and expertise on alternatives to POPs. One outcome of this request is UNEP's "POPs Database on Alternatives". This database was published by the UNEP in 1999 and drew the attention of PAN Germany. A first quick analysis by PAN Germany led to great concerns that the "POPs Da-

The Initial Twelve POPS

Pesticides:

Aldrin
Chlordane
Dieldrin
DDT
Endrin
Heptachlor
Hexachlorobenzene (HCB)
Mirex
Toxaphene

Industrial Chemicals:

Polychlorinated biphenyls
Hexachlorobenzene (HCB)

Unintentional By-Products

Dioxins
Furans

2 UNEP Press Release (2000): Klaus Töpfer, Executive Director of the United Nations Environment Programme (UNEP), Speech held on the 10th of November 2000, UNEP, Nairobi/ Geneva

tabase on Alternatives" could be used to promote the substitution of POPs pesticides with pesticides which are also very toxic to humans and the environment.

Due to pressure from PAN Germany, in 1999 the introduction to the database was changed and the following sentence was placed up front: "The POPs Database on Alternatives is a reference database and should not be used nor interpreted as a list of recommended alternatives."[3]

This sentence stands in contradiction with the original purpose of this database which was to provide information on alternative substances, techniques and methodologies which can lead to reduction/ elimination of releases of the 12 POPs - and - this database is still available for everyone in the internet as "UNEP's POPs Database on Alternatives".

In this report PAN Germany evaluates, based on internationally recognised scientific criteria, the CHEMICAL SUBSTITUTES of the nine POPs pesticides as listed in UNEP's "POPs Database on Alternatives". The chemical substitutes are evaluated regarding their human and environmental toxicity. The fact that the use of pesticides often happens under conditions of poverty is also taken into consideration.

3 Goals

This study has four major goals:

- to evaluate the CHEMICAL SUBSTITUTES of the POPs pesticides listed in UNEP's "POPs Database on Alternatives" regarding their human and environmental toxicity;
- to assess the usability of the POPs chemical substitutes under conditions of poverty;
- to present the possible use of the POPs chemical substitutes by commodity and specific application (e.g. pest, disease).
- to compose a list of POPs chemical substitutes which are not sustainable alternatives and therefore not to be recommended by PAN Germany.

The overall goal of this study is to prevent the replacement of dangerous pesticides with other dangerous pesticides.

4 Methods

Data Source: UNEP's "POPs Database on Alternatives"

UNEP's "POPs Database on Alternatives" is accessible through UNEP's POPs website:

http://irptc.unep.ch/pops/ or directly: http://dbserver.irptc.unep.ch:8887/irptc/owa/ini.init. The "POPs Database on Alternatives" is actually divided into various databases. It starts with one of the POPs chemicals and is further divided into the different approaches to reduce/ eliminate this specific POP chemical. These databases are built on 119 Specific Uses and Applications of the nine POPs pesticides. The specific uses and applications are categorised in four socio-economic sectors: agriculture and forestry; construction and habitation; extermination, vermin control; and public health and sanitation. Each of the Specific Uses and Applications contains

3 Website of the UNEP POPs Programme: http://irptc.unep.ch/pops/ (accessed 18.09.2000)

a list of chemical substitutes to the POPs pesticides. The database on “Chemical Substitutes” of the nine POPs pesticides is the subject of this study.

The UNEP “POPs Database on Alternatives” lists under “Chemical Substitutes” 84 chemicals, chemical classes, mechanical methods, botanical pesticides, microbial and predatory organisms (see Appendix 2) for 119 Specific Uses and Applications (see Appendix 1) of the nine pesticides. Altogether, there are 347 listings in the database.

Properties of the specific chemical substitutes like CAS numbers (chemical abstract registry number), synonyms, chemical properties etc. can be found in a link. Another link leads to regulations of the specific substitute in some nations.

Data Identification

The identification process of the chemical substitutes began by downloading the list of the specific uses and applications, including the substitutes and their properties.The downloaded data were then transferred into a database. Obvious errors and double entries were deleted, gaps in the data such as missing CAS numbers or misspelled chemicals were corrected using the U.S Environmental Protection Agency (U.S. EPA) Office of Pesticide Programmes (OPP) Chemical Ingredients Database Query.[4] Some botanical, microbial and mechanical alternatives are included in the “Chemical Substitutes” as well as groups of chemical classes such as pyrethroids or organophosphates. The list of the 84 chemical substitutes, including their CAS number, chemical classes, main uses, the substituted POP pesticide, and the number of specific uses and applications can be found in Appendix 2. Chemical classes and main uses were added with data downloaded from the Compendium of Pesticides Common Names[5] and from the World Health Organisation (WHO) classification of pesticides.[6] Additional information regarding the classifications for main uses and chemical classes were taken from literature which is cited below Appendix 2.

Figure 1 presents the chemical classes of the 84 substitutes. The list of the POPs chemical substitutes is directly applied to the use of the POPs pesticides, Figure 2 shows the chemical classes by their percentage of listing in the Specific Use and Application.

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4 U.S Environmental Protection Agency (U.S. EPA)/ Office of Pesticide Programmes (OPP) (2000): Chemical Ingredients Database Query. Accessible through the website of the California EPA Department of Pesticide Regulation http://www.cdpr.ca.gov/docs/epa/epachem.htm

5 Wood, A. (2000): Compendium of Pesticide Common Names. Website: http://www.hclrss.demon.co.uk/introduction.html,

6 World Health Organisation (1999): The WHO Recommended Classification of Pesticides by Hazard and Guidelines to Classification 1998-99, (WHO/PSC/98.21/Rev.1), WHO, Vienne, Switzerland

Figure 1: Chemical Classes of the 84 Substitutes

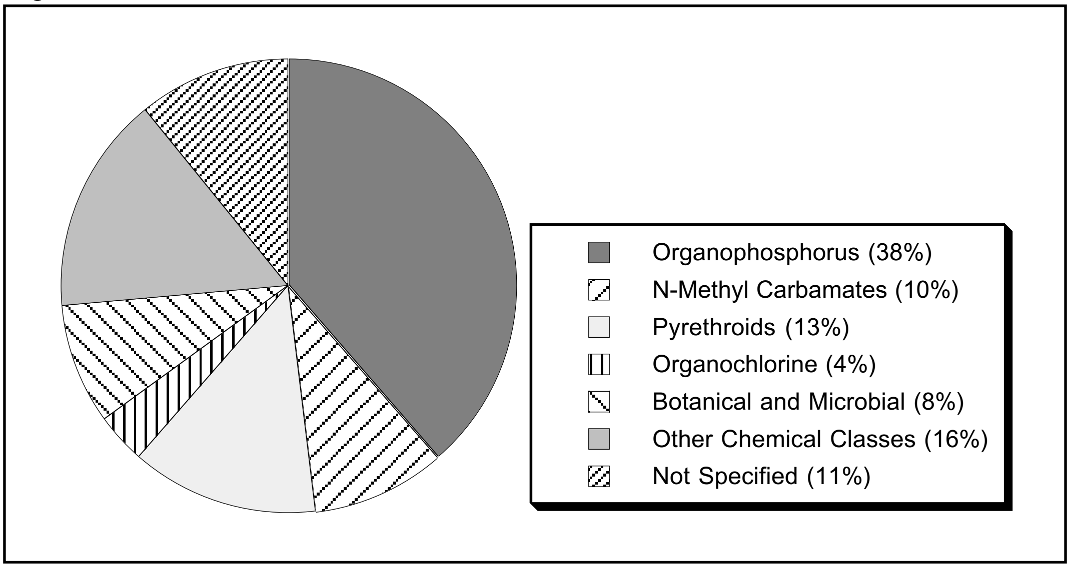
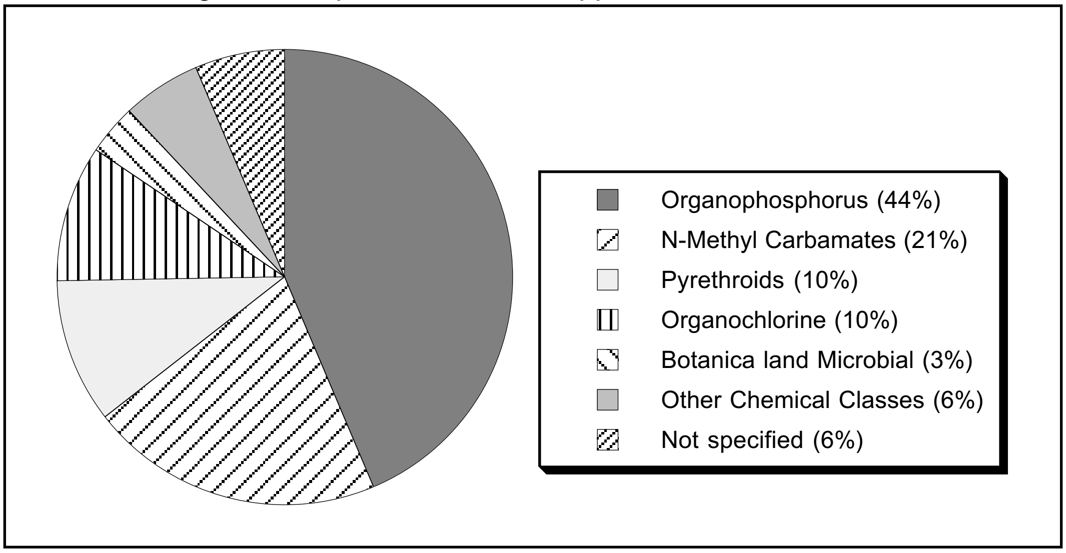


Figure 2: Chemical Classes based on the Percentage of the Number of Listings in the Specific Uses and Applications



Data Exclusions

This study only evaluates 60 of the 84 substitutes; non-chemical pesticides such as biological agents (botanicals, microbial and predatory organisms), WHO obsolete pesticides, mechanical methods, entire chemical classes and unclassified oils are not part of the study. Those substitutes which are not evaluated can be found *italised* in Appendix 2, as well as listed in Appendix 3. Due to this exclusion, 113 Specific Uses and Applications, which result in a total number of 304 (100%) listings, can be evaluated.

Data Correlation

Using the function of 'relational databases', the list of chemical substitutes were matched by CAS Number and/or name with databases on human and environmental toxicity.

Data Extraction

In order to present the planned use of the POPs chemical substitutes by commodity and specific application (e.g. pest, disease) the down loaded UNEP databases were summarised, sorted and grouped.

Evaluation Method - Ranking

The evaluation methods will be described separately in Chapter 9. 1 Evaluation Method: Rank-Order System on page 31.

5 Use of the POPs Pesticides and Their Chemical Substitutes

The "POPs Database on Alternatives" of the United Nations Environment Programme (UNEP) is based upon 119 Specific Uses and Applications of the nine POPs pesticides. As a summary, Appendix 1 represents the use of the nine POPs pesticides by their Specific Uses and Applications. Appendix 3 lists the Specific Uses and Applications of the chemical substitutes. The commodities in the Appendix were extracted from the Specific Uses and Applications. This list includes major crops such as banana, rice, cotton and corn which are grown on very large areas of production, involving millions of farm workers in developing countries.

6 Human Toxicity

The human toxicity defines the different types of chronic and acute toxicity pesticides cause in humans, including cancer, reproductive and developmental toxicity, endocrine disruption and cholinesterase inhibition.

Various international established criteria for the evaluation of the human toxicity do exist. The generally accepted "Recommended Classification of Pesticides by Hazard And Guidelines to Classification" published by the World Health Organisation (WHO)[7] will be used to evaluate the acute toxicity of the 60 chemical substitutes. Irreversible effects will be evaluated using classifications of the International Agency of Research on Cancer (IARC), the European Union, the U.S. Environmental Protection Agency (U.S. EPA), Proposition 65 of the State of California and the *acceptable daily intake* (ADI) of the WHO. Additional information about adverse effects, such as endocrine disrupting effects and cholinesterase inhibition will be provided as well.

The summarised listings and categories of the POPs chemical substitutes in the criteria of the following chapters can be found in Table 7 (page 21) as well as in Appendix 4.

7 World Health Organisation (1998-99): The WHO Recommended Classification of Pesticides by Hazard And Guidelines to Classification 1998-99 (WHO/PCS/98.21/Rev.1), WHO, Vienne, Switzerland

6. 1 Acute Toxicity - World Health Organisation (WHO)

All evaluated POPs Chemical Substitutes are classified by the WHO: Seven as Extremely Hazardous, 14 as Highly Hazardous, 25 as Moderately Hazardous, 7 as Slightly Hazardous and 7 as Unlikely to present hazard in normal use.

The acute toxicity of a substance is widely used and accepted as criteria for risk assessment. Standardised animal tests, primarily with rats, are employed to determine the LD_{50}, the estimated dose which is lethal to 50 percent of the tested population.

In 1975 the WHO published, with approval from the 28th World Health Assembly, their first classification of pesticides by hazard. The guidelines on the classification of individual pesticides, the actual tables, were established in 1978 and have since been revised at two-year intervals.[8] The WHO classification is based on the physical state of an active ingredient ("solid" or "liquid") and on LD_{50} values for rats via dermal and oral routes. The recommended classification of pesticides are presented in Table 1. LD_{50} values via inhalation are not included in the classification. This is a major deficiency because users of pesticides are often exposed by air. Formulations and mixtures are also not included in the classification. The acute toxicity of formulations and mixtures can be calculated with a given calculation which is derived from the percentage and the LD_{50} values of active ingredients in the formulation or mixture. The potential increase in acute toxicity due to so-called 'inert' ingredients[9] [10] is neglected in this calculation. Health effects other than acute toxicity, such as carcinogenicity, have been taken into account for many compounds; the classification has been accordingly adjusted.

Table 1: WHO Recommended Classification of Pesticides by Hazard

Classification		LD_{50} in rat (mg/kg body weight)			
		Oral		Dermal	
		Solids	Liquids	Solids	Liquids
Ia	Extremely hazardous	5 or less	20 or less	10 or less	40 or less
Ib	Highly hazardous	5 - 50	20 - 200	10-100	40 - 400
II	Moderately hazardous	50 - 500	200 - 2000	100-1000	400 - 4000
III	Slightly hazardous	Over 500	Over 2000	Over 1000	Over 4000
U	Unlikely to present hazard in normal use	Over 2000	Over 3000	-	-

Source: World Health Organisation (1998-99): The WHO Recommended Classification of Pesticides by Hazard And Guidelines to Classification 1998-99

The WHO classification guidelines are a collection of proposed data reviewed by the International Programme on Chemical Safety (IPCS). Any interested party can propose new entries or comment on entries, provided tests and data are representative.

8 World Health Organisation (1998-99): The WHO Recommended Classification of Pesticides by Hazard And Guidelines to Classification 1998-99 (WHO/PCS/98.21/Rev.1), WHO, Vienne, Switzerland

9 "inert" ingredient: substances which can enhance the efficiency of the active substance, make a product more degradable or easier to use. 'Inerts' are mostly handled as trade secrets of the manufacturer, which means they are not labelled on the product and therefore not included in the calculation. (More information see footnote 10.)

10 Marquardt, S., Cox, C., Knight, H. (1998): Toxic Secrets, "Inert" Ingredients in Pesticides 1987-1997, Northwest Coalition for Alternatives on Pesticides, Californians for Pesticide Reform

When several LD_{50} values have been reported, the WHO/IPCS uses the lowest reliable value. Usually the oral route values are used, except when the dermal route value places the substance in a more hazardous class.

All of the 60 chemical substitutes are listed in the WHO classifications. The acute toxicity classification of the substitutes can be found in Appendix 4 as well as in Table 7 on page 21. The following figures summarise the acute toxicity classification of the chemical substitutes and the classifications by their number of listings.

Figure 3: Acute Toxicity (WHO) of the POPs Chemical Substitutes

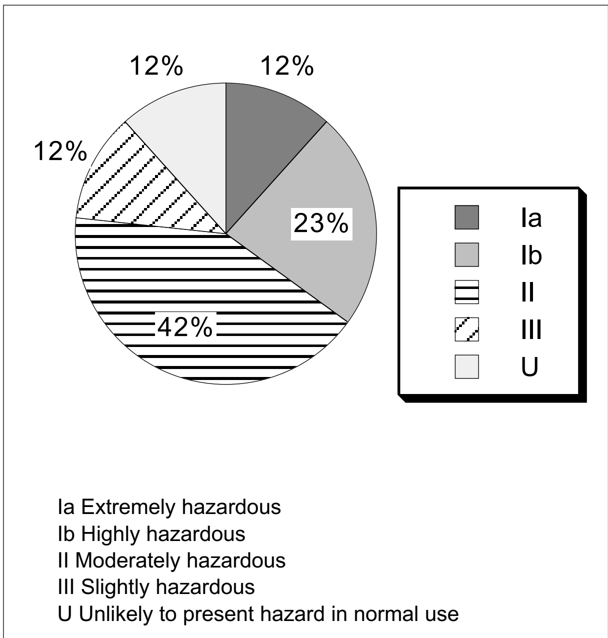
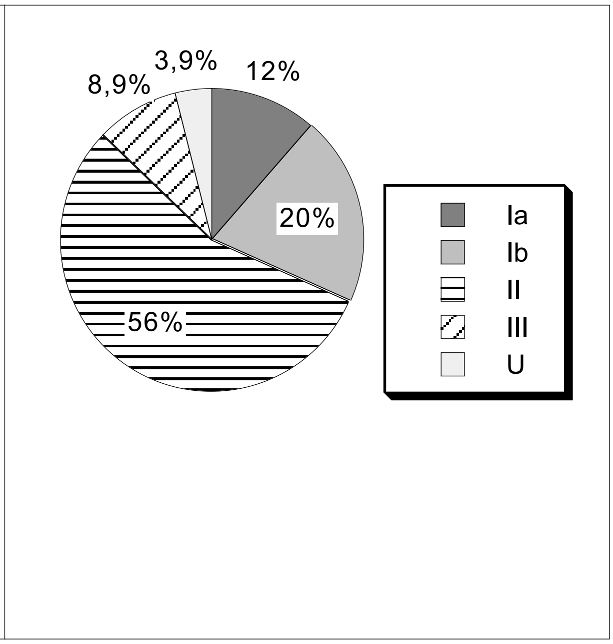


Figure 4: Acute Toxicity (WHO) by Number of Listings



6. 2 Acute Toxicity - European Union

Forty-nine of the 60 evaluated POPs Chemical Substitutes are classified by the European Union: 17 as Very Toxic, 13 as Toxic, 18 as Harmful and 1 as Irritant.

The major legislative framework in force dealing with dangerous substances in the European Union is the Council Directive 67/548/EEC of 27 June 1967 on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substances.[11] There have been 28 amendments, adoptions and/ or modifications since establishing this framework. Most of them can be found on the website of the European Union.[12] The list of chemicals, their risk classification, information on labelling, packaging and safe use can be found as Annex I of this directive. This Annex I was completely and updated obtained from the responsible European Chemicals Bureau.[13] The classification system of the EU goes further than the WHO acute toxicity classification. The combination of danger symbols

11 European Union (1967): Council Directive 67/548/EEC of 27 June 1967 on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substance, Official Journal 196, Brussels, Belgium

12 European Union (2000): Legislation in Force, http://www.europa.eu.int/eur-lex/en/lif/dat/1994/en_294A0103_51.html, Brussels, Belgium

13 personel communication with Dr. Elisabet Berggren (Classification/Labelling and Export/Import), European Chemicals Bureau, Italy, April 2001

for acute hazards with descriptive risk phrases for acute as well as subchronic and chronic toxicity, plus the categories for mutagenic, carcinogenic and reproductive effects, presents a fairly comprehensive instrument for the evaluation of chemicals.

The symbols and risk phrases describe following effects:

- acute toxicity (lethal and irreversible effects after a single exposure)
- subacute, subchronic or chronic toxicity
- corrosive and irritant effects
- sensitising effects
- specific effects on health (carcinogenicity, mutagenicity and reproductive toxicity)

The description of the criteria can be found in the amendment paper 393L0021 (Commission Directive 93/21/EEC of 27 April 1993), a modification to the directive 67/548/ EEC.

There are three acute toxicity classifications (see following table) and, in contrast to the WHO classification, the exposure routes via air are included in the classification system. The specific effects on health such as carcinogenicity, mutagenicity and reproductive toxicity will be addressed in Chapter 6. 4. 4.

The toxicity of the 60 POPs chemical substitutes, according to the classification of the European Union, can be found in Appendix 4 as well as the risk phrases and the descriptions of the symbols.

Table 2: Acute Toxicity Classification - Danger Symbols and Risk Phrases in the European Union

Classification		LD50 in rat mg/kg body weight			Risk Phrases
		Oral	Dermal[a]	Inhalation[b]	
T+	Very toxic	25	50	0,25	28, 27, 26, 39[c]
T	Toxic	25 -200	50 - 400	0,25 to 1	23, 24, 25, 39, 48[d]
Xn	Harmful	200 - 2000	400 - 2000	1 to 5	(22)[e], 65, 40[f], 48

a test species rat or rabbit for “Dermal”
b Lethal Concentration = LC50 in rat mg/litre par 4 hours
c Danger of very serious irreversible effects - Strong evidence that irreversible damage is likely to be caused by a single exposure
d Danger of serious damage to health by prolonged exposure
e replaced by R65
f Possible risk of irreversible effects - strong evidence that irreversible damage is likely to be caused by a single exposure

The partly remarkable differences between the acute toxicity classification of the WHO and the EC are due to the fact that the WHO incorporates other health effects in addition to the acute toxicity for some substances. Several entries into the toxicity category define different toxicities for different exposure routes. The risk phrases 24-26/28, for instance, mean R24: Toxic in contact with skin and R26/28: Very toxic by inhalation and if swallowed.

6. 3 Cholinesterase Inhibition

Thirty seven of the sixty two evaluated POPs Chemical Substitutes are cholinesterase inhibitors (ChE).

Pesticides undergo different modes of action: organophosphorus (OP) and N-methyl carbamate (CB) pesticides inhibit primarily the acetylcholinesterase (AChE) and butyrylcholinesterase (BuChE) enzymes by phosphorylation and carbamation, respectively. This simply means that these pesticides change the enzyme structure, and therefore the enzyme becomes inactivated. Acetylcholinesterase is responsible for turning off the signal flow ensured by the neurotransmitter acetylcholine between a nerve cell and a target cell; for instance, a muscle fiber, gland or another nerve cell. Since the neurotransmitters are in charge of passing on a signal which leads to a stimulation, the inhibition of the signal-stopping enzyme leads to an overstimulation. This overstimulation is the reason, usually due to pulmonary secretion and respiratory failure, for the death of the poisoned person.[14]

As in all poisoning, the grade of poisoning is dependant upon several parameters: exposure time, exposure dose, age, gender and constitution of the affected person.

There is very little knowledge regarding the function of butyrylcholinesterase (BuChE) in the nervous system. Several uncertainties have been defined. For example, it is not known if BuChE plays a role in the development and/or functioning of the nervous system, nor is it known if BuChE and/or AChE and other esterases play a more general role in cell growth and cell death, including in carcinogenesis. Over cholinergic pathways, the neurotransmitter acetylcholine acts in the entire human body: in the central nervous system (brain and spinal cord), as well as the peripheral nervous system. Little is known about the distribution of cholinergic pathways in the brain and their functions. Behavioural, cognitive, and psychological changes can only be observed on humans; animal testing fails here in most cases. There is also little knowledge about the effects of longer term/ low dose exposures. The complexity of cholinesterase inhibition caused by pesticides can therefore hardly be assessed.

The approach of the U.S. EPA Office of Pesticide Programmes (OPP) is to measure cholinesterase inhibition in blood cells, but they also admit that more research needs to be done to appropriately address the complex effects. The Science Advisory Panel of OPP notes that *"...under SOME circumstances, measurement of SOME blood-borne cholinesterases would be appropriate to consider in establishing RfDs*[15] *for anticholinesterases....*",and *"Measured inhibition of cholinesterase activities in any of the blood fractions is best regarded as an imperfect mirror of enzyme inhibition in the true target tissues...."*[16]

At least two organisations use the measurement of cholinesterase inhibition in the blood: the California Department of Health Services (CDHS) removes agricultural workers who have been in contact with highly toxic organophosphorous or carbamate compounds and whose blood plasma or red blood cell levels show a certain percentage of cholinesterase inhibition from the workplace. The World Health Organisation (WHO) has similar guidelines as the CDHS and considers plasma inhibition of 50% a 'toxic' decrease.[17]

14 Reigart, J. R., Roberts, J. R. (1999): Recognition and Management of Pesticide Poisonings, Office of Prevention, Pesticides, and Toxic Substances, US Environmental Protection Agency, Washington, USA

15 Reference Dose, (note of the author)

16 U.S. EPA, Office of Pesticide Programmes (2000): Science Policy on The Use of Data on Cholinesterase Inhibition for Risk Assessments of Organophosphorous and Carbamate Pesticides, p. 16. Office of Pesticide Programme, US Environmental Protection Agency, Washington, USA

6. 4 Chronic Toxicity and Irreversible Damages

Chronic toxicity and irreversible damages caused by pesticides include: cancer; mutagenic, developmental, and reproductive toxicity; endocrine disrupting; and potential after-effects of cholinesterase inhibition. The latter has been discussed in Chapter 6. 3.

The procedures by which most organisations classify chemicals as carcinogenic, mutagenic or developmental and reproductive toxicants are often very similar. They mostly involve first the selection of chemicals to evaluate, then bringing together a board of scientists who evaluate the available data and make a decision about a ranking, based upon the weight of the evidence. The data evaluated include in most cases epidemiological studies on humans exposed to the chemical, as well as studies on laboratory animals. Some organisations also use the evaluation results of other authorities and apply a new classification to it. Pesticides which have been on the market for a longer time have been studied often more extensively than 'newer' chemicals. The more available data base results in a presumably more accurate rating.

6. 4. 1 Carcinogenicity Classification - International Agency for Research on Cancer (IARC)

Eleven of the 60 POPs Chemical Substitutes are evaluated by the IARC: one is classified as possibly carcinogenic to humans. Ten chemical substitutes are considered as not classifiable as carcinogenic to humans.

The International Agency for Research on Cancer (IARC) is part of the World Health Organisation (WHO). The goal of IARC is to evaluate, with the assistance of international working groups of experts, critical reviews and evaluations of evidence of carcinogenicity and to publish them in monographs. This series of monographs started in 1972 and since then, some 860 agents have been reviewed. Participants in the working groups are individual scientists who do not represent organisations, industry or governments.Their task is:

- to ensure that all appropriate data have been collected;
- to select the relevant data;
- to prepare summaries of the data to enable the reader to follow the reasoning of the working group;
- to evaluate the results of epidemiological and experimental studies on cancer;
- to evaluate data relevant to the understanding of mechanism of action; and
- to make an overall evaluation of the carcinogenicity of the exposure to humans.[18]

17 U.S. EPA, Office of Pesticide Programmes (2000): Science Policy on The Use of Data on Cholinesterase Inhibition for Risk Assessments of Organophosphorous and Carbamate Pesticides, Office of Pesticide Programme, US Environmental Protection Agency, Washington, USA

18 International Agency for Research on Cancer (1999): Preamble to the IARC Monographs, IARS Monographs, accessible through: http://www.iarc.fr/, Lyon, France

The evaluation leads to a classification which is divided into five groups as displayed in the Table 3.

Table 3: IARC Classification on Carcinogenicity

Category	Description
Group 1	The agent (mixture) is carcinogenic to humans.
Group 2A	The agent (mixture) is probably carcinogenic to humans.
Group 2B	The agent (mixture) is possibly carcinogenic to humans.
Group 3	The agent (mixture) is not classifiable as to its carcinogenicity to humans.
Group 4	The agent (mixture) is probably not carcinogenic to humans.

The substitute *Dichlorvos/DDVP* is classified as possibly carcinogenic to humans (Group 2B). This classification is applied when limited evidence of carcinogenicity in humans and less than sufficient evidence of carcinogenicity in experimental animals exist. It also may be used when adequate evidence of carcinogenicity in humans does not exist but there is sufficient evidence of carcinogenicity in experimental animals. In some cases, a substance for which adequate evidence of carcinogenicity in humans does not exist *but* for which limited evidence of carcinogenicity in experimental animals together with supporting evidence from other relevant data is present, may be placed in this group. Ten chemical substitutes are not classifiable as carcinogenic to humans (Group 3). This group is applied mostly for substances for which the evidence of carcinogenicity is inadequate in humans and inadequate or limited in experimental animals.

6. 4. 2 Carcinogenicity Classification - U.S. Environmental Protection Agency (U.S. EPA)

Twenty seven of the evaluated POPs Chemical Substitutes have been placed into one of the five categories of the U.S. EPA: two are known to cause cancer in animals, 11 are possibly carcinogenic to humans, for two the carcinogenicity cannot be determined and 12 are probably not carcinogenic to humans.

The U.S. EPA Office of Pesticide Programmes maintains a List of Chemicals Evaluated for Carcinogenic Potential.[19]This list is a product of the general risk assessment included in the process of the pesticide registration. This classification can be seen as a development of the IARC classification system, but also includes the potential exposure of humans.[20] Therefore, a low exposure potential can place a pesticide in a lower category even when sufficient evidence of carcinogenicity exists. The categories used by U.S. EPA are:

19 US Environmental Protection Agency Office of Pesticide Programmes (2000): List of Chemicals Evaluated for Carcinogenic Potential, U.S. EPA Office of Pesticide Programmes, Washington, DC, USA

20 Altenburger, R., Bödeker, W., Brückmann, S., Oetken, G., Weber, C., (1999) Zur Human- und Ökotoxizität von Pestiziden, die im Bananenanbau verwendet werden, Pestizid Aktions-Netzwerk e.V. (PAN Germany), Hamburg, Germany

Table 4: U.S. EPA Classification of Carcinogenic Substances	
Category	Description
Category A	Known to cause cancer in humans. Generally based on epidemiological data showing sufficient evidence to support a causal association between exposure to the substance and cancer.
Category B	Known to cause cancer in animals but not yet definitively shown to cause cancer in humans. These chemicals are designated “probable human carcinogens.” Category B is further split into pesticides for which some evidence exists that it causes cancer in humans (B1) and those for which evidence exists only in animals (B2).
Category C	Possible human carcinogens, where the data show limited evidence of carcinogenicity in the absence of human data.
Category D	This category is for chemicals for which the data are either incomplete or ambiguous and is labelled “cannot be determined.” This category is appropriate when tumour effects or other key data are suggestive or conflicting or limited in quantity and are thus not adequate to convincingly demonstrate carcinogenic potential for humans. In general, further chemical-specific and generic research and testing are needed to be able to describe human carcinogenic potential.
Category E	Probably not carcinogenic, with no evidence of carcinogenicity in at least two adequate animal tests in different species in adequate epidemiological and animal studies. This classification is based on available evidence and does not mean that the agent will not be a carcinogen under any circumstances.

Source: EPA (2000): List of Chemicals Evaluated for Carcinogenic Potential

6. 4. 3 Classification of Carcinogenic, Developmental and Reproductive Toxicants - State of California - Proposition 65

Three of the 60 evaluated POPs chemical substitutes are rated as known to cause cancer in Proposition 65, two are listed as reproductive toxicants.

In 1986 California voters agreed upon an initiative concerning the exposure to toxic chemicals. Result of this initiative was the *The Safe Drinking Water and Toxic Enforcement Act of 1986*, also known as Proposition 65. According to Proposition 65 the Governor has to publish an annually updated list of chemicals that are known to the State of California to cause cancer, birth defects or other reproductive damage. Three mechanisms by which carcinogens and reproductive toxicants are listed have been defined:

- A chemical is listed when a body, considered authoritative under Proposition 65, such as the IARC, NIOSH, NTP, U.S. EPA and FDA,[21] lists this chemical;
- *or* when it is identified by a state or federal agency as a carcinogen and/or reproductive toxicant;
- *or* when California’s state experts lead by the California Environmental Protection Agency Office of Environmental Health Hazard Assessment

21 International Agency for Research on Cancer (IARC), National Institute for Occupational Safety and Health (NIOSH), the National Toxicology Programme (NTP), the US Environmental Protection Agency (US EPA), and the US Food and Drug Administration (FDA).

evaluates the chemical according to a specific procedure as carcinogenic or as a developmental or reproductive toxicant.

Sufficient evidence of carcinogenicity from studies in humans or experimental animals places a chemical on the list for cancer. 'Sufficient evidence' indicates that there is an increased occurrence of malignant tumours, or combined benign and malignant tumours, in multiple species, in multiple experiments, or to an unusual degree in a single experiment under specific conditions.[22] There are two criteria which place a chemical on the list for developmental reproductive toxicants: studies in humans indicate a relationship between the chemical and reproductive toxicity *or* studies indicate an association between adverse reproductive effects and the chemical in experimental animals. At the end of an evaluation process, which also allows for objections from the public, the evaluated chemical is listed as "known to the state to cause cancer" or "known to the state to cause reproductive toxicity" or it is not listed.

The chemicals are listed with CAS number and date of entry; removed chemicals are marked. The reproductive toxicants are further divided into two categories: toxicity for female, and toxicity for male reproduction.

Three of the 60 evaluated POPs chemical substitutes are placed on the list for cancer in Proposition 65 (*alachlor, dichlorvos/DDVP, lindane*), all three of them are also listed in a category of the IARC or the U.S. EPA, (see Appendix 4 and Table 7) but while these categories rate with a less rigid classification, Proportion 65 rates them as "known".

One of the 60 evaluated chemical substitutes (*resmethrin*) is listed as developmental toxicants under the list "known to the state to cause reproductive toxicity".

6. 4. 4 Classifications of Carcinogenic, Mutagenic and Reproductive Toxicants - European Union

Two of the 60 evaluated POPs chemical substitutes cause concern for humans due to possible carcinogenic effects and have been placed into the carcinogenicity category 3 by the EU.Three of the POPs chemical substitutes cause concern for humans owing to possible mutagenic effects and have been placed into the mutagenicity category 3.

The classification of carcinogenic, mutagenic and reproductive toxicants is part of the Council Directive 67/548/EEC of 27 June 1967 on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substances.[23] In the 18th amendment[24] of this directive the procedure of labelling and classification is described. The process of classification differs considerably from other organisations.

22 State Of California, Environmental Protection Agency Office Of Environmental Health Hazard Assessment (2000): Safe Drinking Water And Toxic Enforcement Act Of 1986, Chemicals Known To The State To Cause Cancer Or Reproductive Toxicity, assessable through: http://www.oehha.ca.gov/prop65/, Sacramento, USA

23 European Union (1967): Council Directive 67/548/EEC of 27 June 1967 on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substance, Official Journal 196, Brussels, Belgium

24 European Union (1993): Council Directive 93/21/EEC of 27 April 1993 adapting to technical progress for the 18th time Council Directive 67/548/EEC on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substance, Official Journal L 110, Brussels, Belgium

The manufacturer of a substance is required to implement the testing according to Annex V of the Directive 67/548/EEC, which describes the methods to determine the physical-chemical properties, the human and the environmental toxicity.[25] They have to submit all available relevant data to the Member State in which the substance is planned to be sold. In addition the manufacturer has to label its substance provisionally according to the EU criteria. If the manufacturer gains new relevant data, these are also required to be presented as soon as possible to the Member State. The preliminary classification applied by the manufacturer is valid as long as no other conclusions about the substance can be reached or as long as no Member State has relevant information justifying (or not) the categories. Member States which have relevant data on this substance are obligated to forward this information to the Commission. The Commission forwards the information about classification and labelling of the substance to all Member States, who may notify the Commission in case their own data prove the classification inappropriate. If no objections or newer relevant data arise, the preliminary classification is valid until the substance is officially classified and registered by the EC. The following chapter describes the EC classification of carcinogenic and mutagenic substances. None of the evaluated POPs chemical substitutes are rated as a reproductive toxicants by the EC, therefore the classification of reproductive toxicants has been omitted.

Carcinogenicity

The European Union defines three categories for carcinogenicity, which are presented in Table 5. There are inherent difficulties in assigning substances into Category 1 due to the fact that this is done on the basis of epidemiological data.[26] Therefore it seems to be impossible to classify products which have been on the market for a short time or for products with a low volume of production i.e. low exposure potential. The exact processes and the principles of assessment to place a substance in Category 1 have not been documented.

Placing a substance into Categories 2 and 3 is based primarily on animal experiments. To assign a substance to Category 2, two animal species should show positive results, or one species should show clear evidence of carcinogenicity. In addition, other supporting evidence must exist.

Category 3 places substances which are well investigated but for which the evidence of carcinogenic effects are insufficient for classification in Category 2. Category 3 also places substances which are insufficiently investigated. The available data are inadequate, but they raise concern for humans. This classification is temporary; further investigations are necessary before a final classification can be made. For a distinction between Category 3 and a classification as non-carcinogenic, the following criteria are valid:

- the substance should not be classified in any of the categories if the mechanism of experimental tumour formation is clearly identified, with good evidence that this process cannot be extrapolated to humans,

25 This Annex has been updated regularly in light of the technical progress. Test methods of the OECD are mostly being used.

26 European Union (1993): Council Directive 93/21/EEC of 27 April 1993 adapting to technical progress for the 18th time Council Directive 67/548/EEC on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substance, Official Journal L 110, Brussels, Belgium

- the substance may not be classified in any of the categories if the only available tumour data are liver tumours in certain sensitive strains of mice, without any other additional evidence,
- particular attention should be paid to cases where the only available tumour data are the occurrence of neoplasms at sites and in strains where they are well known to occur spontaneously with a high incidence.

The EU description of the criteria fails to mention whether or not 'newer' substances due to insufficient investigation are automatically placed into Category 3.

Table 5: EU Classification of Carcinogenic Substances

Category	Description	Symbol & Risk Phrases
Category 1	Substances known to be carcinogenic to humans. There is sufficient evidence to establish a causal association between human exposure to a substance and the development of cancer.	T; R45 May cause cancer; T; R49 May cause cancer by inhalation
Category 2	Substances which should be regarded as if they are carcinogenic to humans. There is sufficient evidence to provide a strong presumption that human exposure to a substance may result in the development of cancer, generally on the basis of appropriate long-term animal studies or other relevant information.	T; R45 May cause cancer T; R49 May cause cancer by inhalation
Category 3	Substances which cause concern for humans owing to possible carcinogenic effects but in respect of which the available information is not adequate for making a satisfactory assessment. There is some evidence from appropriate animal studies, but this is insufficient to place the substance in Category 2.	Xn; R40 Possible risk of irreversible effects

Mutagenicity

The European Union defines three categories for mutagenicity, which are presented in Table 6. With Directive 2000/32/EEC of 19th May 2000 the European Union modified the Directive 67/548EEC for the 26th time.[27] This modification deals almost solely with testing methods for mutagenic substances and has to be enforced by the Member States by the 1st June of 2001. It is to expect that the application of newer test methods will change the assessment and classification of substances in the EU.

To place a substance in Category 1, positive evidence from human mutation epidemiology studies is needed. According to the EU, examples of such substances are not known to date. For Category 1 mutagenicity the same objections as for Category 1 in the Chapter on Carcinogenicity (page 18) may arise. To place a substance in Category 2, positive results are needed from experiments showing mutagenic effects or other cellular interactions relevant to mutagenicity in germ cells of mammals in vivo, or mutagenic effects in somatic cells of mammals in

27 European Union (2000): Council Directive 2000/32/EEC of 19 May 2000 adapting to technical progress for the 26th time Council Directive 67/548/EEC on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substance, Official Journal L 136, Brussels, Belgium

vivo in combination with clear evidence that the substance or a relevant metabolite reaches the germ cells.

It is to note that the Symbol "Xn" plus the Risk Phrase 40 is used to label the Category 1 of both carcinogenicity and mutagenicity. Three of the POPs chemical substitutes, *fenthion*, *monocrotophos* and *phosphamidon* have been placed into Category 3. To place a substance in Category 3, positive results are needed in experiments showing mutagenic effects or other cellular interaction relevant to mutagenicity, in somatic cells in mammals in vivo. The latter especially would usually be supported by positive results from in vitro mutagenicity experiments.

Additionally, a distinction between Category 3 and no classification is not described.

Table 6: EU Classification of Mutagenic Substances

Category	Description	Symbol & Risk Phrases
Category 1	Substances known to be mutagenic to humans. There is sufficient evidence to establish a causal association between human exposure to a substance and heritable genetic damage.	T; R46 May cause heritable genetic damage.
Category 2	Substances which should be regarded as if they are mutagenic to humans. There is sufficient evidence to provide a strong presumption that human exposure to the substance may result in the development of heritable genetic damage, generally on the basis of appropriate animal studies, or other relevant information.	T; R46 May cause heritable genetic damage.
Category 3	Substances which cause concern for humans owing to possible mutagenic effects. There is evidence from appropriate mutagenicity studies, but this is insufficient to place the substance in Category 2.	Xn; R40 Possible risk of irreversible effects.

6. 4. 5 Chronic Toxicity - Acceptable Daily Intake (WHO/FAO)

In absence of an international classification system for chronic toxicity, the acceptable daily intake (ADI) is used in this study as a measurement for chronic toxicity.

The acceptable daily intake (ADI) has been developed to assess chronic hazards posed by pesticide residues. It is the assumed amount a human can consume on a daily basis without causing damages to health. The ADI is assigned by the Joint FAO/WHO Meeting on Pesticide Residues (JMPR) on the basis of an examination of available information, including data on the biochemical, metabolic, pharmacological, and toxicological properties of the pesticide extracted from studies of experimental animals and observations in humans. Used as the starting-point is the no-observed-adverse-effect level (NOAEL) for the most sensitive toxicological parameter, usually in the most sensitive species of experimental animal. To take into account the type of effect, the severity or reversibility of the effect, and the problems of inter- and intraspecies variability, a safety factor is applied to the NOAEL to determine the ADI for humans.[28]

28 Global Environment Monitoring System – Food Contamination Monitoring and Assessment Programme (GEMS/Food) and Codex Committee on Pesticide Residues (1997): Guidelines for Predicting Dietary Intake of Pesticide Residues, WHO/FSF/FOS/97.7, Programme of Food Safety and Food Aid (FAO), World Health Organization (WHO)

The ADI value of the POPs chemical substitutes can be found in Table 7 and in Appendix 4. For 45 of the substitutes an ADI value has been assigned.[29]

Table 7: Human Toxicology of the POPs Chemical Substitutes

			EU Classification		Cancer Classification								
Substitute	CAS Number	WHO	Symbol	Risk Phrase	EC	IARC	U.S EPA	Prop 65	Prop 65 Reprod.	EU Muta.	ChE	ADI mg/kg/bw	Number of Listings
acephate	30560-19-1	III	Xn	22			C				Yes	0,03	2
alachlor	15972-60-8	Ia	Xn	22-40-43-50/53	3			Yes					1
aldicarb	116-06-3	Ia	T+	24-26/28-50/53		3	E				Yes	0,003	2
alpha-cypermethrin	67375-30-8	II											3
azinphos-methyl	86-50-0	Ib	T+	24-26/28-43-50/53			E				Yes	0,005	1
bendiocarb	22781-23-3	II	T	21-23/25-50/53							Yes	0,004	4
bifenthrin	82657-04-3	II					C					0,02	2
bitertanol	55179-31-2	U										0,01	2
carbaryl	63-25-2	II	Xn	22-40-50	3	3	C				Yes	0,003	23
carbofuran	1563-66-2	Ib	T+	26/28-50/53							Yes	0,01	30
carbosulfan	55285-14-8	II	T	23/25-43-50/53							Yes	0,01	7
carboxin	5234-68-4	U											2
chlorfenvinphos	470-90-6	Ib	T+	24-28-50/53							Yes	0,0005	1
chlorpyrifos	2921-88-2	II	T	24/25-50/53			E				Yes	0,01	31
cyfluthrin	68359-37-5	II	T+	23-28-50/53								0,02	2
cypermethrin	52315-07-8	Ib					C					0,05	4
DDVP	62-73-7	Ib	T+	24/25-26-43-50		2B	C	Yes			Yes	0,004	3
deltamethrin	52918-63-5	II	T	23/25-50/53		3						0,01	9
diazinon	333-41-5	II	Xn	22-50/53							Yes	0,002	15
dicrotophos	141-66-2	Ib	T+	24-28-50/53							Yes		1
diflubenzuron	35367-38-5	U					E					0,02	2
dimethoate	60-51-5	II	Xn	21/22			C				Yes	0,002	4
disulfoton	298-04-4	Ia	T+	27/28-50/53			E				Yes	0,0003	3
endosulfan	115-29-7	II	T	24/25-36-50/53			E					0,006	20
ethofenprox	80844-07-1	U					C					0,03	1
fenitrothion	122-14-5	II	Xn	22-50/53			E				Yes	0,005	8
fenthion	55-38-9	II	T	21/22-23-40-48/25-50/53			E			3	Yes	0,007	2
fenvalerate	51630-58-1	II				3	E					0,02	3
flucythrinate	70124-77-5	Ib										0,02	1
fonofos	944-22-9	Ia	T+	27/28-50/53			E				Yes		6
fuberidazole	3878-19-1	III	Xn	22-50/53									2
guazatine	13516-27-3	II	Xn	21/22-36/38-50/53								0,03	1
isazophos	42509-80-8	Ib	T+	24/25-26-43-48/20-50/53							Yes		2
isofenphos	25311-71-1	Ib	T	24/25							Yes	0,001	3
isoprocarb	2631-40-5	II	Xn	22-50/53							Yes		1
lambda cyhalothrin	91465-08-6	II	T+	21-25-26-50/53									1

Table 7: Human Toxicology of the POPs Chemical Substitutes

			EU Classification		Cancer Classification								
Substitute	**CAS Number**	**WHO**	**Symbol**	**Risk Phrase**	**EC**	**IARC**	**U.S EPA**	**Prop 65**	**Prop 65 Reprod.**	**EU Muta.**	**ChE**	**ADI mg/kg/bw**	**Number of Listings**
lindane	58-89-9	II	T	23/24/25-36/ 38-50/53			B2/C	Yes				0,001	13
malathion	121-75-5	III	Xn	22		3	D				Yes	0,3	11
methamidophos	10265-92-6	Ib	T+	24-28-36-50			E				Yes	0,004	1
methomyl	16752-77-5	Ib	T+	28-50/53							Yes	0,03	2
metribuzin	21087-64-9	U	Xn	22-50/53			D						1
monocrotophos	6923-22-4	Ib	T+	24-26/28-40- 50/53						3	Yes	0,0006	10
parathion	56-38-2	Ia	T+	27/28-50/53		3	C				Yes	0,004	8
permethrin	52645-53-1	II	Xn	22		3	C					0,05	7
phenthoate	07.03.2597	II	Xn	21/22							Yes	0,003	2
phorate	298-02-2	Ia	T+	27/28			E				Yes	0,0005	12
phosalone	2310-17-0	II	T	21-25-50/53							Yes	0,02	2
phosphamidon	13171-21-6	Ia	T+	24-28-40-50/53			C			3	Yes	0,0005	3
phoxim	14816-18-3	II	Xn	22							Yes	0,004	2
pirimiphos ethyl	23505-41-1	Ib	T	21-25-50/53							Yes		1
pirimiphos-methyl	29232-93-7	III	Xn	22							Yes	0,03	3
propoxur	114-26-1	II	T	25-50/53			B2				Yes	0,02	3
pyrethrins	8003-34-7	II	Xn	20/21/22-50/53								0,04	1
quinalphos	13593-03-8	II	T	21-25							Yes		3
resmethrin	10453-86-8	III	Xn	22-50/53					Yes				2
sulfluramid	4151-50-2	III											2
tetrachlorvinphos	22248-79-9	U				3					Yes		3
triazophos	24017-47-8	Ib	T	21-23/25-50/53							Yes	0,001	1
trichlorfon	52-68-6	III	Xn	22-43		3					Yes	0,02	5
trifluralin	1582-09-8	U	Xi	36-43-50/53		3	C					0,048	1

29 World Health Organisation/ International Programme on Chemical Safety (2000): Inventory of IPCS and other WHO pesticide evaluation and summary of toxicological evaluations performed by the Joint Meeting on Pesticide Residues (JMPR) through 2000, WHO/IPCS, Vienne, Switzerland

7 Endocrine Disruption

The issue of endocrine (hormone) disrupting effects of pesticides is a relatively new subject, resulting in the fact that there are no confirmed lists of pesticides with endocrine disrupting properties on an official national or international (e.g. WHO, EU) level. This issue has been addressed more intensively by a wide range of scientists in several organisations only in the last ten years. It is important to notice that not even the endocrine system of the human body is fully understood, therefore the range of effects hormone mimicking or blocking chemicals may cause cannot be fully understand. This Chapter attempts to summarise aspects of the existing knowledge on endocrine disrupting effects on humans and the environment.

In the human body two communication systems exist which regulate all responses and functions of the body: the endocrine system and the nervous system. The endocrine system functions through chemical messengers (hormones) which are produced by glands, whereas the nervous system functions through electrochemical messengers running along certain pathways to the brain and back to the peripheral nervous system (see also Chapter 6. 3 Cholinesterase Inhibition on page 12). Hormones composed by the endocrine system instruct body cells more subtly and slowly than the messengers sent over the nervous system. There are several features of the endocrine system which make it a) very complex and complicated to understand, and b) susceptible to chemical input from the outside world. Hormones are specific, slow-acting chemical messengers which travel through the bloodstream and encounter special receptors, and their effects usually continue in the body for long periods of time. The 'specific' aspect of hormones is a particularly striking feature: this means that a hormone fits into a particular receptor, precisely as a key fits only the lock it is made for. This simple description serves as more of a symbol; it does not depict the reality that while many keys may fit into the lock, not all of them induce the appropriate effect, but may instead block the receptor.[30] However, the specification does not exclude a certain flexibility. A specific receptor can be present on different kinds of cells in different organs of the body, which means that a hormone which belongs to this receptor can be used by the body to achieve different effects in different tissues.[31]

Hormones are responsible for the regulation of a large range of human activities and functions, including mutations in DNA nucleotides, biorhythm, mood, concentration of blood calcium and blood sugar, development of secondary sex characteristics and functioning of sex organs. Since certain hormones can alter gene expression and play important roles in regulating the growth and differentiation of cells, they are also involved in carcinogenesis. This is experimentally proven in cases of prostate and breast cancer. Possibilities of environmental contamination are of great concern, in that the introduction of very small amounts of chemicals can significantly effect hormones which play such an important part in the functioning of our bodies.

Most research dealing with endocrine disrupting chemicals has either been done on the alterations of reproductive organs or on the connection between cancer and hormones. As previously explained, hormones work with a kind of lock-key scheme and this is where environmental contaminants come into play. They may mimic other hormones, which means that there are suddenly "fake" hormones in the body which have not been induced by signals

30 McLachlan, J.A., Arnold, S.F.,(1996): Environmental Estrogens, American Scientist, accessible through http://www.amsci.org/amsci/articles/96articles/McLachla.html

31 Eubanks, M. W. (1997): Environmental Health Perspectives Volume 105, Number 5, National Institute of Environmental Health Sciences (NIEHS), USA

from endocrine glands and which subsequently log on to the receptors and stimulate an effect. What puzzles scientists is the fact that chemicals which mimic hormones do not necessarily resemble the chemical structure of the hormone. Blocking a hormone from inducing an effect is another way environmental contaminants can act.

There is evidence that certain pesticides are endocrine disruptors, for example the organochlorine POPs pesticides DDT, *dieldrin*, *toxaphene* and *chlordane, mirex,* and the POPs substitutes *endosulfan.*[32] These pesticides act as estrogens and can alter the sex organs and/or induce cancer. The high hazard potential of endocrine disrupting chemicals has been demonstrated in lab experiments, occurrences in wildlife, and in pesticide accidents. After exposure to estrogenic pollutants an effect called 'feminisation' occurred in wildlife: fish species and amphibia which were exposed developed more female offspring than usual, and experiments showed that eggs (turtle eggs in this case) exposed to estrogens only develop female offspring. As a result of an accident with Kepone (synonym *chlordecone*), exposed men experienced a lower sperm count. The dramatic decrease in sperm count in men all over the world may be due to unintentional exposure to endocrine disrupting chemicals.[33]

Unintentional endocrine disrupting is a subtle and largely unknown process whose symptoms in humans and wildlife may be apparent only decades later. Scientists all over the world have been alerted to these possible adverse effects and while research continues to assess the hazards of these chemicals, Non-Profit Organisations[34] which apply the precautionary principle have been calling for a ban of all known and suspected endocrine disrupting chemicals. Appendix 5 lists the evaluated POPs substitutes and their potential to disrupt the endocrine system. In the absence of existing official national or international sources, this list has been taken from other sources.

The issue of endocrine disrupting far extends the scope of this study; a short list of references has been included in Appendix 5 for further reading.

8 Environmental Toxicity

Pesticides can be released into the environment in many ways. Through run off from the fields they make their way into ditches, rivers, lakes, and ultimately through the water cycle they reach the oceans.They leach into groundwater which is then discharged into streams or is subsequently used for irrigation. Drift, evaporation and precipitation carry pesticides into both nearby and far habitats, and, via the foodchain accumulated in animal tissue, they can travel far distances and arrive at places in which they were never applied. Entire ecosystems are effected by the use of pesticides -not only by POPs pesticides: birds, mammals, insects and all other living creatures are poisoned either directly or indirectly by feeding upon poisoned food; they experience reductions in food supply and habitat for both themselves and their prey due to the extensive use of pesticides. Pesticides have been created to do harm, and the chemical input into the environment is more pervasive and insidious than any other impact humans have had on their habitat.

32 McLachlan, J.A., Arnold, S.F., (1996): Environmental Estrogens, American Scientist, accessible through http://www.amsci.org/amsci/articles/96articles/McLachla.html

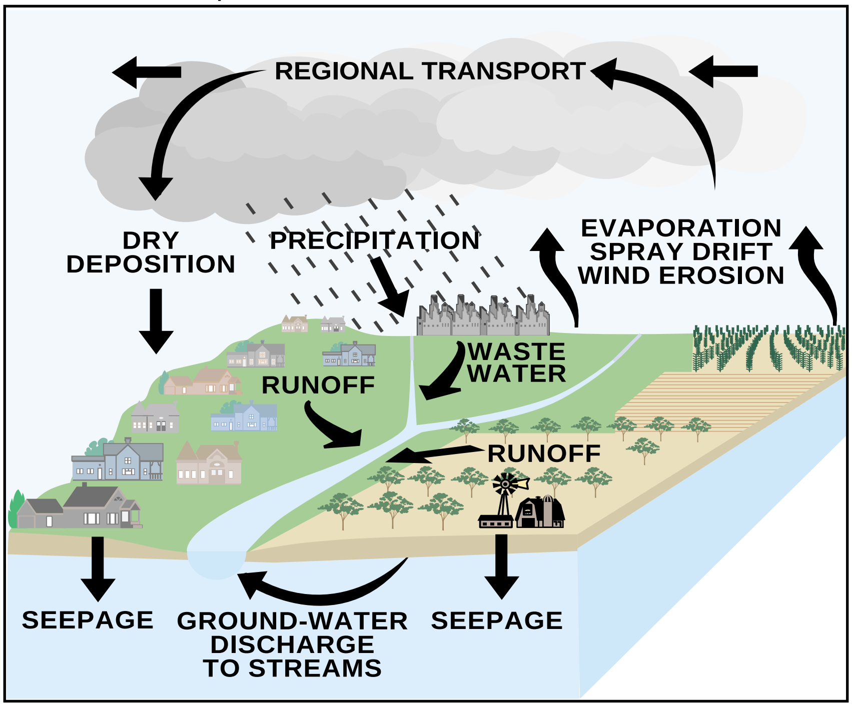
33 McLachlan, J.A., Arnold, S.F., (1996): Environmental Estrogens, American Scientist, accessible through http://www.amsci.org/amsci/articles/96articles/McLachla.html

34 Pesticide Action Network Europe Conference (2000): PAN Europe Position on pesticides with endocrines disrupting effects, 6th through 8th October 2000, Rhöndorf, Germany

Additionally, the fate and functioning of chemicals in the environment is to a great extent unknown and the occurrence of multiple chemicals and their reactions with each other is another serious gap in the knowledge of modern science. Environmental symptoms such as a shift in sex ratios, cancer in wildlife animals, impaired fertility and/or other physical abnormalities can barely be explained at the current stage of scientific knowledge.[35]

A few toxicity tests implemented for the pesticide registration process such as testing of a the lethal concentration to certain fish species or waterfleas do not mimic reality at all. The following Chapter present different approaches to assess the environmental impact of pesticides. The effects of endocrine disruption have already been addressed separately in Chapter 7 on page 23 because it effects human as well as environmental health.

Figure 5: Model of Transportation of Pesticides in the Environment[36]



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8. 1 Classification of the European Union

Forty-nine of the 60 evaluated POPs chemical substitutes are classified by the EU: Thirty-eight of them are classified as "Dangerous for the Environment" and have been assigned with the Symbol "N".

8. 1. 1 Aquatic Environment

The major legislative framework in force dealing with dangerous substances in the European Union is the Council Directive 67/548/EEC of 27 June 1967, on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substances.[37] The classification of dangerous substances regarding their environ-

35 Kegley, S., Neumeister, L., Martin, T., (1999): Disrupting the Balance, Ecological Impacts of Pesticides in California, Pesticide Action Network North America, Californians for Pesticide Reform, San Francisco, USA

36 "Pesticides in Surface Waters", Reprinted with permission from U.S. Geological Survey Fact Sheet FS-039-97, http://water.wr.usgs.gov/pnsp/rep/fs97039/index.html,

mental hazards can be found in the amendment paper 393L0021[38] (Commission Directive 93/ 21/EEC of 27 April 1993), a modification to the directive 67/548/ EEC. The present criteria of this classification refer to aquatic ecosystems, but it is acknowledged that certain substances may affect other ecosystems as well. Table 8displays the classification and the applied risk phrases valid in the European Union. The tests leading to the evaluations are originally described in Annex V of the Directive 67/548 EEC. Amendments and modifications to this Annex have been done and they are to find in separate documents. Comments on the determination of certain effects can also be found in Document 393L0021.

Table 8: EU Classification: "Dangerous for the Environment" (aquatic)

Symbol	Acute Toxicity			Risk Phrase
	Fish LC_{50}[a], mg/L, 96h	Daphnia LC_{50}[b], mg/L, 96h	Algae IC_{50}[c], mg/L 72h	
N	1	1	1	R50
N	1	1	1	R50/53
N	1 ≥ 10	1 ≥ 10	1 ≥ 10	R51/53
-	10 ≥100	10 ≥100	10 ≥100	R52/53
-	-	-	-	R52

a The LC_{50} = lethal concentration is defined as the amount of pesticide present per liter of aqueous solution that is lethal to 50% of the test organisms within the stated study time. Units are mg or µg of pesticide per liter of solution. Equivalent units are ppm (mg/L) and ppb (µg/L).

b The EC_{50} = effective concentration of the pesticide in mg/L or µg/L that produces a specific measurable effect in 50% of the test organisms within the stated study time. The measurable effect is lethality for zooplankton and a reduction in photosynthetic activity by 50% for phytoplankton.

c The IC_{50} = inhibitive concentration of the pesticide defined as the amount of pesticide present per liter of a solution that inhibits the growth of a algae culture by 50% within the stated study time.

R50: Very toxic to aquatic organisms
R51: Toxic to aquatic organisms
R52: Harmful to aquatic organisms
R53: May cause long-term adverse effects in the aquatic environment

Combined Risk Phrases should be read with a 'comma' between the phrases, as in R50/53: Very toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

For aquatic organisms tests are carried out using either static or flow-through methods. In the static method, the pesticide and test organisms are added to the test solution and kept there for the remainder of the experiment. In the flow-through method, a freshly prepared, pesticide-spiked test solution flows through the test chamber continuously for the duration of the test. The flow-through method provides a higher continuous dose of the pesticide; however, the static method does not remove waste products and may accumulate toxic breakdown products. Neither method exactly mimics a natural system. The EU recommends in Document 398L0073[39]

37 European Union (1967): Council Directive 67/548/EEC of 27 June 1967 on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substance, Official Journal 196, Brussels, Belgium

38 European Union (1993): Document 393L0021, Council Directive 93/21/EEC of 27 April 1993 adapting to technical progress for the 18th time Council Directive 67/548/EEC on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substance, Official Journal L 110, Brussels, Belgium

from 1998 the flow-through method for fish according to the test method of the Organisation for Economic Co-operation and Development (OECD) TG 305, but also approves data from other test methods. For *daphnia* species (preferred *Daphnia magn*a, but *Daphnia pulex* is also possible) and algae (*Selenastrum capricornutum* and *Scenedesmus subspicatus*), the static method should apply. The Risk Phrase "R53: May cause long-term adverse effects in the aquatic environment" is applied to substances which are not readily degraded and therefore pose a long time threat to the environment. The test methods are described in Document 392L0069[40] 17th amendment of Directive 67/548 EEC. Please note that the test method for fish from Document 398L0073 replaces the test method from Document 392L0069.

Thirty-three of the POPs chemical substitutes are classified as "Dangerous for the Environment" and have been assigned with the Symbol "N"; eleven substitutes have not been evaluated by the EU at all and eighteen substitutes have not been classified as "Dangerous for the Environment", neither for terrestrial, aquatic, or other environments. (see following Chapter).

The EU Symbols and Risk Phrases of the POPs Chemical Substitutes can be found in Table 10and in Appendix 6.

8. 1. 2 Terrestrial Environment

The EC also classifies substances according to the dangers they pose to environments other than the aquatic environment. If one of the following Risk Phrases apply to a substance the Symbol "N" for "Dangerous for the Environment" is to assign:

R54: Toxic to flora
R55: Toxic to fauna
R56: Toxic to soil organisms
R57: Toxic to bees
R58: May cause long-term adverse effects in the environment
R59: Dangerous for the ozone layer.

The EC does not require testing for those criteria and test methods have not been described in Document 392L0069. Document 393L0021 simply states that this classification is applicable when available evidence shows that pesticides may present a danger for ecosystems and that the criteria will be elaborated later. Classifying a substance as R59 occurs whether or not the substance is listed in Annex I Group I, II, III, IV and V to Council Regulation (EEC) No. 594/91 on substances that deplete the ozone layer.[41]

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39 Europäische Gemeinschaft (1998): Dokument 398L0073, Richtlinie 98/73/EG der Kommission vom 18. September 1998 zur vierundzwanzigsten Anpassung der Richtlinie 67/548/EWG des Rates zur Angleichung der Rechts- und Verwaltungsvorschriften für die Einstufung, Verpackung und Kennzeichnung gefährlicher Stoffe an den technischen Fortschritt, Amtsblatt Nr. L 305 vom 16/11/1998, EG, Brüssel, Belgien

40 Europäische Gemeinschaft (1992): Dokument 392L0069, Richtlinie 92/69/EWG der Kommission vom 31. Juli 1992 zur siebzehnten Anpassung der Richtlinie 67/548/EWG des Rates zur Angleichung der Rechts- und Verwaltungsvorschriften für die Einstufung, Verpackung und Kennzeichnung gefährlicher Stoffe an den technischen Fortschritt Amtsblatt nr. L 383 vom 29/12/1992, EG, Brüssel, Belgien

41 European Union (1993): Document 393L0021, Council Directive 93/21/EEC of 27 April 1993 adapting to technical progress for the 18th time Council Directive 67/548/EEC on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substance, Official Journal L 110, Brussels, Belgium

Please note all documents are available in multiple languages on the EC website; the prefix determines the document language e.g. en_392L0069.html, de_392L0069.html

8. 2 Cornell University

The IPM Programme of Cornell University (New York) has developed an elaborated approach to assess the impact of pesticides and pest management practises on the environment. Information on physical properties, toxicities and environmental fate were gathered to develop a model called the Environmental Impact Quotient (EIQ). The equation used in calculating the EIQ is based upon the three components of agricultural production systems: a farm worker component, a consumer component, and an ecological component.[42]

Since the health hazards of the POPs Chemical Substitutes have already been described in the Chapter Human Toxicity, only the ecological component of the EIQ model will be used in this study. The EIQ model is built using a rating system: for each pesticide, parameter values between 1 to 5 according to the properties of the pesticide have been assigned. Low values mean low impact, high values the opposite. The parameter, the applied rating system and the main data sources are displayed in Table 9.

Table 9: Rating System for the Environmental Impact Quotient

Parameter	Rating System		Data Source
Mode of Action	non-systemic	1	EXTOXNET, CHEM-NEWS
	all herbicides	1	
	systemic	3	
Acute Dermal LD_{50} for Rabbits/ Rats	> 2000	1	EXTOXNET, CHEM-NEWS
	200 - 2000	3	
	200 - 5	5	
Long-Term Health Effects	little or none	1	EXTOXNET, CHEM-NEWS
	possible	3	
	definite	5	
Plant Surface Residue Half-life	l -2 weeks	1	EXTOXNET, CHEM-NEWS
	2 - 4 weeks	3	
	> 4 weeks	5	
	pre-emergent herbicides	1	
	post-emergent herbicides	3	
Soil Residue Half-life	< 30 days	1	USDA Agricultural Research Service and Soil Conservation Service
	30 - 100 days	3	
	> 100 days	5	
Toxicity to Fish-96 hr LC_{50}	> 10 mg/l	1	EXTOXNET, CHEM-NEWS
	1 - 10 mg/l	3	
	< 1 mg/l	5	
Toxicity to Birds-8 day LC_{50}	> 1000 mg/l	1	EXTOXNET, CHEM-NEWS
	100 - 1000 mg/l	3	
	1 - 100 mg/l	5	

42 IPM Programme, Cornell University, New York State Agricultural Experiment Station Geneva (1999):A Method to Measure the Environmental Impact of Pesticides, accessible through http://www.nysaes.cornell.edu/ipmnet/ny/Programme_news/EIQ.html, New York, USA

Table 9: Rating System for the Environmental Impact Quotient		
Parameter	Rating System	Data Source
Toxicity to Bees	relatively nontoxic 1 moderately toxic 3 highly toxic 5	New York State Pesticide Recommendations
Toxicity to Beneficials	low impact 1 moderate impact 3 severe impact 5	SELCTV (Oregon State)
Groundwater and Runoff Potential	small 1 medium 3 large 5	USDA Agricultural Research Service and Soil Conservation Service

Within the components, individual factors are weighted differently. To give additional weight to individual factors, coefficients are used based on a one to five scale. Factors with the most weight are multiplied times five, medium-impact factors are multiplied times three and least-impact factors are multiplied times one. The exposure potential is expressed through factors as well, for example, fish toxicity is calculated by determining the toxicity of the pesticide to fish, times the probability (runoff potential) of the fish undergoing exposure to the pesticide.

Even when this model is quite comprehensive and closer to the real-life situation than other approaches to environmental assessment, there are a few inherent weaknesses: toxicities of algae and zooplankton, critical elements of the aquatic environment, have been left out; acute toxicity to mammals is only expressed as dermal $LD_{50,}$ (exposure through the skin) $_;$ and toxicity to birds only as LC_{50} (lethal concentration). The last point is especially critical, since direct ingestion of contaminated food or granular forms of pesticides is often responsible for larger bird kills.[43] Potential endocrine disrupting effects have been left out in the model as well.

For 41 of the POPs Chemical Substitutes the ecological impact according to the model of Cornell University has been calculated. The list of the POPs Chemical Substitutes and their evaluation by Cornell University can be found in Appendix 5. The insecticides *disulfoton*, *propoxur*, *parathion* and *phorate* are the pesticides with the highest ecological impact due to their high toxicity on bees, birds and beneficial organisms. *Phosalone* has the lowest ecological impact according to the model of Cornell University, but the European Union assigned the symbol ‘N’ and the risk phrases R50/53: Very toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment to this pesticide. This contradiction may be explained by the fact that the EU takes into account toxicities to algae and zooplankton; different data sources may be another reason.

43 Kegley, S., Neumeister, L., Martin, T., (1999): Disrupting the Balance, Ecological Impacts of Pesticides in California, Pesticide Action Network North America, Californians for Pesticide Reform, San Francisco, USA

Table 10: The POPs Chemical Substitutes and Their Environmental Hazard Assessment

Substitute	CAS Number	European Union		Evaluation Cornell University (New York)							
		Symbol	Risk Phrases	Fish	Birds	Bees	Beneficial Organism	Groundwater and Runoff Potential	Terrestrial Organisms	Ecological Impact	Nr. of List.
acephate	30560-19-1			1,0	9,0	15,0	18,7	1,0	42,7	43,7	2
alachlor	15972-60-8	N	50/53	9,0	3,0	3,0	25,0	3,0	31,0	40,0	1
aldicarb	116-06-3	N	50/53	3,0	30,0	3,0	16,4	5,0	49,4	52,4	2
alpha-cypermeth-rin	67375-30-8										3
azinphos-methyl	86-50-0	N	50/53	25,0	30,0	15,0	18,3	1,0	63,3	88,3	1
bendiocarb	22781-23-3	N	50/53	9,6	5,0	15,0	17,5	2,1	37,5	47,1	4
bifenthrin	82657-04-3			16,0	6,3	18,5	38,1	2,0	62,9	78,9	2
bitertanol	55179-31-2										2
carbaryl	63-25-2	N	50	9,0	9,0	15,0	19,7	1,0	43,7	52,7	23
carbofuran	1563-66-2	N	50/53	5,0	30,0	15,0	19,4	5,0	64,4	69,4	30
carbosulfan	55285-14-8	N	50/53								7
carboxin	5234-68-4			15,0	15,0	3,0	12,4	1,0	30,4	45,4	2
chlorfenvinphos	470-90-6	N	50/53	16,1	20,6	28,5	23,0	2,0	72,1	88,2	1
chlorpyrifos	2921-88-2	N	50/53	25,0	45,0	15,0	19,9	1,0	79,9	104,9	31
cyfluthrin	68359-37-5	N	50/53	5,0	9,0	45,0	60,0	1,0	114,0	119,0	2
cypermethrin	52315-07-8			25,0	9,0	45,0	61,2	1,0	115,2	140,2	4
DDVP	62-73-7	N	50	9,6	15,0	15,0	19,2	1,0	49,2	58,8	3
deltamethrin	52918-63-5	N	50/53	16,1	3,0	15,0	20,4	2,0	38,4	54,5	9
diazinon	333-41-5	N	50/53	15,0	30,0	15,0	19,5	3,0	64,5	79,5	15
dicrotophos	141-66-2	N	50/53								1
diflubenzuron	35367-38-5			5,0	9,0	15,0	69,0	1,0	93,0	98,0	2
dimethoate	60-51-5			5,0	30,0	45,0	60,9	3,0	135,9	140,9	4
disulfoton	298-04-4	N	50/53	15,0	45,0	45,0	82,8	1,0	172,8	187,8	3
endosulfan	115-29-7	N	50/53	25,0	27,0	9,0	17,6	1,0	53,6	78,6	20
ethofenprox	80844-07-1										1
fenitrothion	122-14-5	N	50/53	3,0	15,0	15,0	20,5	3,0	50,5	53,5	8
fenthion	55-38-9	N	50/53								2
fenvalerate	51630-58-1			25,0	9,0	45,0	57,8	1,0	111,8	136,8	3
flucythrinate	70124-77-5										1
fonofos	944-22-9	N	50/53	25,0	30,0	9,0	18,8	3,0	57,8	82,8	6
fuberidazole	3878-19-1	N	50/53								2
guazatine	13516-27-3	N	50/53								1
isazophos	42509-80-8	N	50/53	16,0	9,0	9,8	17,5	2,0	36,3	52,3	2
isofenphos	25311-71-1			9,7	37,2	19,1	34,3	2,0	90,6	100,3	3
isoprocarb	2631-40-5	N	50/53								1
lambda cyha-lothrin	91465-08-6	N	50/53	25,0	3,0	15,0	17,5	1,0	35,5	60,5	1
lindane	58-89-9	N	50/53	25,0	31,1	28,5	35,5	3,0	95,1	120,1	13
malathion	121-75-5			5,0	3,0	15,0	21,0	1,0	39,0	44,0	11
methamidophos	10265-92-6	N	50	1,0	30,0	45,0	65,3	5,0	140,3	141,3	1
methomyl	16752-77-5	N	50/53	15,0	30,0	15,0	21,5	5,0	66,5	81,5	2
metribuzin	21087-64-9	N	50/53	3,0	27,0	9,0	51,0	5,0	87,0	90,0	1
monocrotophos	6923-22-4	N	50/53								10
parathion	56-38-2	N	50/53	25,0	30,0	45,0	65,1	1,0	140,1	165,1	8
permethrin	52645-53-1			25,0	9,0	45,0	61,8	1,0	115,8	140,8	7
phenthoate	2597-03-7										2
phorate	298-02-2			25,0	45,0	27,0	57,6	1,0	129,6	154,6	12
phosalone	2310-17-0	N	50/53	16,1	3,0	3,0	17,4	2,0	23,4	39,5	2
phosphamidon	13171-21-6	N	50/53	3,0	15,0	15,0	19,9	5,0	49,9	52,9	3
phoxim	14816-18-3										2
pirimiphos ethyl	23505-41-1	N	50/53								1
pirimiphos-methyl	29232-93-7										3

Table 10: The POPs Chemical Substitutes and Their Environmental Hazard Assessment

Substitute	CAS Number	European Union		Evaluation Cornell University (New York)								
		Symbol	Risk Phrases	Fish	Birds	Bees	Beneficial Organism	Groundwater and Runoff Potential	Terrestrial Organisms	Ecological Impact	Nr. of List.
propoxur	114-26-1	N	50/53	16,0	60,0	45,0	55,8	1,0	160,8	176,8	3
pyrethrins	8003-34-7	N	50/53	16,0	9,0	3,0	17,0	2,0	29,0	45,0	1
quinalphos	13593-03-8										3
resmethrin	10453-86-8	N	50/53	16,0	6,3	28,5	39,1	2,0	73,9	89,9	2
sulfluramid	4151-50-2										2
tetrachlorvinphos	22248-79-9										3
triazophos	24017-47-8	N	50/53								1
trichlorfon	52-68-6			16,1	15,0	9,0	20,2	2,0	44,2	60,3	5
trifluralin	1582-09-8	N	50/53	25,0	9,0	3,0	20,0	1,0	32,0	57,0	1

9 PAN Germany Evaluation

While the previous chapters describe different approaches to assess particular effects of pesticides on human health and the environment, the following chapters will attempt to provide an overall evaluation.

Several problems emerge while evaluating pesticides. One of the most severe problems is the occurrence of data gaps, not all POPs Chemical Substitutes have been evaluated by the organisations mentioned in this study. Another substantial problem is that the various existing classification systems cannot easily be compared, because different test methods, data and parameters are being used.

The existing classification systems which finally should lead to conclusions of the acceptance or non-acceptance of a pesticide in the human or natural environment are mostly based on scientific approaches such as tests of the lethal dose or the lethal concentration to 50% of a tested population of mammals, birds, fishes, zooplankton etc. While those established scientific criteria lead to a science-based acceptance or non-acceptance of chemicals in the environment, acceptance in general is not scientifically based. If, for example, 50% of the fish population in a lake die due to a contamination, this might be acceptable to a person in a nearby city, but it might not be acceptable to the fisher who earns his living from this lake. The extensive issue of human and economy-based risk assessment, uncertainty factors, tolerance levels, acceptable doses and risks is not an element of this study.

9. 1 Evaluation Method: Rank-Order System

Pesticide Action Network Germany developed an evaluation method which was first used in the “Toxicological and ecotoxicological evaluation of the EU 90-substance list” and which is based upon work done at the University of Bremen.[44] This method is a rank-order system built on a comparative assessment and is applied in this study. The goal of the rank-order system is to mathematically combine several criteria and compare the results within the existing list of pesticides.

The *first step* in the procedure is the choice of criteria and categories, which must be included in the rank-order system in order to evaluate the pesticides. The criteria chosen in this study

44 Altenburger, R., Boedeker, W., Keuneke, S., Weber, C. (1995): Toxicological and ecotoxicological evaluation of the EU 90-substance list, Pesticide Action Network Germany, Bremen and Hamburg, Germany

are the acute and chronic toxicity, the carcinogenicity, the ecological impact of Cornell University and the endocrine disruptor listings. There are several reasons for exclusion of criteria in the rank-order system. There are two criteria for acute toxicity mentioned in this study (EC, WHO). In those cases categories were chosen which have more complete data bases and/or a more comprehensive evaluation approach. Categories with large data gaps and unclear evaluation approaches have been left out. An exception is the issue of endocrine disrupting properties. This issue raises enormous concern for human health and the environment. In addition there is great uncertainty regarding the effects of endocrine disrupting chemicals; in contrast to other chemically induced effects, even very low exposure doses can lead to fatal consequences.

The *second step* in the process is to assign numeric values to the different categories of toxicities or exposure potencies. This simply means a translation from, for instance, IARC's cancer category: Group 2B (the agent is possibly carcinogenic to humans) to a number. The assignment of the numeric values is flexible and greatly depends upon the existing data in the evaluated list. For category values which are already numeric, such as the ADI value or the ecological impact value, the numbers are left unchanged; here it is important to notice that in some cases (e.g. ADI) small values mean a high toxicity. The following table presents this second step for categories used in this study.

Table 11: Criteria, Categories and their Numeric Values Chosen for the Rank-Order System

Criteria	Category	Numeric Value
Acute Toxicity	WHO Category Ia	5
	WHO Category Ib	4
	WHO Category II	3
	WHO Category III	2
	WHO Category U	1
Carcinogenicity	U.S. EPA Category B2	3
	IARC Group 2B or U.S. EPA Category C	2
	IARC Group 3 or U.S.EPA Category D	1
Chronic Toxicity	WHO/FAO Acceptable Daily Intake value (ADI)	ADI value, inverse, low value equals high toxicity
Ecological Impact	Cornell Ecological Impact	Ecological Impact value, high value high impact
Endocrine Disrupting	"yes", "known", "suspected", "probable"[a]	1
	not listed	0

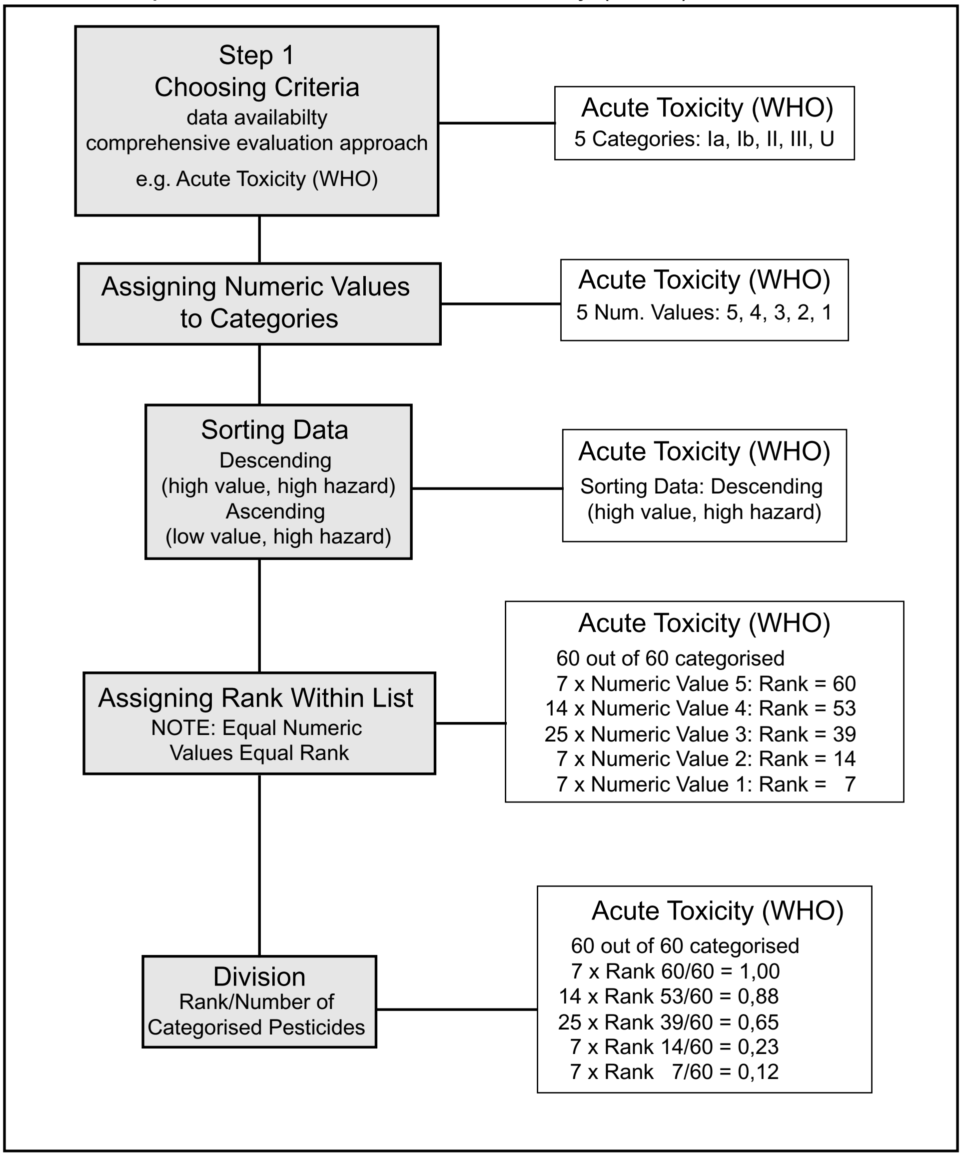
a see Appendix 5

The *third step* is to sort the pesticide list by the numeric value of one criterion. Depending on the existing data the list has to be sorted in either ascending or descending order, in cases where high numeric values also mean high toxicity, the list has to be sorted in descending order and vice versa. For example, pesticides with a numeric value of 5 for the criterion acute toxicity (WHO 'Ia') would be at the top of the list.

The *fourth step* is to rank the pesticides according to their place in the sorting order, all pesticides with the equal numeric value are assigned the same rank. The rank is assigned according to the number of categorised pesticides. For example, all (60) of the 60 POPs Chemical Substitutes are categorised by the WHO, meaning that the highest rank in the sorting order for the highest toxicity is 60.

The *fifth step* is the division. The assigned ranks are now divided by the number of the categorised pesticides. The result for the highest toxicity is therefore always 1,00. For example, the highest rank for the acute toxicity is 60; this number divided by the number of categorised pesticides 60 results in 1,00. The disadvantage is that pesticides with no data cannot be included in this scheme, and therefore the final results have to be analysed again. The following figure displays the first five steps of the rank-order system for the criterion acute toxicity (WHO) for the 60 evaluated POPs Chemical Substitutes.

Figure 6: Steps One through Five of the Rank-Order System With the Example for the Criterion Acute Toxicity (WHO)



In this study the steps one through five were done for all pesticides with data entries in the categories presented in Table 11, with the exception of the criterion Endocrine Disrupting. In absence of official national and international lists, the numeric value 1 was chosen for the entries “yes”, “known”, “suspected”, and “probable”.

The final step, the addition of the single outcomes from step five results in one value for each evaluated pesticide. Since only summarising mathematic functions were used in the rank-order scheme the final result is to interpret as follows: high values mean high toxicity. While this is true for pesticides without data gaps, pesticides with no or low data have to be evaluated differently.

9. 2 Results of the Rank-Order System

The results of the rank-order system can be found in Table 12. The list of the evaluated POPs Chemical Substitutes in the Table is sorted in descending order according to the final result of the rank-order system. The objective of this list is not to provide an evaluation of one active ingredient, it is rather to make a comparison among the pesticides listed by using a limited number of criteria; but even due to data gaps it can be said that the pesticides on top of this list are particularly dangerous to human health and the environment.

Table 12: Results of the Rank-Order System for the Evaluated POPs Chemical Substitutes

Substitute	CAS Number	Fractional Rank					Result
		Acute Toxicity (WHO)	Cancer	Chronic Toxicity (ADI)	Ecological Impact (Cornell)	ED	
lindane	58-89-9	0,65	1,00	0,89	0,78	1	4,32
parathion	56-38-2	1,00	0,50	0,71	0,95	1	4,16
cypermethrin	52315-07-8	0,88	0,90	0,07	0,83	1	3,68
carbaryl	63-25-2	0,65	0,90	0,78	0,24	1	3,57
bifenthrin	82657-04-3	0,65	0,90	0,40	0,49	1	3,44
fenvalerate	51630-58-1	0,65	0,50	0,40	0,80	1	3,35
aldicarb	116-06-3	1,00	0,50	0,60	0,22	1	3,32
dimethoate	60-51-5	0,65	0,90	0,82	0,88	0	3,25
deltamethrin	52918-63-5	0,65	0,50	0,71	0,32	1	3,18
phosphamidon	13171-21-6	1,00	0,90	0,98	0,27	0	3,15
permethrin	52645-53-1	0,65	0,50	0,07	0,85	1	3,07
propoxur	114-26-1	0,65	1,00	0,40	0,98	0	3,03
disulfoton	298-04-4	1,00		1,00	1,00	0	3,00
dichlorvos/DDVP	62-73-7	0,88	0,90	0,82	0,37	0	2,97
phorate	298-02-2	1,00		0,98	0,93	0	2,90
chlorpyrifos	2921-88-2	0,65		0,51	0,73	1	2,89

Table 12: Results of the Rank-Order System for the Evaluated POPs Chemical Substitutes							
Substitute	CAS Number	Fractional Rank					Result
		Acute Toxicity (WHO)	Cancer	Chronic Toxicity (ADI)	Ecological Impact (Cornell)	ED	
cyfluthrin	68359-37-5	0,65		0,40	0,76	1	2,81
endosulfan	115-29-7	0,65		0,56	0,46	1	2,67
methomyl	16752-77-5	0,88		0,22	0,54	1	2,64
methamidophos	10265-92-6	0,88		0,71	0,90	0	2,50
isofenphos	25311-71-1	0,88		0,89	0,71	0	2,48
chlorfenvinphos	470-90-6	0,88		0,98	0,59	0	2,45
flucythrinate	70124-77-5	0,88		0,40		1	2,28
metribuzin	21087-64-9	0,12	0,50		0,66	1	2,28
azinphos-methyl	86-50-0	0,88		0,60	0,61	0	2,09
lambda cyhalothrin	91465-08-6	0,65		0,00	0,41	1	2,06
alachlor	15972-60-8	1,00			0,05	1	2,05
trifluralin	1582-09-8	0,12	0,50	0,09	0,34	1	2,05
pyrethrins	8003-34-7	0,65		0,11	0,12	1	1,88
resmethrin	10453-86-8	0,23			0,63	1	1,87
malathion	121-75-5	0,23	0,50	0,02	0,10	1	1,85
carbofuran	1563-66-2	0,88		0,51	0,44	0	1,83
monocrotophos	6923-22-4	0,88		0,91		0	1,79
triazophos	24017-47-8	0,88		0,89		0	1,77
diazinon	333-41-5	0,65		0,51	0,51	0	1,67
alpha-cypermethrin	67375-30-8	0,65				1	1,65
fonofos	944-22-9	1,00			0,56	0	1,56
fenitrothion	122-14-5	0,65		0,60	0,29	0	1,54
bendiocarb	22781-23-3	0,65		0,71	0,17	0	1,53
trichlorfon	52-68-6	0,23	0,50	0,40	0,39	0	1,52
acephate	30560-19-1	0,23	0,90	0,22	0,07	0	1,43
phenthoate	2597-07-3	0,65		0,78		0	1,43
phoxim	14816-18-3	0,65		0,71		0	1,36
diflubenzuron	35367-38-5	0,12		0,40	0,68	0	1,20
fenthion	55-38-9	0,65		0,53		0	1,18
carbosulfan	55285-14-8	0,65		0,51		0	1,16
isazophos	42509-80-8	0,88			0,20	0	1,08
phosalone	2310-17-0	0,65		0,40	0,02	0	1,07
ethofenprox	80844-07-1	0,12	0,90			0	1,02
dicrotophos	141-66-2	0,88				0	0,88

Table 12: Results of the Rank-Order System for the Evaluated POPs Chemical Substitutes							
Substitute	CAS Number	Fractional Rank					Result
		Acute Toxicity (WHO)	Cancer	Chronic Toxicity (ADI)	Ecological Impact (Cornell)	ED	
pirimiphos ethyl	23505-41-1	0,88				0	0,88
guazatine	13516-27-3	0,65		0,22		0	0,87
isoprocarb	2631-40-5	0,65				0	0,65
quinalphos	13593-03-8	0,65				0	0,65
bitertanol	55179-31-2	0,12		0,51		0	0,63
tetrachlorvinphos	22248-79-9	0,12	0,50			0	0,62
pirimiphos-methyl	29232-93-7	0,23		0,22		0	0,46
carboxin	5234-68-4	0,12			0,15	0	0,26
fuberidazole	3878-19-1	0,23				0	0,23
sulfluramid	4151-50-2	0,23				0	0,23

9. 3 Results of the Ranking of the Chemical Substitutes by Crop and Commodity

The POPs Database on Alternatives of the United Nations Environment Programme (UNEP) is based upon Specific Uses and Applications of the nine POPs pesticides (see Appendix 1 and 3). With this data base it is already known on what commodities or crops the POPs pesticides are mainly used.

In order to develop a list of especially critical crops, the results of the rank-order system were used. The information on crops and commodities from Appendix 3 were first grouped into a crop and commodity list and then combined with the results from the rank-order system (see Table 12 and Appendix 7), after which an average was calculated. Results of this procedure are presented in Table 13. The intention of this list is to illustrate the need of pesticide independent pest management for particular crops.

Table 13: Critical Crops and Commodities According to the Results of the Rank-Order System		
Crop or Commodity	Average Ranking Result	Number of POPs Chemical Substitutes
Dolichos and Lablab	2,96	4
Peas	2,95	4
Cowpeas	2,83	3
Peach	2,64	2
Mango	2,53	5
Grassland	2,45	2
Beans	2,20	8
Okra	2,19	6
Sweet Potatoes	2,17	8
Artichokes	2,11	1
Haricots	2,11	1
Rice	2,11	9

Table 13: Critical Crops and Commodities According to the Results of the Rank-Order System

Crop or Commodity	Average Ranking Result	Number of POPs Chemical Substitutes
Soya	2,09	3
Citrus	2,09	5
Mung Bean	1,93	1
Tobacco	1,79	1
Groundnuts	1,76	10
Cotton	1,74	11
Ants control	1,61	15
Potatoes	1,57	12
Malaria control	1,51	13
Maize, Corn	1,49	12
Wheat	1,49	6
Pecan	1,44	2
Termite control	1,42	11
Coconut	1,41	4
Sugarcane	1,38	14
Chickpea	1,37	4
Banana	1,35	3
Flowers	1,32	1
Grapes	1,24	4
Cabbage	1,16	1
Pineapple	1,16	1
Sorghum	1,12	3
Tomatoes	0,96	2
Storage	0,12	2

The list above is ordered accordingly to the average value of all results of the rank-order system of the single POPs Chemical Substitutes. It must be considered that crops such as banana, corn, rice, soya and cotton are produced on a very large scale. This means that the pesticide exposed environment can be very extensive. In addition it has to be taken into account that the number of farm workers working in the fields vary by crop and commodity as well as the grade of agricultural industrialisation. It is recommended to adjust the list above to this fact.

10 Use of the POPs Chemical Substitutes Under Conditions of Poverty

Conditions of poverty define a situation in which the proper use of pesticides cannot be expected because personal resources (training and information), technical resources (application equipment) and economic resources (intact and adequate protective clothing) are lacking and therefore it is not possible to make an individual user responsible for the misuse of pesticides.[45]

The consequences of pesticide use in developing countries under conditions of poverty are fatal. According to conservative estimations a number of 1,000,000 pesticide incidents resulting in 20,000 deaths happen a year.[46] The World Labour Organisation illustrated in their World Labour Report the following situation: "As one authoritative source puts it, industrialized countries use 80 per cent of the world's agrochemicals but probable suffer only 1 per cent or less of all deaths due to pesticides poisonings; developing countries, on the other hand, suffer 99 per cent of all such deaths while using only 20 per cent of the world's agrochemicals.[47]

While those reported and estimated incidents take only acute cases of poisoning into account, the chronic, subchronic and long-term damages due to pesticide exposure and environmental impacts caused by pesticides remain mainly unknown.

There are various reasons for the occurrence of a high number of incidents in developing countries; on different levels: trade, legislation, contribution and use of pesticides:

- pesticides are aggressively advertised by the manufacturers
- they appear to be a cheap way to increase yields and solve disease problem and they are apparently easy to use
- the legislative framework decisions in developing countries are often based on poor information and financial pressure
- food production and food export have higher priority than human health and the environment
- control procedures for distribution and retail sales do not exist
- they are often sold unlabelled
- they are often sold in former food packages
- they are applied by uneducated farmers or even children
- their hazards and proper uses are often unknown
- protective clothing does not exist or appears "disturbing"

45 Pestizid Aktions-Netzwerk e.V. (PAN Germany), (ed.), (1998): Kein Schutz vor Pestizidvergiftungen in Entwicklungsländern, Eine Bestandsaufnahme deutscher und internationaler Bemühungen zur Verbesserung des Schutzes von Pestizidanwendern, Pestizid Aktions-Netzwerk (PAN) e.V., Hamburg, Germany (Title translation: No Protection from Pesticide Poisonings in Developing Countries, An Analysis of German and International Efforts to Improvements of the Protection of Pesticide Users)

46 Bödeker, W. (1993): Zur Häufigkeit tödlicher und nichttödlicher Pestizidvergiftungen. Eine Betrachtung nationaler und internationaler Morbiditäts- und Mortalitätsstatistiken. In: Bödeker, W. und Dümmler, Chr. (eds.): Pestizide und Gesundheit, Karlsruhe, Verlag C.F. Müller (Titel translation: About the Frequency of Lethal and non-Lethal Pesticide Poisonings. An Examination of National and International Statistics on Morbidity and Mortality)

47 Schwab A., et al. (1989): Pestizideinsatz in Entwicklungsländern, Gefahren und Alternativen, Pestizid Aktions-Netzwerk e.V. (PAN Germany), (ed.),. Hamburg, Verlag Josef Margraf, Weikersheim (Title translation: Pesticide Use in Developing Countries, Dangers and Alternatives)

- they are often used as medicine on people
- traditional knowledge of natural pest control has already disappeared
- pest resistance leads continuously to more dependency on chemical pesticide use.

In addition, the exposed population often has no power to make their voices and interests heard; even if they are heard by the press, owners of plantations for instance may threaten those people and demand the withdrawal of the objections.[48]

Taking into consideration the points above, it can be summarised that a safe use of pesticides under the condition of poverty is not possible.[49]

11 POPs Chemical Substitutes Not Recommended by PAN Germany - Conclusions

This study uses widely accepted classification systems to evaluate the human and environmental toxicity of 60 chemical substitute of the POPs pesticides as listed in the UNEP "POPs Database on Alternatives".The previous chapters clearly show that most of the POPs "Chemical Substitutes" pose a threat to human health and the environment. It also demonstrated that a safe use of pesticides under conditions of poverty is not possible. To minimise environmental and human health risks PAN Germany recommends to exclude POPs Chemical Substitutes, which are classified as follows:

- Acute Toxicity (Ia, Ib by the WHO or T+, T by the EU)
- Dangerous for the Environment (N) by the EU
- Carcinogenicity (B2, C, D by the U.S. EPA; 2B, 3 by the IARC and 3 by the EU).

Additionally, in applying the precautionary principle, PAN Germany recommends to exclude POPs Chemical Substitutes, which are:

- Endocrine Disruptors (ED) (listed as "known", "probable", "suspected", "yes" in Appendix 5)
- Cholinesterase Inhibitors (ChE), (chemicals which belong to the chemical classes *organophosphorus* and *n-methyl carbamate* cause this effect see Appendix 2)
- highly toxic (values over 45) to one of the ecological factors evaluated by the University of Cornell,

as well as those for which no data except the WHO classification and the ADI value exist.

In order to accomplish a list of POPs Chemical Substitutes which are not recommended by PAN Germany a database with all POPs chemical substitutes and their classifications was searched and all pesticides classified as mentioned above were excluded.

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48 Personal Communication with Dr. Romeo Quijano, Pesticide Action Network Asia and the Pacific

49 Pestizid Aktions-Netzwerk e.V. (PAN Germany), (ed.), (1998): Kein Schutz vor Pestizidvergiftungen in Entwicklungsländern, Eine Bestandsaufnahme deutscher und internationaler Bemühungen zur Verbesserung des Schutzes von Pestizidanwendern, Pestizid Aktions-Netzwerk (PAN) e.V., Hamburg, Germany (Title translation: No Protection from Pesticide Poisonings in Developing Countries, An Analysis of German and International Efforts to Improvements of the Protection of Pesticide Users)

Table 14 presents the number of substitutes and their classifications in a matrix. The matrix shows that most chemical substitutes have entries in multiple toxicity category.

The number of the POPs 'Chemical Substitutes' not recommended by PAN Germany results in a total number of 60. This means that PAN does not recommend any of the UNEP POPs chemical substitutes.

Table 14: Number of Chemical Substitutes and Their Classification

		WHO Ia	WHO Ib	EU T+	EU T	EU N	U.S.EPA B2	U.S.EPA C	U.S.EPA D	IARC 2B	IARC 3	EU 3	ED Y	ChE Y	Cornell >45	Data Gaps Y
WHO	**Ia**	7		6		5		2			2	1	3	5	3	
WHO	**Ib**		14	9	3	11		2		1			3	12	2	
EU	**T+**	6	8	17		16		3			2		5	15	5	
EU	**T**		3		13	11	2	1		1	1		4	10	1	
EU	**N**	5	11	16	11	38	2	5	1	1	5	2	14	26	5	
U.S.EPA	**B2**				2	2	2						1	1	1	
U.S.EPA	**C**	2	2	3	1	5	1	12		1	4	1	7	6	3	
U.S.EPA	**D**					1			2		1		2	1	1	
IARC	**2B**		1		1	1		1		1				1		
IARC	**3**	2		2	1	5		4	1		10	1	8	6	3	
EU	**3**	1				2		1			1	2	2	1		
ED	**3**	3		5	4	14	1	7	2		8	2	22	6	6	
ChE	**Y**	5	12	15	10	26	1	6	1	1	6	1	6	37	6	
Cornell	**>45**	3	2	5	1	5	1	3	1	1	3		6	6	12	
Data Gaps	**Y**															3

How to read this matrix: The grey boxes present the number of pesticides placed in one toxicity classification. For example, 38 pesticides are classified as Dangerous for the Environment (Symbol 'N') by the EU. To see how often those 38 pesticides have been placed into other categories, the column up or down or the row left and right of the grey box must be read.

Appendix 1 - Specific Uses and Applications Of the Nine POPs Pesticides

Specific Use and Application	Aldrin	Chlordane	DDT	Dieldrin	Endrin	HCB	Heptachlor	Mirex	Toxaphene
Agriculture & Forestry									
Agriotes obscurus (wireworm) control on Maize							X		
Agrotis segetum A. ypsilon control on Tobacco				X					
Agrotis spp. control on Potatoes	X								
Agrotis ypsilon control on Artichokes				X					
Agrotis ypsilon control on Chickpea	X						X		
Agrotis ypsilon control on Cotton	X				X				
Agrotis ypsilon control on Potatoes		X							
Agrotis ypsilon control on Tomatoes	X		X	X					X
Atactogaster finitimus (Curc.) control on Cotton	X								
Atta capignara (leafcutter ant) control on Tomatoes								X	
Atta texana (leafcutting ant) control on Pine	X						X		
Bunt + dwarf bunt of wheat control						X			
Bupalus piniarius control on Pine			X						
Busseola fusca control on Maize			X						
Cassia obtusifolia control on Soya									X
Castnia licus control on Sugarcane			X						
Cavelarius excavatus (Lyg.) control on Sugarcane					X				
Chilo infuscatellus control on Sugarcane					X				
Chilo infuscatellus Scirpophaga excerptalis control on Sugarcane	X						X		
Conotrachelus hicoriae (Curc.) control on Pecan				X					
Coptotermes gestroi (termites) control on Hevea brasiliensis		X							
Cornitermes cumulus (termites) control on pastures								X	
Cosmopolites sordidus control on Banana	X			X			X		
Cotton pests, including boll weevil (Anthonomus grandis) control									X
Cryptophlebia leucotreta & Pectinophora gosypiella control on Cotton			X		X				
Crytozona belanziri (snail) control on Beans, Dolichos and Lablab	X								
Cutworms control							X		
Cutworms (Noctuids) control on Okra	X								
Cylas formicarius control on Sweet Potatoes		X		X			X		
Diabrotica spp. and M.persicae control on Potatoes	X								
Diaprepes abbreviatus control on Citrus				X					
Diatraea grandiosella control on Maize					X				
Dicocrocis punctiferalis (pod borer) control on Castor					X				
Elasmopalpus lignocellus (lesser cornstalk borer) control on Sorghum	X								
Elateridae spp. (wireworms) control on Potatoes		X							
Ephydra macellaria Chironomus sp. control on Rice					X				
Euborellia annulipes (pod borer) control on Groundnuts							X		
Fire-ant Control								X	
Fungi control						X			
Grain storage	X								
Grubs control on Sugarcane	X			X			X		

Specific Use and Application	**Aldrin**	**Chlordane**	**DDT**	**Dieldrin**	**Endrin**	**HCB**	**Heptachlor**	**Mirex**	**Toxaphene**
Gryllotalpa sp. control on Maize	X				X		X		
Haplothrips ganglbaueri control on Rice					X				
Helicoverpa armigera control on Cotton			X		X				
Helmintho-sporium maydis control						X			
Helminthosporium maydis control on Maize						X			
Heterodera cajani (nematode) control on Mung Bean	X								
Heteronychus sublaevis (Col.) control on Sugarcane		X							
Hodotermes mossambicus (termites) control on Grasslands				X					
Holotrichia serrata (white grub) control on Teak nursery	X								
Hylemyia brassicae control on Cabbage	X								
Lachnus persicae control on Peach					X				
Leavecutter ants (Atta spp., Acromyrmex, spp.) control								X	
Lepidopteran control on Maize, Rice, Cotton and Sugarcane					X				
Lepidopteran pests control (moths and butterflies)			X						
Leucopholis irrorata (white grubs) control on Sugarcane	X	X							
Locusts control (grasshopper)				X					
Lohita grandis (Pyrrhoc.) control			X						
Luperodes sp. (Galeruc.) control on Groundnuts			X						
Macrotermes natalensis (termites) control on Eucalyptus		X							
Maladera matrida (Scar.) control on Sweet Potatoes							X		
Maruca testulalis control on Cowpeas and Beans	X								
Melanotus tamsuyensis (wireworms), Alissonotum impressicolle (white grubs) control on Sugarcane							X		
Microcercopsylla brevicornis control on Mango					X				
Microtermes mycophagus, M. obesi control on Cotton				X					
Microtermes obesi (termites) control on Wheat	X								
Microtus (water voles) control on Orchads					X				
Myrmesia pilosula (Formic.) control		X							
Ophiomyia phaseoli control on Haricots	X								
Oryctes rhinocerus control on Coconut				X			X		
Oryzophagus oryzae (weevil) control on Rice							X		
Ostrinia nubilalis control on Maize			X						
Ostrinia nubilalis Sesamia nonagrioides control on Maize					X				
Otiorhynchus sulcatus control on Grapevine		X							
Otiorhynchus sulcatus control on Ornamentals	X								
Pachydiplosis oryzae control on Rice					X				
Papilio demolens control on Citrus					X				
Rabdoscelus obscurus (weevil borer) control on Sugarcane				X					
Rhinoceros beetles control		X							
Rice root weevils control on Rice	X								
Schistocerca gregaria control				X					
Sesamia cretica, Chilo agammemnon control on Sugarcane							X		
Sesamia sp. control on Maize					X				
Sitona crinitus control on Peas	X								
Sogatodes orizicola control									X

Specific Use and Application	Aldrin	Chlordane	DDT	Dieldrin	Endrin	HCB	Heptachlor	Mirex	Toxaphene
Soil pests control on maize	X								
Solenopsis spp. (ants) + Dysmicoccus brevipes (mealybugs) control on Pineapple								X	
Stomopteryx subsecuvella (leaf miner) control on groundnuts					X				
Teleogryllus commodus control				X					
Termites 3 spp control on Eucalyptus	X								
Termites 7 spp control on Eucalyptus	X								
Termites control in tree nurseries	X								
Termites control on Chickpea	X								
Termites control on Eucalyptus	X								
Termites control on Groundnuts				X					
Termites control on Trees							X		
Termites, nematodes control on Sugarcane							X		
Wireworms, earwigs control on Sugarcane							X		
Zygina sp. (leafhoppers) control on Maize					X				
Extermination Vermin Control									
Anoplolepis longipes crazy ant control	X								
No entry									
Acromyrmex octospinosus control								X	
Wood boring beetles control				X					
Control of Several spp.					X				
Coptotermes formosanus (termites) control		X							
Otiorhynchus sulcatus control	X								
Reticulitermes santonensis (termites) + 4 woodboring beetles control				X					
Termites 2 spp control on Wheat	X	X					X		
Termites 4 spp. control	X								
Termites control	X	X					X	X	
Public Health & Sanitation									
Ants control		X						X	
B. germanica, P. americana (cockroaches) control in houses		X							
Bembisia tabaci control on Cotton			X						
Malaria Control			X						
Mice and voles control					X				
Mosquito-borne filariasis			X						
Psammotermes hybostoma control in houses		X							

Appendix 2 - Chemical Substitutes Of the Nine POPs Pesticides

Substitute	CAS Number	Chemical Class	Main Use	Aldrin	Chlordane	DDT	Dieldrin	Endrin	HCB	Heptachlor	Mirex	Toxaphene	Nr. of List.
diflubenzuron	35367-38-5	Urea	I								X		2
bitertanol	55179-31-2	Triazole	F						X				2
metribuzin	21087-64-9	Triazine	H									X	1
ethofenprox	80844-07-1	Pyrethroid esther	I			X							1
alpha-cypermethrin	67375-30-8	Pyrethroid	I		X	X							3
bifenthrin	82657-04-3	Pyrethroid	I		X					X			2
cyfluthrin	68359-37-5	Pyrethroid	I	X		X							2
cypermethrin	52315-07-8	Pyrethroid	I	X	X		X						4
deltamethrin	52918-63-5	Pyrethroid	I	X	X	X	X	X		X	X		9
fenvalerate	51630-58-1	Pyrethroid	I	X	X		X			X			3
flucythrinate	70124-77-5	Pyrethroid	I					X					1
lambda cyhalothrin	91465-08-6	Pyrethroid	I			X							1
permethrin	52645-53-1	Pyrethroid	I		X	X	X			X			7
resmethrin	10453-86-8	Pyrethroid	I	X						X	X		2
pyrethrins	8003-34-7	Pyrethroid	I			X		X					1
acephate	30560-19-1	Organophosphorus	I		X					X			2
azinphos-methyl	86-50-0	Organophosphorus	I										1
bromophos[a]	2104-96-3	Organophosphorus	I				X						1
chlorfenvinphos	470-90-6	Organophosphorus	I					X					1
chlorpyrifos	2921-88-2	Organophosphorus	I	X	X	X	X	X		X	X	X	31
diazinon	333-41-5	Organophosphorus	I	X	X	X		X		X			15
dichlorvos/ DDVP	62-73-7	Organophosphorus	I				X	X					3
dicrotophos	141-66-2	Organophosphorus	I				X						1
dimethoate	60-51-5	Organophosphorus	I					X				X	4
disulfoton	298-04-4	Organophosphorus	I		X			X					3
fenitrothion	122-14-5	Organophosphorus	I		X	X	X	X					8
fensulfothion[b]	115-90-2	Organophosphorus	I	X			X			X			1
fenthion	55-38-9	Organophosphorus	I		X		X			X			2
fonofos	944-22-9	Organophosphorus	I	X	X		X			X			6
isazophos	42509-80-8	Organophosphorus	I-S	X	X								2
isofenphos	25311-71-1	Organophosphorus	I	X	X								3
malathion	121-75-5	Organophosphorus	I			X	X	X					11
methamidophos	10265-92-6	Organophosphorus	I										1
parathion	56-38-2	Organophosphorus	I	X		X		X					8
phenthoate	2597-03-7	Organophosphorus		X	X								2
phorate	298-02-2	Organophosphorus	I	X	X			X		X			12
phosalone	2310-17-0	Organophosphorus	I	X		X							2
phosphamidon	13171-21-6	Organophosphorus	I					X					3
phoxim	14816-18-3	Organophosphorus	I	X									2

Substitute	CAS Number	Chemical Class	Main Use	Aldrin	Chlordane	DDT	Dieldrin	Endrin	HCB	Heptachlor	Mirex	Toxaphene	Nr. of List.
pirimiphos ethyl	23505-41-1	Organophosphorus	I	X		X							1
pirimiphos methyl	29232-93-7	Organophosphorus	I	X		X							3
quinalphos	13593-03-8	Organophosphorus	I	X		X							3
tetrachlorvinphos	22248-79-9	Organophosphorus	I			X		X					3
triazophos	24017-47-8	Organophosphorus	I					X					1
trichloronat[c]	327-98-0	Organophosphorus	I	X									1
trichlorfon	52-68-6	Organophosphorus	I	X		X	X	X		X	X	X	5
monocrotophos	6923-22-4	Organophosphorus	I	X		X		X		X			10
chlordecone[d]	143-50-0	Organochlorine	I	X			X						1
endosulfan	115-29-7	Organochlorine	I	X	X	X	X	X		X			20
lindane	58-89-9	Organochlorine	I	X	X	X		X		X			13
Petroleum oil, unclassified	68815-10-1	Oil - petroleum	I, Adj.		X								1
aldicarb	116-06-3	N-Methyl Carbamate	I	X						X			2
bendiocarb	22781-23-3	N-Methyl Carbamate	I		X	X				X			4
carbaryl	63-25-2	N-Methyl Carbamate	I	X	X	X	X	X		X	X		23
carbofuran	1563-66-2	N-Methyl Carbamate	I	X	X		X	X		X			30
carbosulfan	55285-14-8	N-Methyl Carbamate	I	X						X			7
isoprocarb	2631-40-5	N-Methyl Carbamate	I		X								1
methomyl	16752-77-5	N-Methyl Carbamate	I	X				X					2
propoxur	114-26-1	N-Methyl Carbamate	I		X	X							3
avermectin/abamectin	71751-41-2	Microbial[e]	I								X		1
Bacillus thuringiensis	68038-71-1	Microbial	I			X							4
Baculovirus		Microbial			X								1
Beauveria bassiana	63428-82-0	Microbial[f]	I			X							1
Agrotis segetum[g] *Granulosis Virus*		Microbial	I				X						1
microsporodians		Microbial[h]	I				X						1
sulfluramid	4151-50-2	Fluorine	I								X		2
trifluralin	1582-09-8	Dinitro aniline	H									X	1
carboxin	5234-68-4	Carboxamide	FST						X				2
nicotine	54-11-5	Botanical	I					X					1
Neem	8002-65-1	Botanical	I			X	X						2
fuberidazole	3878-19-1	Benzimidazole	F						X				2
guazatine	13516-27-3	Aliphatic nitrogen	F						X				1
alachlor	15972-60-8	Acetanilide	H									X	1
carbon dioxide	124-38-9		I, F, R		X			X					2
carbon monoxide	630-08-0												2
Other Substitutes													
anticoagulants		not specified						X					2
insect growth regulators		not specified			X					X	X		3

Substitute	CAS Number	Chemical Class	Main Use	Aldrin	Chlordane	DDT	Dieldrin	Endrin	HCB	Heptachlor	Mirex	Toxaphene	Nr. of List.
synthetic pyrethroids		not specified				X		X				X	6
organophosphates		not specified				X							2
carbamates		not specified				X							1
botanical pesticides		not specified				X	X	X					4
nematodes		not specified			X								1
traps		not specified						X					1
netting on the houses and use of mosquito pyrethroid-treated bednets		not specified				X							2

a. obsolete according to the WHO Table 6: The WHO Recommended Classification of Pesticides by Hazard and Guidelines to Classification 1998-99, (WHO/PSC/98.21/Rev.1), WHO, Vienne, Switzerland
b. obsolete according to the WHO Table 6: The WHO Recommended Classification of Pesticides by Hazard and Guidelines to Classification 1998-99, (WHO/PSC/98.21/Rev.1), WHO, Vienne, Switzerland
c. obsolete according to the WHO Table 6: The WHO Recommended Classification of Pesticides by Hazard and Guidelines to Classification 1998-99, (WHO/PSC/98.21/Rev.1), WHO, Vienne, Switzerland
d. obsolete according to the WHO Table 6: The WHO Recommended Classification of Pesticides by Hazard and Guidelines to Classification 1998-99, (WHO/PSC/98.21/Rev.1), WHO, Vienne, Switzerland
e. Derivate from soil bacterium Streptomyces avermitilis, Source: Oregon State University, EXTOXNET, Extension Toxicology Network (1996): Pesticide Information Profiles, Oregon
f. entomopathogenic fungi, Source: Bischoff, R. (1998): Untersuchungen zur Wirksamkeit insektenpathogener Pilze gegen die vorratsschädlichen Motten Ephestia kuehniella und Plodia interpunctella (Lepidoptera : Pyralidae), Humboldt University (ed.), Berlin
g. common cutworm, turnip moth (german: Saateule --the author), Source: Bourner, T.C. ; Cory, J.S. (1995): Nuclear Polyhedrosis And Granulosis Viruses For The Control Of The Common Cutworm, Agrotis segetum (Lepidoptera: Noctuidae), Department of Ecology, Massey University, Palmerston North, New Zealand; Institute of Virology and Environmental Microbiology, Oxford, UK.
h. Mau, R.F.L.; Matin, J. L. (1992): Bactrocera dorsalis (Hendel), Department of Entomology, Honolulu, Hawaii

Key Main Use:

Abbreviation	Description
I	Insecticide
A	Acaricide
F	Fungicide
F	ST Fungicide for seed treatment
R	Rodenticide
H	Herbizide
I-S	Insecticide-applied to soil: not used with herbicides or plant growth
Adj.	Adjuvant

Appendix 3 - Specific Uses and Applications of the Chemical Substitutes

Specific Use an Application of POPs Pesticides	Commodity	POPs Chemical Substitutes	POPs Chemical Substitutes not evaluated by PAN Germany
Leavecutter ants (Atta spp., Acromyrmex, spp.) control	Ants control	deltamethrin, diazinon, resmethrin, sulfuramid	
Ants Control	Ants control	chlorpyrifos, deltamethrin, diazinon, difluben-zuron, isazophos, lindane, carbaryl	Petroleum oil, unclassified
Anoplolepis longipes crazy ant control	Ants control	chlorpyrifos, pirimiphos-methyl, quinalphos, parathion	
Myrmesia pilosula (Formic.) control	Ants control	bendiocarb,chlorpyrifos, diazinon, permethrin, propoxur	
Agrotis ypsilon control on Artichokes	Artichokes	endosulfan	
Cosmopolites sordidus control on Banana	Banana	aldicarb, carbofuran, pirimiphos-ethyl	chlordecone, fensulfothion
Crytozona belanziri (snail) control on Beans, Dolichos and Lablab	Beans, Dolichos and Lablab	carbaryl, carbofuran, chlorpyrifos, lindane, phorate	
Hylemyia brassicae control on Cabbage	Cabbage	diazinon	trichloronat
Dicocrocis punctiferalis (pod borer) control on Castor	Castor	DDVP, fenitrothion, parathion	
Helicoverpa armigera control on Chickpea	Chickpea	malathion, monocrotophos	Neem
Termites control on Chickpea	Chickpea	endosulfan, monocrotophos, phenthoate,	
Agrotis ypsilon control on Chickpea	Chickpea	endosulfan	
Papilio demolens control on Citrus	Citrus	carbaryl, lindane, malathion	
Diaprepes abbreviatus control on Citrus	Citrus	azinphos-methyl, carbaryl, dicrotophos	
Oryctes rhinocerus control on Coconut	Coconut	carbofuran, endosulfan, fenthion, fonofos	
Cotton pests, including boll weevil (Anthonomus grandis) control	Cotton		synthetic pyrethroids
Bembisia tabaci control on Cotton	Cotton		pyrethroids + organophosphates + IPM
Cryptophlebia leucotreta & Pectinophora gosypiella control on Cotton	Cotton	monocrotophos	
Agrotis ypsilon control on Cotton	Cotton	deltamethrin, diazinon, endosulfan, flucythri-nate, methomyl, chlorpyrifos	
Atactogaster finitimus (Curc.) control on Cotton	Cotton	chlorpyrifos	
Microtermes mycophagus, M. obesi control on Cotton	Cotton	chlorpyrifos	

Specific Use an Application of POPs Pesticides	Commodity	POPs Chemical Substitutes	POPs Chemical Substitutes not evaluated by PAN Germany
Helicoverpa armigera control on Cotton	Cotton	carbaryl, dimethoate, tetrachlorvinphos, triazophos	
Lepidopteran control on Maize, Rice, Cotton and Sugarcane	Cotton, Maize, Rice, and Sugarcane	carbaryl, chlorpyrifos, endosulfan	biological control, botanical pesticides, pyrethroids
Maruca testulalis control on Cowpeas and Beans	Cowpeas and Beans	carbaryl, cyfluthrin, methomyl, monocrotophos	
Otiorhynchus sulcatus control on Ornamentals	Flowers	carbofuran	
Atta texana (leafcutting ant) control on Pine	Forestry	resmethrin	
Bupalus piniarius control on Pine	Forestry	phosalone, tetrachlorvinphos	
Wood boring beetles control	Forestry	permethrin	
Holotrichia serrata (white grub) control on Teak nursery	Forestry	diazinon, phorate	
Reticulitermes santonensis (termites) + 4 wood-boring beetles control	Forestry	cypermethrin, deltamethrin, fenvalerate, permethrin	
Termites 3 spp control on Eucalyptus	Forestry	carbosulfan	
Termites 7 spp control on Eucalyptus	Forestry	carbofuran, carbosulfan, chlorpyrifos	
Termites control in tree nurseries	Forestry	carbofuran, carbosulfan, chlorpyrifos, cypermethrin	
Termites control on Eucalyptus	Forestry	carbofuran, carbosulfan, cypermethrin,	
Termites control on Trees	Forestry	carbaryl,lindane	
Macrotermes natalensis (termites) control on Eucalyptus	Forestry	alpha-cypermethrin, carbofuran, carbosulfan, phorate	
Coptotermes gestroi (termites) control on Hevea brasiliensis	Forestry	alpha-cypermethrin, bifenthrin, chlorpyrifos, cypermethrin, permethrin,	
Otiorhynchus sulcatus control on Grapevine	Grapes	acephate, bendiocarb, carbofuran, isofenphos	nematodes
Hodotermes mossambicus (termites) control on Grasslands	Grassland	carbaryl, endosulfan	bromophos
Stomopteryx subsecuvella (leaf miner) control on groundnuts	Groundnuts	DDVP, dimethoate, endosulfan, fenitrothion, parathion	
Termites control on Groundnuts	Groundnuts	carbofuran	

Specific Use an Application of POPs Pesticides	Commodity	POPs Chemical Substitutes	POPs Chemical Substitutes not evaluated by PAN Germany
Luperodes sp. (Galeruc.) control on Groundnuts	Groundnuts	carbaryl, endosulfan, lindane, malathion, parathion, quinalphos	
Euborellia annulipes (pod borer) control on Groundnuts	Groundnuts	carbaryl	
Ophiomyia phaseoli control on Haricots	Haricots	endosulfan	
B. germanica, P. americana (cockroaches) control in houses	Health sector	chlorpyrifos, diazinon, fenitrothion	
Psammotermes hybostoma control in houses	Health sector	chlorpyrifos, propoxur	
Agriotes obscurus (wireworm) control on Maize	Maize	phorate, fonofos	
Sesamia sp. control on Maize	Maize	monocrotophos	
Zygina sp. (leafhoppers) control on Maize	Maize	disulfoton, phosphamidon, phorate	
Gryllotalpa sp. control on Maize	Maize	chlorpyrifos	
Diatraea grandiosella control on Maize	Maize	carbofuran, diazinon, monocrotophos, tetrachlorvinphos	
Soil pests control on maize	Maize	carbaryl, chlorpyrifos	
Ostrinia nubilalis Sesamia nonagrioides control on Maize	Maize	carbaryl, endosulfan, trichlorfon	
Ostrinia nubilalis control on Maize	Maize	carbaryl, diazinon	Bacillus thuringiensis (Berliner), Botanical Pesticides
Busseola fusca control on Maize	Maize	endosulfan, trichlorfon	Bacillus thuringiensis (Berliner)
Malaria Control	Malaria control	alpha-cypermethrin, bendiocarb, cyfluthrin, deltamethrin, endosulfan, etofenprox, fenitrothion, lambda-cyhalothrin, lindane, malathion, permethrin, pirimiphos-methyl, propoxur	netting on the houses and use of mosquito pyrethroid-treated bednets
Microcercopsylla brevicornis control on Mango	Mango	carbaryl, dimethoate, malathion, parathion, phosphamidon	
Mosquito-borne filariasis	Moscquito control		netting on the houses and use of mosquito pyrethroid-treated bednets
Heterodera cajani (nematode) control on Mung Bean	Mung Bean	phorate	
Schistocerca gregaria control	not specified	malathion	
Teleogryllus commodus control	not specified	malathion	

Specific Use an Application of POPs Pesticides	Commodity	POPs Chemical Substitutes	POPs Chemical Substitutes not evaluated by PAN Germany
Fire-ant Control	not specified		insect growth regulators
Rhinoceros beetles control	not specified	endosulfan, isoprocarb, lindane, phenthoate	Biological control using baculovirus
Sogatodes orizicola control	not specified	chlorpyrifos, dimethoate	
Otiorhynchus sulcatus control	not specified	chlorpyrifos, fonofos	
Helmintho-sporium maydis control	not specified	carboxin	
Cutworms control	not specified	acephate, carbofuran, chlorpyrifos,	Bacillus thuringiensis (Berliner), Botanical Pesticides
Lohita grandis (Pyrrhoc.) control	not specified	carbaryl, chlorpyrifos	
Control of Several spp.	not specified	carbaryl, diazinon, lindane, malathion	
Locusts control (grasshopper)	not specified	chlorpyrifos, deltamethrin, fenitrothion, malathion	Botanical pesticides (neem i.a.); microsporodians
Fungi control	not specified	bitertanol,carboxin,fuberidazol	
Lepidopteran pests control (moths and butter-flies)	not specified	pyrethrins	Bacillus thuringiensis (Berliner), car-bamates, organophosphates,
Acromyrmex octospinosus control	not specified		avermectin
Mice and voles control	not specified		anticoagulants in baits, carbon dioxide, traps
Cutworms (Noctuids) control on Okra	Okra	carbofuran, cypermethrin, deltamethrin, fenva-lerate, monocrotophos, phorate,	
Microtus (water voles) control on Orchards	Orchards	chlorpyrifos	anticoagulants carbon monoxide, carbon dioxide,
Cornitermes cumulus (termites) control on pas-tures	Pastures	carbaryl	
Lachnus persicae control on Peach	Peach	malathion, parathion	nicotine
Sitona crinitus control on Peas	Peas	carbaryl, endosulfan, lindane, parathion	
Conotrachelus hicoriae (Curc.) control on Pecan	Pecan	carbofuran, fonofos	
Solenopsis spp. (ants) + Dysmicoccus brevipes (mealybugs) control on Pineapple	Pineapple	diazinon	
Agrotis ypsilon control on Potatoes	Potatoes	disulfoton, fonofos, phorate	
Elateridae spp. (wireworms) control on Pota-toes	Potatoes	carbofuran, fonofos	

Specific Use an Application of POPs Pesticides	Commodity	POPs Chemical Substitutes	POPs Chemical Substitutes not evaluated by PAN Germany
Agrotis spp. control on Potatoes	Potatoes	carbaryl, chlorpyrifos, endosulfan, isofenphos, phorate, phosalone, phoxim, quinalphos	
Diabrotica spp. and M.persicae control on Potatoes	Potatoes	aldicarb, carbofuran,	
Ephydra macellaria Chironomus sp. control on Rice	Rice	endosulfan	
Pachydiplosis oryzae control on Rice	Rice	diazinon, disulfoton	
Rice root weevils control on Rice	Rice	carbofuran, lindane, phorate	
Oryzophagus oryzae (weevil) control on Rice	Rice	carbofuran	
Haplothrips ganglbaueri control on Rice	Rice	carbaryl, lindane, malathion,	
Elasmopalpus lignocellus (lesser cornstalk borer) control on Sorghum	Sorghum	carbofuran, diazinon, monocrotophos	
Cassia obtusifolia control on Soya	Soya	alachlor, metribuzin, trifluralin	
Grain storage	Storage	pirimiphos-methyl, pyrethrum	
Castnia licus control on Sugarcane	Sugarcane	trichlorfon	
Sesamia cretica, Chilo agammemnon control on Sugarcane	Sugarcane	trichlorfon	
Rabdoscelus obscurus (weevil borer) control on Sugarcane	Sugarcane	chlorpyrifos, DDVP, fenitrothion	
Chilo infuscatellus control on Sugarcane	Sugarcane	chlorpyrifos, endosulfan, monocrotophos	
Cavelarius excavatus (Lyg.) control on Sugarcane	Sugarcane	chlorfenvinphos, chlorpyrifos, fenitrothion, phosphamidon	
Wireworms, earwigs control on Sugarcane	Sugarcane	carbofuran, chlorpyrifos	
Leucopholis irrorata (white grubs) control on Sugarcane	Sugarcane	carbofuran, diazinon, isazophos	
Melanotus tamsuyensis (wireworms), Alissonotum impressicolle (white grubs) control on Sugarcane	Sugarcane	carbofuran	*fensulfothion*
Chilo infuscatellus Scirpophaga excerptalis control on Sugarcane	Sugarcane	carbofuran, lindane, phorate	
Chilo infuscatellus, termites, Scirpophaga excerptalis control on Sugarcane	Sugarcane	carbofuran, monocrotophos	

Specific Use an Application of POPs Pesticides	Commodity	POPs Chemical Substitutes	POPs Chemical Substitutes not evaluated by PAN Germany
Heteronychus sublaevis (Col.) control on Sugarcane	Sugarcane	carbofuran, phorate	
Grubs control on Sugarcane	Sugarcane	carbofuran	
Termites, nematodes control on Sugarcane	Sugarcane	carbofuran	
Castnia licus control on Sugarcane	Sugarcane		Beauveria bassiana
Cylas formicarius control on Sweet Potatoes	Sweet Potatoes	carbaryl, carbofuran, deltamethrin, fenthion, fenvalerate, permethrin	
Maladera matrida (Scar.) control on Sweet Potatoes	Sweet Potatoes	bifenthrin, deltamethrin, diazinon,	
Coptotermes formosanus (termites) control	Termite control	chlorpyrifos, fenitrothion	
Termites 4 spp. control	Termite control	carbofuran, carbosulfan, chlorpyrifos	
Termites Control	Termite control	bendiocarb,carbaryl, carbofuran, carbosulfan, chlorpyrifos, endosulfan, isofenphos, permethrin, phoxim, sulfuramid	insect growth regulators
Agrotis segetum A. ypsilon control on Tobacco	Tobacco	methamidophos	Agrotis segetum Granulosis Virus
Agrotis ypsilon control on Tomatoes	Tomatoes	trichlorfon	
Atta capignara (leafcutter ant) control on Tomatoes	Tomatoes	diflubenzuron	
Microtermes obesi (termites) control on Wheat	Wheat	chlorpyrifos, endosulfan	
Termites 2 spp control on Wheat	Wheat	chlorpyrifos, lindane	
Bunt + dwarf bunt of wheat control	Wheat	bitertanol, fuberidazole, guazatine	

Appendix 4 - Human Toxicology of the POPs Chemical Substitutes

Appendix 4 presents the human toxicity of the 62 POPs chemical substitutes according to several organisations. The classifications were taken from the from the World Health Organisation (WHO) and its Programme, from the European Union (Directive 67/548EEC), from the International Agency on Research of Cancer (IARC), from the U.S. Environmental Protection Agency (U.S. EPA) and from California's *The Safe Drinking Water and Toxic Enforcement Act of 1986* also known as Proposition 65. Additional information was taken from scientific literature as noted in the footnotes of the describing chapters. To make this Appendix easier to read a list of abbreviations as well as a short repetition of the classifications will follow. Please note that the description of the classification can be found in the single chapters. The source of the data can be found at the end of each classification.
The number of listings in the Specific Uses and Applications is the count of each substitute in UNEPs POPs Alternative Database.

List of Abbreviations - Appendix 4

CAS Number	Chemical Registry Abstract Number
WHO	World Health Organisation
EC	European Community
IARC	International Agency on Research of Cancer
U.S. EPA	U.S. Environmental Protection Agency
Prop 65	California's *The Safe Drinking Water and Toxic Enforcement Act of 1986* (Proposition 65)
ChE	Cholinesterase Inhibition
ADI	Acceptable Daily Intake in mg/kg/bw
bw	Body Weight
Muta	Mutagenicity
Reprod.	Reprod. Toxicant

Acute Toxicity - World Health Organisation (WHO)

Classification	
Ia	Extremely hazardous
Ib	Highly hazardous
II	Moderately hazardous
III	Slightly hazardous
U	Unlikely to present hazard in normal use

Source: World Health Organisation (1998-99): The WHO Recommended Classification of Pesticides by Hazard And Guidelines to Classification 1998-99

Classification of the EU

Symbol	Description
T+	Very toxic
T	Toxic
Xn	Harmful
Xi	Irritant

Several entries into the toxicity category define different toxicities for different exposure routes, the risk phrases 24-26/28 for instance means R24: Toxic in contact with skin and R26/28 Very toxic by inhalation and if swallowed.
The next list shows the risk phrases applied for the POPs chemical substitute in Appendix 4. The risk phrases in the Appendix table are complete, including environmental hazards (R50, R51, R53), which are going to be described in another place.

List of EC Risk Phrases to find in Appendix 4

Risk Phrase	Explanation
R20	Harmful by inhalation.
R21	Harmful in contact with skin.
R23	Toxic by inhalation.
R24	Toxic in contact with skin.
R25	Toxic if swallowed.
R26	Very toxic by inhalation.
R27	Very toxic in contact with skin.
R28	Very toxic if swallowed.
R29	Contact with water liberates toxic gases.
R36	Irritating to eyes.
R40	Possible risks of irreversible effects.
R43	May cause sensitization by skin contact.
R65	Harmful: may cause lung damage if swallowed.
Combination of Risk Phrases	
R20/21/65	Harmful by inhalation, in contact with skin and if swallowed.
R21/65	Harmful in contact with skin and if swallowed.
R23/25	Toxic by inhalation and if swallowed.
R24/25	Toxic in contact with skin and if swallowed.
R26/28	Very toxic by inhalation and if swallowed.
R27/28	Very toxic in contact with skin and if swallowed.
R36/38	Irritating to eyes and skin.
R48/20	Harmful: danger of serious damage to health by prolonged exposure through inhalation.
R48/21	Harmful: danger of serious damage to health by prolonged exposure in contact with skin.
R48/25	Toxic: danger of serious damage to health by prolonged exposure if swallowed.

Cancer Classification of the EC

Category	Description
Category 1	Substances known to be carcinogenic to humans. There is sufficient evidence to establish a causal association between human exposure to a substance and the development of cancer.
Category 2	Substances which should be regarded as if they are carcinogenic to humans. There is sufficient evidence to provide a strong presumption that human exposure to a substance may result in the development of cancer, generally on the basis of appropriate long-term animal studies or other relevant information.
Category 3	Substances which cause concern for humans owing to possible carcinogenic effects but in respect of which the available information is not adequate for making a satisfactory assessment. There is some evidence from appropriate animal studies, but this is insufficient to place the substance in Category 2.

Source: European Community (1967): Council Directive 67/548/EEC of 27 June 1967 on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substance, Official Journal 196, Brussels, Belgium, plus several amendments, adaptions and modifications as noted in the footnotes of the chapters

Cancer Classification of the IARC

Group	Description
Group 1	The agent (mixture) is carcinogenic to humans.
Group 2A	The agent (mixture) is probably carcinogenic to humans.
Group 2B	The agent (mixture) is possibly carcinogenic to humans.
Group 3	The agent (mixture or exposure circumstance) is not classifiable as to its carcinogenicity to humans.
Group 4	The agent (mixture) is probably not carcinogenic to humans.

Source: International Agency for Research on Cancer (1999): Preamble to the IARC Monographs, IARS Monographs, accessible through: http://www.iarc.fr/, Lyon, France

Cancer Classification of the U.S. EPA

Category	Description
Category A	Known to cause cancer in humans. Generally based on epidemiological data showing sufficient evidence to support a causal association between exposure to the substance and cancer.
Category B	Known to cause cancer in animals but not yet definitively shown to cause cancer in humans. These chemicals are designated "probable human carcinogens." Category B is further split into pesticides for which some evidence exists that it causes cancer in humans (B1) and those for which evidence exists only in animals (B2).
Category C	Possible human carcinogens, where the data show limited evidence of carcinogenicity in the absence of human data.
Category D	This category is for chemicals for which the data are either incomplete or ambiguous and is labelled "cannot be determined." This category is appropriate when tumour effects or other key data are suggestive or conflicting or limited in quantity and are thus not adequate to convincingly demonstrate carcinogenic potential for humans. In general, further chemical-specific and generic research and testing are needed to be able to describe human carcinogenic potential.
Category E	Probably not carcinogenic, with no evidence of carcinogenicity in at least two adequate animal tests in different species in adequate epidemiological and animal studies. This classification is based on available evidence and does not mean that the agent will not be a carcinogen under any circumstances.

Source: US Environmental Protection Agency Office of Pesticide Programmes (2000): List of Chemicals Evaluated for Carcinogenic Potential, U.S. EPA Office of Pesticide Programmes, Washington, DC, USA

Mutagenicity Classification of the EU

Category	Description
Category 1	Substances known to be mutagenic to humans. There is sufficient evidence to establish a causal association between human exposure to a substance and heritable genetic damage.
Category 2	Substances which should be regarded as if they are mutagenic to humans. There is sufficient evidence to provide a strong presumption that human exposure to the substance may result in the development of heritable genetic damage, generally on the basis of appropriate animal studies, or other relevant information.

Category	Description
Category 3	Substances which cause concern for humans owing to possible mutagenic effects. There is evidence from appropriate mutagenicity studies, but this is insufficient to place the substance in Category 2.

Source: European Community (1967): Council Directive 67/548/EEC of 27 June 1967 on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substance, Official Journal 196, Brussels, Belgium, plus several amendments, adaptions and modifications as noted in the footnotes of the chapters.

California Proposition 65

Source: State Of California, Environmental Protection Agency Office Of Environmental Health Hazard Assessment (2000): Safe Drinking Water And Toxic Enforcement Act Of 1986, Chemicals Known To The State To Cause Cancer Or Reproductive Toxicity, assessable through: http://www.oehha.ca.gov/prop65/, Sacramento, USA

Cholinesterase Inhibition

Sources: 1. U.S. EPA, Office of Pesticide Programmes (2000): Science Policy on The Use of Data on Cholinesterase Inhibition for Risk Assessments of Organophosphorous and Carbamate Pesticides, Office of Pesticide Programme, US Environmental Protection Agency, Washington, USA

2. U.S. EPA, Office of Pesticide Programmes (2000): Science Policy on The Use of Data on Cholinesterase Inhibition for Risk Assessments of Organophosphorous and Carbamate Pesticides, p. 16. Office of Pesticide Programme, US Environmental Protection Agency, Washington, USA

Acceptable Daily Intake (WHO)

The values in Appendix 4 should be interpreted as follows: the smaller the value i.e. the amount a human can consume on a daily basis, the greater is the chronic toxicity of the pesticide. *Disulfoton* (0,0003 mg/kg/bw), *chlorfenvinphos, phorate, phosphamidon* (all 0,0005 mg/kg/bw) and *monocrotophos* with 0,0006 mg/kg/bw are therefore the pesticide with the highest chronic toxicity in the list of evaluated pesticides.

Source: World Health Organisation/ International Programme on Chemical Safety (1999): Inventory of IPCS and Other WHO Pesticide Evaluation and Summary of Toxicological Evaluations Performed by the Joint Meeting On Pesticide Residues (JMPR) through 1999, WHO/ IPCS, Vienna, Switzerland

Substitute	CAS Number		EU Classification		Cancer Classification								
		WHO	Symbol	Risk Phrase	EC	IARC	U.S EPA	Prop 65	Prop 65 Reprod.	EC Muta	ChE	ADI mg/kg/bw	Number of Listings
acephate	30560-19-1	III	Xn	65			C				Yes	0,03	2
alachlor	15972-60-8	Ia	Xn	65-40-43	3			Yes					1
aldicarb	116-06-3	Ia	T+	24-26/28-50/53		3	E				Yes	0,003	2
alpha-cypermethrin	67375-30-8	II											3
azinphos-methyl	86-50-0	Ib	T+	24-26/28-43-50/53			E				Yes	0,005	1
bendiocarb	22781-23-3	II	T	21-23/25-50/53							Yes	0,004	4
bifenthrin	82657-04-3	II					C					0,02	2
bitertanol	55179-31-2	U										0,01	2
carbaryl	63-25-2	II	Xn	65-40-50	3	3	C				Yes	0,003	23
carbofuran	1563-66-2	Ib	T+	26/28-50/53							Yes	0,01	30
carbosulfan	55285-14-8	II	T	23/25-43-50/53							Yes	0,01	7
carboxin	5234-68-4	U											2
chlorfenvinphos	470-90-6	Ib	T+	24-28-50/53							Yes	0,0005	1
chlorpyrifos	2921-88-2	II	T	24/25-50/53			E				Yes	0,01	31
cyfluthrin	68359-37-5	II	T+	26/28-50/53								0,02	2
cypermethrin	52315-07-8	Ib					C					0,05	4
DDVP/dichlorvos	62-73-7	Ib	T+	24/25-26-43-50		2B	C	Yes			Yes	0,004	3

Substitute	CAS Number	EU Classification			Cancer Classification								
		WHO	Symbol	Risk Phrase	EC	IARC	U.S EPA	Prop 65	Prop 65 Reprod.	EC Muta	ChE	ADI mg/kg/bw	Number of Listings
deltamethrin	52918-63-5	II	T	24/25-50/53		3						0,01	9
diazinon	333-41-5	II	Xn	65-50/53							Yes	0,002	15
dicrotophos	141-66-2	Ib	T+	24-28-50/53							Yes		1
diflubenzuron	35367-38-5	U					E					0,02	2
dimethoate	60-51-5	II	Xn	21/65			C				Yes	0,002	4
disulfoton	298-04-4	Ia	T+	27/28-50/53			E				Yes	0,0003	3
endosulfan	115-29-7	II	T	24/25-36-50/53			E					0,006	20
ethofenprox	80844-07-1	U					C					0,03	1
fenitrothion	122-14-5	II	Xn	65-50/53			E				Yes	0,005	8
fenthion	55-38-9	II	T	21/65-23-40-48/25-50/53			E			3	Yes	0,007	2
fenvalerate	51630-58-1	II				3	E					0,02	3
flucythrinate	70124-77-5	Ib										0,02	1
fonofos	944-22-9	Ia	T+	27/28-50/53			E				Yes		6
fuberidazole	3878-19-1	III	Xn	65-50/53									2
guazatine	13516-27-3	II	Xn	21/65-36/38-50/53								0,03	1
isazophos	42509-80-8	Ib	T+	26-24/25-48/20-50/53							Yes		2
isofenphos	25311-71-1	Ib	T	24/25							Yes	0,001	3
isoprocarb	2631-40-5	II	Xn	65-50/53							Yes		1

Substitute	CAS Number	EU Classification			Cancer Classification								
		WHO	Symbol	Risk Phrase	EC	IARC	U.S EPA	Prop 65	Prop 65 Reprod.	EC Muta	ChE	ADI mg/kg/bw	Number of Listings
lambda cyhalothrin	91465-08-6	II	T+	21-25-26-50/53								0,02	1
lindane	58-89-9	II	T	23/24/25-36/38-50/53			B2/C	Yes				0,001	13
malathion	121-75-5	III	Xn	65		3	D				Yes	0,3	11
methamidophos	10265-92-6	Ib	T+	24-28-36-50			E				Yes	0,004	1
methomyl	16752-77-5	Ib	T+	28-50/53							Yes	0,03	2
metribuzin	21087-64-9	U	Xn	65-50/53			D						1
monocrotophos	6923-22-4	Ib	T+	24-26/28-40-50/53						3	Yes	0,0006	10
parathion	56-38-2	Ia	T+	27/28-50/53		3	C				Yes	0,004	8
permethrin	52645-53-1	II	Xn	65		3	C(q)					0,05	7
phenthoate	2597-07-3	II	Xn	21/65							Yes	0,003	2
phorate	298-02-2	Ia	T+	27/28			E				Yes	0,0005	12
phosalone	2310-17-0	II	T	21-25-50/53							Yes	0,02	2
phosphamidon	13171-21-6	Ia	T+	24-28-40-50/53			C			3	Yes	0,0005	3
phoxim	14816-18-3	II	Xn	65							Yes	0,004	2
pirimiphos ethyl	23505-41-1	Ib	T	21-25-50/53							Yes		1
pirimiphos-methyl	29232-93-7	III	Xn	65							Yes	0,03	3
propoxur	114-26-1	II	T	25-50/53			B2				Yes	0,02	3
pyrethrins	8003-34-7	II	Xn	20/21/65-50/53								0,04	1

Substitute	CAS Number	EU Classification			Cancer Classification								
		WHO	Symbol	Risk Phrase	EC	IARC	U.S EPA	Prop 65	Prop 65 Reprod.	EC Muta	ChE	ADI mg/kg/bw	Number of Listings
quinalphos	13593-03-8	II	T	21-25							Yes		3
resmethrin	10453-86-8	III	Xn	65-50/53					Yes				2
sulfluramid	4151-50-2	III											2
tetrachlorvinphos	22248-79-9	U				3					Yes		3
triazophos	24017-47-8	Ib	T	21-23/25-50/53							Yes	0,001	1
trichlorfon	52-68-6	III	Xn	65-43		3					Yes	0,02	5
trifluralin	1582-09-8	U	Xi	36-43		3	C					0,048	1

Appendix 5 - Chemical Substitutes and Their Listing as Endocrine Disruptors

Substitute	CAS Number	Colborn	Benbrook	EPA Illinois	Keith	Nr. of Listings
acephate	30560-19-1					2
alachlor	15972-60-8	Y	Y	P	Y	1
aldicarb	116-06-3	Y	Y	S	Y	2
alpha-cypermethrin	67375-30-8	Y				3
azinphos-methyl	86-50-0					1
bendiocarb	22781-23-3					4
bifenthrin	82657-04-3	Y				2
bitertanol	55179-31-2					2
carbaryl	63-25-2	Y	Y	S	Y	23
carbofuran	1563-66-2					30
carbosulfan	55285-14-8					7
carboxin	5234-68-4					2
chlorfenvinphos	470-90-6					1
chlorpyrifos	2921-88-2		Y		Y	31
cyfluthrin	68359-37-5	Y				2
cypermethrin	52315-07-8	Y	Y	S	Y	4
deltamethrin	52918-63-5	Y				9
diazinon	333-41-5					15
dichlorvos/ DDVP	62-73-7					3
dicrotophos	141-66-2					1
diflubenzuron	35367-38-5					2
dimethoate	60-51-5					4
disulfoton	298-04-4					3
endosulfan	115-29-7	Y	Y	K	Y	20
ethofenprox	80844-07-1					1
fenitrothion	122-14-5					8
fenthion	55-38-9					2
fenvalerate	51630-58-1	Y		S		3
flucythrinate	70124-77-5	Y				1
fonofos	944-22-9					6
fuberidazole	3878-19-1					2
guazatine	13516-27-3					1
isazophos	42509-80-8					2
isofenphos	25311-71-1					3
isoprocarb	2631-40-5					1
lambda cyhalothrin	91465-08-6	Y				1
lindane	58-89-9	Y	Y	K	Y	13
malathion	121-75-5	Y		S	Y	11
methamidophos	10265-92-6					1
methomyl	16752-77-5	Y	Y	S	Y	2
metribuzin	21087-64-9	Y	Y	S	Y	1

Substitute	CAS Number	Colborn	Benbrook	EPA Illinois	Keith	Nr. of Listings
monocrotophos	6923-22-4					10
parathion	56-38-2	Y	Y	P	Y	8
permethrin	52645-53-1	Y	Y	S		7
phenthoate	2597-03-7					2
phorate	298-02-2					12
phosalone	2310-17-0					2
phosphamidon	13171-21-6					3
phoxim	14816-18-3					2
pirimiphos ethyl	23505-41-1					1
pirimiphos methyl	29232-93-7					3
propoxur	114-26-1					3
pyrethrins	8003-34-7	Y				1
quinalphos	13593-03-8					3
resmethrin	10453-86-8	Y				2
sulfuramid	4151-50-2					2
tetrachlorvinphos	22248-79-9					3
triazophos	24017-47-8					1
trichlorfon	52-68-6					5
trifluralin	1582-09-8	Y	Y	P	Y	1

P= Probable S= Suspected K= Known Yes = Listed

Sources:

Illinois Environmental Protection Agency, (1997): Report on Endocrine Disrupting Chemicals, Illinois EPA, USA

L. H. Keith, (1997):Environmental Endocrine Disruptors: A Handbook of Property Data, Wiley Interscience, New York, USA

T. Colborn, D. Dumanoski, and J. P. Myers, (1996) Our Stolen Future, Penguin Books, New York, USA, accessible through http://www.osf-facts.org/

C. M. Benbrook, (1996):Growing Doubt: A Primer on Pesticides Identified as Endocrine Disruptors and/or Reproductive Toxicants, National Campaign for Pesticide Policy Reform

Further Readings

McLachlan, J.A., Arnold, S.F., (1996): Environmental Estrogens, American Scientist, accessible through http://www.amsci.org/amsci/articles/96articles/McLachla.html

Commission on Life Sciences, (2000): Hormonally Active Agents in the Environment, The National Academy of Science, Washington DC, USA, accessible through http://www.nap.edu/books/0309064198/html/

National Institute of Environmental Health Sciences (1997): Environmental Health Perspectives, Hormones and Health, USA, accessible http://ehpnet1.niehs.nih.gov/qa/105-5focus/focus.html

U.S. Environmental Protection Agency - Region 5 (1997): Proceedings Of The 1997 Great Lakes Endocrine Disrupters Symposium, U.S. EPA, Chicago, USA

Web links

The Global Endocrine Disruptor Research Inventory: http://endocrine.ei.jrc.it/gedri/pack_edri.All_Page

U.S. EPA, Office of Science Coordination and Policy: http://www.epa.gov/scipoly/oscpendo/resource.htm

Center for Bioenvironmental Research Tulane/Xavier Universities (CBR): http://www.som.tulane.edu/ecme/eehome/

Greater Boston Physicians for Social Responsibility: http://www.igc.org/psr/protect-child.htm

Environment Canada: http://www.ec.gc.ca/eds/fact/index.htm

Appendix 6 - Chemical Substitutes and Their Environmental Hazard Assessment

Appendix 6 presents the environmental toxicity of the 62 POPs chemical substitutes according to several organisations. The classifications were taken from the from the European Community (Directive 67/548EEC) and from the IPM (Integrated Pest Management) Programme of the University of Cornel.To make this Appendix easier to read a short repetition of the classifications will follow. Please note that the description of the classification can be found in the single chapters. The number of listings in the Specific Uses and Applications is the count of each substitute in UNEPs POPs Alternative Database.

Aquatic Toxicity - European Union

	Acute Toxicity			
Symbol	Fish LC_{50}, mg/L, 96h	Daphnia LC_{50}, mg/L, 96h	Algae IC_{50}, mg/L 72h	Risk Phrase
N	1	1	1	R50
N	1	1	1	R50/53
N	1 ≥ 10	1 ≥ 10	1 ≥ 10	R51/53
-	10 ≥100	10 ≥100	10 ≥100	R52/53
-	-	-	-	R52

The Risk Phrases in the aboveTable mean the following:

R50: Very toxic to aquatic organisms
R51: Toxic to aquatic organisms
R52: Harmful to aquatic organisms
R53: May cause long-term adverse effects in the aquatic environment

Combined Risk Phrases should be read with a ‘comma’ between the phrases, as in R50/53: Very toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

Source: European Community (1993): Document 393L0021, Council Directive 93/21/EEC of 27 April 1993 adapting to technical progress for the 18th time Council Directive 67/548/EEC on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substance, Official Journal L 110, Brussels, Belgium

Ecological Impact - University of Cornell

Source: IPM Programme, Cornell University, New York State Agricultural Experiment Station Geneva (1999):A Method to Measure the Environmental Impact of Pesticides, accessible through http://www.nysaes.cornell.edu/ipmnet/ny/Programme_news/EIQ.html, New York, USA

Substitute	CAS Number	European Union		Evaluation Cornell University (New York)							Nr. of Listings
		Symbol	Risk Phrases	Fish	Birds	Bees	Beneficial Organism	Groundwater and Runoff Potential	Terrestrial Organisms	Ecological Impact	
acephate	30560-19-1			1,0	9,0	15,0	18,7	1,0	42,7	43,7	2
alachlor	15972-60-8	N	50/53	9,0	3,0	3,0	25,0	3,0	31,0	40,0	1
aldicarb	116-06-3	N	50/53	3,0	30,0	3,0	16,4	5,0	49,4	52,4	2
alpha-cypermethrin	67375-30-8										3
azinphos-methyl	86-50-0	N	50/53	25,0	30,0	15,0	18,3	1,0	63,3	88,3	1
bendiocarb	22781-23-3	N	50/53	9,6	5,0	15,0	17,5	2,1	37,5	47,1	4
bifenthrin	82657-04-3			16,0	6,3	18,5	38,1	2,0	62,9	78,9	2
bitertanol	55179-31-2										2
carbaryl	63-25-2	N	50	9,0	9,0	15,0	19,7	1,0	43,7	52,7	23
carbofuran	1563-66-2	N	50/53	5,0	30,0	15,0	19,4	5,0	64,4	69,4	30
carbosulfan	55285-14-8	N	50/53								7
carboxin	5234-68-4			15,0	15,0	3,0	12,4	1,0	30,4	45,4	2
chlorfenvinphos	470-90-6	N	50/53	16,1	20,6	28,5	23,0	2,0	72,1	88,2	1
chlorpyrifos	2921-88-2	N	50/53	25,0	45,0	15,0	19,9	1,0	79,9	104,9	31
cyfluthrin	68359-37-5	N	50/53	5,0	9,0	45,0	60,0	1,0	114,0	119,0	2
cypermethrin	52315-07-8			25,0	9,0	45,0	61,2	1,0	115,2	140,2	4
DDVP	62-73-7	N	50/	9,6	15,0	15,0	19,2	1,0	49,2	58,8	3
deltamethrin	52918-63-5	N	50/53	16,1	3,0	15,0	20,4	2,0	38,4	54,5	9
diazinon	333-41-5	N	50/53	15,0	30,0	15,0	19,5	3,0	64,5	79,5	15
dicrotophos	141-66-2	N	50/53								1
diflubenzuron	35367-38-5			5,0	9,0	15,0	69,0	1,0	93,0	98,0	2

Substitute	CAS Number	European Union		Evaluation Cornell University (New York)							Nr. of Listings
		Symbol	Risk Phrases	Fish	Birds	Bees	Beneficial Organism	Groundwater and Runoff Potential	Terrestrial Organisms	Ecological Impact	
dimethoate	60-51-5			5,0	30,0	45,0	60,9	3,0	135,9	140,9	4
disulfoton	298-04-4	N	50/53	15,0	45,0	45,0	82,8	1,0	172,8	187,8	3
endosulfan	115-29-7	N	50/53	25,0	27,0	9,0	17,6	1,0	53,6	78,6	20
ethofenprox	80844-07-1										1
fenitrothion	122-14-5	N	50/53	3,0	15,0	15,0	20,5	3,0	50,5	53,5	8
fenthion	55-38-9	N	50/53								2
fenvalerate	51630-58-1			25,0	9,0	45,0	57,8	1,0	111,8	136,8	3
flucythrinate	70124-77-5										1
fonofos	944-22-9	N	50/53	25,0	30,0	9,0	18,8	3,0	57,8	82,8	6
fuberidazole	3878-19-1	N	50/53								2
guazatine	13516-27-3	N	50/53								1
isazophos	42509-80-8	N	50/53	16,0	9,0	9,8	17,5	2,0	36,3	52,3	2
isofenphos	25311-71-1			9,7	37,2	19,1	34,3	2,0	90,6	100,3	3
isoprocarb	2631-40-5	N	50/53								1
lambda cyhalothrin	91465-08-6	N	50/53	25,0	3,0	15,0	17,5	1,0	35,5	60,5	1
lindane	58-89-9	N	50/53	25,0	31,1	28,5	35,5	3,0	95,1	120,1	13
malathion	121-75-5			5,0	3,0	15,0	21,0	1,0	39,0	44,0	11
methamidophos	10265-92-6	N	50	1,0	30,0	45,0	65,3	5,0	140,3	141,3	1
methomyl	16752-77-5	N	50/53	15,0	30,0	15,0	21,5	5,0	66,5	81,5	2
metribuzin	21087-64-9	N	50/53	3,0	27,0	9,0	51,0	5,0	87,0	90,0	1
monocrotophos	6923-22-4	N	50/53								10

Substitute	CAS Number	European Union		Evaluation Cornell University (New York)							Nr. of Listings
		Symbol	Risk Phrases	Fish	Birds	Bees	Beneficial Organism	Groundwater and Runoff Potential	Terrestrial Organisms	Ecological Impact	
parathion	56-38-2	N	50/53	25,0	30,0	45,0	65,1	1,0	140,1	165,1	8
permethrin	52645-53-1			25,0	9,0	45,0	61,8	1,0	115,8	140,8	7
phenthoate	2597-03-7										2
phorate	298-02-2			25,0	45,0	27,0	57,6	1,0	129,6	154,6	12
phosalone	2310-17-0	N	50/53	16,1	3,0	3,0	17,4	2,0	23,4	39,5	2
phosphamidon	13171-21-6	N	50/53	3,0	15,0	15,0	19,9	5,0	49,9	52,9	3
phoxim	14816-18-3										2
pirimiphos ethyl	23505-41-1	N	50/53								1
pirimiphos-methyl	29232-93-7										3
propoxur	114-26-1	N	50/53	16,0	60,0	45,0	55,8	1,0	160,8	176,8	3
pyrethrins	8003-34-7	N	50/53	16,0	9,0	3,0	17,0	2,0	29,0	45,0	1
quinalphos	13593-03-8										3
resmethrin	10453-86-8	N	50/53	16,0	6,3	28,5	39,1	2,0	73,9	89,9	2
sulfluramid	4151-50-2										2
tetrachlorvinphos	22248-79-9										3
triazophos	24017-47-8	N	50/53								1
trichlorfon	52-68-6			16,1	15,0	9,0	20,2	2,0	44,2	60,3	5
trifluralin	1582-09-8	N	50/53	25,0	9,0	3,0	20,0	1,0	32,0	57,0	1