Annex 2

Report of Phase 1
of the Aquatic Risk Indicators Project

Executive Summary

This report summarises the work completed in Phase 1 of the OECD Working Group on Pesticides' Aquatic Risk Indicators Project. The project is part of a larger project to develop pesticide risk indicators for both human health and the environment. The indicators are intended to help countries measure progress in reducing the risks associated with pesticide use.

Phase 1 of the Aquatic Risk Indicators Project started in Spring 1998. In two meetings (April and June 1998), an Expert Group:

- identified the main approaches that could be used to calculate aquatic risk indicators, and selected two (each with two variations) that will be tested in Phase 2;
- defined the data on pesticide use, toxicity, and environmental fate and exposure that will be used;
- developed different options for combining those data into indicators. These options include different levels of aggregation (i.e., from a regional crop-specific indicator to a national aggregate indicator across all crops and pesticides) and allow for adjustment to country-specific conditions (e.g. in landscape structure, farming practices, and use of buffer zones);
- developed a number of general principles for the use of data in indicators (e.g., combining different types of data and handling missing data); and
- developed a method to estimate pesticide ***use*** data (which are not available to most countries) from national ***sales*** data (more widely available).

The selected indicators will now undergo thorough testing during Phase 2 of the project. The testing will include a sensitivity analysis to be carried out using real data on the hazard and use of specific pesticides. The results will be reviewed in a June 1999 OECD workshop that will make recommendations for follow-up work with the indicators. The ultimate goal is to develop indicators that OECD member countries could use to calculate aggregate risk indices on a regular basis. The indices could be reported to OECD for use in environmental statistics as are published by the OECD Group on the State of the Environment and the Joint Working Party for Agriculture and Environment.

Overview of the Main Sections of the Report:

INTRODUCTION:

- background, scope, information on related projects

GENERAL ISSUES AND MAIN APPROACHES

- describes briefly the two main indicator types (section II.1): one based on exposure-toxicity ratios, the other based on scoring. Within scoring, two sub-types were found: (a) scores for all variables are calculated independently from each other, and (b) scores for certain variables influence the scores for other variables (e.g., toxicity scores are increased if the substance is also persistent)
- discusses general issues relevant to the selection and use of input data on pesticide fate, toxicity, sales and use (sections II.2. – II.4), and on situations in which governments might want to use indicators (sections II.3, II.7)
- compares the proposed indicators to the range of existing ones (section II.6)

REVISED WORKPLAN

- lists the different indicators and data sets to be tested in Phase 2

EXPOSURE/TOXITY RATIO APPROACH

- detailed description of the Exposure-Toxicity ratio indicator, including basic scenario, input data and formula. Important issues are:
  - the indicators proposed are ***hierarchically structured***, so that they can be applied at different levels of aggregation and can accommodate pesticide use data of different levels of precision.
  - the underlying scenarios as well as input data relating to use conditions, application methods and other risk mitigation measures need to be ***adjusted to country-specific conditions*** (e.g. in landscape structure, farming practices, use of buffer zones, etc.).

SCORING APPROACH

- detailed description of the scoring indicators, including scoring tables for input data. Important issues are:
  - two sub-types have been identified: (a) scores for all variables are calculated independently from each other, and (b) scores for certain variables influence the scores for other variables (i.e., toxicity scores are increased if the substance is also persistent).
  - the indicators can be ***hierarchically structured*** in a similar way to the exposure-toxicity ratio indicator.
  - the underlying scenarios as well as the specific scoring of input data relating to use conditions, application methods and other risk mitigation measures need to be ***adjusted to country-specific conditions*** (e.g. landscape structure, farming practices, buffer zones, etc.).
  - both ***graphical*** and numerical presentations of scoring indicator results will be tested.

ATTACHMENTS

Attachment 1: Detailed description of a method for estimating crop-specific pesticide use data from national sales data and other information. This is important for the majority of countries which do not have detailed use data.

Attachment 2: Revised workplan for Phases 2 and 3, including schedule up to June 1999 workshop.

Attachment 3: Compilation of questions that governments might use indicators to answer.

Attachment 4: Description of a exposure-toxicity ratio indicator scenario covering hydraulic catchment areas. The scenario was not included in the testing because it requires fairly sophisticated input data which might not be readily available. It was kept in the attachment, however, because countries might find the approach useful, e.g. for regional indicators, or for probabilistic risk assessment.

Report of Phase 1

I. INTRODUCTION

I.1. Background

This report summarises the work completed in Phase 1 of the OECD Working Group on Pesticides' Aquatic Risk Indicators Project.

This project is part of a larger project to develop pesticide risk indicators for both human health and the environment. The project is being carried out as part of the Working Group on Pesticides' work on pesticide risk reduction, and is intended to help OECD countries measure their progress in reducing the risks associated with pesticide use.

The project is being carried out according to a proposal agreed by the Working Group on Pesticides at its 7th meeting, in February 1998. Developed by the Working Group's Risk Reduction Steering Group (RRSG), the proposal laid out a workplan, timeline and criteria for the project such that it would correspond to the recommendations of the OECD workshop on pesticide risk indicators held in Copenhagen in April 1997. The proposal divided the work on aquatic risk indicators into three phases, to be carried out by an Expert Group (**EG**) composed of 13 experts in aquatic risk and other relevant areas. The proposal also outlined the initial background work that would be done in preparation for later projects to develop indicators in other risk areas.

This report was written by the Aquatic Risk Indicators **EG,** which met on 6-8 April 1998 in Paris and on 16-19 June in York.

I.2. Objectives

As outlined in the project workplan, Phase 1 was to select or develop a number of indicator models that were then to be tested with real data in Phase 2. Specifically, the Phase 1 objectives were to:

- identify the main approaches that could be used to calculate aquatic risk indicators;
- identify existing indicators that could be used (or further developed) to represent these main approaches;

- identify the data on pesticide use, toxicity and environmental fate/exposure to be used in the indicators;
- identify different ways to combine these data to derive indicators - i.e., specify the indicator models to be tested in Phase 2;
- check that these models are representative of the main approaches and fit the criteria of the RRSG and the Copenhagen workshop;
- review and further develop the workplan.

I.3. Scope of the project

The EG decided to focus on risk to surface fresh water (organisms). The EG agreed not to consider the risk of leaching into groundwater because this involves a separate set of issues, with different routes of exposure and additional assessment endpoints mainly relevant to human health.

The EG also confirmed that the project would deal with the use of pesticides in the agricultural sector, including forestry and horticulture where appropriate, but would not include non-agricultural (biocide) uses.

I.4. Related projects

Several members of the EG are involved in related projects which are currently under way:

- Within OECD, the Joint Working Party for Agriculture and Environment (JWP) is working on a similar set of agri-environmental indicators. The Working Group on Pesticides Project is intended to contribute (a set of) pesticide risk indicator(s) to the JWP project. Link: Jeanne Richards (not an EG member, but participating on behalf of the OECD Secretariat)
- Eurostat has recently developed guidelines for the collection of pesticide usage statistics. Although intended for use by EU member states, the guidelines have also been positively received by the Working Group on Pesticides and will be submitted for adoption as OECD guidance in 1998. Link: Miles Thomas
- The EU launched a project (CAPER = Concerted Action on Pesticide Environmental Risk Indicators) aimed at farmer decision tools by comparing 8 existing models, using data from around 20 pesticides. Link: Volkmar Gutsche
- Another EU project (ELISA = Environmental Indicators for Sustainable Agriculture in the EU) on developing a set of environmental indicators for sustainable agriculture, including landscape quality etc., also started in 1998. Link: Volkmar Gutsche
- The French government uses a scoring system (*SIRIS*) for prioritising pesticides with potential to contaminate groundwater and surface water. Link: Jean-Michel Jouany
- In the UK, the Scottish Agricultural College has examined existing indicators to assess their suitability as policy tools. A draft report was distributed to the members of the EG in May 1998, and a final report is now available. Link: Miles Thomas

II. GENERAL ISSUES AND MAIN APPROACHES

II.1. Main approaches to be covered in Phase 2

In general, the EG decided to aim for modular structures of the model indicators, so that countries can use those parts of the indicators which are relevant to them, and for which they have the necessary data.

Based on the conclusions and documentation of the Copenhagen workshop, the EG confirmed that the following two approaches should be tested in Phase 2:

- **REXTOX,** an **Exposure-Toxicity Ratio approach** (see section IV for details): this approach combines several fate and/or use parameters in a mechanistic model (similar to those used in regulatory risk assessment) to estimate an environmental concentration, which is then used in a ratio of toxicity and exposure. The algorithms proposed cover three scenarios of which the first two are proposed for testing in Phase 2.

  - **acute local scenario** which considers the acute risk in an adjacent water body. It will accordingly use those toxicity values relevant for short-term exposure.

  - **long-term local scenario** which considers the risk of long-term exposure in an adjacent water body. An algorithm was developed which simply multiplies the result from the acute local scenario with a weighting factor which incorporates degradation and long-term toxicity :

  - Initially, also a **long-term catchment scenario** was discussed which could consider the risk of long-term exposure in the receiving water body of a large catchment area, taking into account flow rates, hydraulic residence time, ratio between treated surface and receiving water bodies etc. Time-weighted average concentrations and long-term toxicity values would be used. However, in view of concerns from EG and RRSG members, specifically about the complexity of input data required, the EG proposes to discontinue the development of this scenario. Details on this scenario can be found in Attachment 4.

- **Scoring and ranking approach** (see section V for details): this approach generally converts input data into scores which are then combined to derive a final score for the risk index. Combination of scores is normally done by addition or multiplication, without actually trying to model the interactions of input parameters (i.e., without trying to build a mechanistic model). Within the scoring method, two different ways of combining scores are proposed to be tested in Phase 2 :

  - **ADSCOR**, an **additive scoring** method where scores are assigned independently from those for other variables, and combined mainly by adding them together.

  - **SYSCOR**, a **synergistic scoring** method adapted from the French SIRIS scheme, in which scores for different variables are linked synergistically.

For ***both*** the ratio and the scoring approaches, the EG considered that ***less complex*** systems might also be needed, using only few data on fate and use. Such systems could be easier to compute, requiring fewer input variables, but might lose responsiveness. They might also require fewer assumptions on scenarios. No currently available models appeared suitable. The EG considers that they will best be achieved by eliminating the least important parameters from the more complex variations, using the results of a ***sensitivity analysis*** in Phase 2.

A third indicator type based on ***label statements*** (including specifications of use conditions) was also considered during the development of the workplan, specifically because labels are issued after the final, overall evaluation of a pesticide, and could therefore potentially reflect higher tiers of risk assessment. However, the EG identified the following problems with the label-based system:

- part of the label information is based on hazard rather than risk
- labels are likely to include 'hidden' benefits information (e.g. the size of a protective buffer zone may be reduced for a pesticide judged to have high crop protection benefits);
- labelling criteria change over time and are not always well documented;
- labelling systems are not consistent between countries.

For these reasons, the EG decided not to include the label-based approach in Phase 2.

II.2. Data elements to be used

In line with the Copenhagen recommendations, the EG focused on selecting those data from standard tests that are **generally available** to regulators in OECD countries.

II.2.1. Ecotoxicity

II.2.1.1. General principles/issues

Consistency over time in calculating the indicators is more important than precision. In order to compare trends over time or detect differences between two practices, regions etc, it is the ***change*** of indicator values that matters, not the absolute value at one point.

Using acute or long-term[1] data: Generally, both acute and long-term tests are available for *Daphnia* and fish. The results of acute tests are usually reported as EC_{50}'s; the results of long-term tests are reported as NOEC values. In view of the considerations that

(a) both acute and long-term effects may have population consequences,

[1] Throughout this report, the term 'long-term' was preferred over 'chronic', because 'chronic' is interpreted as involving a full life cycle of organisms. Only the algae test is a true chronic one in this sense, while the 21-28 day tests with *Daphnia* and fish cover only parts of the lifetime.

(b) some risk reduction activities may reduce acute exposure more than long-term exposure, while others may act the other way round, and
(c) using both acute and long-term data will enable indicators to respond to both,

the EG decided to use both acute and long-term toxicity data, where possible using each in its appropriate context of exposure (long-term data like NOEC's are particularly relevant to stable compounds and to repeated applications). Algae tests are of short duration but they are true chronic tests with respect to the life cycles of algae (comprising full life cycles). They should be used in any case.

The EG also noted that countries could use toxicity values from non-standard tests instead whenever such results are available and considered more relevant (e.g., mesocosm studies).

Combining acute and long-term data: As stated above, it is desirable that the indicators be responsive to changes of acute toxicity and exposure as well as of long-term toxicity and exposure. The EG therefore proposes that indicator models should where possible address the two time scales separately.

Combining toxicity data from different taxa: Where the calculation of an indicator is related to a specific taxon (e.g. for reasons of specific protection or interest), only toxicity data related to that taxon should be used. Also, a shifting of the risk from one taxon to another - e.g. from *Daphnia* to algae (which might be caused by a change of the pesticide active ingredients typically used on a certain crop) - can only be detected if the indicator is calculated separately for each taxon. If it is nonetheless decided to combine data from different taxa, options for doing so include using the most sensitive species, or a distribution of species sensitivities. Current risk assessment practices generally use the most sensitive species. However, countries may decide which option they want to apply. As long as countries use this method ***consistently***, the specific method chosen would not influence the indicator's ability to detect differences in magnitude of values.

Using data from different endpoints: The EG noted that different types of effects define the NOEC in different studies (e.g., mortality, growth, reproduction). Hence, an aggregated indicator that combines, e.g., the *Daphnia* NOEC's for several substances would in fact combine different endpoints. However, the EG considered this to pose little concern, because they noted that countries would be expected to use only one specific NOEC value per species for a given substance. This value would be derived from the study considered most valid and relevant. As long as countries used this value for each substance ***consistently***, the specific endpoint chosen would not influence the indicator's ability to detect differences. Only if a new study became available, and the previous toxicity value were replaced by a new one, might it be necessary to recalculate indicator values for previous years. The same would be true if new ***acute*** toxicity data became available.

II.2.1.2. Specific issues

Algae: This test is routinely used to generate EC_{50} and NOEC values, for effects on both growth rate and biomass. There is an ongoing debate about whether growth rate (which might be ecologically more relevant) or the more sensitive of the two endpoints should be chosen. The EG concluded that this choice should be left to member countries since it might also depend on data availability. As long as countries choose the same endpoint for a given substance ***consistently***, the indicator's ability to detect differences would not be compromised.

Fish: Data currently submitted to OECD Member countries vary with regard to species endpoint, duration, etc (e.g., to meet countries' different testing requirements), but this does not affect countries' ability to assess national risk trends over time, nor would it prohibit an international comparison of general trends among countries. As for other parameters, the EG concluded that as long as countries chose the same endpoint or species for a given substance ***consistently***, the specific choice taken would not influence the ability of an indicator to detect differences.

Other taxa: The EG discussed aquatic vascular plants and benthic invertebrates. More data for these may be available in the future. By using the principles of combining (or not combining) toxicity data as outlined above, data on other taxa could easily be used in the indicator(s) in future, if appropriate.

Bioaccumulation: The Copenhagen workshop recommended using the BCF or the log K_{ow} within indicators as a measure of potential bioaccumulation. The EG concluded, however, that bioaccumulation should not be taken up in the exposure-toxicity ratio approach for the aquatic compartment. The EG members' experience has shown that inclusion of the BCF would complicate the algorithm considerably (e.g. requiring a special sub-model). The scoring approaches could, however, more easily accomodate the log K_{ow} which is both a measure of bioaccumulation and a factor in the context of exposure and mobility (*discussion on if/how to separate those e.g. by including the* K_{oC} *is still ongoing*). The EG also noted that bioaccumulation in aquatic organisms may lead to exposure of organisms higher in the food chain, such as fish-eating birds or mammals. There, bioaccumulation would contribute to the calculation of the exposure, and should be taken up in indicators which are aimed at risks for birds and mammals.

Missing long-term toxicity data: Extrapolation from acute to long-term toxicity data (e.g. from acute EC_{50} values to NOEC's) may be necessary where long-term toxicity data are lacking. The EG discussed two ways this could be done: (1) by dividing by standard factors, such as those recommended by OECD Environmental Monograph 59 or used in a national registration procedure, and (2) by using the mean of the ratios between acute and long-term toxicity data for the same taxon from other substances of the same class or group of chemicals. The EG noted that as long as countries consistently apply the same method, the particular method chosen would not affect the indicator's ability to detect differences.

II.2.2. Environmental fate and exposure data

All of the data referred to on page 11 of the Copenhagen report under *Soil* and *Water* are generally available to OECD governments. The water-phase DT_{50} from a water/sediment-study was regarded as the most relevant parameter within the water body, but is still sometimes (e.g. for older substances) lacking (in which case DT_{50} values from either soil or water studies have to be used).

However, not all the data listed in the Copenhagen report might be equally important, or be applicable in all indicator types. The EG selected those parameters pertinent to their approaches. In doing so, the subgroups also aimed at reducing the number of variables, e.g. by looking at correlations between them. The specific lists of input data can be found in sections IV and V.

II.2.3. Conditions of use

Use conditions influence risk by changing exposure. In many OECD countries, risk reduction policies include modifications to application methods and other restrictions on the conditions of use aimed at reducing exposure to both humans and the environment. The EG therefore noted that risk indicators developed for OECD governments should include sufficient data on use conditions to reflect the effect of these policies on exposure and risk.

The EG reviewed the pesticide use parameters listed by the Copenhagen workshop's ecotoxicology and environmental fate working groups. The EG concluded that the exposure-toxicity ratio indicator could take their effects into account by altering either **D** (the use rate), **p** (the probability or frequency of treatment), or **L** (the amount of chemical lost from the crop to water), as indicated in Table 4 in section IV. The scoring methods are less amenable to inclusion of some of these data, but Section IV gives the list of proposed data and possible scores.

II.2.4. Sales and usage

Information on actual pesticide use - or at a minimum, an estimate of actual use based on the probability and extent of applications - is essential for the development of valid risk indicators.

The recent Eurostat project on ways to collect pesticide use data concluded that the following variables are essential and should always be included when undertaking surveys in individual countries:

- crop
- area grown
- area treated
- product
- rate of application or amount used

- method of application (restricted to distinguishing between sprays, granular applications, seed treatments etc. - often known from the product identity)
- date of application.

Details of tank mixes (i.e. which products are applied together - can usually be inferred from date of application) and crop variety were regarded by Eurostat as desirable and should be collected if resources allow (they are, however, not relevant for the indicators proposed here).

The 'essential' parameters cover all of the use parameters identified above for use in indicators, except for detailed aspects of application method (see Table 4).

If real use data are not available, it may be *possible to estimate (most of) the necessary parameters from sales data and other information* (e.g. total crop areas). Some existing indicators do this, to varying extents. Attachment 1 provides a detailed method for estimating the amount of a given substance applied in a given crop (targeted at a given pest) from national sales data. Table 1 lists the main data sources for estimating the main parameters:

Table 1: Input data for estimation of use data on base of national sale data

Term (as used in Attachment 1)	**Definition**	**Data sources**
SQi	Quantity of active substance (a.i.) sold by year	National sales data provided by industry
Aj	Total area planted to crop j	National agri-statistical data
Ri	Recommented dose rate of each permissible application of each a.i.	Product label (e.g. 'Register of authorized plant protection products')
Pi	Estimated probability of each permissible application of each a.i.	Expert judgment (e.g. extension service)

The performance of this method will be evaluated in **Phase 2** by comparing estimates based on sales data with use data from surveys, and assessing how they influence indicator outputs. This evaluation shall be done as follows: Aggregated UK use data will be used to estimate sales. These estimates will then be used to estimate use, based on the method described in Attachment 1. The level of agreement between estimated and actual use will be considered a measure of the accuracy of the method. This test can be done at different levels to simulate the different levels of national sales data that different countries may have - such as by active ingredient, or by pesticide group (e.g. total herbicides sold).

II.3. Aggregating across different levels

Indicators could be calculated at different *levels of aggregation*, i.e.:

- per application of a specific substance in a specific crop in a specific region (lowest, most specific level)
- substance-specific, all applications of the substance aggregated
- crop-specific, all applications of all substances used aggregated
- nation/region-wide (per crop)
- nation/region-wide (over crops)
- aggregation over all pesticides used, or
- aggregation over only the most important **n** pesticides used (e.g., 'top ten'), or
- combinations or subsets of those.

Clearly, indicators which address specific crops and regionally different conditions require equally detailed input data, particularly on pesticide use, whereas more general use data could support an overall, nation-wide indicator across all crops and pesticides. If data pertinent to a specific level are not built into the indicator, then such indicator can not be usefully applied to that specific level. Accordingly, not all indicators may be able to address all different levels of aggregation, as shown in Table 3 in section IV.

The *quality* of input data available to different countries is expected to vary widely. If, for example, only national level sales or use data are available, questions addressing lower levels can not be answered unless more data are collected or estimates made. Where estimates are used, the uncertainty in the indicator calculation and interpretation inevitably increases. Phase 2 will include an analysis as to how higher-level data can be used to estimate lower-level data, and how accurate such estimates can be.

As for the indicators to be tested in Phase 2, risk trends will be will calculated for four levels of aggregation:

- nation-wide (over crops and pesticides)
- region-wide (over crops and pesticides)
- crop-specific, all applications of all substances used aggregated
- substance-specific, all applications of the substance aggregated (one or several crops).

II.4. Suitability of proposed indicators for biological pesticides

The EG also considered how the proposed indicators could reflect the use of biological pest control agents (BCA). BCAs are often seen as a means to reduce the use of chemical pesticides, and therefore to contribute to overall risk reduction. BCAs fall into three broad categories, though only the first two are generally recognised as BCAs in the EU. Even where recognised, BCAs are not always considered as 'pesticides' for regulatory purposes.

The first class of BCAs is ***live predators*** or ***parasites*** introduced into a crop, such as *Encarsia formosa*, a parasite of whitefly. Such organisms pose no risk to any of the aquatic species considered in these risk indicators (presenting neither hazard nor exposure), and would therefore contribute nothing to the overall risk index. The movement from conventional chemical pesticide use toward reliance on biological controls of this type would be seen indirectly, through a reduction over time in the overall risk trend.

The second class of BCAs includes ***microbial pesticides*** - those based on *Bacillus thuringiensis,* nuclear polyhedrosis viruses, or other bacteria, viruses, or fungi specifically toxic to certain pests. These are often sprayed onto crops in a manner similar to conventional pesticides, and are tested for hazard before regulatory approval, so it is tempting to treat them like conventional pesticides. To do so, however, may not be sound. Although the toxicity tests required for this class of BCAs are similar to those for conventional pesticides, their fate in the environment, and thus their potential to reach surface waters, cannot be assessed meaningfully in terms of the standard measures of solubility, persistence, etc. used in the scoring approaches. Further consideration of how best to address this class of BCAs in the risk indicators is required.

The third class of BCAs, generally recognised as such only in the USA, includes ***plants genetically modified*** to incorporate genes from organisms such as *B. thuringiensis,* that make the plant itself toxic to pests when they consume it. As in the first class discussed above, these modified plants have no intrinsic toxicity to aquatic organisms and contribute neither to aquatic exposure nor to the overall risk index. Thus the impact of movement from conventional chemical pesticide use toward reliance on BCAs of this type would similarly be seen indirectly through a reduction over time in the overall risk trend.

II.5. Suitability of proposed indicators for metabolites

Countries might eventually decide that indicators should also take account of relevant metabolites of active substances. The EG proposes that the same indicators may be applied, using input data relevant to the metabolite(s) in question (e.g., toxicity and fate values). Those input data may be available in cases where such metabolites had been identified as relevant in the registration process. The 'application rate' might have to be calculated from the application rate of the active substance and the transformation rate at which the metabolite is formed. However, such uses will certainly require further thought, and could not adequately be addressed by the EG so far.

II.6. Relation of proposed model indicators to the range of existing approaches

The plan for this project stated that the model indicators to be tested should be examples of the main approaches that exist, to enable the relative merits of those approaches to be assessed. The extent to which the indicators developed in Phase 1 (exposure-toxicity ratio, additive scoring, and synergistic scoring) are representative of existing approaches is assessed below.

Simplicity vs. complexity
The models are more complex than many existing approaches, though it should be noted that some existing approaches are hazard indicators rather than risk indicators. The effect of simplification by omitting some variables will be examined as part of the sensitivity analysis in Phase 2.

Consistency with regulatory criteria
The indicators differ in their consistency with regulatory risk assessment, as do other existing indicators. The exposure-toxicity ratio approach uses a ratio of toxicity and an estimated environmental concentration, as in regulatory risk assessment. The exposure element is based on methods of modeling pesticide fate which are used in risk assessment. The two scoring approaches use the same data as risk assessment, but combine them in different ways, thus producing an exposure estimate different from an estimated environmental concentration.

Types of input data
The indicators use the same range of toxicity data for the aquatic environment as existing approaches, except that it was decided not to use bioconcentration factors (BCF) which do appear in some indicators. The indicators use the full range of exposure and pesticide consumption data used by existing approaches, while trying to achieve higher precision and degree of reality with use and consumption data.

Methods of scoring
The additive scoring model uses only step functions for most variables (in Phase 2, also the raw unconverted data for area and toxicity will be investigated). Linear, non-linear and elicited scoring functions are not included at present. The synergistic scoring indicator allows non-linear scoring but in a different way than other existing indicators. At the mid-point of Phase 2, consideration will be given whether to carry out a more systematic assessment of different methods of scoring.

Weighting
The EG preferred not to combine weighted measures of risk to different species groups. No explicit weights are attached to the toxicity and exposure scores in the additive scoring indicator. Weights are attached to the toxicity and exposure variables in the synergistic scoring indicator by ranking them, and alternative rankings will be examined. Further weighting can be achieved within the synergistic scoring indicator by altering the 'penalties' for different combinations of scores: this will be investigated at the start of Phase 2 to enable the EG to decide whether to explore the use of alternative penalties.

Fuzzy logic
The EG felt that indicators using fuzzy logic were likely to be unsuitable for use by national governments because their internal workings would be difficult for users to understand. It was therefore decided not to test a representative of this approach.

Methods for dealing with missing data
The options to be tested for dealing with missing data will be decided early in Phase 2, once the extent of missing data in the test data set has been determined.

Combining toxicity and exposure
Existing approaches use any of four methods:

(1) Exposure and toxicity are not combined at all
(2) Exposure and toxicity are combined by division or multiplication
(3) Exposure and toxicity are combined by addition
(4) Exposure and toxicity are combined by using fuzzy logic.

The EG decided that (2) best represents its understanding of the relationship between toxicity, exposure and risk. A graphical method will also be tested (i.e. no arithmetic combination, equivalent to (1)). The EG decided not to test (3) or (4).

Combining crops and pesticides
Existing indicators aggregate data either by addition, or by taking averages weighted by pesticide consumption. Some do not aggregate at all. This project will examine different levels of aggregation which in effect cover all three options.

Scale of output
Existing indicators produce output at a wide range of levels (from individual application to national aggregates), depending on their intended purpose. This project will examine output at the application, regional and national levels. Outputs at farm level (i.e. indicators as farmer decision tools) were considered less relevant to the remit of the project, to develop indicators for use by national governments.

Conclusion
On most characteristics the indicators cover the range of approaches used in existing indicators, although some details (e.g. methods for supplying missing data) remain to be decided early in Phase 2, and some options (e.g. fuzzy logic) were rejected. The main omission is in the types of scoring function used: the models currently do not include linear, non-linear or elicited functions. It was decided more important to establish the structure of the indicators first. Different scoring functions could be examined in the second half of Phase 2, if desired. A decision on this could be made by the EG or the RRSG when reviewing the Progress Report in October 1998.

II.7. Potential Uses of Risk Indicators by National Governments

On several occasions (Copenhagen workshop, RRSG meeting in September 1997, preparation for York meeting), possible questions were compiled which governments might want pesticide risk indicators to answer (Attachment 3). The EG grouped them into 3 major types:

I. ***descriptive***: to describe risk trends over time or differences between regions.
II. ***analytical/predictive***: to identify the main contributing factors to the final indicator value, or to simulate the effect of predicted changes of specific parameters.
III. ***ecological***: to 'measure' ecosystem health.

In reviewing the questions, the EG concluded that:

- It is unlikely that all of them can be answered by the same indicator, or by an indicator at all. This is especially true for the questions related to measuring ecosystem health. The EG emphasised that indicators are not meant to replace monitoring in the field.

- The indicators should demonstrate the effects of risk reduction measures and hence should include data and assumptions that reveal these effects. The validity of the indicator therefore depends on the validity of any underlying assumptions.

- The indicators are likely to include data from different scales and units. Hence, their absolute value should not be interpreted as an absolute measure of real risk. Rather, the indicators should be used as a means to show changes over time and should be interpreted in the context of the model(s) used to derive them.

- Equally, the change of an indicator value by x% should not necessarily be interpreted as a change of the absolute risk by the same percentage. This is especially true for scoring-based indicators, due to the 'crudeness' inherent in most scoring functions. Ratio-based indicators are, as experience in the Netherlands shows, more likely to allow quantitative interpretation of the magnitude of an observed change.

- Changes in indicator values might not necessarily require immediate action but rather a careful analysis for possible causes.

With these caveats in mind, indicators can usefully be applied to answer questions of descriptive and analytical/predictive character, as shown in Table 2. 'Ecological' questions are unlikely to be answered, mainly because the relationship between pesticide hazard, use and actual ecological impact has yet to be quantified. No simple relationships that could be used for building an indicator are known at this moment.

Table 2: Potential Uses of Risk Indicators by National Governments

Type of use	*Examples*	*Implications for indicator design*
I. DESCRIPTIVE	Are risk indexes changing over time? Has policy goal for indicator change been achieved? How do risk indexes vary between regions?	Requires consistency - results must be comparable over time and between regions.
IIa. ANALYTICAL[2]	Why has risk index changed? Which factor contributes most to the overall risk index? Has policy X changed risk index?	Requires either: 1. test for correlations between indicator output and external data on possible causes of change, or 2. ability to identify which aspects of input data caused changes in output. Of these, (2) is much more sensitive but requires input data at level consistent with policy question (e.g. pesticide, crop).
IIb. PREDICTIVE	Will risk continue to decline? Will policy Y reduce risk index if adopted?	Indicator design same as for descriptive uses. Requires ability to forecast input data (pesticide properties and use) for future years based on expected effect of policy changes. Requires input data at level consistent with policy question (e.g. pesticide, crop).
III. ECOLOGICAL	Have policy goals for sustainability or reduction of impacts been achieved?	Requires known relationship between indicator values and actual ecological risk or impacts.

Note: Some questions combine more than one of the above types. For example, 'what do I need to do to achieve sustainability?' is both predictive and ecological.

[2] 'analytical' and 'predictive' may be seen as the same type of questions/analysis, with 'analytical' looking backward and 'predictive' looking forward in time.

III. REVISED WORKPLAN

III.1. Indicators to be tested

The EG confirmed the selection of three indicators to be tested in Phase 2:

∗ **Exposure-Toxicity Ratio** approach (**REXTOX**) (split by acute and long-term)
- acute risk - specific acute risk potential, specific acute risk probability, acute risk index, aggregated acute risk index
- long-term risk - specific long-term risk potential, specific long-term risk probability, long-term risk index, aggregated long-term risk index

∗ **Additive scoring** approach (**ADSCOR**) (split by acute and long-term)
- toxicity and exposure both scored - with and without scale factor
- unscored toxicity, scored exposure - with and without scale factor

∗ **Synergistic scoring** approach (**SYSCOR**) (acute only)
- toxicity and exposure scored using synergistic method, adapted from SIRIS, with 3 alternative rankings of toxicity variables, and 2 alternative rankings of exposure variables - initially without scale factor

III.2. Combination of toxicity and exposure in scoring approaches

Two approaches to combining toxicity and exposure will be investigated for the additive and synergistic scoring indicators:
- multiplication to provide a numerical index of risk;
- graphically, plotting toxicity scores against exposure scores and examining trends and differences visually.

III.3. Levels of aggregation

The Group agreed the range of crops, pesticides and levels of aggregation to be considered in Phase 2:

Pesticides
Analyses will be conducted at three levels:
- individual pesticides
- all pesticides
- subset of ‘most-important’ pesticides (e.g. top ten by area treated)

Arable crops	unscaled[3]	regional	national
winter wheat	✓	✓	✓
all cereals	✓	✓	✓
all arable crops	✓	✓	✓

Tree fruit	unscaled	regional	national
apples	✓	✓	✓
all tree fruit	✓	✓	✓

Arable crops and tree fruit
Aggregation of both crop groups, at national level only.

III.4. Estimation of usage data

Where detailed use data are not available, it will be necessary to use from sales data and other information (e.g. total crop areas from agricultural statistics; application rates and frequency from extension services). Attachment 1 provides a detailed method for estimating the amount of a given substance applied in a given crop (targeted at a given pest) from national sales data. The performance of this method will be evaluated by comparing estimates based on sales data with use data from surveys, and assessing how they influence indicator outputs. This evaluation will also determine the accuracy of the estimation method.

III.5. Workplan

The group reviewed the workplan for Phases 2 and 3. It was not possible to assess in detail the amount of work required to complete all the combinations of crops and levels of aggregation listed above, so the consultants will do this early in Phase 2 and consult with the EG if necessary. The following modifications and additions were agreed:

- Revised specification of crops, levels of aggregation etc. as listed above.
- Analysis of alternative types of consumption data to concentrate on sales data, use data, and use estimated from sales. Brief consideration will also be given to the possibility of using sales data together with limited use information.
- Two new tasks to allow for consultation between the Consultants and the EG early in Phase 2. This will be accommodated within the original budget.
- The deadline for review of the Progress Report was brought forward so as to be completed before the meeting of the Working Group on Pesticides on 2 November.

The Workplan for Phases 2 and 3 has been revised to incorporate decisions made at the York meeting and is presented in Attachment 2.

[3] 'unscaled' refers to the versions of each indicator model which omit the scale factor - in the case of the REXTOX indicator this is the specific risk potential and specific risk probability.

III.6. Additional arrangements for Phase 2

If the consultants need to consult with members of the EG this will be done by email, copied to all members of the EG (and fax to those members without email).

If the EG needs to consult with the RRSG during periods when the Chairman is unavailable this will be done through the OECD Secretariat.

IV. EXPOSURE-TOXICITY RATIO APPROACH

IV.1. General approach

In the exposure-toxicity ratio approach, risk to aquatic ecosystems is characterized by the ratio of the concentration of an active ingredient in water, CONC, to some ecotoxicologically relevant concentration, TOX: the Exposure-Toxicity Ratio, ETR.

$$ETR = CONC/TOX$$

CONC values are derived from knowledge of actual use of the pesticide, combined with assumptions about the proportion of it that is lost to water through spray drift and run-off under crop- and region- specific conditions. TOX values are derived from standard single-species toxicity test results.

If sufficient information is available, basic ETRs are determined for single application events, at the field level, for specific crops in specific regions. Aggregates of basic ETRs can be obtained for crops, regions, classes of active ingredients, or combinations of these. If the data needed to derive ETRs at the field level are not available, ETRs are determined at some higher level of aggregation. In all cases, eventual nation-wide aggregation for all pesticides is done, yielding the Aggregated Pesticide Risk Indicator.

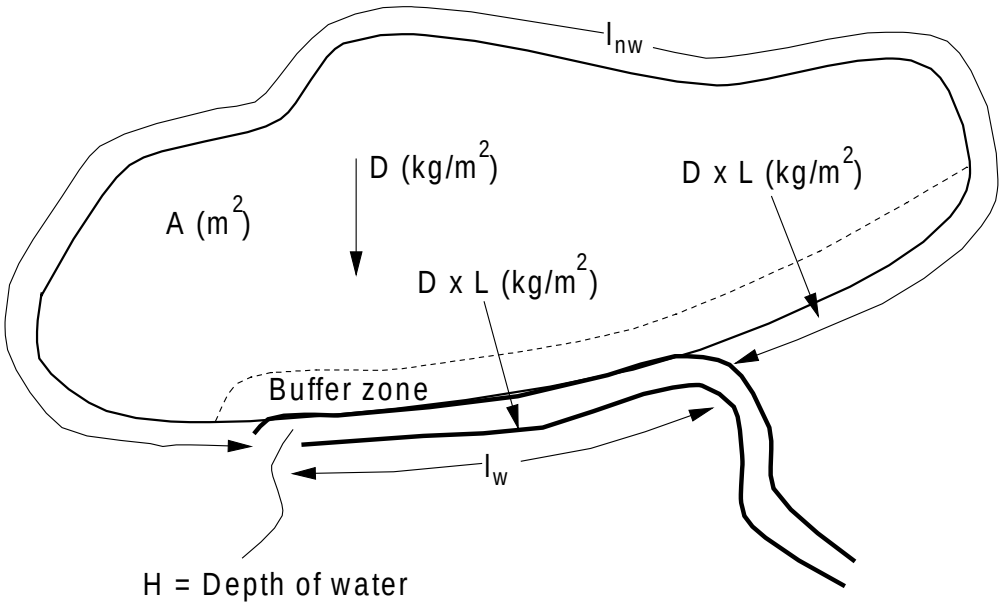
Exposure scenarios

During and shortly after application of a pesticide, loss of active ingredient to water takes place by different mechanisms, mainly spray drift and surface run-off. ETRs and aggregates thereof are derived for acute and long-term exposure scenarios (Figure 1). Both scenarios consider water bodies immediately adjacent to the site of application of the pesticide. Acute risk is calculated by comparing peak concentrations (time scale: minutes) to acute EC_{50} data. Long-term risk is calculated by comparing time-weighted average concentrations (time scale: weeks) to long-term NOEC data. In both scenarios, basic ETRs are derived for a typical treated hectare of a specific crop in a specific region.

The approach chosen is based on a ***hierarchical*** structure. Depending on the specific question, or the quality of data available, a country can choose the hierarchical level on which to calculate an indicator. Each higher level indicator is calculated by adding information to the lower level indicator:

- a ***local worst case*** (Specific Risk Potential): a field is always bordered by a surface water body, and is always treated
- the ***probability of this worst case actually occurring*** (Specific Risk Probability), by incorporating real dose rates and probability of treatment
- the ***regional extent of this situation*** (Risk Extent), by incorporating the area on which the specific crop is grown, and a factor which accounts for the relation between agricultural area and water bodies (low for regions with very few water bodies, high for wetlands with many ditches)
- the ***nation-wide sum*** (Aggregated Risk Extent), per crop, or across crops, and/or across pesticides.

FIGURE 1: EXPOSURE SCENARIO



$$WI = \frac{l_w}{l_{nw} + l_w} \quad (\sim)$$ Water Index

$$CONC = \frac{D \times L}{H} \quad (kg/m^3)$$

$$SARpot = \frac{CONC}{TOX} \quad (\sim)$$ Specific Acute Risk Potential

$$SARprob = SARpot \times p_1 \times p_2 \quad (\sim)$$ Specific Acute Risk Probability

$$ARE = SARprob \times WI \times A \quad (m^2)$$ Acute Risk Extent

IV.2. Acute Risk Scenario

IV.2.1 Specific Acute Risk Potential

The basic acute exposure-toxicity ratio, SARpot is obtained by:

$$SARpot_i = CONC_a/TOX_a = (DxL/H) / TOX_a$$

with

$CONC_a$	peak concentration immediately after application (kg/m^3)
TOX_a	aquatic toxicity, based on acute EC_{50} values (kg/m^3)
D	recommended application rate of active ingredient to specific crop, by a specific mode of application (kg/m^2)
L	proportion of the dose lost to water (dimensionless)
H	water depth (m)

This is the acute toxic effects ratio for active ingredient i in the waters along and in fields that are treated with the recommended dose[4]. Being based on a recommended rate of application, rather than on the actual dose rate, this represents a worst case, potential risk: the (dimensionless) specific acute risk potential.

IV.2.2. Specific Acute Risk Probability

Not all the fields grown are treated, whereas other fields are treated more than once, and actually applied dosages may differ from recommended application rates. A typical region-wide specific acute risk probability for active ingredient i, $SARprob_i$, is obtained by multiplying $SARpot_i$ with the probability of treatment and the proportion of the recommended dose applied:

$$SARprob_i = SARpot_i \times p_1 \times p_2$$

with

p_1	probability of treatment (dimensionless)
p_2 :	proportion of the recommended dose applied[5] (dimensionless)

$SARprob_i$ is the (dimensionless) average acute exposure-effects ratio for active ingredient i in water immediately adjacent to the fields where the crop considered is grown in the region: the specific actual risk probability.

[4] The exposure scenario considered is similar to the one used for registration purposes, although TOX may be derived differently.

[5] Note that if the average field is treated more than once, or if actual dosages greater than the recommended rates are applied, p2 may take a value greater than 1.

IV.2.3. Acute Risk Index

The extent of the risk that results from application of an active ingredient i to a certain crop in a certain region is proportional to the total area grown in that region, and to the probability of having water along the perimeter of a field in that region. The probability of water along the field is expressed in the water index. This is the average length of water, as a proportion of the average circumference of field in a region. The extent of risk is obtained by multiplying $SARprob_i$ by the area grown and by the water index:

$$ARE_i = SARprob_i \times A \times WI$$

with

A	area grown (m^2)
WI	water index (dimensionless)

It should be noted that this way of indicating risk does not distinguish between low exposure-toxicity ratios that apply to small areas and high exposure-toxicity ratios that apply to small areas. Neither does it distinguish between high ratios in regions with little water (low water index) and low ratios in regions with much water (high water index). The ARE has the dimension of m^2, and can be viewed as an equivalent area of land with standard SARprob, which may be the result of either low risk probability on a large area with a large water index, or high risk probability on a small area with a small water index.

IV.2.4. Aggregated Acute Risk Extent

Aggregation of acute risks across active ingredients per crop, and/or across crops per active ingredient in the region is done by addition of the ARE-values (m^2). Further addition of the regional agregates eventually yields a nation-wide Aggregated Acute Risk Extent:

$$AARE = SIGMA\ AR_i$$

IV.2.5. Data needed

This calculation presumes that

- The loss to water (by spray drift and/or run-off), L (-), can be estimated. Different methods and technologies of application, use conditions, application of buffer zones, etc. are reflected in L (see section ‘Loss to water’).
- The water depth, H (m), is known or can be assumed.
- The acute toxicity, TOX_a (kg/m^3), of the pesticide for aquatic ecosystems can be characterized somehow on the basis of laboratory toxicty test results (*e.g.* $L(E)C_{50}$ of most sensitive taxa, average of $L(E)C_{50}$'s, 5th percentile of $L(E)C_{50}$'s, etc.).
- The probability of treatment, p1 (-), and the proportion of the recommended dose applied, p2 (-), can be obtained from knowledge of actual use, or can be estimated by other means.
- The water index (length of ‘adjacent water’ as a proportion of the field circumference) is known or can be estimated or assumed (e.g., a national scenario, if no specific data are available).

IV.2.6. Sensitivity to policy measures

The indicator is expected to respond to changes in

- Dose and area. Reduction of the amounts (D) applied per unit area will reduce ETR; reduction of the area treated will reduce ARE_i.
- Loss to water. Changes in application technology, buffer zones, protective measures, etc. should be reflected in the percentage lost to water, and reduce ETR.
- Properties of pesticide. Use of alternate (new?) pesticides may result in lower doses and higher values for TOX, and hence reduce ETR.

Table 3: Sensitivity of proposed indicators

Indicator	responds to:
Specific Acute Risk Potential	recommended dose, fraction lost to water, toxicity
Specific Acute Risk Probability	as above + probability of treatment, proportion of recommended dose applied
Acute Risk Extent	as above + area grown
Aggregated Acute Risk Extent	as above

The indicator will **not** respond to

- The parameters H and WI, that characterize the field lay out, which can hardly be changed.
- Changes in persistence of the pesticides used. The indicator is ***not*** designed to respond to this; only acute effects are considered.

Remark: *In The Netherlands acute risk of pesticide use to aquatic ecosystems is reported since 1997 in the National State of the Environment Reports. The procedure used there (see separate document by Luttik) is very similar to the acute scenario described here. The results demonstrate a downward trend in the acute risk of spray-drifted pesticides in The Netherlands.*

IV.3. Long-term risk scenario

IV.3.1 Proposed indicators

The same stepwise approach, from a local worst case to an aggregated risk extent, is proposed for a long-term scenario, simply by incorporating long-term toxicity and fate information. In analogy to what is described for the acute risk scenario, first a ***specific long-term risk potential***, SLRpot, is calculated:

$$SLRpot_i = CONC_c/TOX_c$$

With

$CONC_c$ time-weighted average concentration during a 21-day period (or any other period of time corresponding to the chosen toxicity value) following the application event (kg/m^3)

TOX_c aquatic toxicity, based on long-term NOECs (kg/m^3)

The values for $CONC_c$ and TOX_c for an active ingredient i can be derived from $CONC_a$ and TOX_a, respectively, by applying acute-to-long-term corrections on both. This acute-to long-term conversion needs to be done once for each active ingredient.

$$SLRpot_i = SARpot_i \times (C1/C2)_i$$

with:

C_1 ratio of $CONC_c$ and $CONC_a$ = $[DT_{50}/(21 \times \ln 2)] \times [1-\exp[(-21 \times \ln 2)/DT_{50}]]$

(with DT_{50} in days. The factor 21 relates to the duration of many long-term toxicity tests. It should be the same as the test duration of the NOEC in TOX_c

C_2 ratio between TOX_c and TOX_a

Specific Long-term Risk Probability, Long-term Risk Extent, and ***Aggregated Long-term Risk Extent*** are calculated on the basis of $SLRpot_i$, in exact analogy with the acute risk scenario.

IV.3.2. Data needed

In addition to the data needed for the acute risk scenario, the following data are needed

- DT_{50} in water
- long-term NOECs

IV.3.3. Sensitivity to policy measures

The long-term risk indicator will respond similarly to policy measures as does the acute risk indicator, except that the long-term indicator should also respond to shifts toward use of less persistent chemicals.

Remark: The response of the indicator to shifts in persistence is the result of changes in intrinsic degradability of the chemical in water. One should be aware that this shift may overestimate the change in actual risk to ecosystems. In reality, concentrations in water are often controlled by the hydraulic residence time of the water. As residence times are generally in the order of days, only shifts to DT_{50} in this order will affect the real risk.

IV.4. Catchment area scenario

One of the major concerns with respect to use of pesticides is that low concentrations of many pesticides together, at greater distances from the fields of application, may in the long term adversely affect health or ecosystems. This concern is not adequately addressed by either the acute or the long-term risk scenarios described above. A catchment area scenario was designed to account for this (Attachment 4). This scenario regards long time scales and large spatial scales. Water in this scenario is a hypothetical composite of all the individual bodies of water in the area. Steady state is assumed for all the pesticides used, and it is assumed that

all active ingredients are present together. In the catchment scenario, risk is expressed in terms of combined toxic stress from all the active ingredients together. This scenario could account for the concerns mentioned, but calculations would require input data that are not always easily accessible, and communication of the results might be difficult. The calculation might not be simple and transparent enough to serve the purpose of a pesticide risk indicator. In view of concerns from EG and RRSG members, this scenario is not further developed or tested.

IV.5. Use data and application methods

Risk reduction policies may include modifications to application method (e.g. buffer zones). In such cases, governments may want to use risk indicators which reflect the effect of the modified methods on exposure and risk.

The group therefore listed the aspects of application methods which might influence exposure of aquatic organisms to a potentially significant extent (see Table 4). It was identified that in principle two things were necessary to enable the indicator to take any of these factors into account:

a) an estimate of how much the application parameter would affect D or L
b) information on how much of the total use is affected (e.g. estimates or surveys of the proportion of applications with buffer zones).

Table 4: Use and application method parameters

Use Parameter	Fate variable affected	Comments
Volume (kg applied)	p	
Area treated	p	
Application rate (kg/ha)	D	
Frequency of applications	p	
Interval between applications	-	not considered in the ratio approach
Formulation type (where it affects the loss of pesticides from the field)	L	This refers to differences between sprays, seed treatment, granular etc. Other aspects of formulation (e.g. EC versus WP) are less important and will probably be ignored. Coformulants cannot be considered due to lack of data.
Crop and crop growth stage	L	Influences interception of spray etc. Also affects choice of application method (see below). Also necessary to allow crops to be analysed separately.
Region	DT_{50} , L	Differing climatic conditions may affect water DT_{50} directly, and L via the soil DT_{50}. Also important in enabling regional analysis and/or comparisons (*but regional* DT_{50} *values may only occasionally be available, and for soil only*)
Application method parameter	**Fate variable affected**	**Data Availability**
Reduced application rates	D	Known directly if usage data is available. May be possible to estimate from other information if using sales data.
Buffer zones	L	Options: 1. assume label recommendations and conditions are always followed 2. obtain information on actual use of buffer zones
Incorporation in soil	L	Information on the main application methods (injection, incorporation, sprays, broadcasting) would usually be incorporated in usage data.
Training and/or certification of users	L	Statistics may or may not be available.
Spray technology (e.g. nozzle types, pressures, adjuvants, air blast vs. recycling)	L	May be possible to estimate, predict or survey how often these methods are used. Unlikely to be included in standard use data.
Broadcast vs. strip treatments vs. spot treatments	D	Likely to be included in standard use data.
No-till, minimum and conventional tillage (may affect runoff and leaching)	L	Not likely to be included in use data. May be possible to estimate from other information e.g. data on previous crop in disease incidence surveys.
Misuse (wrong crop, overdosing, non-approved products)	L	May be picked up by use surveys, but likely to be underestimated.
Disposal of containers, tank washings, unused spray, unused formulation, inappropriate storage methods	L	Not included in use surveys. Might be possible to estimate or survey separately.

IV.6. Estimation of L

IV.6.1. Direct loading of surface water

The direct loading of surface water is caused by spraydrift. The percentage of the application rate contaminating the surface water body depends on:

- technical application conditions
- distance to the water body
- crop and crop stage.

The technical application conditions comprise the mode of application (seed treatment, granule application, incorporation into soil, foliar application, air application). For the '*protected' /indoor applications* the loss by direct loading of surface water is considered to be neglectible, that means *L is set to Zero*.

For foliar and aerial applications we propose to estimate L using published spraydrift tables. Such tables should cover the prevailing agricultural techniques ***in each country***. These values should be listed as percentage deposition as function of the distance to surface water body and the crop/crop stage treated (e.g. Ganzelmeier, 1997).

Table 5: Ganzelmeier - table of spraydrift (percent of the applied dose)

Distance (meter)	vine early stage	vine late stage	fruit trees early	fruit trees late	arable crops early	arable crops late	hops early	hops late
1	23.2	20	46.2	26.7	4	5	47.6	23.4
2	8	12	34.5	22.3	1.6	1.8	39.9	19.9
3	4.9	7.5	29.6	19.6	0.9	1.4	32.3	17.7
4	2.6	5.8	23.8	15.3	0.6	1.0	26.1	15.4
5	1.6	5.2	19.5	10.1	0.5	0.7	18	12.7
7.5	1	2.6	14.1	6.4	0.3	0.5	8.5	10.8
10	0.4	1.7	10.6	4.4	0.3	0.4	4.8	8.9
15	0.2	0.8	6.2	2.5	0.2	0.2	1.7	4.7
20	0.1	0.4	4.2	1.4	0.1	0.1	0.8	3.8
30	0.1	0.2	2.0	0.6	0.1	0.1	0.3	2.1
40	0.1	0.2*	0.4	0.6*	0.1*	0.1*	0.1	0.3
50	0.1	0.2*	0.2	0.6*	0.1*	0.1*	0.1	0.3

* no experimental data available

For the calculations that will be performed in Phase 2 of the project, the REXTOX subgroup recommends not to consider aerial spraying and to use the Ganzelmeier table. Countries can replace this in the final indicators by their own spraydrift tables or models.

IV.6.2. Indirect load

In the proposed ratio approach, direct loads and indirect loads are considered to be independent single events.

The main entry routes of the indirect loads are considered to be run-off events, drainage sub-surface flow and atmospheric deposition. Computerised simulation models for these entry-routes were reviewed by the Forum for the Coordination of Pesticide Fate Models and Their Use (FOCUS, Adriannse et al. 1997). For the time being, validated standard models are not

available. Since the existing ones seem to be too complex for the purpose of the risk indicator, the following *simplified formula for indirect loadings caused by run-off* is proposed for use in Phase 2[6]:

$$\mathbf{L\%_{runoff} = (Q / P) \bullet f \bullet exp(-3 \bullet ln2 / DT_{50\ soil}) \bullet 100 / (1+Kd)}$$

Where:

$L\%_{runoff}$	Percentage of application dose being available in run-off water as dissolved substance
Q	Run-off amount (mm) calculated according the model of Lutz & Maniak (1984, 1992)
P	Precipitation amount (mm)
$DT_{50\ soil}$	Half-life time of a.i. in soil
f	Correction factor, with $f = f_1 \bullet f_2 \bullet f_3$
f_1	Factor, that reflects the influence of field slope on L% (see figure 2):

if slope < 20%: $f_1 = 0.02153 \bullet slope + 0.001423 \bullet slope^2$

if slope ≥ 20%: $f_1 = 1$

(Modified formula of Beinat & Berg, 1996)

f_2	Factor, that reflects the influence of plant interception PI (%) on L% $f_2 = 1 - PI / 100$
f_3	Factor, that reflects the influence of a densely covered buffer zone on L% (see figure 3)

$f_3 = 0.83^{WBZ}$

with WBZ = Width of the buffer zone (metres); if the buffer zone is not densely covered with plants, in which case the width is set to zero.

Kd	$K_{OC} \bullet \%OC / 100$ with K_{OC} – Sorption coefficient of a.i. to organic carbon %OC – Organic carbon content of soil

In the formula it is assumed that 3 days after application a run-off event happens. For simplification the run-off volumes for 3 scenarios calculated by means the Lutz & Maniak model are given in Table 6.

[6] As with spraydrift tables, countries can replace this by their own models or default values. Phase 2 will also include an analysis of the extent to which the runoff component influences the indicator values.

Scenario I represents a bare soil with a high soil moisture, scenario II a bare soil with a low soil moisture and scenario III a covered soil with a low soil moisture, respectively. Within each scenario the run-off values for more sandy soils and for more loamy soils are calculated.

Figure 2: Slope depending factor f (slope) for the calculation of $L\%_{runoff}$

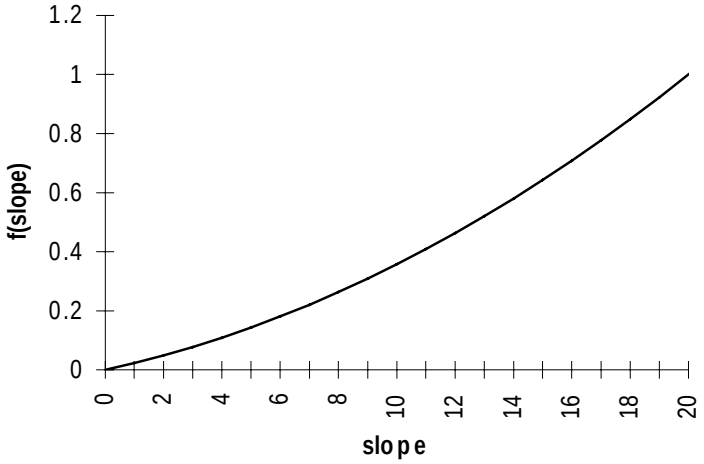


Figure 3: Correction factor for the influence of densely covered buffer zones

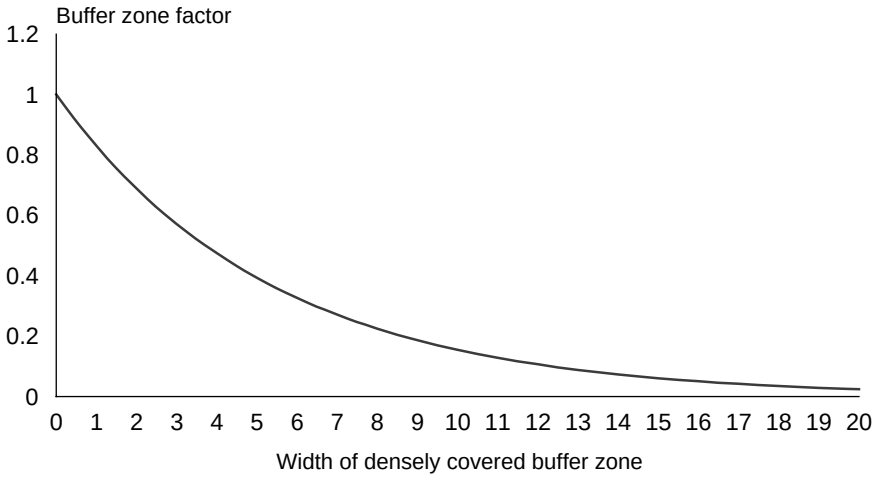


Table 6: Run-off volume according to the model of Lutz & Maniak

Precipitation (mm)	Run-off volume (mm)					
	Scenario I		Scenario II		Scenario III	
	sandy soil	loamy soil	sandy soil	loamy soil	sandy soil	loamy soil
6	0.10	0.45	0.04	0.19	0.02	0.13
8	0.28	0.82	0.12	0.35	0.07	0.24
10	0.54	1.29	0.23	0.56	0.13	0.38
12	0.88	1.86	0.38	0.81	0.21	0.55
14	1.29	2.51	0.56	1.11	0.32	0.76
16	1.78	3.24	0.78	1.45	0.44	0.99
18	2.32	4.05	1.03	1.83	0.59	1.26
20	2.92	4.93	1.31	2.25	0.75	1.55
22	3.58	5.88	1.63	2.72	0.94	1.88
24	4.29	6.88	1.98	3.22	1.14	2.23
26	5.04	7.95	2.35	3.76	1.36	2.61
28	5.84	9.06	2.76	4.34	1.59	3.02
30	6.69	10.23	3.19	4.95	1.85	3.45
32	7.57	11.45	3.65	5.59	2.12	3.91
34	8.48	12.70	4.13	6.27	2.40	4.39
36	9.44	14.00	4.65	6.99	2.71	4.90
38	10.42	15.34	5.18	7.73	3.03	5.44
40	11.43	16.71	5.75	8.51	3.36	6.00
42	12.47	18.11	6.33	9.31	3.71	6.58
44	13.53	19.54	6.94	10.14	4.08	7.18
46	14.62	21.01	7.57	11.01	4.46	7.81
48	15.73	22.50	8.22	11.90	4.85	8.46
50	16.87	24.01	8.90	12.81	5.26	9.13
55	19.78	27.89	10.67	15.22	6.34	10.89
60	22.79	31.90	12.57	17.78	7.50	12.79
65	25.89	36.01	14.57	20.48	8.74	14.80
70	29.06	40.20	16.68	23.31	10.06	16.92
75	32.29	44.47	18.89	26.26	11.44	19.15
80	35.57	48.80	21.19	29.33	12.89	21.48
85	38.90	53.18	23.58	32.51	14.40	23.91
90	42.26	57.60	26.04	35.79	15.97	26.44
95	45.65	62.06	28.58	39.16	17.60	29.04
100	49.07	66.55	31.18	42.61	19.29	31.74

To demonstrate the effects of intrinsic attributes of the substances, two ***examples*** are shown in Tables 7 and 8, respectively. The active ingredients isoproturon and bifenox are considered in the example. The following physico-chemical parameters are used:

Isoproturone: $DT_{50\ soil}$ = 29d, log K_{ow} = 2.48, %OC = 1.3%, estimated Kd = 3.089

Bifenox: $DT_{50\ soil}$ = 7d, log K_{ow} = 4.48, %OC = 1.3%, estimated Kd = 349.8.

For estimation of K_{oc} the formula log K_{oc} =1.029 log K_{ow} – 0.18 (Bonazountas & Wagner, 1984) was chosen. A pre emergence application (plant interception PI=0) and no densely covered buffer zone (WBZ=0) are assumed.

The examples show that in the worst case, 7.37% of the applied dose of isoproturon is lost by a heavy rainfall of 50mm and a field slope of 15% whereas in case of bifenox *de facto* no loss is calculated by the formula. (The results concerning the realistic worst case assumptions proposed below are marked in bold print.)

Table 7: % loss of isoproturon caused by run-off events

Precipitation (mm)	Slope (%)	Scenario I		Scenario II	
		Sandy soil	Loamy soil	Sandy soil	Loamy soil
10	5	0.18	0.44	0	0.20
	15	0.83	1.98	0.35	0.86
30	**5**	0.76	**1.16**	0.36	0.53
	15	3.42	5.23	1.63	2.53
50	5	1.15	1.64	0.61	0.87
	15	5.18	7.37	2.73	3.93

Table 8: % loss of bifenox caused by run-off events

Precipitation (mm)	Slope (%)	Scenario I		Scenario II	
		Sandy soil	Loamy soil	Sandy soil	Loamy soil
10	5	0	0	0	0
	15	0.01	0.02	0	0.01
30	**5**	0.01	**0.01**	0	0
	15	0.03	0.05	0.01	0.02
50	5	0.01	0.01	0	0.01
	15	0.05	0.06	0.02	0.03

For the calculations in the REXTOX indicator in Phase 2 we recommend the following assumptions for a realistic worst case:

- ***Herbicides: scenario I, loamy soil, PI = 0***
- ***Insecticides and fungicides: scenario III, loamy soil, PI = 70%***
- ***Slope: 5% for arable crops, fruit trees and hops***
  10% for vineyards
- ***Precipitation of the run-off event: 30 mm***
- ***No densely covered buffer zone (WBZ = 0)***

V. SCORING METHOD

V.1. General approach

The scoring method converts input data values to scores for each of the two components of risk, hazard and exposure. Scores for individual variables are combined either by addition in the additive scoring indicator (ADSCOR), or by synergistic linkage in order of logical precedence in the synergistic scoring indicator (SYSCOR). The composite scores are then combined by various methods to give an overall risk score.

Variations on the scoring approach are discussed below under the headings of 'Synergistic Scoring Methods' and 'Additive Scoring Methods'.

V.2. Additive Scoring Methods

V.2.1 Acute risk scenario

The first variation of an additive scoring method considered is roughly comparable to the 'acute local risk scenario' discussed in the previous chapter. It considers only acute hazard variables, and only exposure factors relevant to an assessment of acute risk.

V.2.1.1 Scoring acute hazard values

The following would be a complete set of **acute hazard** data for the additive scoring method:

- EC_{50} for algae
- acute EC_{50} or LC_{50} for fish
- acute EC_{50} or LC_{50} for *Daphnia*

All these data are expected to be available from registration files. When multiple studies are available for any of these types of data, a single representative value needs to be chosen for each taxon for use in the scoring method. This may be done by choosing the lowest numerical result (i.e., the most sensitive.study, as will be done in Phase 2) or within a single taxon, by taking the geometric mean of all directly comparable study results, or by any other method chosen by a country.

A country could choose to use as many of these measures as they like - so long as they either have or can estimate values for whichever measures they choose for all a.i.'s. The total acute hazard score for an active ingredient would be the sum of scores for all included measures - not more than 15 points in the scheme laid out below in Table 9a. The break points provided here are preliminary, and intended for Phase 2 testing. They may be adjusted later in this project, and could be adjusted by any country choosing this method of hazard scoring.

Table 9a: Acute Hazard Scores

Acute hazard measure	Values	Interpretation	Score
Toxicity to algae: 96- or 120-hr or 7-day EC_{50} (mg/l)	> 100	practically non-toxic	1
	> 10 - 100	slightly toxic	2
	> 1 - 10	moderately toxic	3
	0.1 - 1	highly toxic	4
	<0.1	very highly toxic	5
Acute toxicity to fish: representative 96-hr LC_{50} (mg/l)	> 100	practically non-toxic	1
	> 10 - 100	slightly toxic	2
	> 1 - 10	moderately toxic	3
	0.1 - 1	highly toxic	4
	<0.1	very highly toxic	5
Acute toxicity to *Daphnia*: 24-, 48-, or 96-hr LC_{50} (mg/l)	> 100	practically non-toxic	1
	> 10- 100	slightly toxic	2
	> 1 - 10	moderately toxic	3
	0.1 - 1	highly toxic	4
	<0.1	very highly toxic	5
		Total score for acute hazard	3-15

Two ways to present acute hazard will be tested in Phase 2. The first is by simple addition of component scores, as shown in the table above. The scores from each available acute hazard measure are added to arrive at a total score for acute hazard. Since the range of possible scores for each of the three acute hazard measures is from 1 to 5, assuming all three arc present, the range of possible total scores for acute hazard is from 3 to 15.

The second method of presenting acute hazard scores will use a ***continuous scale*** - i.e. the real, unscored test results expressed in mg/l. Two variations within this method will be considered: first, constructing the acute hazard scale using the most sensitive acute toxicity value (LC_{50} or EC_{50}) among all taxa available, and second, considering the acute toxicity scores for each taxon (algae, *Daphnia*, fish) separately in the calculation of three separate indices. In this second variation the separate taxon-specific indices can then be evaluated simultaneously by the user to arrive at a sense of overall risk.

In Phase 2, missing acute hazard data could be filled in by assigning the average value for all a.i's in the same pesticide class (herbicides, insecticides, fungicides), or the average value for all pesticides in the same chemical class (triazines, pyrethroids, etc.), or the middle scoring value within the function being scored. Alternative approaches will be tested in Phase 2.

V.2.1.2 Scoring acute exposure attributes

The span of time relevant to an estimate of acute exposure is too short for the physico-chemical properties and environmental fate parameters of a pesticide to come into play. Therefore a complete set of exposure-related data relevant to an acute risk scenario would be limited to the following - all specific to each a.i., crop, region, and method of application:

a) Use-specific factors:

- dosage (application rate for each treatment)
- number of treatments per season for treated area
- method of application
- observance of buffer zones
- approximate ratio of adjacent surface water shoreline to total treated field perimeter

b) Scale of use:

- area treated

If survey data on actual usage and use practices are not available, they may be estimated from other sources. If total national sales data are available, the crop area treated can be estimated using the technique of Gutsche and Rossberg (see Attachment 1). In the absence of survey data on actual application rates, frequency of treatment, method of application, and observance of buffer zones, these can be estimated from registration or label information, at the national level if not on a regional basis. The approximate ratio of surface water volume to crop area treated can be estimated crudely for purposes of the scoring indicator from available land use data, or this factor can be omitted from the calculation. If appropriate survey data are not available by region, the indicator can only be used at the national level.

An acute exposure score is developed for each unique combination of a.i., crop, region, and method of application, assigning scores as shown in Table 10 below, and then multiplying the sum of scores from Table 10 by a score reflecting the scale of the use, as shown in Table 11.

Table 10: Scores for use conditions

Application/Use Properties	Values	Interpretation	Score
Application rate (kg/ha) *[This may need to rescaled for herbicides, insecticides, fungicides, and other classes of pesticide]*	<1	low	0
	1-3	moderate	1
	>3	high	2
Number of treatments per season for treated area	<1.1	low	0
	1.1-3.0	moderate	1
	>3.0	high	2
Method of application	traps, pheromones, seed treatments		0
	injected, in-furrow, soil-incorporated		1
	unincorporated broadcast granular		2
	unincorporated broadcast spray		3
	air blast or aerial application		4
Other mitigating or exacerbating factors	buffer zones observed, and/or use restricted to specially trained or certified applicators		-1
	high ratio of surface water shoreline to treated area perimeter		+1
		Total exposure score for use conditions:	-1 - +9

There are two possible ways to handle the ***scale*** factor. Scale can be scored on a small/medium/large basis (or with more than three steps, one of which could be zero). Alternatively, the actual treated area could be used as a continuous variable. Each method has its advantages and disadvantages.

The main advantage of a scored scale factor is that it can be used even when the precise area treated is unknown, so long as its rough magnitude can be estimated. The main disadvantage of a scored scale factor is that the breakpoints between small, medium, and large scale must be redefined to suit the circumstances and agricultural practices in each country, and whenever the area of analysis changes. That is, if aggregation is national, the breakpoints defining small, moderate, and large areas must reflect the patterns of agricultural land use in that nation as a whole; if aggregation is regional the breakpoints must be redefined on the basis of regional patterns of agricultural land use.

The awkward requirement to redefine breakpoints for each regional analysis can be avoided by incorporating the scale factor directly, as an unscored continuous variable. Under this approach the use conditions score for each use would be multiplied by the actual area treated in hectares. This would yield a much more precise distinction among differing scales, but it would also require estimating point values for missing data - for which there is likely, to be little basis.

Because the scale term is used as a multiplier it strongly influences the exposure score. A country choosing to score the scale factor might wish to define more than three levels of scale, to reduce 'notchiness'. For example, so that approved uses with no usage don't artificially inflate the indicator, a score of zero could be added, corresponding to zero usage. In addition, more levels of scored scale would allow somewhat more subtle distinctions between, say, very small/small/moderate/moderately large/large scales.

For at least the initial round of testing in Phase 2, scale will be scored at three levels, with no zero, as shown in Table 11. An unscored scale factor will be tested later, if Phase 2 resources permit.

Table 11: Scoring scale of use

Scale of Use	Values	Interpretation	Score
Area treated one or more times per season (ha)	Must be redefined for each region analysed	Small scale (could be all of a minor crop, or a small area of a major crop)	1
		Moderate scale	2
		Large scale	3

V.2.1.3 Calculating acute exposure scores

The following formula is applied to derive the acute exposure score for each unique combination of a.i./crop/region/method of application:

Acute Exposure = 1+ (use conditions score) * scale factor.

The theoretically possible values of the use conditions score range from -1 to +9, but in fact the score will not go below zero, since that would require a trap, pheromone, or seed treatment use with a buffer zone - a combination that simply doesn't exist. A use conditions score of zero is, however, possible, so the addition of 1 to the score ensures a non-zero product when the scale multiplier is applied. After scaling, the range of permissible values for the use-specific acute exposure score is from 1 to 27.

This formula without the scale factor could be used to approximate the exposure associated with a hypothetical standard field for comparison with similarly developed scores for other specific pesticide regimens. The scale factor can then be applied to arrive at a regional or national composite exposure scores.

V.2.2 Long-term risk scenario

A similar process is used to calculate long-term hazard and long-term exposure scores for each unique a.i., crop, region, and method of application.

V.2.2.1 Scoring long-term hazard variables:

In addition to the studies cited in the discussion of acute risk above, the following additional studies are needed for this scenario:

- long-term NOEC for fish
- long-term NOEC for *Daphnia*

All these data are expected to be available from registration files. When multiple studies are available for any of these types of data, a single representative value needs to be chosen for each taxon for use in the scoring method. This may be done by choosing the lowest numerical result (i.e., the most sensitive study, as will be done in Phase 2) or within a single taxon, by taking the geometric mean of all directly comparable study results.

The total long-term hazard score for an active ingredient would be the sum of scores for both measures - from 2 to 10 points in the scheme laid out below in Table 9b. The breakpoints provided here are preliminary, and intended for Phase 2 testing. They may be adjusted later in this project, and could be adjusted by any country choosing this method of hazard scoring. So long as breakpoints are consistent for all direct comparisons made across time, it will not matter precisely where they are set.

Table 9b: Scoring Long-term Hazard

Long-term hazard measure	Values	Interpretation	Score
Long-term toxicity to fish: 21-day NOEC (mg/1)	> 10	practically non-toxic	1
	> 1 – 10	slightly toxic	2
	> 0.1 – 1	moderately toxic	3
	0.01-0.1	highly toxic	4
	<0.01	very highly toxic	5
Long-term toxicity to *Daphnia*:: 21-day NOEC (mg/1)	> 10	practically non-toxic	1
	> 1 – 10	slightly toxic	2
	> 0.1 – 1	moderately toxic	3
	0.01-0.1	highly toxic	4
	<0.01	very highly toxic	5
		Total score for long-term hazard	2-10

Long-term hazard scores, like acute hazard scores, could be presented either as simple sums of component scores or as continuous ‘true’ values. For the sake of simplicity, and because the use of continuous scores will be adequately tested for acute hazard, only the addition method will be used for long-term hazard scores in Phase 2.

In Phase 2, missing long-term hazard data will be filled in by whichever of the three methods discussed above is settled on for filling gaps in the acute hazard database.

V.2.2.2 Scoring long-term exposure attributes

In addition to the use-specific exposure-related data required for the acute scenario, a complete set of exposure-related data relevant to a long-term risk scenario would include the following additional data on the fate and degradation of each active ingredient. All are expected to be available from registration files:

- solubility of the active ingredient in water (mg/l)
- octanol/water partition coefficient (K_{ow})
- soil persistence (DT_{50}, months)
- study of hydrolysis and biodegradation in water (DT_{50}, months)
- study of photolysis in water (DT_{50} days)

Bioaccumulation potential is considered in the scoring system only indirectly, in that both K_{ow} and DT_{50} are included as active ingredient properties.

Table 12: Scoring Long-term Exposure: AI Fate and Degradation

Active Ingredient Properties	Values	Interpretation	Score
Solubility in water (mg/l)	< 1	very low solubility	0
	<1-100	low to moderate solubility	1
	> 100	high solubility	2
Octanob/water partition coefficient (K_{ow})	< 100	bioconcentration is unlikely	0
	100 - 1000	trigger for further studies	1
	> 1000	concern for potential bioaccumulation	2
Persistence in soil (DT_{50} in months)	< 1 .5	non- or slightly persistent	0
	1.5-6	moderately persistent	1
	> 6	persistent	2
Biotransformation in water or water/sediment (DT_{50} in months; Incorporates hydrolysis)	< 1.5	non- or slightly persistent	0
	1.5 - 6	moderately persistent	1
	> 6	persistent	2
Rate of photolysis in water (DT_{50} in days)	≤ 5	photolabile	0
	> 5	non –or slightly photolabile	1
		Long-term exposure score for ai fate and degredation	0-9

The use-specific data required for development of the long-term exposure score is the same as for the acute scenario, and the same comments about compensating for missing data apply here.

A long term exposure score is developed for each unique combination of a.i./crop/region/method of application, reflecting the sum of scores assigned on the basis of use conditions, as shown in Table 10, and active ingredient properties, as shown in Table 12, all multiplied by a score reflecting the scale of the use, as shown in Table 11.

V.2.2.3 Calculating long-term exposure scores

The following formula is applied to derive the long-term exposure score (LTE) for each unique combination of a.i./crop/region/method of application:

LTE = 1+ [(use conditions score) + (AI fate & degradation score)] * scale factor.

This formula differs from the acute exposure formula only in the addition of the AI fate and degradation score, which can range from zero to 9. The range of possible values for the use-specific long term exposure score is from 1 to 54.

V.2.3 Overall Risk Scenario

Use of the additive scoring indicator to encompass both acute and long-term risk scenarios would require summing the three acute hazard scores from Table 9a and the two long-term hazard scores from Table 9b to obtain an overall hazard score, ranging from 5 to 25, which could then be combined with the long-term exposure score by either multiplication or graphically, as discussed at V.4.

V.2.4 Aggregation

The only hierarchy in the structure of this indicator arises from the process of aggregating composite acute exposure scores. No intermediate values directly comparable to the 'specific acute risk potential' or 'specific acute risk probability' in the REXTOX indicator are derivable, since the indicator is built from the beginning on the best available information on actual application rates and areas treated. As noted earlier, however, ***it is possible to use the formulas without the scale factor*** to compare hypothetical standard fields under different sets of assumptions.

Exposure scores - either acute or long-term - can be aggregated for all methods of application of a particular a.i. to a particular crop, for all regions, or for all crop uses of a particular ai by adding the appropriate use- and region-specific scores. To derive, for example, a composite acute exposure score for all uses of a particular pesticide used nationally, then all the use-specific and region-specific acute exposure scores for that pesticide would be summed. These composite exposure scores for each ingredient must then be related to the hazard scores for the same ai by either of the two methods described in section V.4 below.

If an ingredient is approved for many uses, and is in fact used widely, its composite exposure score may take on a very high absolute value. It is important to remember that this absolute value has no units and is not important except as it may be higher or lower than the score for another pesticide. Thus in the course of any analysis using this indicator, composite exposure scores may be rescaled for convenience. So long as all ingredients are treated consistently, no distortion will thereby be introduced.

In addition to the example above of a national aggregate for all pesticides, scores for individual pesticides, crops, regions, and method of application can be aggregated in many other ways, for example:

- The composite exposure scores for all uses of a particular active ingredient can be aggregated either before or after integration with the hazard composite scores.

- The combined exposure and toxicity scores for all active ingredients used on a particular crop can be aggregated.

- The combined exposure and toxicity scores for either or both active ingredients or uses can be aggregated for a region.

- Regional aggregates can be combined to form national aggregates.

V.3. Synergistic Scoring (SYSCOR) approach

This approach is derived from the SIRIS scheme ('System of Integration of Risk with Interaction of Scores') developed by Vaillant et al. (1995) to produce ranked scores. Briefly, the method involves three steps, which are conducted separately for toxicity and exposure:

- inventory of the decision criteria (i.e. input variables) and coding of their modalities (i.e. conversion into scores, typically with 2 or 3 categories per variable).
- classification of the variables according to their importance (i.e. ranking the variables according to their perceived contribution to exposure or toxicity; variables may be given the same rank if they are of similar importance unless they are considered to interact - see below for example)
- graduation of the scales (i.e. assigning values to all the possible combinations of the variables, based on their rank and any interactions between them).

In order to be consistent with the REXTOX and ADSCOR indicators, separate indicators are needed for acute and chronic risk. Also for consistency, the SYSCOR indicator will be computed both with and without a scale factor which, as in the additive approach, is the area of crop treated.

V.3.1. Toxicity

Inventory and scoring of variables

The group decided to use 5 toxicity variables for the SYSCOR approach. Toxicity values (LC_{50}; EC_{50}) for algae, *Daphnia* and fish were scored as follows:

Score	EC_{50}/LC_{50}
0	≥ 10 mg/l
1	= l to 10mg/l
2	≤ 1mg/l

Long-term fish and *Daphnia* toxicity were scored as

Score	NOEC
0	≥ 1 mg/1
1	= 0.l to l mg/l
2	≤ 0.l mg/l

These breakpoints will be reviewed once the distribution of toxicity values in the test dataset is known. For the long-term values where multiple endpoints exist, the value for the most sensitive endpoint is used.

Classification of variables

Alternative ranking orders will be considered in Phase 2 to explore the sensitivity of this method to alternate weightings. These are:

1. acute fish>acute *Daphnia*> algae *versus* algae>acute *Daphnia*>acute fish
2. long-term fish>long-term *Daphnia versus* long-term *Daphnia*> long-term fish.

Graduation of the scales

The details of how to apply values ('penalties') to the variable scores will be investigated in the early stages of Phase 2. Initially, the 'minimax' scale (Vaillant, 1995) will be calculated, in which each penalty increment is set equal to one.

V.3.2. Exposure

Inventory and scoring of variables

The group identified 11 variables for inclusion in the exposure score. One of these (area of crop treated) will be used as a scale factor (see below). The other 10 variables (listed in Table 13, below) are combined using the method of Vaillant et al. The number and definition of the categories for each variable is similar to those used for the Additive Scoring Approach (see section V.2).

Classification of variables

Application methods were ranked highest because they were seen as being of primary importance in determining the extent to which a pesticide reaches water. This variable included allowance for the mitigative effects of buffer zones: note that this implies some assumptions about the extent to which farmers comply with buffer zones and their effectiveness in reducing exposure. Solubility, K_d and soil DT_{50} were given lowest priority, as might be appropriate in a country or region where runoff is rare: in other situations a higher priority would be appropriate for these variables. Photolysis and water DT_{50} were seen as important once a pesticide enters water, but not as important as the higher ranked variables which influence whether the pesticide enters water in the first place. The ordering of the intermediate variables (ranks 4 - 6) was assigned rather arbitrarily.

SYSCOR allows for the representation of both additive and non-additive ('interactive') relations between variables. In order to represent interactions, the variables concerned must be placed in separate ranks or classes (Vaillant et al., 1995). This was thought to apply to application rate, method and water index. For example, the amount of pesticide reaching an adjacent water body by spray drift increases with increasing application rate, but if an effective buffer zone is in operation then the rate of increase is lower. Similarly, the adverse effect of an unusually high water index is less if buffer zones are in force than otherwise, or for seed treatments. Also, the importance of degradation in water (photolysis and DT_{50}) increases, the higher the proportion of the pesticide which reaches water.

The full set of variables and ranks will be used for the SYSCOR index of *long-term* exposure. For *acute* exposure, the DT50 in water and photolysis will be excluded, as these determine persistence in water and hence are primarily relevant to long-term exposure. The variables ranked 7 are retained in the acute model because of their relevance to run-off events.

The EG was concerned that the SIRIS method would give too much weight to the top-ranked variables. To test the sensitivity of the SYSCOR indicator to the ordering of variables it was proposed that in Phase 2, two rankings should be investigated:

- that shown in Table 13
- as in Table 13, but placing the variables ranked 6 and 7 above those ranked 4 and 5.

Graduation of the scales

The details of how to apply values ('penalties') to the variable scores and represent the various interactions will be investigated in the early stages of Phase 2. Initially, the 'minimax' scale will be calculated, as for the hazard scores.

Table 13: Ranking and scoring of exposure variables using SIRIS approach. For each variable, higher categories represent increased potential for exposure.

Variable rank	Variable	Categories
1	Application method	0 = seed treatment; other methods with very low exposure potential 1 = applications with buffer zones to protect aquatic habitats; injected, in-furrow, soil-incorporated applications 2 = granular without buffer zone 3 = unincorporated broadcast spray 4 = air blast spray; aerial application 5 = applications to crops grown in water (e.g. rice, watercress).
2	Water index (volume of water per unit area of crop)	1 = region or country with unusually high water index (see Additive Scoring Approach, above). 0 = otherwise.
3	Application rate	0 ≤100 g/ha 1 = 100 to 500 g/ha 2 ≥ 500 g/ha.
4	Trained users	0 = Use restricted to personnel with special certification or training 1 = Other users (e.g., the 'normal' farmer)
5	Average frequency of treatment of treated area	0 ≤ 1.1 1 = 1.1 to 3.0 2 ≥ 3.0
6	DT_{50} in water	0 ≤ 1.5 months 1 = 1.5 to 6 months 2 ≥ 6 months
6	Photolysis	0 ≤ 5 days 1 ≥ 5 days
7	Water solubility	0 ≤ 1 mg/l 1 = 1- 100 mg/l 2 ≥ 100 mg/l
7	log K_d (desorption constant)	0 ≥ 4 1 = 1 to 4 2 ≤ 1
7	DT_{50} in soil	0 ≤ 1.5 months 1 = 1.5 to 6 months 2 ≥ 6 months

Use of area treated as a scale factor

The response from the RRSG to the draft of this report indicated support for the distinction made in the ratio approach between the 'risk probability' (e.g. SARprob) and the 'risk extent' which takes account of the regional extent of risk (e.g. ARE). A similar distinction will be made in the SYSCOR indicator by computing versions with and without the use of a scale factor. It is proposed to use 'area of crop treated' as the scale factor, for consistency with the ADSCOR indicator. Computations will therefore proceed in two stages. For long-term exposure, the SIRIS method will be applied to all the variables in Table 13 to produce an unscaled long-term exposure index. This will then be multiplied by area of crop treated, to produce the scaled long-term exposure index. Similarly, the reduced set of variables from Table 13 will be used to produce an unscaled acute exposure index, which will then be multiplied by area of crop treated to give the scaled acute exposure index.

The scale factor (area of crop treated) could either be used as a continuous variable in its original units (hectares) or converted to a score. Both options will be considered in Phase 2. For the scored version, the categories will be defined using the same breakpoints as are used for this variable in the ADSCOR indicator.

Aggregation

The options listed earlier for aggregating the ADSCOR indicator over method of application/pesticide/crop/region also apply to the SYSCOR indicator. If the scores are aggregated by summing, then the use of 'area of crop treated' as a scale factor will in effect weight the contribution of each pesticide according to the area on which it is used. If the unscaled index is aggregated then each pesticide will have equal weight in the final index, regardless of the area on which it is used. The various options for aggregation will be explored in Phase 2.

Sensitivity to policy measures

The exposure scores for SYSCOR will be responsive to changes in application rate and various aspects of application method, i.e. the use of buffer zones, formulation (seed treatments) and application techniques, restriction to trained users, and restriction of repeated applications.

V.4. Combining scores for toxicity and exposure

For ***scoring methods in general***, the group identified three major options for combining scores for toxicity and exposure:

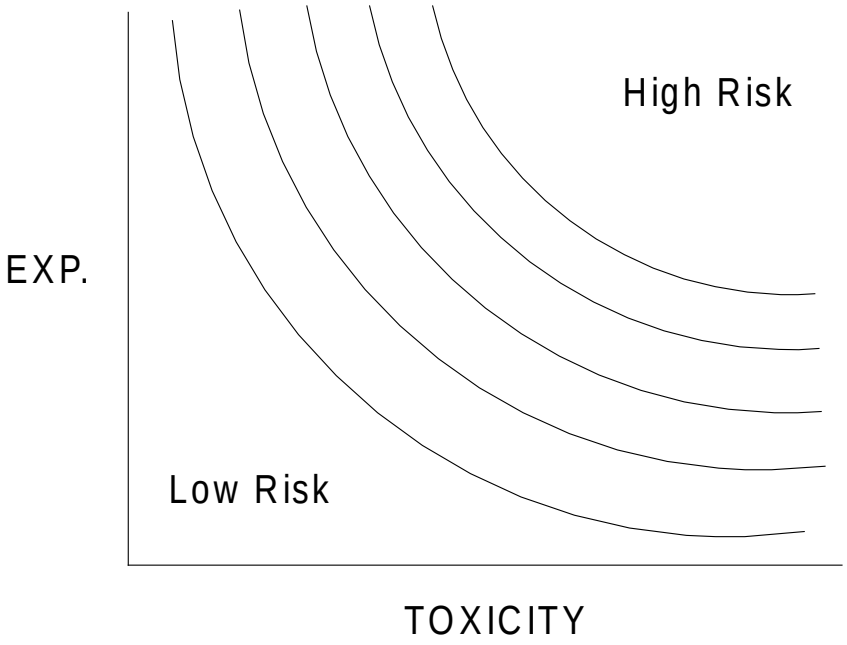
- addition
- multiplication
- graphical methods.

Vaillant et al. (1995) advocate the use of a graph plotting toxicity and exposure, such that points nearer the origin represent chemicals of lower risk and those further away (exposure and toxicity both high) represent high risk chemicals. In general, if either exposure or toxicity are low then risk will be low. When the axes represent quantitative estimates of exposure and toxicity in the same units this relationship is best represented by a multiplicative combination of toxicity and exposure (equivalent to a toxicity-exposure ratio). This is equivalent to a graphical representation with contours joining points of equal risk in the manner shown in Figure 4.

For the scoring approaches the precise relationship of the axes in Figure 4 to actual toxicity and exposure is unknown. Consequently, the precise shape and position of the contours is also unknown. This is the reason why Vaillant et al. (1995) prefer not to combine exposure and toxicity mathematically. Instead they interpret risk from the scatter of points on the graph. This can include identifying high and low risk areas of the graph, based on the positions of points for particular chemicals for which risk is well understood.

If the methods used for scoring are reasonably successful in identifying and combining the variables which determine toxicity and exposure, the general shape of the relationship between them is likely to be close to multiplicative. In this case the product of exposure and toxicity scores could be used as an index of risk, provided it is remembered that small changes in the index may be unreliable (i.e. a small increase in the index might occur when the actual risk had decreased by a small amount). The group therefore decided that Phase 2 should initially explore both the multiplicative and graphical options for combining exposure and toxicity, and assess their relative reliability and suitability as risk indicators. This will be done for both the SYSCOR and ADSCOR indicators.

Figure 4: **Derivation of risk index by multiplication of toxicity and exposure**. The contour lines join points for which risk is equal if the relationship between toxicity and exposure is assumed to be multiplicative. Pesticides which present a high risk (toxicity and exposure both high) fall in the top right of the graph, while those of low risk (toxicity and/or exposure low) fall towards the bottom and the left of the graph.



Interpretation

It is important to remember that the outputs of the scoring approaches will not bear any direct relationship to actual risk or impacts. This is because, although knowledge of the mechanisms of exposure and toxicity have been used in constructing the scoring approaches, they do not attempt to model the mechanisms as such.

Instead, the scores produced by these methods should be regarded as approximate indices of risk: substantial increases indicate higher levels of risk, but the relationship between the magnitude of the indicator change and the magnitude of the change in actual risk is unknown. So for example, a 50% decrease in the indicator does not necessarily indicate a 50% decrease in risk: trends over time can show whether risk is changing in a favourable direction but not by how much. As noted earlier, a small change in the index may be misleading if toxicity and exposure scores are multiplied together, so interpretation should focus on larger changes.

These uncertainties about the relation between the indicators and actual risk also imply that there is no point in setting targets for indicator reductions when using scoring approaches, since the significance of achieving the target is unknown.

References

Adriannse,P., Allen,R., Gouy,V., Hosang,J., Jarvis,T., Klein,M., Layton,R., Linders,J., Schäfer,L., Smeets,L., Yon,D.: Surface Water Models and EU Regristration of Plant Protection Products. Dok. 6476/VI/96, 24.2.97

Beinat, E., van den Berg, R., 1996: EUPHIDS, a decision support system for admission of pesticides. Report no. 712405002, National Institute of Public Health and the Environment, Bilthoven, The Netherlands

Bonazountas, M., Wagner, J., 1984. SESOIL: A Seasonal Soil Compartment Model. Designed for the U.S. Environmenta Protection Agency, Washington D.C., Arthur D. Little, Inc., Cambridge, Mass., p. AD-10

Ganzelmeier, H., 1997: Abtrift und Bodenbelastung beim Ausbringen von Pflanzenschutzmitteln. Mitt. Biol. Bundesanstalt Land- u. Forstwirtschaft, Berlin-Dahlem, H.328, S. 115-124

Gutsche, V., Rossberg, D., 1996. SYNOPS 1.1 – a model to assess and to compare the environmental risk potential of active ingredients in plant protection products. Agriculture, Ecosystems & Environment 64(1997) 181-188

Gutsche, V., Rossberg,; 1997: Die Anwendung des Modells SYNOPS1.2 zur synoptischen Bewertung des Risikopotentials von Pflanzenschutzmittelwirkstoffgruppen für den Naturhaushalt. Nachrichtenbl. Deut. Pflanzenschutzd., 49 (11), S. 273-285

Lutz, W. 1984: Berechnung von Hochwasserabflüssen unter Anwendung von Gebietskenngrößen. Mittlg. Inst. Hydrologie Wasserwirtschaft, Univ. Karlsruhe, Heft 24

Maniak, U. 1992: Regionalisierung von Parametern für Hochwasserabflußganglinien. In: Regionalisierung der Hydrologie (H.B. Kleeberg), DFG, Mittlg. Senatskomm. für Wasserf. 11, S. 325-332

Attachment 1: Estimating use data from sales

A proposal for estimating the quantity of pesticide active ingredients applied by crop based on national sales data

Volkmar Gutsche and Dietmar Rossberg, Federal Biological Research Centre for Agriculture and Forestry (BBA), Institute for Technology Assessment in Plant Protection, Germany

Often the only quantitative information available on the actual use of pesticides is national-level data on the quantity of each pesticide sold. The method described below can be used to estimate the proportion of the total volume of each active ingredient applied to each crop or group of crops.

1. Method

Input data

The method uses the following input data:

- A list of all approved pesticide active ingredients including their authorized application sites, use patterns, and conditions. In Germany this would be the ”Register of Authorized Plant Protection Products” edited by the BBA
- National-level data on annual volume sold for each active ingredient,
- National-level data showing the area under cultivation for each major crop, and
- Data on the probability of infestation that requires a treatment of each major pest (optional).

Step 1: Classification of application sites

The approach to classification will depend on the purpose of the analysis and on the structure of agriculture in the country being studied. The purpose will determine the appropriate level of detail in classification of crops–i.e., the number of classes; conditions in each country will determine what groupings of crops are appropriate. A first, rough classification in Germany might distinguish field crops, grasslands, vegetables, fruits, vines, and hops. At the next finer level the field crops might be subdivided into cereal grains, root crops, oil seeds, feed and forage crops, etc.. Table 14 (at the end of this attachment) provides an example of such a classification, and shows in the last column the scheme used by the German model SYNOPS.

Step 2: Determination of use patterns for each active ingredient

Approved use patterns are defined by the terms of registration of each pesticide. For simplicity, the method assumes application to each crop at the maximum permissible rate, with the maximum permissible number of applications per season. If they are available, historical data on the likelihood of pest infestation can be used to refine the estimate of theoretical maximum volume applied to each crop resulting from these assumptions. Examples based on the application patterns of *fenpropimorph* and of *mecoprop-P* are shown in Table 15.

Step 3: Estimating the quantity of each active ingredient applied to each crop

We define:

SQ	quantity of the active ingredient sold per year
A_i	maximum treated area (Aj * m)
R_i	maximum permissible dose rate of the active ingredient of application i [g/ha]
P_i	probability of application i ($0 \leq P_i \leq 1$) (independent of compound) *(Remark: If the same pest requires repeated applications then the sum of the concerning probabilities is equal to the frequency of the treatment)*
n	maximum number of permissible applications of the active ingredient to all crops
m	maximum number of permissible applications of the active ingredient to crop ($m \leq n$)

First, we calculate the quantity of the active ingredient theoretically necessary for all permissible applications to each crop. We name this quantity Q_{crop} and obtain

$$Q_{crop} = \sum_{i=1}^{m} (Ai * Ri * Pi)$$

Second, we calculate the quantity of the active ingredient theoretically necessary for all permissible applications to all crops. We name this quantity Q_{all} and obtain

$$Q_{all} = \sum_{i=1}^{n} (Ai * Ri * Pi)$$

Incomplete knowledge of application probability can be addressed by assigning the same probability (= 1) to all applications, or alternatively assigning a probability of 1 only to those uses with unknown probabilities. Either way some precision would be lost in the calculation.

Third, we calculate for each crop the proportion of the crop-specific theoretical maximum quantity of use to the total theoretical maximum quantity of use, assuming that the ingredient for all applications is used with the same preference by the farmer:

$$S_{crop} = Q_{crop} / Q_{all}$$

Finally, we apply this ratio to the total volume of the ingredient sold to estimate the quantity of the ingredient Q_{use} used on each crop:

$$Q_{use} = S_{crop} * SQ.$$

Table 16 provides some examples of these calculations.

2. Discussion

The proposed method can be used to estimate the quantity of a particular active ingredient applied to a particular crop (or crop class). By applying it to all active ingredients approved for any particular crop, it can also be used to estimate quantities of all approved pesticides applied to any single crop. The method can also be applied selectively to estimate quantities of only high-volume active ingredients used on only the most important crops. So a ranking of the most sold chemicals will be possible.

The method has some ***limitations***:

a) The quantity of an active ingredient sold per year is only a rough approximation of the quantity applied. Differences can arise because pesticides can be stored, may be imported or exported by farmers, or can be used for applications not considered in the model (e.g. forestry, stored food and feed treatments, seed treatments, or non-agricultural uses.)
The probability of application of any particular active ingredient to any particular crop depends strictly on the levels of pest infestation in a particular year, which depends in turn mainly on weather conditions. This probability could differ markedly from one year to the next.
b) The assumption, that the ingredients for all applications are used with the same preference, is arbitrarily and may not be in agreement with the practical reality.
c) The model may exaggerate actual use rates by assuming treatments are always at maximum dose and with maximum numbers of repeat applications. German farmers, for example, often apply pesticides effectively at less than the maximum authorized rate. But since these assumptions are used to estimate a proportional share of the total for each crop, the distortion they introduce should be distributed evenly across all crops for each pesticide.

All these limitations could, in principle, be addressed by considering additional data. But since this method requires so little input data, in spite of its limitations we think it is useful when little data is available.

A ***check of the plausibility*** of the estimates can be made by calculating the treated area of a certain crop against a certain pest in two different ways and comparing the calculated values:

First way: We calculate the area of a crop potentially treated for a specific pest based on :
A(crop) - cultivated area of the crop, and
P(crop,pest) - application probability that requires a treatment derived from history of pest infestation of that crop.
We name this area A_{ptr} (crop, pest) and obtain

$$A_{ptr}(\text{crop, pest}) = (A(\text{crop}) * P(\text{crop,pest}))$$

In case of repeated application against a pest in a crop, P(crop,pest) is calculated as the sum of the single application probabilities.

Second way: We calculate the area of the same crop treated for the same pest according to the estimated applied quantities of all ingredients approved for that site and pest. The number of all ingredients approved for the site and pest is named k.

The potential application quantity of ingredient j in a crop against a certain pest is calculated by

$$Q_j \text{ (crop, pest)} = A_{ptr} \text{ (crop, pest)} * R_j \text{ (crop, pest)}$$

where R_j (crop, pest) is the authorized maximum dose rate of ingredient j for that site and pest combination.

The estimated use of the ingredient j in a crop against a certain pest on base of its sale date SQ_j is given by:

$$Q_{use,j} \text{ (crop, pest)} = (Q_j \text{ (crop, pest)} * SQ_j) / Q_{all,\ j}$$

Finally we determine the cultivated area (A_{etr} (crop, pest)) of the considered crop which is treated for the considered pest according to the estimated applied quantities.

$$A_{etr} \text{ (crop, pest)} = \sum_{j=1}^{k} (Q_{use.\ j} \text{ (crop, pest)} / R_j \text{ (crop, pest)})$$

Comparison:

If ($|A_{etr} - A_{ptr}| < 0{,}1 * A_{ptr}$) then the estimated quantities may be regarded as confident.

Table 14: Classification of the application fields of pesticides in Germany

Crops	Area under cultivation (rounded; 1996) [hectare x 1000]	
cereals	**6700**	
winter wheat		2250
winter barley		1410
rye		810
spring barley		800
triticale		410
maize (corn)		370
oats		300
others		50
root crop	**870**	
sugar beet		515
potatoes		335
others		20
oil seeds	**885**	
rape		850
others		5
feeding crops	**1820**	
silage maize		1330
clover		230
grasses		220
others		40
grassland	**3640**	**3640**
vegetables	**80**	
cabbage		13
cauliflower		6
onions		7
carrots		8
others		46
fruits	**80**	
apples		65
others		15
hop	**22**	**22**
vine	**105**	**106**

Table 15: Application pattern of selected active ingredients (in Germany, 1996)

Fenpropimorph

crop	development stage of crop [BBCH-code]	pest	application rate (average, [g/ha])	application probability [%]
winter wheat	37	powdery mildew	750	50
winter wheat	55	powdery mildew and/or brown rust	750	30
winter barley	47	powdery mildew and/or dwarf leaf rust and/or Rhynchosporium secalis	750	60
spring barley	37	powdery mildew	750	20
rye	47	powdery mildew	750	10

Mecoprop-P

crop	development stage of crop [BBCH-code]	pest	application rate (average, [g/ha])	application probability [%]
winter wheat	23	dicotyledonous weeds	1200	100
winter barley	29	dicotyledonous weeds	1200	45
rye	23	dicotyledonous weeds	1200	50
spring barley	23	dicotyledonous weeds	1200	100
oats	23	dicotyledonous weeds	1200	100
Grassland		chickweed	1800	?
Vine	11	dicotyledonous weeds	1200	35
Vine	69	dicotyledonous weeds	1200	35

Table 16: Examples for calculation of Q_{use}

Example 1

Question: How many tons of fenpropimorph were applied in cereals in Germany in 1996 ?

Answer: Because all applications of fenpropimorph are only authorized for cereal crops, the whole sold quantity of this year was applied in cereals.

Example 2

Question: How many tons of fenpropimorph were applied in winter barley in Germany in 1996 ?

Calculation:

Q_{all} = (2250000 * 750 * 0,5) + (2250000 * 750 * 0,3) +
(1410000 * 750 * 0,6) + (800000 * 750 * 0,2) +
(810000 * 750 * 0,1) = 2165250000

Q_{crop} = (1410000 * 750 * 0,6) = 63450000

S_{crop} = 0,29

Answer: 29 % of the sold quantity of fenpropimorph was applied in winter barley.

Example 3

Question: How many tons of mecoprop-P were applied in vine in Germany in 1996 ?

Calculation: (with assumption: application probability in grassland = 100 %)

Q_{all} = (2250000 * 1200) + (1410000 * 1200 * 0,45) +
(810000 * 1200 * 0,5) + (80000 * 1200) +
(300000 * 1200) + (3640000 * 1800) +
(105000 * 1200 * 0,35 * 2) = 1190760000

Q_{crop} = 2 * (105000 * 1200 * 0,35) = 88200000

S_{crop} = 0,0075

Answer: 0,75 % of the sold quantity of mecoprop-P was applied in vine.

Attachment 2: Revised workplan

Phase 2: Testing and Evaluation of Models; June 1998 – February 1999

Phase 2 Tasks	Timing	Responsibility
1. Compile the required data on pesticide consumption (sales and usage) in the United Kingdom between 1977 and 1996 using databases held by the consultant, augmented where necessary by data from public sources. Collate toxicity and exposure data for the pesticides included in the consumption data. The data compiled will be those required to compute the model indicators defined in the final report of Phase 1.	June-July	Consultant
2. Organise all the data collected in Phase 2 task 1 into a single database, so they can be used efficiently in the remaining Phase 2 tasks.	June-July	Consultant
3. Submit Preliminary Report to Expert Group on: • distribution of data for each variable and suggested break-points for scoring • proportions of missing data for each variable • initial scores for SIRIS method • feasibility of completing all proposed combinations of crops and levels of aggregation	17 July*	Consultant
4. Respond to Preliminary Report, including: • confirmation of breakpoints for scoring • confirmation of methods to deal with missing data • adjustments to scoring for SIRIS, if required • prioritisation of workplan to fit within available budget, if required	31 July*	Expert Group

5. Construct software to combine and manipulate the data, with modules to calculate each of the indicator models selected in Phase 1. Test the software with dummy data to detect any programming errors.	July-August	Consultant
6. Run the data on pesticide consumption, toxicity and exposure through the software to determine how each of the indicator models would describe risk trends in the UK between 1977 and 1996. Produce risk trends for three different levels of consumption data (sales data only, usage data estimated from sales data, and usage data alone) and different levels of aggregation (as listed in the final report on Phase 1). Test agreement between usage data and usage estimated from sales data. Keep in mind that the first priority of OECD governments is to identify trends at a national level using either actual usage or sales data.	Sept-Oct	Consultant
7. Compare the output of the different indicator models, and the results obtained with different levels of consumption data and different levels of aggregation. Identify the causes of differences between the models. Identify any unexpected results and analyse the calculations to determine which components of the models are responsible for them. Submit a brief Progress Report to the Expert Group and seek approval for any significant changes to the workplan, as appropriate.	16 October	Consultant
8. Review the Progress Report and provide comments to the Consultant (this may require a meeting – to be decided later).	30 October	Expert Group

9. Modify the model indicators if necessary, and the corresponding software modules, to correct any inappropriate behaviour identified. Re-run the pesticide data through the modified models and analyse the results. Carry out additional model runs and analyses to address the following questions: • are the indicators sensitive to changes in risk resulting from specific policy measures and regulatory actions? (this will be done by comparing the results with independent information, held by the consultant, about policy and regulatory changes in the UK during the time period under analysis) • what minimum level of data is required to produce a useful indicator, e.g. sales or usage data, and how many types of toxicity and exposure data? • how is the performance of indicators affected by the simplicity or complexity of the input data and calculations? • at what levels of aggregation can indicators be calculated and to what extent should they be aggregated from field to national level, across crops, and across pesticides? • what is the relative utility of indicators calculated at different levels of aggregation, with different levels of simplicity/complexity, and requiring different amounts of resources to operate? Conduct a sensitivity analysis of the indicator models to determine whether they are sufficiently robust or are excessively sensitive to small changes in input data (e.g. use of different toxicity values, small changes in usage of minor pesticides, alternative methods of dealing with missing data).	Nov-Jan	Consultant
10. Prepare a report for the Expert Group covering: • the results of the full evaluation of the indicator models, and • what the consultant learned from the exercise about developing a prototype indicator.	Jan-Feb	Consultant

Phase 3: Report and Workshop; March - June 1999

Phase 3 Tasks	Timing	Responsibility	Cost
1. Review the consultant's report on the evaluation of the indicator models. Consider the implications of the results for the further development of risk indicators for aquatic organisms. Identify lessons learned that would apply to development of risk indicators in other areas, e.g. terrestrial and human health.	early March	Expert Group	10-20h per member travel to and participation in one 2-day meeting (3rd meeting of the Expert Group)
2. Develop a draft project report for submission to Risk Reduction Steering Committee.	end March	Expert Group	40h for 1 person to write it, 10h each for the others to review, 10h for 1 person to edit
3. Review the draft project report and provide comments to the Expert Group.	early April	Risk Reduction Steering Committee	10-20h per member meeting or conference call
4. Develop and submit final project report.	end April	Expert Group	20-40h for 1 person to deal with comments and edit final version, depending on number and significance of comments, 10h per member for review
5. Distribute report to people nominated to participate in June workshop and to Pesticide Forum.	May	OECD Secretariat	4h for photocopying and preparation for mailing

6. Attend workshop.	1–3 June	Expert Group Risk Reduction Steering Committee	travel to and participation in 3-day workshop in Germany PLUS participation in half-day pre-workshop planning meeting to prepare presentations etc.

Attachment 3: Potential Uses of Risk Indicators by National Governments

Compilation of listings received (for information; result of brainstorming)

Copenhagen list (workshop report, April 1997)

1. obtain baseline information about pesticide use and risks, and then track risk trends over time
2. identify potential trouble spots and areas where action is needed to reduce risks
3. monitor the impacts of agriculture and pesticide policies
4. communicate the aims and results of risk reduction policies and programmes
5. compare pesticide risks
6. obtain information about aggregated risks associated with use of multiple pesticides
7. compare pesticide use in different situations (e.g. agricultural production systems using different levels of inputs)
8. provide information for other types of indicators, e.g. decision tools for farmers, green labels for food products, indicators of advances in IPM
9. plan and prioritise research on pest control methods

Paris list (mini-steering group, September 1997)

1. Are pesticide risks changing over time?
2. How much have risks changed in the last 5-10 years?
3. Have risks changed since the introduction of certain policies/programmes?
4. Has a particular policy significantly reduced health and/or environmental risks?
5. Have policy goals for risk reduction been achieved?
6. Will goals be achieved if current measures are maintained?
7. Will a particular policy reduce risk if it is adopted?
8. Why are risks changing?
9. What contributions are particular policy measures making to risk reduction?
10. What other factors are influencing changes in risk (e.g. weather, pest/disease levels, market influences on cropping patterns)?
11. Where are the most significant risks or problem areas?
12. Which aspects of current farming/crop protection practices are most harmful to human health or the environment?
13. Which contribute most to risk reduction?
14. How do different pest control regimes (spraying sequence, pesticide cocktail) change the risk?
15. Did changing from mixture to isomer change risks?
16. Did changing from product A to product B change risks?
17. How did switching crops change risks to targets?
18. Which pesticide in a control regime contributes most of the risk?
19. What do I need to do to get desired risk reduction?
20. What does all this mean in real terms for human incidents, wildlife kills, decline of soil fertility, declining populations, IPM?
21. Is the level of risk reduction sufficient to sustain in future the viability of species or ecosystems?
22. What are the main factors that affect risk reduction? What is driving the risk trends?
23. Why is risk from one class of pesticides increasing while that from others is decreasing?
24. Why did risk apparently increase during a period when risk reduction policies were operating? Was the increase real or spurious?

Netherlands list (May 1998)

1. Aggregate effects of pesticides on the quality of surface water into one number
2. How do risk-reduction measures affect this number?
3. Can this number be used to show trends over the last 5-10 years?
4. Does the loading of non-target areas, expressed in toxic units, change over time?
5. Does the exposure of non-target species, expressed in toxic units, change over time?
6. Does the ecological risk in non-target areas change over time?

UK response (May 1998)

1. Not just be summary or descriptive statistics
2. Should be strongly linked to:
    - Objectives - 'what we want to achieve'
    - Action - to achieve our objectives
3. Need to be developed to:
    - Communicate with and encourage actors
    - Monitor actions

Herbert Koepp list, June 1998

1. Compare trends before and after banning something, or registering something 'safe' on the fast track.
2. Compare how easily different pesticides pass the hurdle of regulatory criteria.
3. Region X has light soils, sensible groundwater aquifers, important drinking water reserve. Does it help my leaching problem if farmers switch from corn to alfalfa?
4. Orchards in California and Oregon: different climate, hence different pest pressure, different efficacy, hence some different compounds used. Does the Oregon applicator live/work more safely than the Californian? And, do both live more safely now than ten years ago? (Human risk questions)
5. We banned those mixtures of active and inactive isomers. Only the active ones are used now. Tonnage applied of those compounds should be halved. Which specific risks are reduced as well, and which aren't?
6. We've got low-dose herbicides now. Any change in the risk for groundwater, surface waters, applicator,...?
7. No change in registrations but we introduced obligatory training and information for farmers about IPM, beneficial arthropods etc. Does it help anything?
8. Some triggers or levels of concern in the registration system were changed. After two years, is the new batch of compounds any better than the old ones?

Attachment 4: Catchment area scenatio

Scale

This scenario considers long-term effects of average concentrations in water bodies that are not immediately adjacent to the site of application of the pesticide. This scenario attempts to address the mean of different waters (main water courses, (small) rivers, lakes,etc.) downstream of a region where different pesticides are applied on different crops at different times. The spatial scale is 'catchment area', 'polder', etc. (maximally tens of kilometers). The time scale is at least one growing season.

General approach

Risk is characterized for the average long-term exposure situation in off-site surface water during at least one growing season. It is assumed that the water considered receives contributions from many different fields to which different pesticides are applied almost continuously. It is also assumed that the receiving water is non-stagnant; it is continuously being refreshed with clean water from upstream, unpolluted sources. It is further assumed that the water contains steady concentrations of all the pesticides used in the region considered. the steady-state concentrations in water are calculated with:

$$Q_j(LC) = \frac{C_j}{CT_j} = \frac{\sum_k U_{j,k} \cdot L_{j,k}}{k_j \cdot V \cdot CT_j}$$

with:

C_j	steady-state concentration of pesticide j in the waters downstream of the area considered, during a growing season (g/m^3)
CT_j	long-term aquatic toxicity (mean, lowest, quantile, of long-term NOECs) of the pesticide j (g/m^3)
$U_{j,k}$	amount of pesticide j used in the area (kg/day) on different crops k
$L_{j,k}$	loss of pesticide j used on different crops k to water (dimensionless)
k_j	lumped first-order rate constant (day^{-1}) for removal of pesticide j due to volatilization, sedimentation, degradation and flow
V	total volume of water in the area (m^3)

Data needed

The formula presumes that

- The total use rates in the catchment area, U (kg/day), are known per pesticide and per crop. Whether or how this information can be obtained or estimated is not discussed here.
- The loss to water (by spray drift, run-off and perhaps atmospheric deposition), L (%), is known as a proportion of the dose applied for the different crops in the area. Semi-quantitative

relationships between conditions of use and application methods on the one hand, and loss percentages on the other hand are proposed in a separate document by Kiefer. The contribution of run-off to the percentage loss to water is described in a document by Gutsche.

- The rate of removal of the pesticide from the water in the catchment area can be characterized with a simple first-order rate constant (per day). This rate constant would be the sum of the firts-order rate constant of the various processes that contribute to the removal: flow (k=(Q/V), degradation and sedimentation (k-value to be obtained from standard tests data), volatilization (k to be estimated from Henry's Law constant or perhaps to be neglected?).
- The total volume of water in the catchment area , V (m^3), to which the pesticide is lost is known or can be assumed. In Germany this sort of information is available from a GIS system.
- The long-term toxicity, CT (g/m^3) of the pesticide for aquatic ecosystems can be characterized somehow on the basis of laboratory toxicity test results (average of NOECs, NOEC of most sensitive taxa, 5th percentile of NOECs, or fraction thereof). In a recent study at RIVM (De Zwart et al.), the aquatic toxicity database AQUIRE of US EPA Duluth has been analyzed. This study has shown that generally interspecies variations in sensitivity can be described with simple log-logistic distribution functions with variances that predictably relate to the toxic mode of action. This work provides a scientific basis for deriving the CT-values needed from standard toxicity data.

Aggregation

Aggregation can be done for crops (crop-specific use rates U and loss percentages L), or over all crops in the area. This results in effects quotients per pesticide. The challenge here is to aggregate the results for the different pesticides that are assumed to be present simultaneously. Simply adding the quotients would yield a useful indication of risk: the higher the sum of quotients, the higher the ecotoxicological risk.
However, simply adding the quotients would be toxicologically correct only in the case of similar toxic mode of action. In such cases the combined toxic effect is known to be expressed by the sum of the toxic units (TU). The only toxicologically correct way of aggregation of pesticides that are known to act according to different (independent) toxic modes of action is through toxicological effect addition:

$$(1-combiPAF) = (1-PAF_a)\cdot(1-PAF_b)\cdot\ldots$$

with

combiPAF	proportion of the species potentially affected by the simultaneous toxicity of pesticides of different modes of action
$PAF_{a,b}$	proportion of species potentially affected by the toxicity of class a or class b

In order to make this applicable, combined toxicity values of pesticides with the same mode of action need to be expressed in terms of the proportion of species potentially affected (PAF). This can be done by means of suitable expressions of the cumulative NOEC-distribution function.

Interpretation in terms of eco-risk

Aggregation via combiPAF would yield a toxicologically meaningful aggregate. CombiPAF expresses the proportion of the aquatic species that is exposed to concentrations that exceed the NOEC. This is to be interpreted as toxic stress on ecosystems. The PAF-approach to mixture toxicity was developed recently at RIVM, on the basis of previous work by Van Straalen and co-workers at the Free University of Amsterdam.