



## **4FUN**

"The FUture of FUIIy integrated human exposure assessment of chemicals: Ensuring the long-term viability and technology transfer of the EU-FUNded 2-FUN tools as standardised solution"

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# Deliverable D2.2. List of criteria to be used for SWOT analysis

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## 1 Introduction

Organisms, man included, are exposed to chemicals through the environmental media. The exposure of human beings is an important part in the risk assessment of chemicals. Man can be exposed through the environment directly via inhalation, soil ingestion and dermal contact, and indirectly via food products and drinking water. Assessment of exposure concentrations can be done by measurement or by other means of estimation such as model-based computation.

This involves estimating emissions, pathways and rates of movement of a substance and its transformation or degradation in order to obtain concentrations or doses to which human populations or environmental compartments are or may be exposed. It involves describing the nature and size of the populations or compartments exposed to a substance and the magnitude and duration of their exposure.

In principle, exposure concentrations can be qualitatively and quantitatively understood as the net results of emissions and fate processes. To calculate concentrations it is essential that the mass flows affecting the concentration of the chemical at a given place and time are properly quantified. The net result of the mass flows can then be calculated by solving the mass balance equation for that specific situation. The process of quantifying the mass flows of a chemical and calculating the resulting concentrations in the environment by means of mathematical expressions is known as exposure modelling.

The development of an exposure model should consider information about all the 5 elements included in the conceptual model representing the process from chemical emissions to possible receptors illustrated in Figure 1.



Figure 1: Conceptual models including all elements to be considered in human health exposure and risk assessment.

Exposure models are critical for comprehensive exposure assessment because we will never be able to monitor or measure exposure everywhere. The need for models increases proportionally with the growing universe of chemicals under consideration. Exposure modelling represents the best hope and means of understanding the exposure and ultimately managing the risk to humans from the myriad of chemicals encountered every day in our natural environment. Exposure models can be classified as single-media models if they are based on one environmental compartment (e.g. air, soil, etc.), or as multimedia models if they consider multiple compartments. Multimedia models are used if a chemical is released into several compartments simultaneously, or after release into one compartment is transported to other compartments. Examples of multimedia models are EUSES, CALTOX, 2-FUN, etc.

The 2-FUN tool was developed under the sixth Framework Program of the European Union (contract n° FP6-2005-GLOBAL-4-036976) within the project "Full-chain and uncertainty approaches for assessing health risks in future environmental scenarios". 2-FUN aimed to provide decision-makers with state of the art tools to analyse the current and future trends in environmental conditions and pressures that may lead to health problems. Its main objective was to support the evaluation and ranking of management options through a range of functionalities able to generate outputs of high concern for health risk assessment: building of long-term environmental and socio-economic scenarios, exposure and effects assessment, provision of uncertainty margins, and identification of sensitive pathways and risks. The 2-FUN multimedia modelling tool allows the user to assemble a model for a specific scenario, to enter input data and parameter values for selected contaminants and finally to run deterministic (best estimate) or probabilistic (Monte Carlo) simulations.

This tool is however only a prototype software containing a library of models for exposure assessment, coupling environmental multimedia and pharmacokinetic models. The objective of the 4-FUN project is to further improve and standardise the 2-FUN tool and guarantee its long-term technical and economic viability.

## 2 Objectives

The main objective of WP2 is to identify strengths and weaknesses of the 2-FUN tool and other exposure tools using a SWOT (Strengths-Weaknesses-Opportunities-Threats) analysis. SWOT analysis (alternatively SWOT Matrix) is a structured planning method used to evaluate the **S**trengths, **W**eaknesses, **O**pportunities, and **T**hreats involved in a project or in a business venture. This identification will be used as an input for the design of the final integrated 2-FUN tool (WP3). The specific objective of this report is to develop a list of criteria to be used for the SWOT analysis.

Reviews of exposure tools have been conducted in the frame of past projects, but resulting analyses generally remain subjective and qualitative because they are not based on a set of transparent and structured criteria (See 3.1). To overcome this drawback and to facilitate thus an objective and reproducible SWOT evaluation, a comprehensive list of criteria will be set up to structure the characteristics of exposure tools.

## 3 Methodology

To identify and select a set of criteria to analyse and compare exposure models the following methodology was applied:

- 1. Review of exposure models
- 2. Categorization of model aspects
- 3. Criteria selection

These tasks will be described in detail in paragraph 3.1 to 3.3.

Multi-Criteria Decision Analysis (MCDA) has been chosen as a suitable approach for supporting a structured and quantitative comparison between the exposure models, therefore in paragraph 3.4 background information about MCDA will be provided while the specific MCDA approach proposed for this task will be briefly introduced and described in paragraph 3.5.

### 3.1 Review of exposure models

A review of exposure models has been performed in order to identify relevant features and functionalities of exposure models to be considered in the comparison of existing models with 2FUN tool and to identify therefore significant evaluation criteria. By assessing the strengths and limitations of publicly available exposure models and modelling systems in regard to the needs defined for 4FUN development, a determination can be made regarding the features of the various models that may be incorporated later into 4FUN.

Reviews of exposure tools have been conducted in the frame of past projects. For example, the EU FP7 RISKCYCLE project reviewed 20 risk assessment/life cycle assessment models (Qwasi, Ecopoints, ChemCAN, ECOSENSE, WMPT, EDIP, Eco-indicator 99, CSOIL 2000, CaITOX, IMPACT 2002+, EUSES2.0, HUMANEX, XtraFOOD, RAIDAR, 2-FUN, ReCiPe, USEtox, USES-LCA, GLOBOX and MAFRAM). This review used selection criteria to select appropriate risk assessment methodologies. The following criteria were applied to the 20 models:

- Impact categories
- Exposure routes
- Fate, exposure and effect
- Chemicals considered
- Media considered
- Spatial variation
- Source code availability
- Model availability
- Population category

The EU FP7 BROWSE project intends to review and extend models currently used in the risk assessment of plant protection products, to evaluate the exposure of operators, workers, residents and bystanders. The following aspects were considered as input for the development of the model to be developed within the BROWSE project:

- Source of the model
- Type of exposure

- Basis of the model
- Source of the model (data, year, etc.)
- Type of exposure (dermal, inhalation)
- Basis of the model (conceptual model, mechanistic model, measurement data)
- In case of measurement data:
  - What kind of data (GLP/non-GLP, measurement method, potential/actual dermal exposure, inhalation/dermal, duration)
  - o Available description of studies
  - o Availability raw data
- Scenario's covered (equipment, indoors/outdoors, type of formulation, crops)
- Determinants included in model (application rate, area treated, container size, etc.)
- Inclusion of personal protective equipment (PPE)
- Validation of model
- Way of normalization of parameters, structure of model (units of exposure, area treated, body weight operator, PPE, inhalation rate, absorption, body parts, etc.)
- Calculation estimated inhalation and dermal exposure (external or internal exposure)
- Choice of statistical point estimate (percentiles)
- Regional differences or location data measurements
- Possible gender differences

In another study, WHO (2005) described information intended to serve both the developers and users of concentration, exposure and dose models. They suggested using ten characteristics to evaluate the selected models:

- General description of the purpose of the model and its components
- Individual- or population-level analysis (level of aggregation)
- Modelled time resolution
- Applicability to diverse exposure scenarios
- Description of data inputs
- Modelling tool methodology
- Model code and platform
- Model performance and evaluation summaries
- Description of model outputs
- Model sensitivity and uncertainty analysis

These 10 principles for model characteristic description was applied by EC Joint Research Centre's Consumer Exposure Modelling Task Force to collect information about existing consumer exposure models worldwide. The consumer exposure models that were reviewed included the following: CONSEXPO, PROMISE, E-FAST, SCIES, MCCEPA, DERMAL, SHEDS, DERM, AirPEx, BEAT, CALENDEX, CARES, LIFELINE, EUSES.

Fryer et al. (2004, 2006) wanted to develop a unified approach to exposure modelling for chemical risk assessment in the UK. In order to develop such a unified approach, it was necessary to understand and evaluate models currently used. 15 exposure models (ADMS, Calendex, CalTOX, CARES, CLEA, Consumer, ConsExpo, EASE, EUSES, Intake Program, LifeLine, POEM, Rex, RISC, SHEDS) were selected to cover a comprehensive range of exposure situations. Models are judged against a series of criteria to determine their suitability as comprehensive exposure modelling tools.

The following criteria have been used to evaluate model suitability for use as a single human exposure model for chemical risk assessment in the UK:

- Does the model account for all potential sources of exposure?
- Does the model account for all potential pathways and routes of exposure?
- Does the model have the ability to consider population subgroups with potentially high levels of exposure as well as general populations?
- Does the model consider/quantify variability and uncertainty?
- Is the model applicable for appropriate temporal and spatial scales?
- Is the model valid for its exposure remit?
- Can the data requirements of the model be met for UK situations?
- Is the model transparent and user-friendly?

Each model was assessed against the following criteria:

- Model developer
- Intended use of the model
- Whether the model adopts a deterministic, distributional, parametric or fully probabilistic approach to the exposure assessment
- Receptor populations that can be assessed by the model
- Model input parameters required
- Exposure routes considered
- Exposure pathways considered
- Whether the model can aggregate exposure from multiple exposure pathways
- Exposure durations that can be evaluated
- Substances that can be evaluated by the model
- Whether the cumulative exposure assessments of multiple chemicals can be performed
- Model approaches for addressing variability and uncertainty
- Availability of the model

For the development of TRIM.Expo, a total risk integrated methodology providing an analysis of the relationships between various chemical concentrations in the environment and exposure levels of humans (EPA, 1999), numerous air quality and exposure models and modelling systems, including 10 multimedia exposure models were reviewed. The following model features were reported for each model:

- General (Model name, pollutants of concern, reference, model status, contact/affiliation, stochastic, variability, uncertainty)
- Modelled area, study population and modelling period (study areas, spatial designation, sub-areas, exposure duration, general population, special subgroups, special attributes for subgroups, etc.)
- Exposure events (environmental media, exposure media, pathways, routes, time resolution, etc.)
- Concentration and sources (outdoor concentration determination method, etc.)
- Extrapolation to study population

ConsExpo, a consumer exposure-modelling tool, was improved by adopting certain features from other existing consumer exposure modelling tools (Park et al., 2006). Hence, ConsExpo was compared with other existing consumer exposure modelling tools in an investigation to discover whether the tools contained any exposure scenarios, mathematical models or other features that might be useful for ConsExpo. This study was specifically focused on improving ConsExpo and therefore other models were judged in perspective of the ConsExpo model. Nonetheless, some aspects, which can be translated into general criteria for assessing

multimedia exposure models could be identified for this deliverable (e.g., distributed input values, choice of distribution types).

The OECD Series on Testing and Assessment No. 45 (2004) is a guidance document on the use of multimedia models for estimating overall environmental persistence and long-range transport. In Chapter 3 of this document general model aspects are discussed. The following aspects are considered for characterizing multimedia models:

- Accuracy and uncertainty of models: e.g. complexity of a model
- Complexity and level of detail of environment description of available models: e.g. generic models, multi-zone multimedia models
- Differences in e.g. equilibrium compartments, advective and dispersive transport processes,...
- Data requirements and availability e.g. distribution processes, degradation

The Office of Pollution Prevention and Toxics (OPPT, US EPA) has developed several exposure assessment methods, databases, and predictive models to help evaluating the fate of chemicals when they are used and released to the environment and how workers, the general public, consumers and the aquatic ecosystems may be exposed to chemicals. When characterizing the quality of an exposure estimate based on models, OPPT believes that in addition to presenting exposure estimates obtained from the models, the assessment should address:

- What was the modelling objective (i.e. conservative estimate of exposure, an estimate of typical exposures to the population of interest, etc.)?
- What is the model algorithm and what are the key assumptions used in the model?
- What is the scenario that is being modelled?
- What are the key inputs to the model?
- Has the model been peer reviewed?
- Has the model been evaluated by testing it against other models or against monitoring data?
- What are the key uncertainties in the model estimate of exposure?

Some of these aspects are less related to the model itself but should be included in the model evaluation.

Schwartz et al. (1998) described an evaluation of the software quality of EUSES 1.00. Quality criteria for software products for the risk assessment of chemicals were developed. They were derived from common standards, publications and newly established requirements. For the generation of computer programmes for exposure assessment Good Modelling Practice (GMoP) should be developed and established. The quality criteria given below were used to evaluate EUSES:

- Product description (e.g. indication of the version, system requirements, etc.)
- Documentation (Correctness, completeness, consistency, comprehensibility, clarity, applicability)
- Technical requirements (Installation and system requirements, stability and reliability, state-of-the-art, network support)
- Correctness of calculations
- User interface and operability (Programme control, flexibility, output, error messages)
- Transparency (free insight, modularity, complexity)
- Features (messages, relationships, variable units, comments)
- Cooperation with other programmes

- Uncertainty analyses
- Support

Mackay et al. (2001) described multimedia mass balance models, especially their use for estimating persistence and long-range transport. The nature and structure of real and evaluative compartmental or box models is described for single and multiple box systems, including the various methods by which individual multimedia models are linked linearly, in a circular configuration, nested one within another, or as a network.

Webster et al. (2005) described the development and application of models of chemical fate in Canada. In this report, 13 different models were described briefly giving a model overview, input data and results and intended uses.

Evaluation of currently used exposure models/LCA models was also discussed in Rovira et al. (2013) where strengths and weaknesses of 15 models (EUSES, USEtox, GLOBOX, SADA, MAFRAM, etc.) were presented. From several publications such as Huijbregts et al. (2005), Chen & Ma (2006), Rong-Rong et al. (2012), Rosenbaum et al. (2008), essential model characteristics can be identified and translated to the necessary model criteria.

In general, from the literature review it resulted that different aspects, features and functionalities related to exposure models can be divided into the following categories:

- General model information: model developer, operating system, etc.
- Model context: model approach, range, complexity, temporal and spatial resolution, etc.
- Model development: targeted population, exposure routes, compartments, processes, chemical substance, etc.
- Model evaluation: validation, uncertainty, probabilistic approach, etc.
- Output: reporting, results accessibility, etc.
- Model application: model framework, scenario analysis, etc.
- User-friendliness: helpdesk, manual, etc.

#### 3.2 Criteria selection

The different aspects related to the description of an exposure model can be translated into criteria to be used as guideline for evaluating and comparing several exposure models. Firstly, criteria were selected based on the general elements to be considered in each exposure assessment as described in the conceptual model in Figure 1. To obtain these criteria, previously described reviews on exposure models (see 3.1) were used to cover the majority of the aspects.

Secondly, criteria related to regulatory frameworks were selected. The requirements of one regulation to another might differ. E.g. spray drift is an important aspect in the plant protection products regulation while it is not considered in the REACH regulation.

The following regulatory frameworks in which 4FUN can be used to predict human exposure were covered:

- REACH (EC 1907/2006)
- Plant protection products (EC 1107/2009)
- Biocides (Directive 98/8/EC)

These regulatory frameworks were selected as they are relevant at the EU level in the context of chemical substances management and they deal with different classes of chemicals which have the potential to cause indirect exposure to humans via the environment. 4FUN might also be applicable in the evaluation of chemicals in a local/regional regulation, however the specificities of these regulations might be quit variable and are therefore not taken into account in the selection of the criteria.

In order to organize the criteria in a coherent structure. The obtained criteria were organised according to four Lines of Evidence (LoE), corresponding to different information domains:

- Reliability: Reliability covers the inherent quality of a computed result (here an exposure output) related to a modelling methodology or specification. This LoE can include criteria like validation process, standardisation process, statistical methods and data sources for parameterisation, incorporation of the key processes, compliance of model structure to data, accepted sampling or parameter estimation methods, etc.
- Relevance. Relevance covers the extent to which a modelling tool is appropriate for a
  particular risk assessment. The objective is to provide a comprehensive overview of
  all the factors taken into account for ranking the relevance of a given modelling tool
  respective to a given assessment context. This LoE can include criteria like
  exposure routes availability, decision endpoints, comparison of model results to
  endpoints, applicability to chemical substance groups, regulatory acceptance.
- Uncertainty. The different sources and types of uncertainty associated to exposure tools are identified, i.e. (a) decision-rule uncertainty (e.g. exposure scenarios, safety factors, 'single substance' approach, etc.); (b) structure uncertainty (e.g. assumed extrapolations, statistical models applied, etc.); (c) parameter uncertainty (natural variability and estimation uncertainties) and (d) inclusion of application factors or other uncertainty factors. Such a classification is a prerequisite for a better understanding of the confidence to affect a given data. Another point is whether the model incorporates uncertainty assessment and if so, which approaches have been adopted
- Practical use of the tool (e.g. easiness to understand, possibilities to identify meaningless input values (difficult-to-abuse), availability and feasibility for estimating parameters, user-friendliness and flexibility).

Finally, in order to support the evaluation of exposure models by selected experts, all the obtained criteria can be transformed into the form of questions. A set of experts will be asked to use the resulting questionnaire as a guideline to evaluate each exposure model considered in the comparative assessment, as will be detailed in paragraph 3.5.

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#### 3.3 Categorization of questions

The questions related to the selected evaluation criteria are organized based on a hierarchical structure, which relates the different aspects of exposure models in a clear and solid fashion. The hierarchy is based on 4 Lines of Evidence (LoE). Each LoE is subdivided into categories, which are further subdivided in specific sub-categories. Finally sub-categories are composed of assessment criteria, which are evaluated through the use of questions. Questions are at the lowest level of the hierarchy, the one that must be addressed to the user (Figure 2). The complete procedure for the evaluation and comparison of

exposure model is based on a Multi-Criteria Decision Analysis (MCDA) approach, therefore in paragraph 3.4 background information on MCDA will be provided.



### 3.4 Multi-Criteria Decision Analysis

Belton and Stewart (2002) define Multi Criteria Decision Analysis (MCDA) as, "*an umbrella term to describe a collection of formal approaches which seek to take explicit account of multiple criteria in helping individuals or groups explore decisions that matter*". The general definition stated above outlines three dimensions of MCDA, namely: (1) the formal approach, (2) the presence of multiple criteria, and (3) that decisions are made either by individuals or groups of individuals.

Furthermore, MCDA can be defined as a decisional support tool whose main goal concerns the **selection**, **ranking**, **scoring** or **screening**, among a set of admissible alternatives, on the basis of **multiple criteria**, taking into account Decision Makers/Stakeholders' preferences and Experts' knowledge (Koksalan *et al.* 2011, Figueira *et al.* 2005). MCDA includes a wide variety of methods for the evaluation and ranking, or selection, of different alternatives that consider all the aspects of a decision problem involving many actors (Giove *et al.*, 2009).

On the other hand, the term "Weight of Evidence" (WoE) constitutes neither a scientifically well-defined term nor an agreed formalised concept characterised by defined tools and procedures (Weed, 2005). An evidence-based approach involves an assessment of the relative values/weights of different pieces of available information, which have been retrieved and gathered in previous steps. WoE refers to a large family of methods and is applied into various scientific projects, mainly known for the applications to human health and ecological risk assessments. Weed (2005) and Linkov *et al.* (2009, 2011) have provided comprehensive critical reviews on the concept and the uses of Weight of Evidence, both in an exploratory way as well as in an effort to provide a categorisation of the available qualitative and quantitative WoE methods and their use in environmental assessments.

Combining MCDA methods and WoE approaches allows to:

- classify available information according to a hierarchical structure based on different 'Lines of Evidence' (corresponding to different information "domains"), each of them being subdivided into several levels of criteria;
- normalise information, i.e. affecting common units to qualitative (e.g. originating from expert judgement), semi-quantitative (e.g. Boolean information) or quantitative information;
- assign different weights and relations to the selected criteria in order to rank and compare them through an integrated approach;
- define decision indices that integrate all the selected criteria on the basis of experts' judgements and decision makers' insights.

In this context, the use of a MCDA-based Weight of Evidence approach is considered suitable for the scopes of the 4FUN project, due to the extended capabilities it provides to analysts for assessing the strengths, and therefore also weaknesses, of human exposure models. Further details on the used approach are provided in paragraph 3.5.

#### 3.5 MCDA-based approach for comparison of exposure models

In the framework of the AMORE research project, a Weight of Evidence methodology has been developed for the evaluation of the reliability and relevance of ecotoxicological data. In order to identify and quantify strengths and weaknesses of the 2FUN tool and compare it to other available human exposure models, the AMORE methodology, thanks to its flexibility, can be adopted, adjusted and used for the purposes of 4FUN project.

The methodology incorporates the use of MCDA methods and specifically is based on the use of Multi-Attribute Value theory (MAVT), combined with fuzzy logic as well as basic elements of group decision theory (Isigonis *et al.*, 2012).

It is not intended to present here the complete details of how the methodology interprets the provided input, how it transforms the information and through which procedure it aggregates it into a score for a given exposure model under assessment, but rather to provide the main background of the methodological steps that the procedure is based upon and how the methodology can be used efficiently for analysing and comparing human exposure models.

The pillars, upon which the WoE methodology is developed, are:

- 1. the creation of a hierarchical evaluation structure;
- 2. the collection of the knowledge and input of an expert panel;
- 3. the analysis of the hierarchical structure;
- 4. the assessment of elements on the basis of the hierarchical structure;
- 5. the automatic calculation of a final graded score based on pillars 1, 2, 3 and 4.

Gathering the knowledge of experts on the topic is vital for the application of the methodology, as this knowledge is interpreted and used as a basis for a fast, reproducible and efficient assessment of human exposure models on the basis of multiple criteria.

The methodology requires the use of transparent and structured evaluation criteria, organised in a hierarchical structure, i.e. a tree formation. This structure has been described in 3.3. The questions, which are unambiguous and clear, can be answered with a simple YES/NO answer that corresponds to an Optimum or Worse evaluation of the criteria.

The constructed hierarchical structure that is used in 4FUN consists of four (4) Lines of Evidence, thirty six (36) categories, forty two (42) sub-categories, and hundred twenty eight (128) criteria/questions, which are presented in detail in Table 1.

The hierarchy is a result of a systematic review of the characteristics of exposure tools and models available in the literature and the incorporation of expert judgement about relevant aspects for environmental exposure modelling. Extended details on the followed process are provided in paragraph 3.1 and 3.2 of the deliverable.

The analysis of the hierarchical structure is performed with the help of an expert panel, which is invited to assess the complete structure through the use of a dedicated online questionnaire. The online questionnaire is designed for collecting the opinions and insights of experts on three basic elements:

- Identification of the relations between criteria;
- Identification of the relative importance of each criterion:
- Identification of the possible inherent uncertainty:
  - in the form of unreported information
  - in the form of disputable information/conditions
  - in the form of lack of knowledge of the experts.

Those elements are used for the evaluation of the complete criteria hierarchy, in a repeatable bottom-up procedure, which starts from the evaluation of criteria (through their related questions) and moving upwards for each level of the hierarchy for the evaluation of sub-categories, categories and Lines of Evidence.

The questionnaire includes the following four points, for which the related questions and outputs are reported:

 Identification of elements whose evaluation overrules (positively or negatively) other elements belonging to the same element group ('Over' and 'Veto' criteria), see Figure 3.

Q: "Does an optimum (i.e. green answer), or conversely, worst (i.e. red answer) evaluation of one of the following criteria make all/some of the other criteria within the same category irrelevant?"

The output of the question can be a set of causal relations, in the form of IF-THEN rules, or a null set, in the cases where the experts do not define any relation.

1. Model validation the model validated for the selected purpose described in the description of the model? 2. QA/QC documentation the model's quality QA/QC documentation (e.g. black box, white box test, benchmarking against other models, etc.) available? 3. (Bio)monitoring data es the model use (bio)monitoring data for validation? 4. Validation process during the validation process the factor predicted versus monitored identified?  ap 1 of 4 is an optimum (i.e. green answer), or conversely, worst (i.e. red answer) evaluation of one of the following criteria mak is an optimum (i.e. green answer), or conversely, worst (i.e. red answer) evaluation of one of the following criteria mak is an optimum (i.e. green answer).
<ul> <li>2. QA/QC documentation</li> <li>2. QA/QC documentation</li> <li>2. QA/QC documentation</li> <li>4. validation process</li> <li>4. Validation process</li> <li>4. Validation process the factor predicted versus monitored identified?</li> <li>2. p1 of 4</li> <li>s an optimum (i.e. green answer), or conversely, worst (i.e. red answer) evaluation of one of the following criteria making or the other criteria within the same category irrelevant?</li> </ul>
3. (bio)monitoring data es the model use (bio)monitoring data for validation? 4. Validation process during the validation process the factor predicted versus monitored identified? <b>p 1 of 4</b> s an optimum (i.e. green answer), or conversely, worst (i.e. red answer) evaluation of one of the following criteria mak some of the other criteria within the same category irrelevant?
4. Validation process during the validation process the factor predicted versus monitored identified? p 1 of 4 is an optimum (i.e. green answer), or conversely, worst (i.e. red answer) evaluation of one of the following criteria mak some of the other criteria within the same category irrelevant?
ap 1 of 4 is an optimum (i.e. green answer), or conversely, worst (i.e. red answer) evaluation of one of the following criteria mak some of the other criteria within the same category irrelevant?
ep 1 of 4 is an optimum (i.e. green answer), or conversely, worst (i.e. red answer) evaluation of one of the following criteria mak iome of the other criteria within the same category irrelevant?
is an optimum (i.e. green answer), or conversely, worst (i.e. red answer) evaluation of one of the following criteria mak iome of the other criteria within the same category irrelevant?
● YES ○ NO
You can change the order of the rules you have already entered by using the arrows. Once you make a change in a rule, make sure to press 'Save All' to store your answer.
You have to complete this question before moving it up or down along the list.
RULE 1 Delete last rule
Delete
N Model is Optimum 💌
Save All FINISH ADD ANOTHER RULE

Figure 3: Identification of 'over' and 'veto' elements

2. Identification of the importance (ranking) of 'Worse evaluation' of each element, see Figure 4.

Q: "Rank the importance of each criterion by assigning each of them to the appropriate category. Each criterion should be ranked, based on your judgement for its effects on the evaluation of human exposure models. For example, think about one model where all the criteria are optimum except to the criterion you are considering here. How would this worst answer degrade the evaluation of the model? You can drag and drop the criteria to the category of your choice."

The output of the question is a classification of each element to five (5) predefined classes (i.e. Prerequisite, Highly important, Moderately important, Slightly important, Not relevant).

lspects	Worst evaluation
	Prerequisite
	This criterion is a basic prerequisite for the assessment of a model, therefore a negative evaluation totally degrades the evaluation of a model.
QA/QC documentation	Highly important
(Bio)monitoring data	A negative evaluation highly degrades the Model validation
	Moderately important
	A negative evaluation moderately degrades the evaluation of a model.
	Slightly important
	A negative evaluation slightly degrades the evaluation of a model.
	Not relevant
	A negative evaluation does not influence my judgment for the evaluation of a model.

Figure 4: Identification of the importance of 'Worse evaluation' of elements

3. Identification of the effects in model evaluation of an element being 'Applicable but not reported' for a given exposure model, see Figure 5.
Q: "Supposing a criterion is applicable for the type of human exposure model under assessment but not reported in the paper/manual or not specified by the person evaluating the model's quality, which action would you take? Each criterion should be assigned, based on your judgment for its effects on model evaluation, in the right answer. You can drag and drop the criteria to the category of your choice" The output of the question is a classification of each element to three (3) predefined classes (i.e. Substituted by optimum, No idea on how to substitute, Substituted by worst).

Substituted by optimum eptable that the criterion is not informed because it corresponds to a I characteristic of exposure models. It can implicitly be assigned to Optimum evaluation.	
eptable that the criterion is not informed because it corresponds to a I characteristic of exposure models. It can implicitly be assigned to Optimum evaluation.	
No idea on how to substitute	
insufficient information for evaluating the effect on the evaluation of a model of an applicable but not reported criterion.	
Cubstituted by west	
substituted by worst	
Worst evaluation.	
	a model of an applicable but net reported criterion. Substituted by worst arion is not informed and, as a consequence, it must be assigned to Worst evaluation.

Figure 5: Identification of effects due to element status 'Applicable but not reported'.

4. Identification of the robustness of the evaluation and the possible existence of disputable conditions, see Figure 6.

Q: "Evaluate if the Optimum/Worst answer is disputable (i.e. highly depend on the model assessor) or consensus-based (i.e. based on largely recognized assumptions/desired conditions). Each criterion should be assigned in the right answer, based on your judgement for its effects on model evaluation. You can drag and drop the criteria to the category of your choice."

The output of the question is a classification of each element to two (2) predefined classes (i.e. Disputable, Undisputable).



Figure 6: Identification of disputable information

It is important to notice that the questionnaire provides the user the possibility to skip the four questions for a given node of the hierarchy (see Figure 7), in case the user does not possess sufficient information or knowledge for evaluating the elements included in that node. This

feature is designed for excluding from the evaluation the possible existing uncertainty, up to the highest possible percentage.

CDITE	
1. Act Does the 2. Ch Does the	LA LADEE e exposure nodel cover acute exposure? noic exposure nodel cover chronic exposure
2.7.1 -	Acute/chronic
Knowled	je?
Do you ti Acute/chi	nk that you have sufficient knowledge for evaluating the criteria and their importance for the group of level 2.7.1 nic?
	Proceed O I am not sure, skin level

Figure 7: Question regarding the sufficiency level of an expert, for a given node of the criteria hierarchy.

Each of the outputs of the four questions is collected, stored and further used for the creation of a knowledge base. This knowledge base allows to clarify and quantify the relations among the evaluation criteria, and further among the rest of the elements of the hierarchical structure, and is subsequently used at the final stage of the assessment process for the analysis of a given human exposure model.

At the final stage of the assessment process, "evaluators" will be asked to assess the given exposure models according to the proposed criteria. Practically, this is done with the collection of the answers to the hundred twenty-eight criteria questions (multiple answer questions), through a specific response sheet filled in by a user (see Table 2, Annex 1), regarding the characteristics and functionalities of each human exposure model.

Lastly, the methodology utilises the aforementioned MCDA methods and specific aggregation techniques for the calculation of a final index, associated with every given human exposure model. The answers provided by the "evaluators" for each criterion are weighted and aggregated through the use of the information stored in the knowledge base. The final index, obtained for each exposure model under assessment, is an indicator of its reliability/performance and can be used for the comparison of models through a standardised unit of measure.

## 4 List of criteria

The final hierarchical criteria structure is presented in Table 1. The question should be answered with 'yes' or 'no'. Depending on whether the answer 'yes' is positive, which means, it is an asset for an exposure model, it is coloured green (e.g. question 1). In contrast, when the answer 'yes' implies a negative aspect of an exposure model, it is coloured red (e.g. question 11, if the model is used for screening-level assessment, it is less accurate and precise).

 Table 1: Final hierarchical criteria structure used in the 4FUN framework

	Evidence		Category		Subcategory		#	Question	YES	NO
1	RELIABILITY	1.1	Validation	1.1.1	Model	1.1.1.1	1	Is the model validated for the selected purpose described in the description of the model?		
						1.1.1.2	2	Is the model's quality QA/QC documentation (e.g. black box, white box test, benchmarking against other models, etc.) available?		
						1.1.1.3	3	Does the model use (bio)monitoring data for validation?		
						1.1.1.4	4	Is during the validation process the factor predicted versus monitored identified?		
		1.2		1.2.1	Default parameters	1.2.1.1	5	Is the origin and description of the default values well described?		
			Model	1.2.2	Model developer	1.2.2.1	6	Is the model developer well identified?		
				1.2.3	Model approach	1.2.3.1	7	Does it incorporate probabilistic (stochastic) simulation capabilities?		
				1.2.4	Model range	1.2.4.1	8	Are the temporal boundary conditions well defined?		

Line of

Line

of

Evidence		Category		Subcategory		#	Question	YES	NO
					1.2.4.2	9	Are the spatial boundary conditions well defined?		
			1.2.5	Model technical and	1.2.5.1	10	Is the model used in regulatory analysis?		
				regulatory requirements	1.2.5.2	11	Is the model used for screening-level assessment?		
	1.3	Software	1.3.1	Error	1.3.1.1	12	In case of error messages, are they clear?		
	1.4	QSAR	1.4.1	QSAR	1.4.1.1	13	Are adequate QSARs used for the calculation of certain parameters?		
					1.4.1.2	14	If QSARs are used, are number and origin of the data used to define the relationships given?		
					1.4.1.3	15	If QSARs are used, are the limits given?		
	1.5	Availability	1.5.1	Source code	1.5.1.1	16	Are model statements and equations documented?		
			1.5.2	Model	1.5.2.1	17	Is the model freely available?		
					1.5.2.2	18	Is the model transparent (i.e. assumptions and limitations are easily visible) ?		
	1.6	User-Manual	1.6.1	User-Manual	1.6.1.1	19	Does the user manual include a description of the conceptual model?		
					1.6.1.2	20	Are references to the scientific literature provided?		
	1.7	Initialization	1.7.1	Initial conditions	1.7.1.1	21	Are the initial conditions well defined (i.e. The initial values of the state variables)?		
	1.8	Input parameters	1.8.1	Value specification	1.8.1.1	22	Is it clearly stated which kind of point value (mode, mean, conservative value, etc.) is required?		
2 <u>RELEVANCE</u>	2.1	Goal	2.1.1	Goal	2.1.1.1	23	Is the goal/purpose of the model documented?		

Line	of									
Evidenc	e		Category		Subcategory		#	Question	YES	NO
		2.2	Exposure population	2.2.1	Exposure population	2.2.1.1	24	Does the model cover exposure to worker (PPP: worker + operator, REACH: consumer, industrial and professional use)?		
						2.2.1.2	25	Does the model cover exposure via the general population (PPP: resident + consumer), reach: indirect via environment)?		
						2.2.1.3	26	Does the model cover exposure to subpopulations (adults, children, etc.)		
		2.3	Compartments	2.3.1	Compartments	2.3.1.1	27	Does the model calculate concentrations in ground water?		
						2.3.1.2	28	Does the model calculate concentrations in surface water?		
						2.3.1.3	29	Does the model calculate concentrations in sediment?		
						2.3.1.4	30	Does the model calculate concentrations in marine water?		
						2.3.1.5	31	Does the model calculate concentrations in soil?		
						2.3.1.6	32	Does the model calculate concentrations in pore water?		
						2.3.1.7	33	Does the model calculate concentrations in air?		
						2.3.1.8	34	Does the model calculate concentrations in the human body?		
						2.3.1.9	35	Does the model calculate concentrations in organs?		
						2.3.1.10	36	Does the model calculate concentrations in milk?		
						2.3.1.11	37	Does the model calculate concentrations in blood?		
						2.3.1.12	38	Does the model calculate concentrations in fish?		
						2.3.1.13	39	Does the model calculate concentrations in leafy crops?		

Line of	f								
Evidence		Category		Subcategory		#	Question	YES	NO
					2.3.1.14	40	Does the model calculate concentrations in root crops?		
					2.3.1.15	41	Does the model calculate concentrations in livestock?		
					2.3.1.16	42	Does the model calculate concentrations in eggs?		
					2.3.1.17	43	Does the model calculate concentrations in dairy products?		
					2.3.1.18	44	Does the model calculate concentrations in earthworms?		
	2.4	Exposure routes	2.4.1	Exposure routes	2.4.1.1	45	Does the model cover exposure by oral intake of food and drinks?		
					2.4.1.2	46	Does the model cover exposure by oral intake of soil or dust ingestion?		
					2.4.1.3	47	Does the model cover exposure through inhalation?		
					2.4.1.4	48	Does the model cover exposure by dermal absorption?		
		Environmental		Environmental					
	2.5	processes	2.5.1	processes	2.5.1.1	49	Does the model cover the run-off process?		
					2.5.1.2	50	Does the model cover leaching of substances in soil?		
					2.5.1.3	51	Does the model cover the volatilization process from water?		
					2.5.1.4	52	Does the model cover the volatilization process from vegetation?		
					2.5.1.5	53	Does the model cover the volatilization process from soil?		
					2.5.1.6	54	Does the model cover wet and dry deposition to soil?		
					2.5.1.7	55	Does the model cover wet and dry deposition to water?		

#### D2.2. List of criteria to be used for SWOT analysis

Line of						
Evidence	Category	Subcategory	#	Question	YES	NO
		2.5.1.8	56	Does the model cover wet and dry deposition to vegetation?		
		2.5.1.9	57	Does the model cover adsorption/desorption processes?		
		2.5.1.10	58	Does the model cover linear/non-linear sorption?		
		2.5.1.11	59	Does the model cover sediment burial?		
		2.5.1.12	60	Does the model cover sedimentation/resuspension?		
		2.5.1.13	61	Does the model cover biotic and abiotic degradation?		
		2.5.1.14	62	Does the model cover degradation in the air compartment?		
		2.5.1.15	63	Does the model cover degradation in the water compartment?		
		2.5.1.16	64	Does the model cover degradation in the sediment compartment?		
		2.5.1.17	65	Does the model cover degradation in the soil compartment?		
		2.5.1.18	66	Does the model cover bioconcentration of substances?		
		2.5.1.19	67	Does the model cover excretion and degradation by animals		
		2.5.1.20	68	Does the model consider different water bodies?		
		2.5.1.21	69	Does the model cover the food processing step of raw material?		
		2.5.1.22	70	Does the model cover the vegetal transpiration process?		
		2.5.1.23	71	Does the model cover transport of the substance by plant death?		

Line	of									
Evidence			Category		Subcategory		#	Question	YES	NO
						2.5.1.24	72	Does the model cover an editable transport factor of the substance at harvest of the vegetation (e.g. only roots, complete plant, etc.)?		
						2.5.1.25	73	Does the model take crop interception into consideration?		
		-				2.5.1.26	74	Does the model take irrigation into consideration?		
	2.	.6	Human processes	2.6.1	Human processes	2.6.1.1	75	Does the model cover internal absorption of substances in the human body?		
						2.6.1.2	76	Does the model cover distribution of substances in the human body?		
						2.6.1.3	77	Does the model cover biotransformation in the human body?		
						2.6.1.4	78	Does the model cover excretion from the human body?		
						2.6.1.5	79	Does the model describe bioavailability of a substance in the human body? (=passage of a substance from the site of absorption into the blood of the general circulation)		
						2.6.1.6	80	Does the model describe the linear and non-linear saturation process in the human body?		
						2.6.1.7	81	Does the model describe accumulation in the human body (i.e. the extent of accumulation reflects the relation between the body-burden compared with the steady-state condition)?		
	2.	.7	Time	2.7.1	Acute/chronic	2.7.1.1	82	Does the model cover acute exposure?		
						2.7.1.2	83	Does the model cover chronic exposure?		
		_		2.7.2	Temporal resolution	2.7.2.1	84	Is the model based on a dynamic approach?		

Line o	of								
Evidence		Category		Subcategory		#	Question	YES	NO
	2.8	Spatial resolution	2.8.1	Spatial resolution	2.8.1.1	85	Does the model cover exposure at the local scale (e.g.1km2)?		
					2.8.1.2	86	Does the model provide spatially explicit outputs (e.g. Spatial distribution of contaminant concentration in an area/region)?		
					2.8.1.3	87	Does the model cover exposure at a regional scale (e.g. The Netherlands)?		
	2.9	Metabolites	2.9.1	Formation	2.9.1.1	88	Does the model cover the formation of metabolites?		
	2.10	Substances	2.10.1	Substances	2.10.1.1	89	Is the model focused on pesticides?		
					2.10.1.2	90	Is the model focused on biocides?		
					2.10.1.3	91	Is the model focused on organics in general?		
					2.10.1.4	92	Does the model cover inorganic chemicals?		
					2.10.1.5	93	Does the model cover metals?		
					2.10.1.6	94	Can the model perform cumulative exposure assessment of multiple chemicals?		
					2.10.1.7	95	Can background concentrations (environmental and human compartments) be taken into account?		
	2.11	Releases	2.11.1	Releases	2.11.1.1	96	Does the model cover point source release?		
					2.11.1.2	97	Does the model cover wide dispersive release?		
		Plant protection		Plant protection					
	2.12	products	2.12.1	products	2.12.1.1	98	Does the model cover exposure to the bystander?		
					2.12.1.2	99	Does the model cover exposure to the surface water and air via spray drift?		

	Line of Evidence	of nce Category Subcategory # Question		Question	YES	NO				
						2.12.1.3	100	Does the model cover transport processes of PPPs to groundwater?		
						2.12.1.4	101	Does the model cover transport processes of PPPs to surface water?		
3	<u>USER</u> <u>FRIENDLINESS</u>	3.1	Input parameters	3.1.1	Input parameters	3.1.1.1	102	Can the data requirements of the model be met for EU situations?		
						3.1.1.2	103	Is the amount of input parameters limited (e.g. between 0-10)?		
						3.1.1.3	104	Is the amount of input parameters large (e.g.> 10)?		
						3.1.1.4	105	Is it possible to change the default parameters?		
						3.1.1.5	106	Are enough data inputs available for the developed model?		
		3.2	Check	3.2.1	Check	3.2.1.1	107	Is a mean available to check that all input parameters and options have been assigned values?		
						3.2.1.2	108	Is a report or summary available with the options and values defined by the user?		
		3.3	Helpdesk	3.3.1	Helpdesk	3.3.1.1	109	ls a helpdesk available?		
		3.4	Import/export	3.4.1	Import/export	3.4.1.1	110	Is communication with other software possible?		
		3.5	Manual	3.5.1	Manual	3.5.1.1	111	Is a user-manual available?		
						3.5.1.2	112	Does the user manual provide assistance in determining model parameters?		
						3.5.1.3	113	Does the user manual provide test examples?		

## Line of

Evidence			Category		Subcategory #		#	Question	YES	NO
		3.6	Repeatability - traceability	3.6.1	Repeatability - traceability	3.6.1.1	114	Is it easy to re-run a previous case study? Will the user be able to refine the same results (conservation of previous versions)?		
		3.7	Time to run the model	3.7.1	Time to run the model	3.7.1.1	115	Does the model take longer than a coffee break to run a simulation?		
3		3.8	Result accessibility	3.8.1	Result accessibility	3.8.1.1	116	Does the user have access to intermediate results (e.g. exposure estimate from individual exposure routes)?		
		3.9	Software	3.9.1	Operating system	3.9.1.1	117	Can the model run under different operating systems?		
		3.10	3.10 Model output 3.10.1 Model output 3.10.1.1 <sup>118</sup> Is it pos		Is it possible to export the output e.g. to excel, word, pdf?					
						3.10.1.2	119	Is it possible to present the output in a graphical form?		
						3.10.1.3	120	Is it possible to present the output in tabular form?		
						3.10.1.4	121	Can calculated intermediate results be overwritten by e.g. measured results ?		
						3.10.1.5	122	Are the units of measurement of the predicted output presented?		
		3.11	Optional components	3.11.1	Optional components	3.11.1.1	123	Does the model have optional components (pathways that can be switched off)?		
4	UNCERTAINTY	4.1	Output	4.1.1	Output	4.1.1.1	124	Does the model output display predicted exposure profiles and associated uncertainties?		
	4.		Method	4.2.1	Method	4.2.1.1	125	Is a scientifically sound probabilistic method used for addressing variability and uncertainty?		
		4.3	Sensitivity analyses	4.3.1	Sensitivity analyses	4.3.1.1	126	Does the model provide identification of key inputs and parameters influencing results?		

Line of Evidence		Category	Subcategory			#	Question		NO
4.4		Distribution type	4.4.1	Distribution type	4.4.1.1	127	<ul><li>Is it possible to define multiple types of probabilitient</li><li>distributions for input values?</li></ul>		
	4.5	Scenario analysis	4.5.1	Scenario analysis	4.5.1.1	128	Is it easy to test and run the model with several conditions, assumptions or mathematical approaches (more or less complex for instance)?		

## 5 Summary

In order to perform an objective and reproducible SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis of the 4FUN model and currently existing exposure models evaluation, a comprehensive list of criteria was set up to structure the assessment of the characteristics of the exposure tools.

Relevant aspects, features, functionalities related to an exposure model were identified and translated into a set of evaluation criteria, which in turn can be written as questions to be submitted to experts. These criteria were the result of a systematic review of the characteristics of exposure tools and models available in the literature, the requirements of regulatory frameworks (REACH, biocides, plant protection products) and the incorporation of expert judgement about relevant aspects for environmental exposure modelling. This resulted in a total of 128 criteria/questions.

The obtained questions are organized based on a hierarchical structure, which relates the different aspects of exposure models in a clear and solid fashion. The questions are then analysed according to a MCDA (Multi-Criteria Decision Analysis) methodology. MCDA includes a wide variety of methods for the evaluation and ranking, or selection, of different alternatives that consider all the aspects of a decision problem involving many actors.

In the assessment process, evaluators will be asked to assess the given exposure models according to the proposed criteria/questions. These evaluations will be then analysed according to a MCDA methodology and specific aggregation techniques. The result is an index obtained for each exposure model under assessment. This index is an indicator of its reliability/performance and can be used for the comparison of models through a standardised unit of measure.

By assessing the strengths and limitations of publicly available exposure models and modelling systems in regard to the needs defined for 4FUN development, the features of the various models are determined that may be further incorporated into 4FUN.

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## Annex 1

#### Table 2: 4FUN response sheet

Question	YES	NO	NOT APPLICABLE	APPLICABLE BUT NOT REPORTED	I DON'T KNOW
Is the model validated for the selected purpose described in the description of the model?					
Is the model's quality QA/QC documentation (e.g. black box, white box test, benchmarking against other models, etc.) available?					
Does the model use (bio)monitoring data for validation?					
Is during the validation process the factor predicted versus monitored identified?					
Is the origin and description of the default values well described?					
Is the model developer well identified?					
Does it incorporate probabilistic (stochastic) simulation capabilities?					
Are the temporal boundary conditions well defined?					
Are the spatial boundary conditions well defined?					
Is the model used in regulatory analysis?					
Is the model used for screening-level assessment?					
In case of error messages, are they clear?					
Are adequate QSARs used for the calculation of certain parameters?					
If QSARs are used, are number and origin of the data used to define the relationships given?					
If QSARs are used, are the limits given?					
Are model statements and equations documented?					

#### D2.2. List of criteria to be used for SWOT analysis

Question	YES	NO	NOT APPLICABLE	APPLICABLE BUT NOT REPORTED	I DON'T KNOW
Is the model freely available?					
Is the model transparent (i.e. assumptions and limitations are easily visible)?					
Does the user manual include a description of the conceptual model?					
Are references to the scientific literature provided?					
Are the initial conditions well defined (i.e. The initial values of the state variables)?					
Is it clearly stated which kind of point value (mode, mean, conservative value, etc.) is required?					
Is the goal/purpose of the model documented?					
Does the model cover exposure to worker (PPP: worker + operator, REACH: consumer, industrial and professional use)?					
Does the model cover exposure via the general population (PPP: resident + consumer), reach: indirect via environment)?					
Does the model cover exposure to subpopulations (adults, children, etc.)					
Does the model calculate concentrations in ground water?					
Does the model calculate concentrations in surface water?					
Does the model calculate concentrations in sediment?					
Does the model calculate concentrations in marine water?					
Does the model calculate concentrations in soil?					
Does the model calculate concentrations in pore water?					
Does the model calculate concentrations in air?					
Does the model calculate concentrations in the human body?					
Does the model calculate concentrations in organs?					
Does the model calculate concentrations in milk?					

Question	YES	NO	NOT APPLICABLE	APPLICABLE BUT NOT REPORTED	I DON'T KNOW
Does the model calculate concentrations in blood?					
Does the model calculate concentrations in fish?					
Does the model calculate concentrations in leafy crops?					
Does the model calculate concentrations in root crops?					
Does the model calculate concentrations in livestock?					
Does the model calculate concentrations in eggs?					
Does the model calculate concentrations in dairy products?					
Does the model calculate concentrations in earthworms?					
Does the model cover exposure by oral intake of food and drinks?					
Does the model cover exposure by oral intake of soil or dust ingestion?					
Does the model cover exposure through inhalation?					
Does the model cover exposure by dermal absorption?					
Does the model cover the run-off process?					
Does the model cover leaching of substances in soil?					
Does the model cover the volatilization process from water?					
Does the model cover the volatilization process from vegetation?					
Does the model cover the volatilization process from soil?					
Does the model cover wet and dry deposition to soil?					
Does the model cover wet and dry deposition to water?					
Does the model cover wet and dry deposition to vegetation?					
Does the model cover adsorption/desorption processes?					
Does the model cover linear/non-linear sorption?					
Does the model cover sediment burial?					
Does the model cover sedimentation/resuspension?					
Does the model cover biotic and abiotic degradation?					

Question	YES	NO	NOT APPLICABLE	APPLICABLE BUT NOT REPORTED	I DON'T KNOW
Does the model cover degradation in the air compartment?					
Does the model cover degradation in the water compartment?					
Does the model cover degradation in the sediment compartment?					
Does the model cover degradation in the soil compartment?					
Does the model cover bioconcentration of substances?					
Does the model cover excretion and degradation by animals					
Does the model consider different water bodies?					
Does the model cover the food processing step of raw material?					
Does the model cover the vegetal transpiration process?					
Does the model cover transport of the substance by plant death?					
Does the model cover an editable transport factor of the substance at harvest of					
the vegetation (e.g. only roots, complete plant, etc.)?					
Does the model take crop interception into consideration?					
Does the model take irrigation into consideration?					
Does the model cover internal absorption of substances in the human body?					
Does the model cover distribution of substances in the human body?					
Does the model cover biotransformation in the human body?					
Does the model cover excretion from the human body?					
Does the model describe bioavailability of a substance in the human body? (=					
passage of a substance from the site of absorption into the blood of the general					
circulation)					
Does the model describe the linear and non-linear saturation process in the					
human body?					
Does the model describe accumulation in the human body (i.e. the extent of					
accumulation reflects the relation between the body-burden compared with the					
steady-state condition)?					
Does the model cover acute exposure?					

Question	YES	NO	NOT APPLICABLE	APPLICABLE BUT NOT REPORTED	I DON'T KNOW
Does the model cover chronic exposure?					
Is the model based on a dynamic approach?					
Does the model cover exposure at the local scale (e.g.1km2)?					
Does the model provide spatially explicit outputs (e.g. Spatial distribution of contaminant concentration in an area/region)?					
Does the model cover exposure at a regional scale (e.g. The Netherlands)?					
Does the model cover the formation of metabolites?					
Is the model focused on pesticides?					
Is the model focused on biocides?					
Is the model focused on organics in general?					
Does the model cover inorganic chemicals?					
Does the model cover metals?					
Can the model perform cumulative exposure assessment of multiple chemicals?					
Can background concentrations (environmental and human compartments) be taken into account?					
Does the model cover point source release?					
Does the model cover wide disperive release?					
Does the model cover exposure to the bystander?					
Does the model cover exposure to the surface water and air via spray drift?					
Does the model cover transport processes of PPPs to groundwater?					
Does the model cover transport processes of PPPs to surface water?					
Can the data requirements of the model be met for EU situations?					
Is the amount of input parameters limited (e.g. between 0-10)?					
Is the amount of input parameters large (e.g.> 10)?					
Is it possible to change the default parameters?					
Are enough data inputs available for the developed model?					

#### D2.2. List of criteria to be used for SWOT analysis

Question	YES	NO	NOT APPLICABLE	APPLICABLE BUT NOT REPORTED	I DON'T KNOW
Is a mean available to check that all input parameters and options have been assigned values?					
Is a report or summary available with the options and values defined by the user?					
Is a helpdesk available?					
Is communication with other software possible?					
Is a user-manual available?					
Does the user manual provide assistance in determining model parameters?					
Does the user manual provide test examples?					
Is it easy to re-run a previous case study? Will the user be able to refind the same results (conservation of previous versions)?					
Does the model take longer than a coffee break to run a simulation?					
Does the user have access to intermediate results (e.g. exposure estimate from individual exposure routes)?					
Can the model run under different operating systems?					
Is it possible to export the output e.g. to excel, word, pdf?					
Is it possible to present the output in a graphical form?					
Is it possible to present the output in tabular form?					
Can calculated intermediate results be overwritten by e.g. measured results?					
Are the units of measurement of the predicted output presented?					
Does the model have optional components (pathways that can be switched off)?					
Does the model output display predicted exposure profiles and associated					
uncertainties?					
Is a scientifically sound probabilistic method used for addressing variability and uncertainty?					
Does the model provide identification of key inputs and parameters influencing results?					
results?					

#### D2.2. List of criteria to be used for SWOT analysis

Question	YES	NO	NOT APPLICABLE	APPLICABLE BUT NOT REPORTED	I DON'T KNOW
Is it possible to define multiple types of probability distributions for input values?					
Is it easy to test and run the model with several conditions, assumptions or mathematical approaches (more or less complex for instance)?					