EFSA Journal 20xx; volume(issue):xxxx

SCIENTIFIC OPINION

DRAFT Guidance for evaluating and using results of field persistence and soil accumulation experiments for exposure assessment of soil organisms to substances in soil

[1]

EFSA Panel on Plant Protection Products and their Residues (PPR)[2, 3]

European Food Safety Authority (EFSA), Parma, Italy

ABSTRACT

The European Commission asked the Panel to revise the Guidance Document on persistence in soil (SANCO/9188VI/1997 of 12 July 2000). Therefore the Panel started the development of a revised methodology for the assessment of exposure of soil organisms. This opinion provides guidance on how to derive the half-life for degradation in the top 30 cm of soil at reference temperature and moisture conditions (ie 20^{o}C and field capacity) from the results of field and laboratory experiments. This half-life is an important input parameter in model simulations of the exposure of organisms in soil and therefore this guidance is an important part of this revised methodology. The Panel recommends evaluating field persistence experiments with models assuming a biphasic decline and taking only the slow phase of this decline, taken to represent degradation in the soil matrix rather than loss processes from the soil surface, into account for estimating this half-life. The Panel proposes basing the relevant population of half-lives for a certain soil exposure scenario on the assumption that a half-life measured for any non-volcanic agricultural soil from temperate regions can be used to predict the half-life for any such soil within the EU. The aim is to estimate the geomean half-life of this relevant population. The Panel considers it necessary to include the uncertainty resulting from the sample size of the population in the estimation of this geomean. If the relevant population of half-lives for a certain exposure scenario consists of a mixture of values obtained in the laboratory and in the field, the Panel recommends rejecting the laboratory values only if the null hypothesis that laboratory and field half-lives are equal is rejected. The Panel considers this guidance proposal also useful for assessment half-lives to be used in scenario calculations on leaching to groundwater and surface water. For future field persistence studies, the Panel recommends incorporating the plant protection product to a depth of about 10 cm in soil immediately after application.

---

[1] On request [from [requesting party] [OR] of EFSA], Question No EFSA-Q-YYYY-NNNNN, adopted on DD Month YYYY.

[2] Panel members [OR] Scientific Committee members: name surname, name surname and name surname. [In case of minority opinion(s), please add:] [Part of this/This] Opinion is not shared by the following members of the Panel: name surname, name surname and name surname. [names of Panel member(s) with minority opinion] [In case of identified conflict(s) of interest, please add:] x [number written in words, e.g. Three] members of the Panel did not participate in [part of] the discussion on the subject referred to above because of potential conflicts of interest identified in accordance with the EFSA policy on declarations of interests. Correspondence: unit-acronym@efsa.europa.eu

[3] [If applicable] Acknowledgement: EFSA wishes to thank the members of the Working Group / Network on [name of the WG / Network] for the preparation of this opinion: name surname, name surname and name surname [names of members of WG and external experts] and EFSA's staff member(s) XXX for the support provided to this EFSA scientific output.

Suggested citation: EFSA Panel on ; DRAFT Guidance . EFSA Journal 20xx; volume(issue):xxxx. [40 pp.]. doi:10.2093/j.efsa.20NN.NNNN. Available online: www.efsa.europa.eu

KEY WORDS

field persistence, degradation, half-life, accumulation, exposure, soil organisms

SUMMARY

The Scientific Panel on Plant Protection Products and their Residues (PPR Panel) of EFSA was asked in November 2007 by EFSA to prepare a revision of the Guidance Document on persistence in soil (SANCO/9188VI/1997 of 12 July 2000). This revision will consist of a tiered exposure assessment for organisms in soil based on scenarios for analytical and numerical models (EFSA, 2010). In this exposure assessment, degradation parameters derived from field persistence and soil accumulation experiments are important input parameters for the numerical models. Therefore this opinion aims to provide guidance on best practice for using the results of field experiments and soil accumulation studies in the exposure assessment of organisms in soil.

The half-life for degradation in the top 30 cm of soil at 20^{o}C and pF = 2 is an important input parameter for numerical models that simulate exposure of organisms in soil. For soil under conventional or reduced tillage, the main use of this half-life is to simulate the degradation rate for soil depths between 1 and 30 cm. When deriving such a half-life from field persistence and soil accumulation experiments, appropriate measures have to be taken to ensure that the value obtained is not influenced strongly by processes in the top millimetres of soil.

Based on current knowledge and data commonly available in dossiers of plant protection products, it is impossible to estimate with enough certainty photodegradation rates of plant protection products in the top millimetres in soil. Studies with sieved soils in the laboratory demonstrate that photodegradation is limited to the top 2 mm of soil. Furthermore there are uncertainties assessing volatilisation for surface-applied compounds.

Current numerical models used for simulating behaviour of plant protection products in soil in the context of the EU regulatory exposure assessment are unable to describe satisfactorily the daily fluctuations of the soil temperature and of the volume fraction of water in the top millimetres of soil.

The parameters describing the relationship between on the one hand the degradation rate coefficient in soil and on the other hand soil temperature (ie the Arrhenius activation energy) or volume fraction of water in soil (ie the exponent *B*) show a considerable variation between soils and plant protection products. This uncertainty results in a considerable uncertainty in the degradation half-life within the top 30 cm of soil obtained from field experiments by inverse modelling assuming default values of the Arrhenius activation energy and the exponent *B*.

Assessment of degradation half-lives in the top 30 cm of soil derived from field persistence experiments can be based on inverse modelling using the approach of normalised decline curves proposed by FOCUS (2006). The normalised decline curves can be either described with the DFOP (double first-order kinetics in parallel) or Hockey-Stick models.

The Panel considers soil accumulation experiments with only two or three soil samplings per year not suitable for estimating the degradation half-life in the top 30 cm of soil because the fraction of the dosage that penetrates to soil depths deeper than a few millimetres cannot be estimated with sufficient accuracy.

Once appropriate degradation half-lives from laboratory and field experiments are available, the estimation of the half-life to be used as input for the required exposure scenario consists of two more steps: (i) assess the relevant population of half-life values for the required exposure scenario, and (ii) estimate reliably the required statistical attribute (certain percentile or some mean value) based on this population. The Panel proposes to base the relevant population of half-lives on the assumption that a half-life measured for any non-volcanic agricultural soil from temperate regions can be used to predict the half-life for any such soil within the EU. This assumption is a working hypothesis that has to be underpinned further. The type of attribute has to be consistent with the scenario-selection procedure

which was based on taking the geomean half-life assuming a log-normal distribution. So the Panel recommends taking the geomean half-life. The estimation of the geomean half-life of the population has to consider the uncertainty resulting from the limited number of samples in the sample population.

If the relevant population of half-lives for a certain exposure scenario consists of a mixture of values obtained in the laboratory and in the field, the Panel recommends excluding the laboratory values only if the null hypothesis that laboratory and field values are equal is rejected. If the relevant population of half-lives for a certain exposure scenario consists of less than four values based on field experiments, the Panel recommends using both laboratory and field values for estimating the geomean.

The Panel considers the guidance proposals for estimating half-lives also useful for assessment of leaching to groundwater and surface water because the main use of the half-lives in these groundwater and surface water scenarios is the same as for the soil exposure assessment considered in this opinion (ie simulating the degradation rate for soil depths between 1 and 30 cm).

The Panel recommends compiling a database of all relevant and reliable half-lives of agricultural top soils within the temperate regions at 20^{o}C and pF = 2 to test the assumption that this half-life does not vary systematically between geographical zones in the temperate regions for non-volcanic soils.

In case the notifier wants to use results of field persistence studies for estimating the half-life in the top 30 cm of soil as an input parameter for exposure models, the Panel recommends incorporating the plant protection product to a depth of about 10 cm into the soil immediately after application.

The Panel recommends improving the validation status of mechanistic models for simulating loss processes at the soil surface (especially for photodegradation and volatilisation).

TABLE OF CONTENTS

BACKGROUND AS PROVIDED BY EFSA

During the review process of the substances of the second list, several concerns were raised regarding the Guidance Document on persistence in soil. A number of Member States have expressed interest in a revision of the current Guidance Document on persistence in soil during the general consultation of Member States on Guidance Documents in answer to the request by the Director of Sciences of EFSA in a letter dated 3 July 2006 sent *via* the Standing Committee on the Food Chain and Animal Health. Furthermore, the EFSA PRAPeR Unit has noted that the Guidance Document needs to be brought in line with the FOCUS degradation kinetics report (SANCO/100058/2005, version 2.0, June 2006).

FOCUS (1997) developed the first guidance at EU level for exposure assessment in soil. This included a simple approach for estimating PEC_{SOIL} but FOCUS (1997) did not develop first-tier scenarios (in contrast to subsequent FOCUS workgroups that developed such scenarios for surface water and groundwater as development of soil scenarios was a lower priority at that time). FOCUS (2006) developed detailed guidance on estimating degradation rate parameters from laboratory and field studies, but did not develop exposure scenarios. Nevertheless there is a need for such scenarios in view of ongoing discussions in PRAPeR experts' groups regarding PEC_{SOIL} as current approaches at EU level only represent the range of climatic conditions covered by available field dissipation and/or accumulation studies, and Member States would like tools to be able to extrapolate to a wider range of climates present in the EU.

The existing Guidance Document on Persistence in Soil (9188/VI/97 rev 8) published in 2000 did not include scenarios. The intention with the new guidance document is to update the existing Guidance Document on Persistence in Soil to include European exposure scenarios for soil and to provide guidance on best practice for using the results of field experiments and soil accumulation studies in the exposure assessment.

The revision will not include guidance that is in the existing guidance document but has been replaced by newer guidance e.g. in FOCUS (2006). Some parts of the current guidance will not be considered in the revision, e.g. for soil-bound residues, as these sections are better dealt with separately. The revision will also exclude risk-management guidance and hazard cut-offs e.g. PBT classification as this is not within the mandate given to EFSA.

Member States and stakeholders have been and will be consulted through web-conferences and stakeholder workshops to collect comments during the revision of the Guidance Document.

TERMS OF REFERENCE AS PROVIDED BY EFSA

The Scientific Panel on Plant Protection Products and their Residues (PPR Panel) of EFSA was asked in November 2007 by EFSA to prepare a revision of the Guidance Document on persistence in soil (SANCO/9188VI/1997 of 12 July 2000).

1. Introduction

1.1. Role of field persistence and soil accumulation experiments in the tiered exposure assessment

EFSA (2010a) proposed a tiered approach for the assessment of exposure of organisms to plant protection products[4] in soil after spray applications in annual crops under conventional and reduced tillage. Its purpose is to assess the all-time high (either peak or TWA values) of the spatial 90th percentile concentration resulting from the use of the plant protection product and considering the population of agricultural fields (in one of the three regulatory zones North-Centre-South) where the crop is grown in which this plant protection product is applied (assuming a fraction of the target crop treated of 100%). The tiered approach consists of six tiers, of which five are based on calculations with simple or numerical models (Figure 1; see EFSA, 2010a, for further details of the tiers).

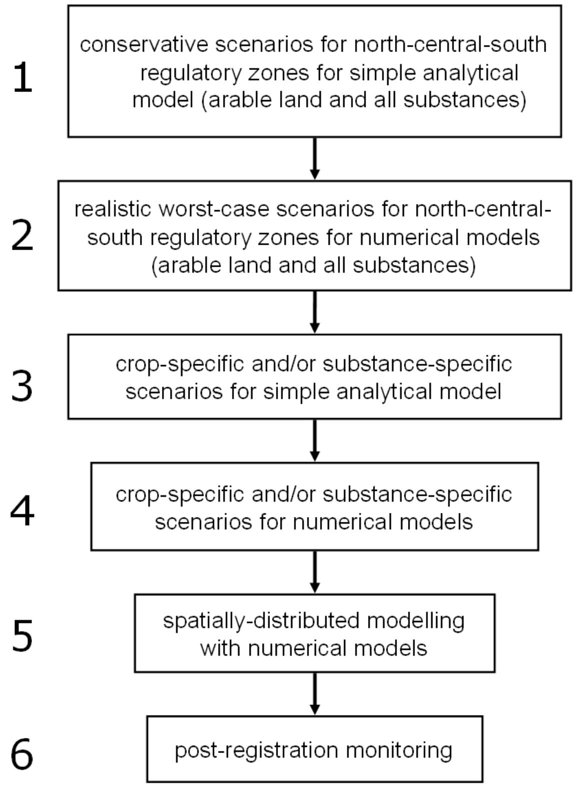

Figure 1: Tiered scheme for the exposure assessment of soil organisms in annual crops with conventional or reduced tillage after spray applications (taken from EFSA, 2010a).

For the exposure assessment in soil, the degradation[5] half-life (*DegT50*) in top soil at 20°C and field capacity (pF = 2) is an important input parameter of the simple and numerical models used in Tiers 1 to 5 (Figure 1). In a dossier there will be usually four laboratory studies on the degradation rate. Annex II to Council Directive 91/414/EC requires four field persistence studies if the degradation half-life (*DegT50*) in top soil at 20°C at pF = 2-2.5 exceeds 60 days. As a consequence, for many plant

---

[4] In the context of this opinion, the term ‘plant protection products’ is used for both the applied formulation and the active substances themselves.

[5] The Panel uses in this opinion the definition of ‘degradation’ (which includes transformation) as suggested by FOCUS (2006).

protection products there are additionally four field persistence studies. For persistent compounds (time needed for 90% dissipation in the field longer than 1 year) there may be additionally one or two soil accumulation studies. In principle all these studies may generate *DegT50* values. EFSA (2010a) proposed basing the estimation of the *DegT50* on a stepped approach (Figure 2) for all relevant tiers: (i) considering only values from laboratory studies, (ii) including also values from field persistence studies and (iii) including additionally values from soil accumulation studies. This is done because field persistence studies and soil accumulation studies may provide more realistic estimates of this half-life than the laboratory studies.

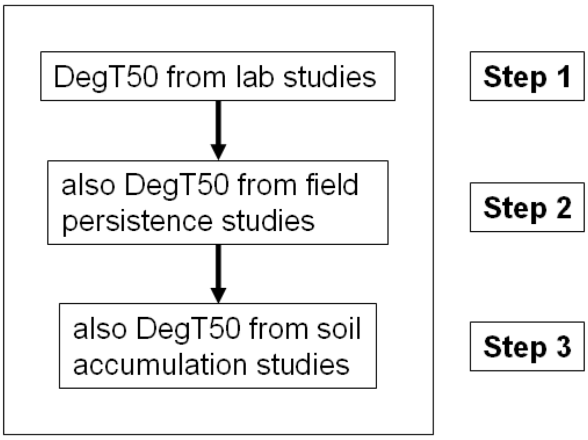

Figure 2: Schematic representation of stepped approach for estimating the *DegT50* in the soil to be used in the tiered exposure assessment (EFSA, 2010a).

It has long been known (Anderson, 1987) that the viability of soil microbial populations decreases with time in laboratory studies. Therefore OECD (2002b) recommended restricting the duration of laboratory studies to 120 days. So field studies may be better suited to measure the degradation rate of persistent substances. A substantial proportion of the parent molecules and metabolites of plant protection products registered at EU level may be so persistent that study duration of 120 days is too short for a good measurement of the degradation rate. As will be explained in detail below, the procedure for estimating the *DegT50* of top soil at 20°C and pF = 2 from field studies is more complicated and has more uncertainties than that from laboratory studies. The Panel proposes to handle these uncertainties by developing procedures based on scientifically conservative methodologies. Conservative is defined in the context of this opinion defined as ‘on the safe side with respect to the risk assessment’. For the tiered exposure assessment of Figure 1, the safe side means higher concentrations. In general, a longer *DegT50* leads to higher exposure concentrations, so a conservative methodology is defined in this opinion as a methodology that generates a *DegT50* that is longer than the true value in case of uncertainties. However, a longer *DegT50* of a parent substance may lead to lower concentrations of soil metabolites. Therefore the proposed guidance in this opinion is restricted to the exposure assessment of parent compounds. For the exposure assessment of soil metabolites, the Panel recommends a case-by-case approach.

Considering a certain exposure scenario in Figure 1, the first step is to select the relevant population of experiments to be included in the estimation of the *DegT50* value for the required exposure scenario. For example, a *DegT50* value at 20°C and pF = 2 derived from a field experiment on a heavy clay soil with 10% of organic matter in Finland may perhaps not be considered relevant for estimating the *DegT50* value at 20°C and pF = 2 for a sandy soil with 1% of organic matter in Spain. Once the relevant population of *DegT50* values has been defined, the question is how to derive the DegT50 value to be used in the exposure assessment from this population. EFSA (2010a) indicated that the *DegT50* should be part of the scenario-selection procedure. EFSA (2010b) developed this scenario selection procedure and they selected scenarios assuming that the median *DegT50* will be used as the input to the scenario calculations. FOCUS (2006; p. 234) recommended using the geometric mean of the *DegT50* values based mainly on the argument that taking the geomean of a number of rate coefficients will give the same result as taking the geomean of the corresponding half-lives. The Panel proposes to use the geomean of the relevant *DegT50* values and considers this to be in line with both EFSA (2010b) and FOCUS (2006) because the median is considered to be a good estimator for the geomean for lognormal distributions (such a distribution is commonly assumed the best guess for quantities that cannot be negative such as the *DegT50*).

As described by EFSA (2010a), there is a complication with respect to the estimation of the individual *DegT50* values from field persistence studies. These *DegT50* values will be used to simulate long-term accumulation of plant protection products with ploughing up to 20 cm depth every year. So they have to reflect the degradation rate within the soil matrix. Field dissipation studies regularly show a fast initial decline (Walker et al., 1983). Immediately after application, the plant protection product is concentrated in the top millimetres of the soil. For example, an application of 1 kg active substance in 250-500 L water per hectare gives a content of 500-1000 mg/kg of this substance in the top 0.1-0.2 mm of soil. In the top millimetres of soil, loss processes other than degradation within the soil matrix may play a significant role (volatilisation, photochemical degradation, runoff etc.). So it has to be ensured that the estimated *DegT50* is not influenced by these loss processes. Additionally, it is not clear whether the degradation rate within the soil matrix in these top millimetres can be safely extrapolated to estimate the degradation rate at depths between 1 and 30 cm (see Chapter 2). Therefore a procedure is needed that ensures that the *DegT50* derived from field persistence studies reflects the degradation rate within the soil matrix between 1 and 30 cm depth with sufficient accuracy. This *DegT50* within the soil matrix in the 1-30 cm layer of soil will be further called $DegT50_{matrix}$. Thus the measured decline has to be split into two parts, one reflecting the behaviour in the top millimetres and the other reflecting the behaviour in deeper soil.

This interpretation problem with respect to the decline in the top millimetres applies also to soil accumulation studies. However, for these studies there is an additional complication. They may contain only two to three samplings per year and the plant protection product may have been sprayed on a full-grown crop. In such a situation it may be difficult to estimate the fraction of the dose that eventually penetrated the soil. This may complicate an accurate estimation of the $DegT50_{matrix}$ from soil accumulation studies. So also here a procedure is needed to ensure that the *DegT50* derived from soil accumulation studies reflects the degradation rate within the soil matrix between 1 and 30 cm depth.

This interpretation problem is relevant for soil exposure assessments in which the concentration endpoint has to be based on multi-year simulations and in which a significant fraction of the dosage penetrates to below 1 cm depth (either by leaching or by soil tillage). This is the case for the soil exposure assessment under conventional and reduced tillage and by definition for the leaching assessment. The relevance of this problem for the soil exposure assessment for no-tillage systems and for permanent crops is not yet clear. This can only be clarified after tiered exposure approaches for no-tillage systems and for permanent crops (similar to the one in Figure 1) have been defined.

This interpretation problem is of no importance if the plant protection product is incorporated into the top 10 cm of soil immediately after application. However, this is not common practice in the field persistence studies available in the dossiers. It is not clear whether incorporation is a solution also for the no-tillage systems because the tiered approach for the no-tillage systems has not yet been defined.

At this moment the only guidance to address this interpretation problem is the bullet list on p. 177 of FOCUS (2006). This list describes only in very general terms how to handle initial loss processes.

This leads in current EU regulatory practice to rejection of a substantial proportion of the field persistence studies.

1.2. Aims of this guidance proposal

In view of the foregoing, the aims of this guidance proposal are:

(i) to develop procedures for estimating $DegT50_{matrix}$ values reliably from results of individual field persistence and soil accumulation experiments

(ii) to develop procedures for assessing the relevant population of $DegT50_{matrix}$ values for the required exposure scenario

(iii) to develop procedures for estimating reliably the geomean of the relevant population of $DegT50_{matrix}$ values for the required exposure scenario.

As described in Section 1.1, procedures will have to be developed for splitting the measured decline found in field persistence studies into the two parts. These procedures will generate as spin-off information on losses from the top millimetres of soil under field conditions (eg due to photodegradation or volatilisation). It may be relevant to take this information into account in the exposure assessment. Therefore the Panel aims at additionally developing procedures for using this information in the exposure assessment. This aim can be split up (in analogy with the guidance for the $DegT50_{matrix}$) into:

(i) to develop procedures for estimating top-soil decline parameters reliably from results of individual field persistence and soil accumulation experiments

(ii) to develop procedures for assessing the relevant population of top-soil decline parameters values for the required exposure scenario

(iii) to develop procedures for estimating reliably the endpoint of the top-soil decline parameters for the required exposure scenario from the relevant population of values.

The processes underlying these top-soil declines were not included in the scenario-selection procedure by EFSA (2010b). Therefore the Panel considers it not justifiable to use, for example, geomean or median values of the top-soil decline parameters. Instead this endpoint of the top-soil decline parameters should be a kind of worst case.

1.3. Bird’s eye view of opinion

Chapter 2 describes the background of the problems of using measured declines in the top millimetres of soil for estimating the $DegT50_{matrix}$ and provides a proposal for the solution of these problems. This proposal is the basis for the guidance for evaluating results from field persistence studies described in Chapter 3. The Panel made an attempt to develop guidance for soil accumulation studies but this proved not to be feasible (Chapter 4). The next step is to use the available and relevant information from all laboratory and field studies for the exposure assessment in the required scenario (Chapter 5). Finally, the Panel considers the possible usefulness of the developed proposals for another purpose, ie the assessment of leaching to groundwater at EU level (Chapter 6).

2. Background of the problems of estimating the *DegT50*$_{matrix}$ from measured declines after spraying onto bare soil in field persistence studies and a proposed solution

2.1. Introduction to the problem

FOCUS (2006) proposed a procedure to derive *DegT50*$_{matrix}$ values at 20^{o}C and pF = 2 from field persistence studies via inverse modelling procedures. This procedure is the current guidance for extracting this *DegT50*$_{matrix}$ value from field persistence studies which has been applied widely in the EU exposure assessments. However, the Panel has serious reservations with respect to this procedure. These reservations are explained below.

Let us first explain the principles of this inverse modelling procedure. It is generally recognised that the degradation rate in soil is a function of soil moisture, soil temperature and soil depth (FOCUS, 2000a). So any *DegT50*$_{matrix}$ is a function of these three soil properties. The relationship between *DegT50*$_{matrix}$ and soil moisture content is commonly described by an empirical equation (Walker, 1974):

$$DegT50_{matrix} = DegT50_{matrix,FC}\left(\frac{\theta}{\theta_{FC}}\right)^{-B} \quad (1)$$

where

'*FC*' = at field capacity, i.e. matric suction of 100 hPa or pF = 2

θ = volume fraction of water in soil (m^3/m^3)

B = moisture-dependency parameter (-).

The relationship between *DegT50*$_{matrix}$ and soil temperature is commonly described with the Arrhenius equation (eg EFSA, 2008) and thus characterised by an Arrhenius activation energy:

$$DegT50_{matrix} = DegT50_{matrix,20Celsius}\exp\left(\frac{E_a}{R}\left[\frac{1}{T}-\frac{1}{T_{ref}}\right]\right) \quad (2)$$

where

E_a = Arrhenius activation energy (kJ/mol)

R = gas constant (0.008314 kJ K^{-1} mol^{-1})

T = soil temperature (K)

T_{ref} = reference soil temperature (20^{o}C = 293.15 K)

The relationship between *DegT50*$_{matrix}$ and soil depth is described by:

$$DegT50_{matrix} = \frac{DegT50_{matrix,\,top soil}}{f_z} \quad (3)$$

where

DegT50$_{matrix,\ top\ soil}$ = *DegT50*$_{matrix}$ of the top 30 cm of soil

f_z = depth parameter (-).

FOCUS (2000a) recommended using $f_z = 1$ for the layer 0-30 cm, $f_z = 0.5$ for the layer 30-60 cm, and $f_z = 0.3$ for the layer 60-100 cm.

It is commonly assumed that the effects of these three soil properties act independently of each other which results in:

$$DegT50_{matrix} = DegT50_{matrix,20Celsius,FC,topsoil} \left(\frac{\left(\frac{\theta}{\theta_{FC}}\right)^{-B}}{f_z} \exp\left(\frac{E_a}{R}\left[\frac{1}{T} - \frac{1}{T_{ref}}\right]\right) \right) \tag{4}$$

When analysing results of field persistence experiments, the inverse of Eqn 3 is more relevant:

$$DegT50_{matrix,20Celsius,FC,topsoil} = DegT50_{matrix} \; f_z \left(\frac{\theta}{\theta_{FC}}\right)^{B} \exp\left(\frac{E_a}{R}\left[\frac{1}{T_{ref}} - \frac{1}{T}\right]\right) \tag{5}$$

For scenario calculations with numerical models, the agreed convention is to specify this $DegT50_{matrix}$ of the top 30 cm of soil at a reference temperature of 20°C and a matric potential of pF = 2 (ie a matric suction of 100 hPa) and to simulate the substance behaviour in soil based on default values for the relationships between on the one hand the $DegT50_{matrix}$ and on the other hand soil moisture, soil temperature and soil depth. Usually most of the plant protection product and of its soil metabolites will remain in the top 30 cm during the field persistence experiment so the depth-dependency of the degradation rate is not considered to have an appreciable role. The moisture content and the temperature of the soil vary of course with time in field persistence experiments. Thus the $DegT50_{matrix}$ has to be calculated back via some inverse modelling procedure to the reference conditions 20°C and pF = 2. Only after this back calculation can the $DegT50_{matrix}$ be compared with $DegT50_{matrix}$ values from the laboratory studies at the same reference conditions. So the $DegT50_{matrix}$ derived from the field experiments is not a direct measurement but may be 'contaminated' by a number of problems resulting from the inverse modelling procedure. The Panel identified several problems that undermine the soundness of this inverse modelling procedure:

(1) it is difficult to exclude loss due to photodegradation from the top millimetres with enough certainty based on current knowledge;

(2) the inverse modelling usually is based on default values for the parameter B and the E_a which may lead to large errors in estimated values of the $DegT50_{matrix}$ at 20°C and pF = 2;

(3) the numerical models commonly used in the inverse modelling procedure (eg PELMO and PEARL) have not been designed to simulate accurately temperature, moisture content and degradation rate in the top millimetres.

These problems are described in more detail in the following sections.

2.2. Difficulties with quantifying photodegradation and volatilisation losses at the soil surface

Photodegradation losses

The Panel considers current knowledge is insufficient to quantify photodegradation rates in the top millimetres of soil under the range of field conditions to be expected in the EU. OECD (2002a) developed a guideline for measuring soil photolysis in the laboratory. This study has become a standard data requirement for plant protection products. However, the Panel is not aware of studies in which photolysis rates measured under field conditions have been tested for a range of plant protection products and soils against predictions of numerical models based on measurements from this OECD guideline. This OECD study is commonly considered to be a ‘route study’ rather than a ‘rate study’, ie it is considered suitable for identifying photometabolites that are formed at the soil surface but it has not been designed to generate photodegradation rates that can be used to predict such rates under field conditions. The Panel recommends improving the validation status of mechanistic models for simulating photodegradation rates at the soil surface.

Light is efficiently absorbed by soil in a wavelength dependent manner (Tester & Morris, 1987). Sometimes it is argued in dossiers that absence of absorption of light from wavelengths from 295 to 800 nm due to shielding by the soil (derived from the or due to the lacking overlap of the sunlight emission spectrum with the absorption spectrum of the substance molecule) indicates that the substance will not be photodegraded on soil surfaces in the field. It is obvious that the absence of absorption of light indicates that direct photolysis of a substance does not occur. However, in surface water there is ample evidence for indirect photolysis. For instance, dissolved humic substances are efficient photosensitizers in surface waters (Miller & Chin, 2002) and may also act as photocatalysts in top soil both in the solid and the liquid phase (i.e. in soil pore water). The Panel considers therefore that indirect photolysis may also occur in the top millimetres of soil because also soil may contain molecules that can act as a catalyst for the photodegradation process. So absence of light absorption cannot be used to exclude photodegradation.

As there is always sunlight in field experiments, these considerations imply that losses from the top millimetres can never be simply attributed to degradation within the soil matrix.

Ciani et al. (2005) found that light penetrated no deeper than 0.2 mm into pellets consisting of a mixture of soils and barium sulphate. Soil photolysis studies with sieved soils indicated that direct and indirect photolysis is usually limited to the top 2 mm of soil (Hebert & Miller, 1990; Frank et al., 2002). These studies were done with soil surfaces that are prepared in the laboratory with sieved soil (mesh of 0.5 mm) as flat as possible (like a plane sheet). In field persistence studies, the soil is usually rolled before application of the plant protection product (B. Gottesbüren, personal communication, 2010). Zhixiong et al. (2005) measured the surface roughness of a rolled Dutch loamy soil and found an average standard deviation of the surface height of 6 mm (the range was between 4 and 8 mm using measurements over lengths varying from 0.5 to 5 m and using different angles of measurement). Zobeck & Onstad (1987) reviewed rainfall and tillage effects on the so-called random roughness of the soil surface. This random roughness is defined as the standard error of individual soil elevations after oriented roughness has been removed. The lowest value of the random roughness in their review is about 5 mm (for a no-tillage system). A rolled soil surface is expected to give a low value of the surface roughness. So this minimum value is consistent with the measurement by Zhixiong et al. (2005). In view of this surface roughness of rolled soil it is not clear whether the photolysis will be limited to the top 2 mm of a rolled field soil and it will be difficult to define the level of the soil surface accurately at a millimetre scale.

Volatilisation losses

It would be helpful for the interpretation of field persistence experiments if volatilisation losses could be excluded on the basis of the properties of the substance. FOCUS (2008) proposed a trigger value of the vapour pressure of > 10^{-4} Pa (20°C) to check whether a substance has the potential to reach the air. However, Smit et al. (1997) collected volatilisation measurements from literature and they showed that measured volatilisation losses from soil are not well correlated to the saturated vapour pressure. Instead, these are better correlated to the fraction of the pesticide calculated to be present in the gas phase. For the evaluation of field persistence experiments, it is sufficient that the volatilisation loss is less than about 5%. Data from Smit et al. (1997) indicate that this requirement is met if the fraction in the gas phase is less than about 10^{-8}. The criteria from FOCUS (2008) and Smit et al. (1997) are based on different properties of the soil-substance system. So for part of the substance-soil systems the vapour pressure may be below 10^{-4} Pa (20°C) whereas the fraction in the gas phase is higher than 10^{-8}. Simulations with numerical models cannot solve this problem as they are at the moment insufficiently accurate for low volatile substances (Ferrari et al., 2003). The Panel recommends improving the validation status of mechanistic models for simulating volatilisation of spray applications at the soil surface.

2.3. Uncertainties resulting from the use of default values of B and E_a

The inverse modelling procedure uses default values of B for the moisture dependency relationship and of E_a for the temperature relationship. Let us first consider B. FOCUS (2000a) recommends using a default B value of 0.7 based on Gottesbüren (1991). However, Gottesbüren (1991) reported 94 B values and these show considerable variability (minimum of 0.03 and maximum of 2.9); ten of these 94 are above 1.5. Figure 3 shows that a B value of 1.5 in air-dry soil (θ / θ_{FC} of about 0.1) will lead to a $DegT50_{matrix}$ that is ten times longer than the default B value of 0.7. So when an inversely modelled $DegT50_{matrix}$ would have been mainly based on the decline in dry soil for a system with a true B value of 1.5, this would lead to a $DegT50_{matrix,FC}$ that is much too long as follows from the following example calculation:

(i) observed $DegT50_{matrix}$ = 50 d in field

(ii) actual θ / θ_{FC} in field of 0.1

(iii) inversely modelled $DegT50_{matrix,FC}$ = 2 d, based on true B of 1.5 using Eqn 5

(iv) inversely modelled $DegT50_{matrix,FC}$ = 10 d, based on assumed B of 0.7 using Eqn 5.

The opposite (ie an inversely modelled $DegT50_{matrix,FC}$ that is too short) may of course also occur. This happens if the true B value is close to zero (see line for B = 0.1 in Figure 3). It may also happen if the $DegT50_{matrix}$ does not decrease continuously with decreasing moisture content as in most studies (see Smelt et al., 1979, for an exceptional example with a $DegT50_{matrix}$ of oxamyl in air-dry soil that was even shorter than the $DegT50_{matrix}$ at a moisture content of 0.2 kg/kg).

A conservative approach is not to simulate θ but to assume that it is continuously at field capacity (this approach is regularly used in regulatory exposure assessments). Then the value of B does not matter (see Eqn 1). However, it should be kept in mind that such an approach may generate an upper limit of the $DegT50_{matrix,FC}$ when using the resulting $DegT50_{matrix,FC}$ further in the exposure assessment (see Section 5.2).

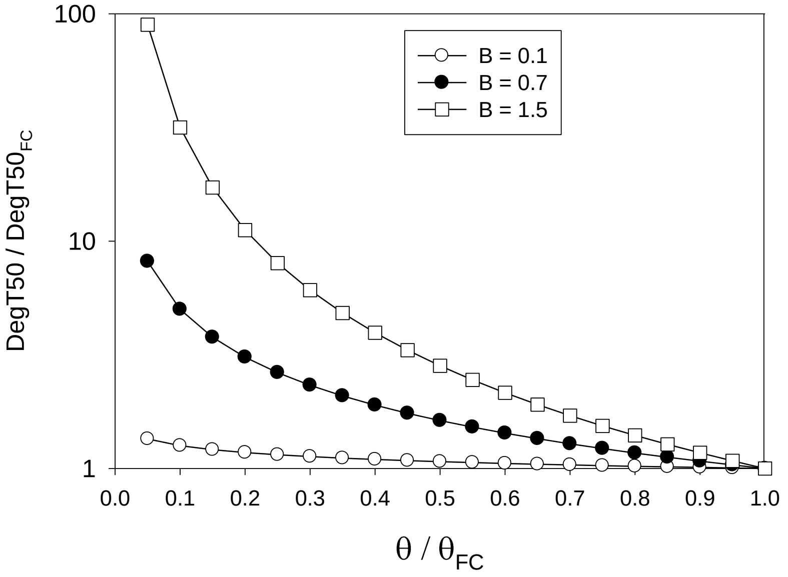

Figure 3: The ratio $DegT50_{matrix}$ / $DegT50_{matrix,FC}$ as a function of the ratio θ/ θ_{FC} for different B values as calculated with Eqn 1.

EFSA (2008) showed that the E_a value of 99 individual substance-soil combinations varied considerably: 95% of the values were in the range from about 35 to about 115 kJ/mol. So use of the default E_a of 65 kJ/mol may lead to a considerable uncertainty in the inversely modelled $DegT50_{matrix}$ at 20°C. Let us consider as an example a field study with an average soil temperature of 14°C that resulted in a $DegT50_{matrix}$ of 100 days. Eqn 5 gives then an inversely modelled $DegT50_{matrix,20Celsius}$ of 68 d for E_a = 65 kJ/mol but for E_a = 35 kJ/mol the inversely modelled value is 81 d and for E_a = 115 kJ/mol it is 51 d. So for true E_a values that are higher than the 65-kJ/mol default value, the inverse modelling procedure using the default value will give a $DegT50_{matrix,20Celsius}$ value that is too long and for true E_a values that are lower than the 65-kJ/mol the inversely modelled $DegT50_{matrix,20Celsius}$ will be too short.

It could be argued that this problem of uncertainty in B and E_a does not matter because the same default values are used in the exposure calculations for the required exposure scenario. For example, if a field persistence study is carried out at an average soil temperature of 10°C, about the same half-life will be calculated in the required exposure scenario at 10°C irrespective of the value of the E_a because the errors cancel out. The Panel agrees that this cancelling out is indeed expected to occur for large numbers of experiments and scenarios. However, a dossier of a plant protection product will usually contain no more than four field persistence studies. Let us assume that a field persistence experiment in northern Germany at an average soil temperature of 10°C results in a $DegT50_{matrix}$ of 50 days. Let us further assume that the true E_a for this soil is 40 kJ/mol. The default E_a of 65 kJ/mol gives a $DegT50_{matrix}$ at 20°C of 19 days with Eqn 5 whereas the true value based on 40 kJ/mol should be 28 days. Next this value of 19 days may be used (admittedly after averaging with a few values from other field persistence experiments) for a scenario in Spain at an average temperature close to 20°C while the true value was 28 days. Thus the Panel considers this argument of cancelling errors not convincing because it is not consistent with the approach of a scientifically conservative methodology at the level of an individual plant protection product (which is the case to be considered).

2.4. Weaknesses of the numerical models for describing moisture and temperature fluctuations and degradation rates in the top millimetres of soil

Numerical models such as PELMO and PEARL assume a potential evaporation rate that is constant over a day. However, measurements by Jackson (1973) showed that there may be a strong daily course in the moisture content of the top millimetres resulting from the daily variation in this evaporation rate (Figure 3). Thus modelling soil moisture dynamics in the top few millimetres is a daunting task. Diurnal surface soil moisture dynamics depends on processes like evaporation, condensation (dew), liquid flow in capillary pores and films and vapour diffusion in air-filled pores. Despite the fact that not all of these processes are included in currently used soil water flow models that are used for pesticide fate modelling in soils, these processes also depend strongly on soil properties and soil structures which change dynamically over time (due to compaction by rain, loosening by wetting-drying cycles, thawing-freezing cycles) **.**

The numerical models usually use numerical compartment thicknesses in the top soil of about 2.5 cm (FOCUS, 2000a). This is another reason for inaccurate simulation of soil moisture contents in the top millimetres: eg measurements by Jackson (1973) showed considerable differences in measured moisture contents between the 0-5 mm and 5-10 mm layers during the drying process. The Panel expects that the numerical models in general will overestimate the soil moisture content of the top millimetres during a drying cycle in the field because of the constant potential evaporation rate and the 2.5-cm thick compartments. Such an overestimation will lead to inversely modelled values of the $DegT50_{matrix}$ at 20^{o}C and pF = 2 that are too long. This is illustrated with the following example in which it is assumed that the total areic[6] mass of plant protection product is present in the top 5 mm of soil at a constant volume fraction of water:

(i) observed *DegT50* = 50 d in field

(ii) actual $\theta = 0.05$, simulated $\theta = 0.10$, $\theta_{FC} = 0.2$

(iii) inversely modelled *DegT50* = 19 d based on actual θ using Eqn 5 with $B = 0.7$

(iv) inversely modelled *DegT50* = 31 d based on simulated θ using Eqn 5 with $B = 0.7$.

---

[6] ‘Areic mass’ means mass per area (Rigg et al., 1985).

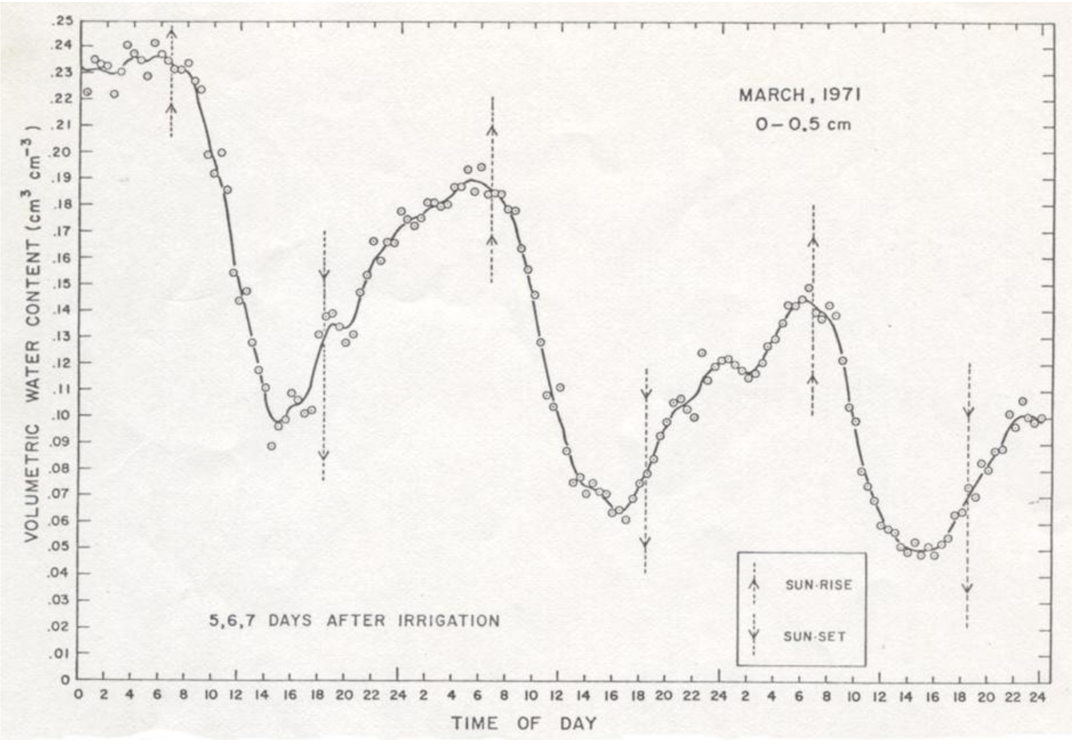

Figure 4: Measured soil water content in the top 5 mm of bare Adelanto loam soil as a function of time on 7-9 March 1971 in Phoenix (Arizona) after 100 mm of irrigation on 2 March (taken from Jackson, 1973). Daily maximum air temperatures ranged from 17 to 24^{o}C and daily minimum air temperatures from -2 to 5^{o}C.

The numerical models use daily average air temperature as input and the effect of solar radiation on the soil temperature is ignored (FOCUS, 2000a). This has been shown to work well for simulation of daily averages of soil temperatures at 5 cm depth (eg Scorza Junior & Boesten, 2005). However it is unlikely that this works well for daily fluctuations in the top millimetres because solar radiation will have a considerable effect in these top millimetres and because also air temperatures may fluctuate considerably during the course of the day. The inadequacy of the numerical models to describe the moisture content in the top millimetres combined with ignoring solar radiation and using daily average air temperatures will therefore predictably lead to poor description of the daily course of soil temperature in the top millimetres. This can be illustrated by measurements by Steenpass et al. (2010) shown in Figure 5. These show daily fluctuations of the soil surface temperature of about 15 to 22 ^{o}C in September in Jülich (Germany) which is at about 51^o Northern Latitude. One may expect that daily fluctuations of soil surface temperatures at more southern European latitudes in spring and summer are considerably higher than those measured in Jülich. This was confirmed by Braud et al (1993), who measured daily fluctuations of temperature at 1 cm depth of a bare silt loam soil from 20 June to 1 July 1991 in Spain. They found that this temperature fluctuated typically between 17 and 50^{o}C and on one day even from 15 to 55^{o}C. So these are daily fluctuations of 33 to 40^{o}C at 1 cm depth.

Steenpass et al. (2010) measured also soil temperatures at 3 and 6 cm depth in this soil and found daily fluctuations of about 14 ^{o}C at 3 cm and 11 ^{o}C at 6 cm (as compared fluctuations of 15-22^{o}C at the soil surface). These data show that the daily fluctuations in soil temperature decrease only moderately with depth in the top centimetres.

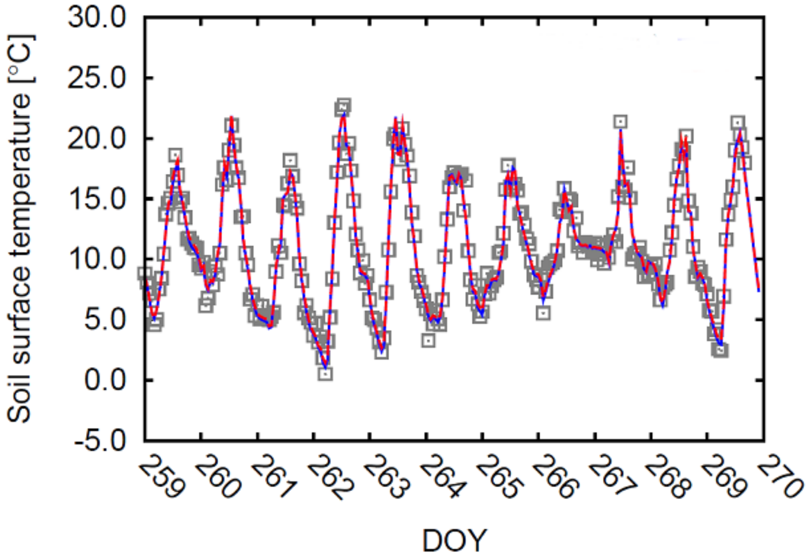

Figure 5: Soil-surface temperature measured from 15 to 26 September 2008 at an experimental field close to Jülich (Germany). The soil was bare and its texture was silt loam. The points are the measurements and the line is a calculated with a simulation model (taken from Steenpass et al., 2010).

Let us assume that the Arrhenius equation gives a reliable description of the relationship between the $DegT50_{matrix}$ and soil temperature in the top millimetres. Let us furthermore consider the following example: (i) a substance with a $DegT50_{matrix}$ of 60 days at 20^{o}C and an Arrhenius activation energy of 65 kJ/mol, (ii) soil temperature fluctuates on a daily basis sinusoidally around an average temperature of 20^{o}C. Figure 6 shows that introducing a fluctuating temperature in this example calculation speeds up the simulated decline. The simulated time points were fitted to a first-order decline and this resulted in half-lives of 60 days for constant temperature, 50 days for an amplitude of 10 ^{o}C and 32 days for an amplitude of 20^{o}C. So an amplitude of 20^{o}C speeds up the degradation rate by about a factor of two. One might argue that this effect of the daily temperature fluctuations is consistently included in the exposure assessment: the fluctuations are both ignored in the inverse modelling procedure and in the scenario calculations with the numerical models. However, the effect of these fluctuations is expected to be considerably larger in Southern Europe than in Northern Europe. Thus it may be questioned whether $DegT50_{matrix}$ values derived from field experiments in Southern Europe can be used for exposure assessments in Northern Europe.

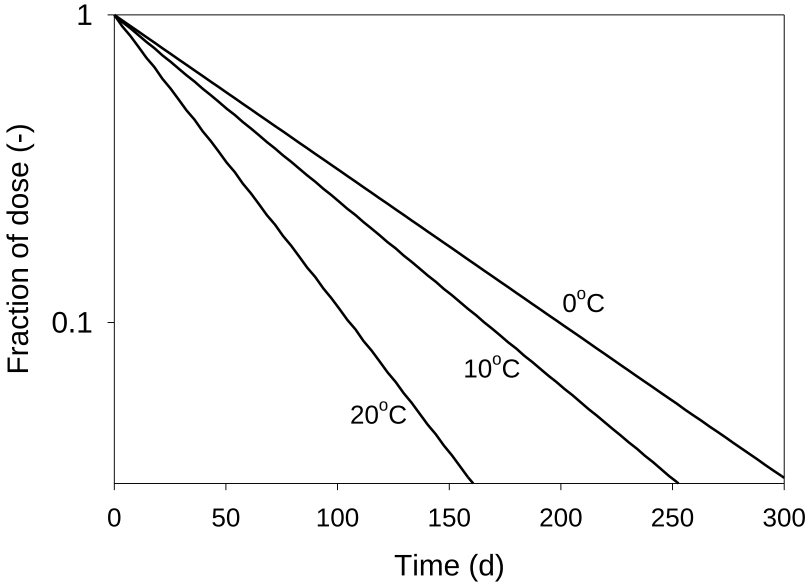

Figure 6: Effect of the daily amplitude of soil temperature on calculated decline of substance in a closed laboratory soil system assuming first-order degradation kinetics and using the Arrhenius equation to describe the effect of temperature on the degradation rate coefficient. The *DegT50* at 20°C was 60 d and the Arrhenius activation energy was 65 kJ/mol. Calculations were made for an average soil temperature of 20°C and a daily sinusoidally fluctuating soil temperature with amplitudes of 0, 10 and 20 °C as indicated in the graph.

So if we assume that the Arrhenius equation is correct at a time scale of hours, the current procedure will lead to an inversely modelled $DegT50_{matrix}$ value that is too short. Additionally, there is the problem that we have no evidence that the Arrhenius equation adequately describes the effect of the temperature on the degradation rate for temperatures that fluctuate at a time scale of hours. So even if the numerical models would be able to describe adequately the soil temperature in the top millimetres at a time scale of hours, the problem remains whether it is appropriate to use the Arrhenius equation at this time scale.

Similarly there is no evidence that the relationship between $DegT50_{matrix}$ and the soil moisture content of Eqn 1 works well at a time scale of hours for changing courses of moisture content with time as shown in Figure 4. Let us assume that Eqn 1 gives a reliable description of the relationship between the $DegT50_{matrix}$ and the volume fraction of water, θ, in the top millimetres. Let us furthermore consider the following example: (i) a substance with a $DegT50_{matrix}$ of 60 days at a θ of 0.2 (field capacity) 20°C and a B value of 0.7, (ii) θ fluctuates on a daily basis sinusoidally around an average θ of 0.1. Figure 7 shows that introducing a fluctuating θ in this example calculation slowed down the degradation rate slightly. However, this problem may be overcome by ignoring the effect of soil moisture in the inverse modelling procedure which leads to a conservative $DegT50_{matrix}$.

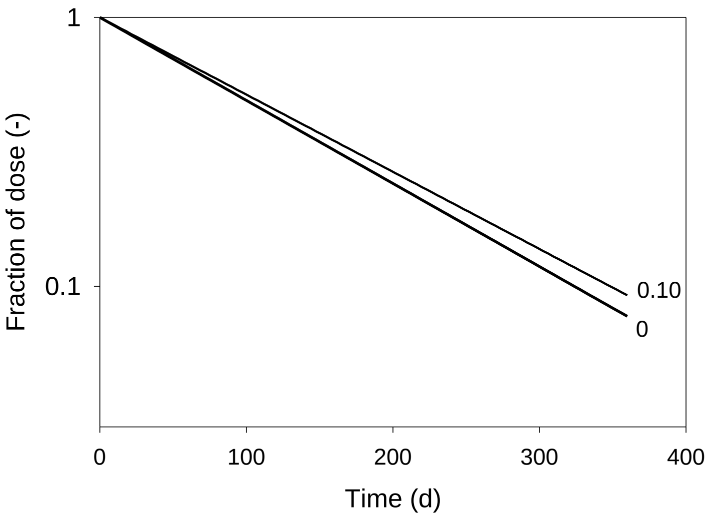

Figure 7: Effect of the daily amplitude of volume fraction of water in soil on calculated decline of substance in a closed laboratory soil system assuming first-order degradation kinetics and using Eqn 1 to describe the effect of the volume fraction of water on the degradation rate coefficient. The *DegT50* at θ = 0.2 was 60 d and the exponent B was 0.7. Calculations were made for a daily sinusoidally fluctuating volume fraction of water with amplitudes of 0 and 0.10 (as indicated in the graph) around an average volume fraction of water of 0.10.

2.5. Concluding remarks on the problem and proposed solution

The problems described in the preceding sections fall into two categories:

A. the impossibility of excluding a competing loss process from the top millimetres

B.the impossibility of obtaining a reliable $DegT50_{matrix}$ at 20°C and pF = 2 from measured declines in the top millimetres via the described inverse modelling procedure.

These two problem categories are independent of each other. Both problem categories are difficult to solve and will require considerable research efforts. If problem A is ignored, this will lead to a too short $DegT50_{matrix}$. The direction of the error in the $DegT50_{matrix}$ resulting from problem B is variable: the $DegT50_{matrix}$ may be either too short or too long. It is in general undesirable that a higher-tier estimation of a model input parameter such as the $DegT50_{matrix}$ is not very reliable. However, this lack of reliability has to be balanced against the advantage that field persistence experiments are closer to the reality to be assessed than are laboratory incubations. For persistent compounds especially, the laboratory incubations may generate too long $DegT50_{matrix}$ values.

The Panel proposes to base this guidance proposal on the assumption that an inversely modelled $DegT50_{matrix}$ at 20°C and pF = 2 needs to be based on a measured decline that took place below the top millimetres of the soil. So the experimental period of a field persistence experiment has to be split into two parts: in the first part the bulk of the substance is still in the top millimetres and in the second part this bulk has moved to lower depths.

The Panel proposes to split the field persistence experiment into two parts based on the following procedure: (i) fit the normalised decline curve to a biphasic decline model, and (ii) accept the rate coefficient of the slow phase of this biphasic decline only if at the transition between the two phases at least 10 mm of rain has fallen since application of the plant protection product. This rainfall criterion is added to ensure that the slow phase of the biphasic decline does not represent a second initial loss process (eg first very quick photodegradation followed by volatilisation without any rain falling onto the field).

3. Proposed guidance for analysing results of field persistence experiments

3.1. Introduction

Field persistence experiments are commonly carried out by spraying a plant protection product onto bare soil in spring, with usually a crop then being grown. The decline of the soil residues with time is measured by regular soil samplings often up to 50 or 100 cm depth. However, the guidance proposal in this chapter is restricted to experiments with spraying onto bare soil; experiments with spraying onto a crop are discussed in Chapter 4.

This guidance proposal is restricted to experiments in which plant uptake did not contribute significantly to the dissipation of the plant protection product. This implies that experiments with weakly sorbing substances in cropped soil are excluded.

This guidance proposal is intended to be used for experiments in which most of the remaining areic mass is present in the top 30 cm depth. The background is that the Panel considers experiments with significant leaching below 30 cm depth not suitable for estimating a $DegT50_{matrix}$ for the top layer in view of the additional uncertainty in the inverse modelling procedure resulting from uncertainty in the depth factor f_z (Eqn 5).

The aims of the guidance proposal in this chapter are the following subset of the general aims described in Section 1.2:

(i) to develop procedures for estimating $DegT50_{matrix}$ values reliably from results of individual field persistence studies

(ii) to develop procedures for estimating top-soil decline parameters reliably from results of individual field persistence experiments.

3.2. Estimation of model input parameters using normalised decline curves

Introduction

In the past five years, the time-step normalisation procedure as described by FOCUS (2006; p. 179) has become popular in the EU registration. This procedure assumes that the decline in the field can be described well by numerical models that assume first-order degradation kinetics such as PELMO, PRZM and PEARL (see Appendix 8 of FOCUS, 2006, for details). The procedure implies that the decline curve after normalisation can be used directly to estimate the $DegT50_{matrix}$ of the top soil at 20^{o}C and pF = 2. As described before, the Panel considers such an estimate only acceptable if measures are taken to ensure that the $DegT50_{matrix}$ is based on the decline in soil below 5 mm depth. Therefore the Panel describes here a proposal to use these normalised decline curves for estimating the $DegT50_{matrix}$ plus a parameter describing the fraction of the initial decline in the soil surface layer.

The proposal is structured as follows. First an overview is given of the available candidate models that might be used to describe the decline curve and the most suitable models are selected. Next stepped approaches are proposed for these models to derive the appropriate endpoints from each field persistence experiment.

Selection of models for describing bi-phasic kinetics

As described earlier, the dissipation rate in field persistence experiments is expected to be faster in the initial stage of the experiment than subsequently. Such dissipation patterns cannot be described adequately with first-order kinetics. Instead models describing biphasic kinetics are to be preferred. FOCUS (2006) recommended three models for describing bi-phasic kinetics: the bi-exponential model, the Gustafsen-Holden model and the hockey-stick model.

The bi-exponential model (hereafter called the DFOP-model from ‘Double First-Order in Parallel’) is based on the assumption that a mass of plant protection product is present in two non-interacting compartments in the system which each degrade the product at their own rate assuming first-order kinetics. This results in the following expression of the time course of the mass m in the system:

$$m = m_{ini,\,fast}\ \exp(-k_{fast}\,t) + m_{ini,slow}\ \exp(-k_{slow}\,t) \qquad (6)$$

where
$m_{ini,fast}$ = mass in system in the fast-degrading compartment at the start (kg)
$m_{ini,slow}$ = mass in system in the slow-degrading compartment at the start (kg)
k_{fast} = rate coefficient in the fast-degrading compartment (d^{-1})
k_{slow} = rate coefficient in the slow-degrading compartment (d^{-1})
t = time (d).

The qualifications ‘slow’ and ‘fast’ have no absolute meaning in this context: the highest rate coefficient of the two is by definition the fast one and the other is thus the slow one.

Eqn 6 can be rewritten as:

$$m = m_{ini}\left(g\ \exp(-k_{fast}\,t) + (-g)\exp(-k_{slow}\,t)\right) \qquad (7)$$

where
m_{ini} = total mass in the system at the start (kg)
g = fraction of total mass in the system applied to the fast-degrading compartment (-)

The Gustafsen-Holden model (hereafter called the FOMC-model from ‘First-Order Multi-Compartment’) is based on the assumptions that there are an infinite number of non-interacting compartments which each degrade at their own rate (assuming first-order kinetics) and that the frequency distribution of the rate coefficients of these compartments can be described by a gamma function. This gives the following equation for the FOMC model:

$$m = \frac{m_{ini}}{\left(\frac{t}{\beta}+1\right)^{\alpha}} \qquad (8)$$

where
α = so-called shape parameter (-)
β = so-called location parameter (d)

The Hockey-Stick model (hereafter called the HS model) is based on the assumption that the mass in the system declines according to first-order kinetics but at a certain point in time (‘the breakpoint’) the rate coefficient changes:

$$\begin{array}{ll} t \le t_b & m = m_{ini}\exp(-k_1 t) \\ t > t_b & m = m_{ini}\exp(-k_1 t_b)\ \exp(-k_2\,(t - t_b)) \end{array} \qquad (9)$$

where

t_b = breakpoint time (d)

k_1 = rate coefficient until t_b (d^{-1})

k_2 = rate coefficient after t_b (d^{-1})

Our aim is to describe a normalised decline of the areic mass of a plant protection product in soil of a field persistence experiment. This decline is expected to show a rapid initial phase in the period that surface loss processes play an important role followed by a slower phase that is dominated by the degradation rate within the soil matrix. It is also possible that the normalised decline shows a slow initial phase followed by a faster decline later. The purpose of this proposal is to use the decline in the second phase to derive a normalised $DegT50_{matrix}$ as input to models such as PRZM, PELMO and PEARL. These models are based on first-order kinetics and also the time-step normalisation procedure is base on the assumption of first-order kinetics. Thus the Panel considers the FOMC model not suitable because it does not describe a first-order decline in the second phase.

So the remaining options are the DFOP and HS models. The Panel recommends considering both models for deriving a normalised $DegT50_{matrix}$. The DFOP model has the advantage that it describes a gradual transition between the two phases but the disadvantage that it can only describe a decline that is faster at the start than at the end. The HS model has the advantage that it can describe both a decline that is faster at the start than at the end and a decline that is slower at the start than at the end. However it has the disadvantage that there is an abrupt transition between the two phases.

Stepped approach for evaluating normalised decline curves with the DFOP or Hockey-Stick models

The Panel proposes to use the DFOP model for evaluating normalised decline curves unless a visual inspection of the measured decline curve shows no slowing down or unless a visual inspection of this curve shows even a speeding up at later times.

The proposal for evaluating results of field persistence experiments with the DFOP model consists of the following steps:
i. transform the measured time series of remaining amounts into a normalised time series using the time-step normalisation approach described by FOCUS (2006; p. 179)
ii. fit the normalised time series to the DFOP model as described by FOCUS (2006)
iii. estimate a breakpoint time t_b from the DFOP fit
iv. use the flow chart in Figure 8 to decide on usefulness of the rate coefficient k_{slow}
v. if this results in a useful k_{slow} then calculate the resulting $DegT50_{matrix}$ as ln 2/ k_{slow} and calculate the rapidly dissipating fraction F_{field} on the basis of the difference between the initial areic mass and the areic mass at the breakpoint time t_b .

The determination of the breakpoint time (step iii) is not straightforward because the slope of the DFOP decreases gradually. The Panel proposes to define the breakpoint time as:

$$t_b = \frac{3 \ln 2}{k_{fast}} \qquad (10)$$

This implies that the breakpoint time corresponds with a time equal to three half-lives of the fast-degrading compartment, so $g \exp(-k_{fast}\, t_b) = 0.125\, g$. This implies that, at this breakpoint time, 87.5% of the decline of the fast-degrading compartment has taken place. Therefore it is likely that after this breakpoint time, the slow-degrading compartment dominates the overall decline. Only for high g values may this not be the case. For example, if $g = 0.9$ then $0.125\, g = 0.11$ whereas $(1 – g)$ may still be close to 0.1. In such a case the breakpoint time estimated with Eqn 10 may be too short.

The rationale behind the flow chart in Figure 8 is as follows. Decision box 1 tests whether g is below 0.75. If no, the Panel recommends using the HS model instead of the DFOP model because the estimate of the breakpoint time with Eqn 10 is not reliable enough. Decision box 2 tests whether cumulative rain is at least 10 mm at the breakpoint. If this is not the case, k_{slow} has to be rejected because it is too strongly influenced by processes in top millimetres. If cumulative rain was at least 10 mm at the breakpoint, box 3 is reached. The problem here is that k_{slow} may be based on only a few data points and thus may be not reliable enough. EFSA (2008, p. 9) required five data points for an accurate *DegT50* calculation for laboratory studies. The scatter in field data may be expected to be larger than in laboratory data. Therefore the Panel considers five data points to be a minimum quality requirement in decision box 3. The decision on the five data points is to be based on the number of data points at times later than the breakpoint time.

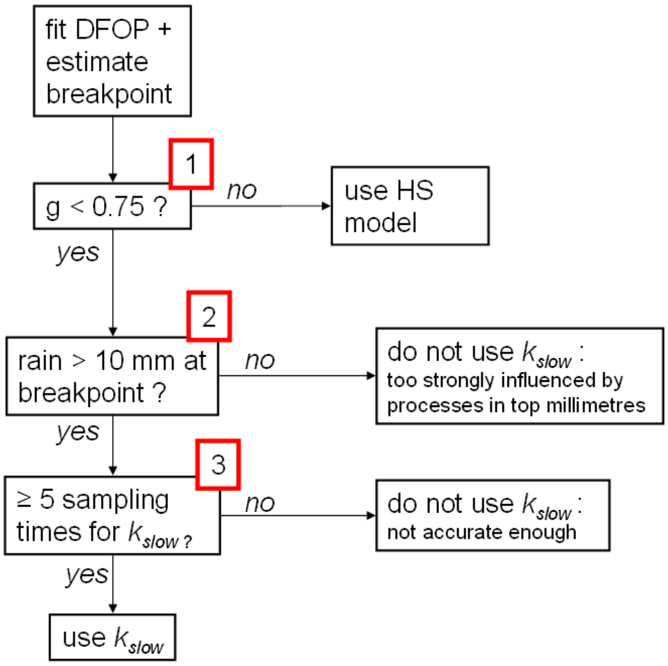

Figure 8. Flow chart for assessment of results of field persistence experiments after analysis with the DFOP model. The numbers 1 to 3 act as references to the corresponding decision boxes in the main text.

The proposal for evaluating results of field persistence experiments with the HS model consists of the following steps:

i. transform the measured time series of remaining amounts into a normalised time series using the time-step normalisation approach described by FOCUS (2006; p. 179)

ii. fit the normalised time series to the HS model as described by FOCUS (2006)

iii. use the flow chart in Figure 9 to decide on usefulness of the rate coefficient k_2

iv. if this results in a useful k_2 then calculate the resulting $DegT50_{matrix}$ as ln 2/ k_2.

For the flow chart in Figure 9, the rationale for the boxes 1 and 2 is the same as for the flow chart of Figure 8. Decision box 3 tests whether $k_1 > k_2$. If this is indeed the case, k_2 can be accepted. If this is not the case, there is the possibility that after some time accelerated degradation occurred in the field experiment which may happen in some soils but not in others. This requires a case-by-case analysis.

It is only meaningful to calculate the rapidly dissipating fraction F_{field} if $k_1 > k_2$. If this is the case, F_{field} can be calculated on the basis of the difference between the initial areic mass and the areic mass at the breakpoint time t_b.

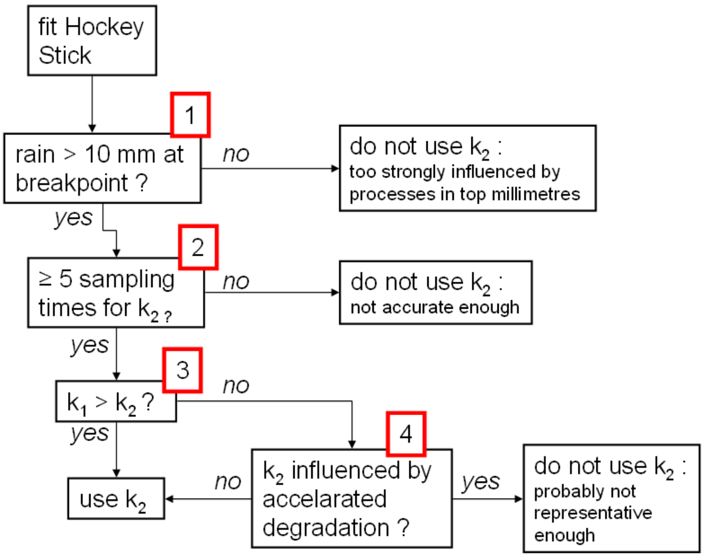

Figure 9. Flow chart for assessment of results of field persistence experiments after analysis with the Hockey-Stick ('HS') model. The numbers 1 to 4 act as references to the corresponding decision boxes in the main text.

The flow charts of Figures 8 and 9 do not consider explicitly cases where k_{slow} is close to k_{fast} or where k_1 is close to k_2. Then the uncertainty in the breakpoint time t_b is considerable. In such a case, the notifier could first assess the time when cumulative rainfall has reached 10 mm, fix the breakpoint to this time and follow the flow charts of Figures 8 and 9.

The findings from this kinetic modelling (DFOP or HS model) should be interpreted with consideration of existing information in the dossier on potential volatilisation and potential photodegradation (Section 2.2.) and the degradation rates from the laboratory soil tests. Once a $DegT50_{matrix}$ value is obtained with either the DFOP or HS model, the Panel recommends checking whether this value is significantly longer (t-test at 5% level) than the laboratory *DegT50* values. In general $DegT50_{matrix}$ values from field studies are expected to be shorter than *DegT50* values from laboratory studies but the opposite may happen in a small proportion of the cases (Beulke et al., 2000). The Panel considers it very unlikely that a laboratory study with a certain soil shows systematically and consistently a faster degradation rate than a field study with the same soil at the same temperature and moisture content. The Panel considers it far more likely that a field $DegT50_{matrix}$ that is significantly longer than the geomean laboratory *DegT50* is caused by systematic errors in the inverse modelling procedure (eg B or E_a values of this substance-soil combination that differ strongly from the assumed default values or poor simulation of soil temperature or soil moisture in the soil layer below 5 mm depth). It can of course also happen by coincidence because the number of measured laboratory *DegT50* values is usually limited to four values in a dossier. Therefore the Panel recommends assessing in such a case the magnitude of the effects of conservative assumptions in the inverse modelling procedure; if this effect is so large that it may explain the difference with the laboratory *DegT50* values, then it is considered justifiable to discard the $DegT50_{matrix}$ value of this field experiment.

4. Proposed guidance for analysing results of soil accumulation experiments

In the context of Tiers 1 to 4 of Figure 1, the possible endpoints from soil accumulations experiments are a $DegT50_{matrix}$ (of top soil at 20°C and pF = 2) plus the F_{field} parameter describing a fast initial decline at the soil surface..

Soil accumulation experiments can broadly be divided into two categories:

A. experiments with only two to three samplings per year: one just before the yearly application, one just after the yearly application and one mid-year

B. experiments in which each year a number of samplings has taken place.

The remainder of this section applies to type-A soil accumulation experiments. If type-B experiments contain enough samplings and if crop interception of the plant protection product was insignificant, the guidance for the field persistence experiments might be applicable.

Based on the experimental design of soil accumulation experiments (two-three samplings per year), the Panel expects that it is impossible to estimate the fraction that penetrates into the soil separately from the $DegT50_{matrix}$.

The Panel considered the option to obtain the $DegT50_{matrix}$ by inverse modelling using a fixed, prescribed fraction that penetrates into the soil. This fixed fraction could be based on the calculations for the exposure scenario (eg using the crop interception tables proposed by FOCUS, 2000a). Thus at least consistency would be assured: the $DegT50_{matrix}$ would be estimated on the basis of inverse modelling using the same fraction that penetrates into the soil as would be used later in the scenario calculations for the exposure assessment.

However, the Panel rejected this option for two reasons:

- the soil accumulation experiment may have been carried out under conditions that differ significantly from the required exposure scenario and thus it may be inappropriate to use the same fraction for strongly different situations (e.g. in the soil accumulation experiment application to full grown wheat crop and in required exposure scenario application to bare soil);

- this procedure prescribes the fraction that penetrates into the soil to the inverse modelling procedure; the true fraction in the soil accumulation experiment will differ from this prescribed fraction; therefore the inverse modelling procedure will return a $DegT50_{matrix}$ value with an unknown systematic error; such a $DegT50_{matrix}$ value cannot be simply compared in statistical tests to $DegT50_{matrix}$ values obtained from other sources (laboratory studies or field persistence studies); so this makes it impossible to give such a $DegT50_{matrix}$ value an appropriate place in the stepped approach of Figure 2.

As a next option the Panel considered the possibility of estimating conservative $DegT50_{matrix}$ values (of top soil at 20°C and pF = 2) from soil accumulation experiments (i.e. upper limits). An upper limit of the $DegT50_{matrix}$ is obtained by assuming a lower limit of the fraction of the dose that penetrates into the soil. This can be illustrated with the following example:

- on 1 June 2008 a dose of 1 kg/ha was sprayed onto a winter wheat crop; one year later 0.25 kg/ha was recovered from the soil

- if it is assumed that the whole dosage penetrated into the soil, the half-life under these field conditions is 0.5 year

- if it is assumed that only half of the dosage penetrated into the soil, the half-life under these field conditions is 1.0 year.

A lower limit of the fraction of the dose that penetrates into the soil implies an upper limit of the crop interception (and ignoring wash-off). The Panel is currently setting up a database of all available crop interception measurements which will be followed by an analysis of these data. The Panel hopes to be able to estimate reliable upper limits of the fraction intercepted by the crop (lower than the trivial 1.0) from this analysis at a later stage. The procedure might work in exceptional cases where the true $DegT50_{matrix}$ in soil accumulation experiments is much shorter than in field persistence experiments.

If soil accumulation experiments are carried out with spray applications to bare soil, another complication occurs: it will usually be impossible to derive from the experiment which fraction of the dose dissipated while most of the areic mass of the plant protection product was still in the top millimetres. If loss processes other than degradation in the soil in this top layer are ignored in the analysis, the $DegT50_{matrix}$ is overestimated which is not defensible.

The consequence from the above reasoning is that processes above and at the soil surface may have a large effect on the build-up of soil residues in soil accumulation experiments, which makes it difficult to extrapolate results of soil accumulation experiments to a range of conditions within the EU.

In view of the above complications, the Panel recommends not using type-A soil accumulation experiments for deriving $DegT50_{matrix}$ values.

5. Proposed guidance for estimating model input parameters for the required exposure scenarios

5.1. Introduction

The guidance in Chapter 3 implies that each laboratory degradation rate experiment and each field persistence experiment will lead to an estimated *DegT50*[7] at 20°C and pF = 2 for the topsoil layer. This guidance further implies that each field persistence experiment will lead to an estimate of F_{field}.

So the next step is to provide guidance on how these data should be used to generate model input data for the required exposure scenario.

The guidance for estimation of model input parameters for the required exposure scenario will not include guidance for parameters derived from soil accumulation experiments in view of the complications described in Chapter 4. This guidance will also not include estimation of model input parameters for Tiers 3 and 4 if these tiers are based on a relationship between the *DegT50* and soil properties such as the pH or clay content. So the guidance below is restricted to substances whose *DegT50* (at 20°C and pF = 2) is not a function of such soil properties.

5.2. Estimation of the geomean *DegT50* for the required exposure scenario from laboratory and field experiments

Once *DegT50* values (top soils at 20°C and pF = 2) from laboratory and field experiments are available, the estimation of the *DegT50* to be used as input for the required exposure scenario consists of two more steps (see Section 1.1):

(i) developing procedures for assessing the relevant population of *DegT50* values for the required exposure scenario

(ii) developing procedures for estimating reliably the geomean of the relevant population of *DegT50* values for the required exposure scenario.

So the first problem is to find the relevant population of *DegT50* values for the required exposure scenario. This problem has been addressed in the current EU leaching assessment. FOCUS (2000a) developed nine EU groundwater scenarios. The *DegT50* is a very important input parameter for the scenario calculations. The current procedure is to calculate a geomean *DegT50* from either laboratory or field studies excluding only measurements with volcanic soils; soils from temperate regions outside the EU are considered also acceptable provided their pH, organic matter and clay contents are within the range of values to be expected for top soils in the EU. For field persistence experiments, it is additionally checked whether temperature and precipitation for the trial site are comparable to those in the EU where the assessed crop is grown. The geomean thus obtained is used for all nine groundwater scenarios. So it is implicitly assumed that a *DegT50* measured for any non-volcanic agricultural soil from temperate regions can be used to predict the *DegT50* for any non-volcanic agricultural soil within the EU. This assumption may be questioned of course: eg for a given substance it cannot be excluded that there are systematic differences in *DegT50* values of top soils (at 20°C and pF = 2) between the EU regulatory zones north and south or between the US and the EU resulting eg from systematic differences in agricultural practices. The current Annex II data

---

[7] This chapter deals with *DegT50* values obtained both in field and laboratory experiments. These will both be represented in this chapter by the acronym *DegT50* so without the ‘matrix’ suffix because it is not meaningful to use this suffix for laboratory studies and because it is assumed in this chapter that the values derived from the field studies are appropriate.

requirements for laboratory measurements of the *DegT50* state that studies with one soil are needed for the degradation route plus three for the degradation rate which sums up to four. With respect to the properties of the soils to be used, the current Annex II refers to SETAC (1995). This guideline specifies ranges of 2-5% organic matter, pH 5.5-7.5 and clay 10-25% for the degradation route. However, for the degradation rate studies, SETAC (1995) only states ‘The additional soils … should cover a range of pH, organic matter and clay content typical of the regions where the pesticide will be used’. The draft version of the revised Annex II refers to OECD (2002a). This guideline prescribes only that ‘the types of soils tested should be representative of the environmental conditions where use or release will occur’. So the geographical origin of the soil is not considered at all.

The Panel doubts whether such a crude approach for defining the relevant population of *DegT50* values for the required exposure scenario is defensible (eg NAFTA, 2006, and US-EPA, 2008, prescribe a more subtle approach: ie to base the soil-selection procedure for field persistence experiment on GIS-based decision support models or on other GIS-based vulnerability assessment tools that account for the critical factors affecting pesticide dissipation). To underpin this crude approach, statistical analyses of existing *DegT50* data of a number of representative plant protection products are needed. On the other hand, the Panel is not aware of information that indicates that this crude approach is not defensible. Therefore the Panel proposes to accept this approach as a working hypothesis and to initiate in parallel activities to test this working hypothesis by careful analysis of relevant literature data.

Let us now assume that a relevant population of *DegT50* values (all at 20^{o}C and pF = 2) is available and that it contains values from both laboratory studies and field persistence studies. The problem is how to get to a geomean *DegT50*. Let us look back at the aim of the estimation of the *DegT50*: use of field persistence studies (Step 2 in Figure 2) is only needed if Step 1 (ie using only laboratory *DegT50* values) does not result in negligible risk to soil organisms. So within this Step 2 the notifier has to demonstrate that a possible risk does not exist. In the context of a tiered approach as in Figure 2, the information from higher steps should indicate a clear need to change the *DegT50* from Step 1. It means also that rejecting laboratory data from Step 1 in favour of field data from Step 2 is only defensible if there are convincing arguments to do so.

Therefore the Panel proposes the flow chart shown in Figure 10. We consider the laboratory *DegT50* as a first conservative and simple step and the field *DegT50* values as a more realistic and more sophisticated second step. Let us consider e.g. the case where we have four laboratory *DegT50* values of 120, 140, 160 and 180 days (geomean of 148 days) and one field *DegT50* value of 115 days. In such a case, the Panel does not consider it defensible to reject immediately all the laboratory *DegT50* and to switch to a *DegT50* of 115 days for the further exposure assessment. It may just be coincidence that this one value is lower than the other four. Therefore the Panel proposes to test statistically the null hypothesis that the geomean *DegT50* value from the laboratory studies is equal to that of the field studies (box A in Figure 10). If this null hypothesis is not rejected, the Panel recommends pooling all the laboratory and field *DegT50* values and calculating the geomean (box B). If the null hypothesis is rejected, then the next test is whether the geomean *DegT50* of the field studies is shorter than that of the laboratory studies (box C). If yes, then we discard the laboratory studies and move to box D. In this box it is tested whether at least four field *DegT50* values are available. The four values are based on the data requirement for laboratory *DegT50* values in Annex II to Council Directive 91/414/EC. If this is indeed the case then the geomean field *DegT50* is calculated as the endpoint of this flow chart (box E). If less than four values are available, the uncertainty of the estimated geomean of the field *DegT50* values will be too high and the Panel proposes to pool all the laboratory and field *DegT50* values (so back to box B).

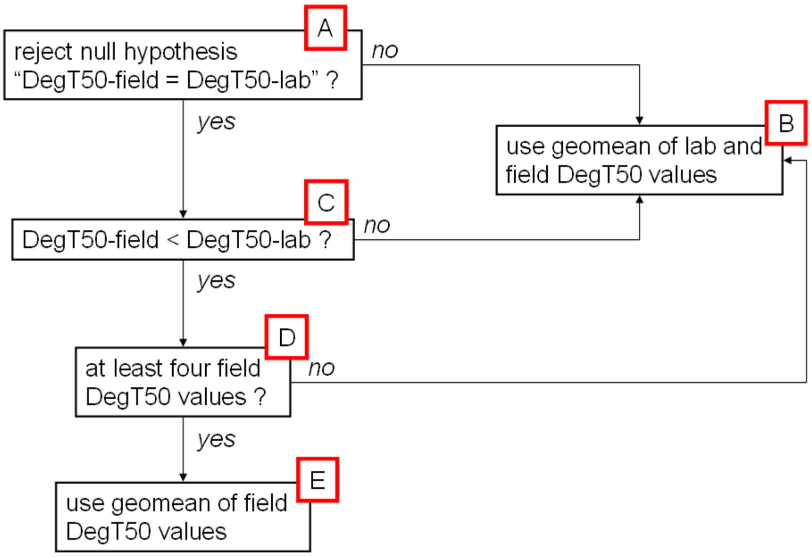

Figure 10: Flow chart for assessment of *DegT50* values from laboratory and field persistence experiments. The letters A to E act as references to the corresponding boxes in the main text.

The calculation procedure for the geomean to be used in the exposure assessment is not straightforward because the geomean of the statistical population is needed and this may differ from the geomean of the sample population. In general, the uncertainty of the estimated geomean decreases with increasing sample size. The Panel intends to produce an estimate of the uncertainty of the geomean as a function of this sample size (which implicitly requires a random set of experimental fields) which can be taken into consideration in the further exposure assessments.

5.3. Estimation of model input parameters describing the decline at the soil surface for the required exposure scenarios

As described above, the dissipation at the soil surface can be described with the parameter F_{field}. The estimation of this input parameter for the required scenario can be subdivided into:

A) does the observed fast decline also occur in the required exposure scenario?

B) which value of the input parameter is to be used?

For Step A, the Panel proposes that the fast surface decline is switched off (F_{field} = 0) unless the notifier provides plausible arguments to support the position that a fast initial decline is expected to occur in the required exposure scenario. Let us consider two examples: a case YES where this is indeed expected and a case NO where this is not expected. In case YES, the field persistence experiment was in Germany and it showed a fast initial decline of 70% of the dose as a result of photodegradation. The required exposure scenario for this case was spraying onto bare soil in southern Europe in spring. In case NO, we have the same field experiment but now the required exposure scenario is spraying onto a crop with 80% deposition on the crop and 20% on the soil with most of the soil usually in the shadow of the plants.

For Step B, the Panel proposes to use the worst-case value of four accepted values. For example, four field persistence experiments show F_{field} values of 30, 40, 60 and 80% for experiments in France, UK, Germany and Spain under normal agricultural use conditions. If less than four such values are available, the Panel proposes to use an estimate of the 12.5th percentile which is equivalent to the worst case of four values.

The argument for using a worst case of four values (as described before) is that the uncertainty resulting from this surface processes was ignored in the scenario selection, so the uncertainty has to be explicitly accounted for in the scenario parameterisation phase. The basis for the worst case of four is that, in EU regulatory practice, field persistence studies with four soils are usually required.

5.4. Proposal for using the revised *DegT50* and F_{field} in the exposure assessments in the different tiers

Based on the previous sections, final values of *DegT50* and F_{field} are assumed to be available. The next step is to use these values in the exposure assessment for spray applications to annual crops under conventional and reduced tillage proposed by EFSA (2010a).

These values are relevant for Tiers 1 to 4 of Figure 1. The Panel proposes that a revised *DegT50* can be used for all these tiers. The Panel proposes to include the fast surface decline only in Tiers 2 or 4. Tiers 1 and 3 are based on simple analytical models (Figure 1) with no crop interception in Tier 1 and probably also no interception in Tier 3. It seems not in balance for Tiers 1 and 3 to exclude crop interception while including a fast surface decline (in contrast to Tiers 2 and 4).

The procedure for the parameterisation of the fast surface decline is given by the following four steps.

Step-1-F_{field} : run the model for the required simulation period (26 years for annual applications, 46 years for application every two years or 66 years for application every three years; see EFSA, 2010a) using a corrected dosage A_{cor} (kg/ha) given by

$$A_{cor} = A\,(1 - F_{field}) \qquad (11)$$

where A is the recommended dosage.

Step-2-F_{field} : calculate from this run (excluding the six ‘warming-up’ years; EFSA, 2010a) the average fraction of the dosage lost due to simulated volatilisation (F_{vola}) and runoff (F_{runoff}).

Step-3-F_{field} : extract from this run the application at which the all-time high concentration occurs.

Step-4-F_{field} : run the model a second time but now with a dosage given by

$$A_{cor} = A\,(1 - F_{field} + F_{vola} + F_{runoff}) \qquad (12)$$

for all applications except the application in the year where the all-time high concentration occurs; for this application use A as the dose.

The background to this procedure is as follows. Firstly there is the problem of ‘double counting’ of loss processes: the measured F_{field} may include runoff and volatilisation and so using F_{field} in combination with a model that already simulates volatilisation and runoff will lead to systematic underestimation of exposure concentrations. This is prevented by Eqn 12. Secondly there is the problem that the all-time high concentration would be systematically underestimated if Eqn 12 were always to be used because in reality the full dosage is sprayed.

If the application is onto a crop, part of the plant protection product will be intercepted by the crop and part will be deposited onto the soil. The areic mass intercepted by the crop will partly be washed off to the soil in the simulations (EFSA, 2010a). So also if there is crop interception, the Panel recommends using Eqn 12 (F_{field}) with A_{cor} being the sum of the areic masses sprayed onto crop and soil.

6. Usefulness of the proposed guidance for assessment of leaching to groundwater and surface water

The degradation rate of plant protection products in soil plays also an important role in the assessment of their leaching to groundwater and surface water. The problems associated with the use of field persistence studies for estimating *DegT50* values described in Chapter 2 apply also to the leaching assessment. In the EU groundwater leaching simulations, the *DegT50* values are even extrapolated to the 30-100 cm layer by assuming a single and unique f_z relationship (see Eqn 3) for all plant protection products and all their metabolites in all soils in EU agriculture (FOCUS, 2000a). So also for the leaching it is very important that the assessment of the *DegT50* is not 'contaminated' by loss processes occurring in the top millimetres of soil.

The Panel considers the guidance proposals for estimating the $DegT50_{matrix}$ as described in Chapter 3 and Sections 5.2 also useful for assessment of leaching to groundwater and surface water because these proposals are not specific for the soil exposure assessment. Also the guidance for the estimation of the model input parameters describing the decline at the soil surface in Section 5.3 is not specific for soil exposure and can therefore be used for the leaching assessments.

However, the guidance for the initial-decline parameters to be used in the soil exposure scenario calculations in Section 5.4 contains elements that are specific to the soil exposure assessment and needs therefore to be modified as follows for leaching assessments:

1. if the leaching calculations are based on the convection-dispersion equation, then the proposed procedure of Step-1-F_{field} to Step-4-F_{field} should be followed with the modification that Eqn 12 can be used for all application years (so it is not necessary to make calculations with a full dose in one of the years); this is justifiable because leaching in such model calculations is a multi-year process;

2. if the leaching calculations include preferential flow, then the calculations have to be carried out assuming $F_{field} = 0$ because preferential flow events may take place shortly after application when the almost the full dosage is still present.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

1. The half-life for degradation in the top 30 cm of soil at 20°C and pF = 2 is an important input parameter for numerical models that simulate exposure of organisms in soil. For soil under conventional or reduced tillage, the main use of this half-life is to simulate the degradation rate for soil depths between 1 and 30 cm. When deriving such a half-life from field persistence and soil accumulation experiments, appropriate measures have to be taken to ensure that the value obtained is not influenced strongly by processes in the top millimetres of soil.

2. Based on current knowledge and data commonly available in dossiers of plant protection products, it is impossible to estimate with enough certainty photodegradation rates of plant protection products in the top millimetres in soil. Studies with sieved soils in the laboratory demonstrate that photodegradation is limited to the top 2 mm of soil. Furthermore there are uncertainties assessing volatilisation for surface-applied compounds.

3. Current numerical models used for simulating behaviour of plant protection products in soil in the context of the EU regulatory exposure assessment are unable to describe satisfactorily the daily fluctuations of the soil temperature and of the volume fraction of water in the top millimetres of soil.

4. The parameters describing the relationship between on the one hand the degradation rate coefficient in soil and on the other hand soil temperature (ie the Arrhenius activation energy) or volume fraction of water in soil (ie the exponent *B*) show considerable variation between soils and plant protection products. This uncertainty results in a considerable uncertainty in $DegT50_{matrix}$ values obtained from field experiments by inverse modelling assuming default values of the Arrhenius activation energy and the exponent *B*.

5. Assessment of $DegT50_{matrix}$ values based on field persistence experiments can be based on inverse modelling using the approach of normalised decline curves proposed by FOCUS (2006). The normalised decline curves can be either described with the DFOP (double first-order kinetics) or Hockey-Stick models.

6. The Panel considers soil accumulation experiments with only two to three soil samplings per year not suitable for estimating the $DegT50_{matrix}$ because the fraction of the dosage that penetrates to soil depths deeper than a few millimetres cannot be estimated with sufficient accuracy from the results of such experiments.

7. Once appropriate *DegT50* values from laboratory and field experiments are available, the estimation of the *DegT50* to be used as input for the required exposure scenario consists of two more steps: (i) assess the relevant population of *DegT50* values for the required exposure scenario, and (ii) estimate reliably the required statistical attribute (certain percentile or some mean value) based on this population. The Panel proposes basing the relevant population of *DegT50* values on the assumption that a *DegT50* measured for any non-volcanic agricultural soil from temperate regions can be used to predict the *DegT50* for any such soil within the EU. This assumption is a working hypothesis that has to be underpinned further. The type of attribute has to be consistent with the scenario-selection procedure which was based on taking the geomean *DegT50* value assuming a log-normal distribution. So the Panel recommends taking the geomean *DegT50* value. The estimation of the geomean *DegT50* of the population has to consider the uncertainty resulting from the limited number of samples in the sample population.

8. If the relevant population of *DegT50* values for a certain exposure scenario consists of a mixture of values obtained in the laboratory and in the field, the Panel recommends excluding the laboratory values only if the null hypothesis that laboratory and field values are equal is rejected. If the relevant population of *DegT50* values for a certain exposure scenario consists of less than four values based on field experiments, the Panel recommends using both laboratory and field values for estimating the geomean.

9. The Panel considers the guidance proposals for estimating *DegT50* values also useful for assessment of leaching to groundwater and surface water because the main use of the *DegT50* values in these groundwater and surface water scenarios is the same as for the soil exposure assessment considered in this opinion (ie simulate the degradation rate for soil depths between 1 and 30 cm).

RECOMMENDATIONS

1. The Panel recommends compiling a database of all relevant and reliable *DegT50* values of agricultural top soils within the temperate regions at 20^{o}C and pF = 2 to test the assumption that this *DegT50* does not vary systematically between geographical zones in the temperate regions for non-volcanic soils.

2. In case the notifier wants to use results of field persistence studies for estimating the $DegT50_{matrix}$ as an input parameter for exposure models, the Panel recommends incorporating the plant protection product to a depth of about 10 cm into the soil immediately after application.

3. The Panel recommends improving the validation status of mechanistic models for simulating loss processes at the soil surface (especially for photodegradation and volatilisation).

REFERENCES

Anderson JPE (1987). Handling and storage of soils for pesticide experiments. In: Somerville L, Greaves MP (Eds). Pesticide effects on soil microflora. Taylor and Francis, London, p. 45-60.

Beulke S, Dubus IG, Brown CD, Gottesbüren B (2000). Simulation of pesticide persistence in the field on the basis of laboratory data – a review. J. Environ. Qual. 29: 1371-1379.

Braud I, Noilhan J, Bessemoulin P, Mascart P (1993). Bare-ground surface heat and water exchanges under dry conditions: observations and parameterization. Boundary-Layer Meteorology 66: 173-200.

Ciani, A, Goss K-U and Schwarzenbach RP (2005). Light penetration in soil and particulate minerals.- European Journal of Soil Science, October 2005, 56, 561–574, doi: 10.1111/j.1365-2389.2005.00688.x

EFSA, 2008. Opinion on a request from EFSA related to the default *Q*10 value used to describe the temperature effect on transformation rates of pesticides in soil. EFSA Journal 622: 1-32.

EFSA, 2010a. Scientific opinion on outline proposals for assessment of exposure of organisms to substances in soil. EFSA Journal 2010; 8(1):1442, 38 pp.

EFSA, 2010b. Selection of scenarios for exposure of soil organisms to plant protection products. EFSA Journal 8(6): 1642, 82 pp.

US-EPA, 2008. Fate, Transport and Transformation Test Guidelines. OPPTS 835.6100 Terrestrial Field Dissipation. www.epa.gov/nscep/, 48 pp.

Ferrari F, Trevisan M, and Capri E (2003). Predicting and measuring environmental concentration of pesticides in air after soil application. J. Environ. Qual. 32:1623–1633.

FOCUS, 2000a. FOCUS groundwater scenarios in the EU review of active substances. Report of the FOCUS Groundwater Scenarios Workgroup, EC Document Reference Sanco/321/2000 rev.2, 202 pp.

FOCUS, 2000b. Guidance Document on persistence in soil (SANCO/9188VI/1997 of 12 July 2000), 17 pp.

FOCUS, 2001. FOCUS Surface Water Scenarios in the EU Evaluation Process under 91/414/EEC. Report of the FOCUS Working Group on Surface Water Scenarios, EC Document Reference SANCO/4802/2001-rev.2, 245 pp.

FOCUS (2006). Guidance Document on Estimating Persistence and Degradation Kinetics from Environmental Fate Studies on Pesticides in EU Registration. Report of the FOCUS Work Group on Degradation Kinetics, EC Document Reference Sanco/10058/2005 version 2.0, 434 pp.

FOCUS (2008). Pesticides in air: considerations for exposure assessment". Report of the FOCUS Working Group on Pesticides in Air, EC Document Reference SANCO/01572/2008 version 2.0, 327 pp.

Frank MP, Graebing P, Chib JS (2002). Effect of soil moisture and sample depth on pesticide photolysis. J. Agric. Food Chem. 50: 2607-2614.

Gottesbüren B (1991). Konzeption, entwicklung, validierung des wissensbasierten herbizid-beratungssystems HERBASYS. Ph.D. Thesis University of Hannover, 212 pp.

Hebert, VR, Miller GC (1990). Depth Dependence of Direct and Indirect Photolysis on Soil Surfaces .- J. Agric. Food Chem. 38, 913-918.

Jackson RD (1973). Diurnal changes in soil water content during drying. In: Bruce RR et al. (eds): Field soil water regime. SSSA Spec.Publ. no. 5. Soil Science Society of America, Madison, Wisconsin, p. 37-55.

Miller PL, Chin YP (2002), J. Agric. Food Chem. 50, 6758-6785: Photoinduced degradation of carbaryl in a wetland surface water.

NAFTA (2006). NAFTA guidance document for conducting terrestrial field dissipation studies. Regulatory directive DIR2006-01, Pest Management Regulatory Agency, Ottawa, Ontario, 56 pp.

OECD (2002a). OECD guideline for the testing of chemicals. Phototransformation of chemicals on soil surfaces. Proposal for a new guideline. OECD, Paris, 16 pp.

OECD (2002b). OECD guideline for the testing of chemicals. Aerobic and anaerobic transformation in soil. Guideline nr 307, OECD, Paris, 17 pp.

Scorza Junior RP & Boesten JJTI, (2005). Simulation of pesticide leaching in a cracking clay soil with the PEARL model. Pest Management Science 61: 432-448.

SETAC (1995). Procedures for assessing the environmental fate and ecotoxicity of pesticides. Ed. Lynch MR. SETAC, Brussels, 54 pp.

Smelt JH, Dekker A, Leistra M (1979). Effect of soil moisture condition on the conversion rate of oxamyl. Neth. J. agric. Sci. 27: 191-198.

Smit, AAMFR, Van den Berg, F, Leistra, M (1997). Estimation method for the volatilisation of pesticides from fallow soils. Environmental Planning Bureau series 2, DLO Winand Staring Centre, Wageningen, The Netherlands.

Steenpass C, Vanderborght J, Herbst M, Šimůnek J, Vereecken H (2010). Estimating soil hydraulic properties from infra-red measurements of soil surface temperatures and TDR data (in press).

Tester M, Morris C (1987). Plant, Cell and Environment 10, 281-286; The penetration of light through soil.

Walker, A. (1974) A simulation model for prediction of herbicide persistence. J. Environ. Qual. 3: 396-401.

Zhixiong L, Nan C, Perdok UD, Hoogmoed WB (2005) Characterisation of soil profile roughness. Biosystems Engineering 91: 369-377.

Zobeck TM, Onstad CA (1987) Tillage and rainfall effects on random roughness: a review. Soil Tillage Research 9: 1-20.

1314 **ABBREVIATIONS**

DegT50	Half-life resulting from transformation of substance in the soil matrix
FOCUS	Forum for Co-ordination of pesticide fate models and their USe
PBT	Persistence Bioaccumulation Toxicity
PEC	Predicted Environmental Concentration
PEC_{SOIL}	Predicted Environmental Concentration in soil
PPP	Plant Protection Product
PPR Panel	Scientific Panel on Plant Protection Products and their Residues
TWA	Time-Weighted Average

1315