Environmental fate studies

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Original thinking... applied

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Addressing E-fate

For a plant protection product (PPP) or veterinary medicine to pass its regulation phase, it must undergo a stringent environmental risk assessment. To maximise the effectiveness of a chemical or medicine and reduce potential risks, an understanding of the processes that alter and control its environmental dynamics is vital. Here, Fera Science summarises the aspects of an environmental fate study.

An environmental exposure assessment provides chemical manufacturers with an indication of what happens to an active substance once it enters the environment, as well as the likely exposure levels for non-target organisms. The data produced is an essential part of the environmental risk assessment, as it determines the chemical's behaviour in soil, water and air, and the potential uptake or bioaccumulation in organisms.

When conducting an exposure assessment, there are two main areas that we need to consider in order to fully understand what affect the chemical will have in the environment. **These are the persistence of the chemical and how it is degraded, and its absorption parameters and mobility.**

Transformation

Chemicals released into the environment may undergo transformation due to a range of processes. Environmental fate studies are conducted to understand how known processes will impact the behaviour and transformation of a chemical once released into the environment.

Abiotic reactions, biological processes, photolysis and hydrolysis are all naturally occurring processes that drive transformation. Environmental fate studies determine the significance, rate and route of transformation pathways in various environmental compartments.

In accordance with **OECD 307, an Aerobic and Anaerobic Transformation** in Soil test must be carried out in order to measure the time it takes for a test substance to degrade in soil under aerobic or anaerobic conditions and understand which transformation products are produced.

During the test, soil samples are treated with the test substance and incubated in the dark in biometer-type flasks or flow-through systems under controlled laboratory conditions for up to four months. At specific timepoints during the incubation samples are extracted and analysed to determine the concentration of parent compound remaining and any transformation products present.

This data can be used to calculate the rate and route of degradation. To enable this testing, often the chemical substance is synthesised to contain a radioactive isotope marker which enables transformation products that contain the radiolabel so to be easily quantified.

The marker also allows for the generation of a mass balance i.e. to allow all the marker applied at the start of the study to be accounted for at any time throughout the incubation. The mass balance is usually made up of remaining test substance, transformation products, carbon dioxide and residues that remain in the soil matrix following extraction.

Similar tests can also be carried out to determine transformation in aquatic sediment systems, **OECD 308, and natural water, OECD 309** to determine the transformation rate and route of a test substance in these environmental compartments.

When chemicals are exposed to light, they may undergo an abiotic reaction that may trigger transformation of the compound. Another key guideline to consider is **OECD 316**. This refers to photolysis in water to determine the effects of solar irradiation on chemicals in surface water.

On the move

An aspect of a chemicals behaviour that must be examined is how mobile a chemical substance is within the environment. Its potential to leach to other environmental compartment should be assessed which is a key input parameter for predictive environmental fate models. Adsorption and desorption studies are a lower tier study to help understand a chemicals behaviour.

A chemical substance can absorb onto soil dependant on the soil properties. It is important to screen the chemical behaviour in various contrasting soil types. This assessment will support an understanding of the leaching behaviour when either too much of a pesticide is applied, a rain fall event occurs soon after application, or when a highly water-soluble substance is use.

The test guideline that estimates the adsorption and desorption behaviour of a chemical on different soil types is an OECD 106 study. Testing carried out using this guideline involves a batch absorption experiment, which estimates the sorption equilibrium coefficient of a chemical substance within an aqueous and soil test system.

The chemical is applied to the soil: solution test system. After shaking the chemical substance partitions between both phases. This partitioning is driven by a number of parameters controlled within the study, such as soil: solution ratio, soil properties and chemical substance concentration.

Once the adsorption coefficient is determined, we can generate a partition coefficient value. The lower the value, the higher the mobility of the compound. For example a K_{foc} (mL g^{-1}) value of 15, would indicate that the chemical substance has a high potential for leaching, and may pose a ground water contamination risk. Where a higher K_{foc} (mL g) value will indicate that the substance is more likely to adhere to soil and potentially accumulate.

The uptake factor

Absorption is the uptake of pesticide molecules into plant tissues. This action removes some of the pesticide from the soil and reduces the amount available to containment water. When developing a plant protection product (PPP), manufacturers must assess this uptake in order to understand the levels of substance that could access groundwater.

The Plant Uptake Factor (PUF) is used in environmental fate models to represent the proportion of chemical absorbed into the plant via its roots. The magnitude of the PUF value can significantly affect the mass of chemical available in the soil and subsequently the predicted concentrations of the chemical in groundwater. Yet, there is no regulatory accepted test guidance for determining PUF values.

In the absence these uptake values, a default of 0.5 is recommended for systemic, non-ionic chemicals and zero for all others. However, this default is probably not an accurate measurement for each and every PPP and could slow down getting products to market. Fera has been a key participant in the **Industrieverband Agrar e.V. and the European Crop Protection Association (IVA/ECPA) protocol design** with the objective of proposing a new standardised, validated test design to develop regulatory robust **Plant Uptake Factors** for leaching models.

Using a hydrophonic system to generate compound specific plant uptake factors enables chemical manufacturers to refine their estimates of ground and surface water concentrations for their PPPs, aiding a more successful path to registration. At Fera, our Good Laboratory Practice (GLP) compliant, state-of-the-art equipment provide chemical manufacturers with a complete range of environmental fate studies to track the transformation and mobility of plant protection products and their metabolites.

In order to deliver a robust risk assessment, chemical manufacturers must supply data detailing how, and where, their products will react in realistic environmental settings. To deliver on this demand, a complete environmental fate study should be carried out to support the product's safety, viability and overall effectiveness.

Getting Your Product To Market Using PUF - Case Study

Plant protection products (PPP) and their metabolites are assessed using a number of laboratory experiments.

Our client had performed the standard experiments for the assessment of their PPP and had identified a significant metabolite (>10%) occurred during the soil transformation assessment (OECD 307). Further environmental testing on this metabolite identified that it had high mobility (OECD 106) and was moderately persistent (OECD 307).

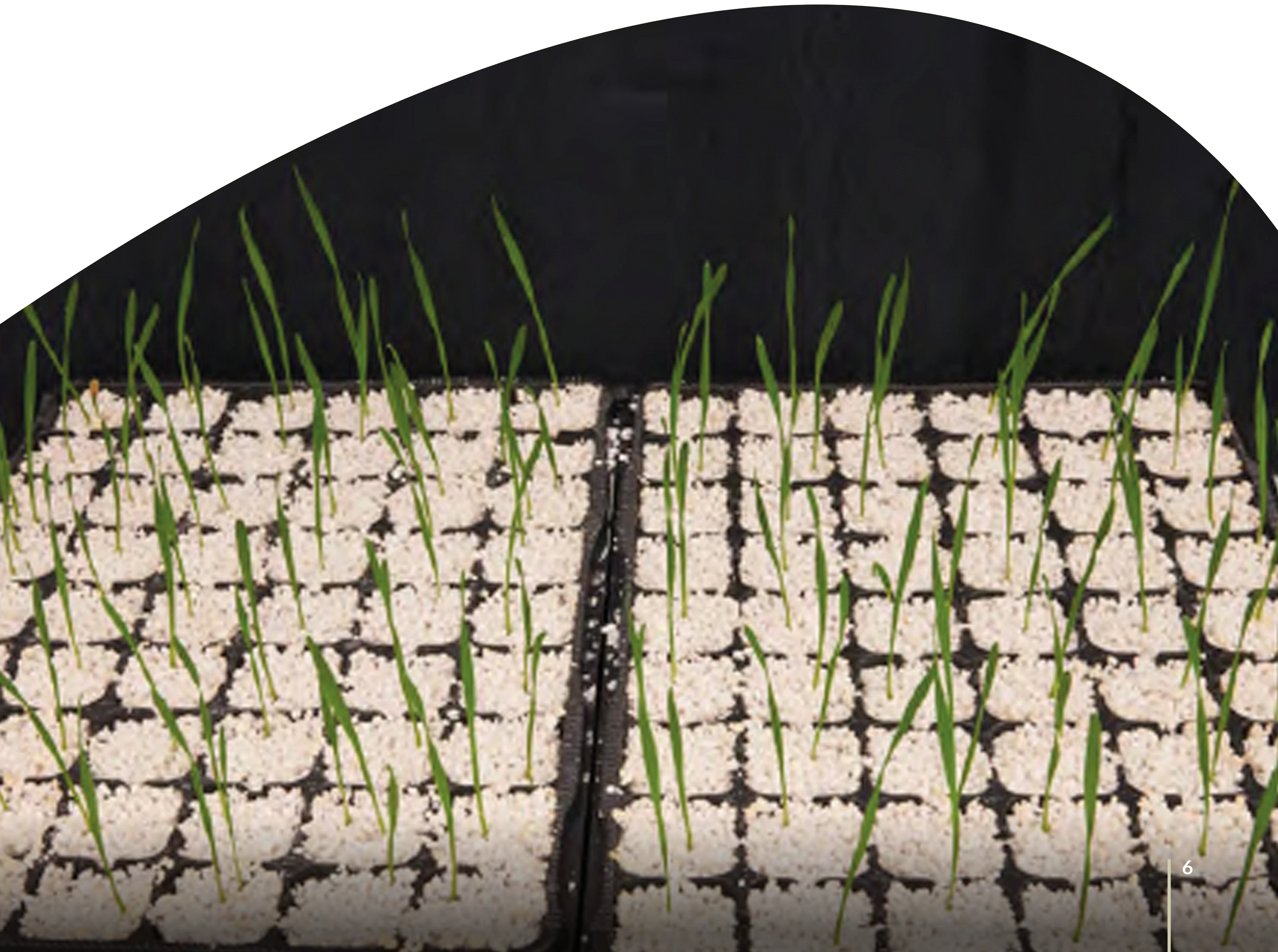
This generated a major issue for our client as it indicated that post application of the parent PPP in the field, this metabolite will be formed during the degradation and is highly likely to leach into groundwater. Computer aided modelling indicated that levels would be above the standardised trigger level of 10 µg/L in the ground water generating an unacceptable risk.

To generate the predicted levels in groundwater, our client was hindered by the fact of a default PUF value of '0', i.e. no uptake, must be used at the modelling stage if no experimental data is available (FOCUS 2014).

Fera performed a PUF assessment on the metabolite of interest and we were able to prove that in reality the metabolite was up taken by the root system of three different crops under laboratory conditions. Fera used three different commercial crops which were a mixture of monocotyledon and dichotomous species to ensure that a robust justification for the results being used in the modelling could be made for a board application PPP. The PUF values ranged between 0.3 and 0.5 for the three crops investigated.

Our client was then able to justify altering the PUF value within the modelling phase and significantly reduce the concentrations within groundwater yielding an acceptable risk.

This helped in supporting the client meeting regulations and contributed towards getting their product to market.



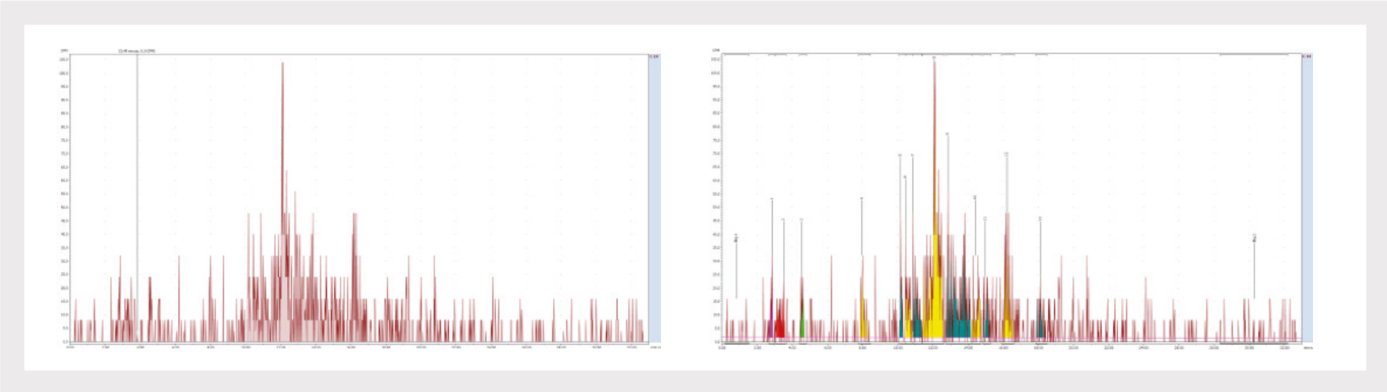
Technology innovation, delivers better data

Metabolite Identification - stop-flow online detection

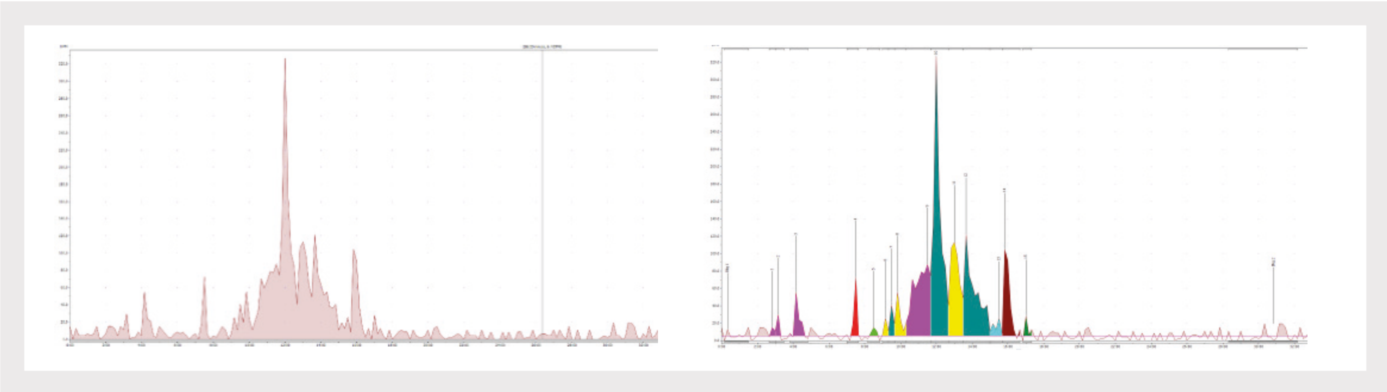
Fera has six βRAM (Lablogic) modules onsite, three of which have the capability to control the LC pump function and stop the eluate flow.

Stop-flow demonstrates superior resolution of metabolite peaks, and an advanced representation of the constituents within the sample. This decreases the risk of triggering artificial major metabolites and improves the reliability and robustness of the data.

Non-Stop Flow



Stop-Flow



Structure elucidation

OrbiTrap coupled with βRAM

This enables Fera to determine unknown transformation products used within eFate and metabolism studies. Fera have coupled their Orbitraps to βRAM model V radioactive detectors to enable the targeted determination of the radioactive transformation products generated.

LC-MS/MS coupled with βRAM

Fera have invested in coupling βRAM model V radio detectors to their high through-put triple quad LC-MS/MS instruments, which enables the rapid determination of co-eluting transformation products, often highly comparable in structure to the parent or known transformation products.

Liquid scintillation counting

We are equipped with up-to-date liquid scintillation (LS) counting capabilities, fully updated with recent electronic data integrity patches to ensure compliance against updated MHRA data integrity guidance (March 2018).

Fera uses LS counting as a staple for eFate and metabolism studies, enabling the accurate quantification of tritium and carbon 14 beta radionuclides. Using a variety of scintillation cocktails, Fera uses this application to determine radioactive residues within a variety of environmental and biological matrices.

Fera's work in environmental fate

Our environmental fate studies include a range of regulatory compliant tests to assess the biodegradation of chemicals in soil and water, and we provide a range of services from single studies to complex, whole programmes, including dossier preparation and submission.

Fera's multidisciplinary teams combine decades of agrochemical and veterinary drug industry experience with world-class technical expertise and analytical capabilities.

We operate in GLP-compliant facilities in the UK and provide regulatory compliant studies for submission in all geographic regions.

Get in touch

For more information and to book a test, call Fera on +44 (0)300 100 0321, email sales@fera.co.uk or visit www.fera.co.uk/environmental-fate-studies

How can Fera help

Environmental fate studies

Bringing new chemical products to market requires an understanding of how they are broken down and degraded in the natural environment. These data allow you to perform the environmental assessments that help meet regulatory requirements.

We offer a full range of degradation testing services for soil and water, with efficient turnaround and innovative bespoke solutions, to get you results more quickly and cheaply than ever before.

Fera fully support our clients from the point of initial study design, through implementation, and dossier submission and response phases. This ensures our clients are fully supported during technical discussions.

We're committed to helping clients get more products to market, with investment in our people and efficient equipment to provide bespoke and innovative solutions.

Degradation Tests	Description
Aerobic and Anaerobic Transformation in Soil (OECD 307)	The purpose of this test is to measure the time course of biodegradation of a test substance in soil under aerobic and anaerobic conditions and to quantify the observations in the form of kinetic rate expressions. Degradation of the test substance will be followed for the parent substance and its potential (known) transformation products. Degradation rate, mass balancing and transformation product pattern will be determined for the test substance. Degradation kinetics will also be followed for any major transformation product, if possible.
Aerobic and Anaerobic Transformation in Aquatic Sediment Systems (OECD 308)	The purpose of this test is to measure the time course of biodegradation of a test substance in aquatic sediment systems under aerobic and anaerobic conditions and to quantify the observations in the form of kinetic rate expressions. Degradation of the test substance will be followed for the parent substance and its potential (known) transformation products. Degradation rate, mass balancing and transformation product pattern will be determined for the test substance. Degradation kinetics will also be followed for any major transformation product, if possible.
Aerobic Mineralisation in Surface Water – Simulation Biodegradation Test (OECD 309)	The purpose of this test is to measure the time course of biodegradation of a test substance at low concentration in aerobic natural water and to quantify the observations in the form of kinetic rate expressions. Degradation of the test substance will be followed for the parent substance and its potential (known) transformation products. Degradation rate, mass balancing and transformation product pattern will be determined for the test substance. Degradation kinetics will also be followed for any major transformation product, if possible.
Ready Biodegradability – CO2 in sealed vessels (Headspace Test) (OECD 301)	Biodegradation is one of the most important factors in assessing the environmental fate of chemicals. Substances coming into the aquatic environment via waste water get in contact with the sewage treatment microorganisms, which is therefore the basis for the assessment of aquatic biodegradation.
Adsorption – Desorption using a Batch Equilibrium Method (OECD 106)	The purpose of this test is to estimate the adsorption/desorption behaviour of a substance on soils. Therefore, the adsorption (binding of a chemical to surfaces of soils) of a test substance on different soil types will be evaluated. The decrease in concentration when aqueous solutions of the test item are in contact with different soil types at room temperature will be determined.
Phototransformation of Chemicals in Water – Direct Photolysis (OECD 316)	Direct photolysis involves the transformation of a chemical resulting from direct absorption of a solar photon. Direct photolysis can be an important dissipation pathway for a chemical that exhibits significant light absorption above 290 nm cut-off of the solar irradiation at the earth´s surface. The purpose of this test is to investigate the potential effects of solar irradiation on the test substance in water. Direct photolysis rate, half-life and quantum yield will be determined for the test item. The transformation product pattern and mass balance can be investigated with the usage of 14C-labelled test item.
OECD DRAFT - Soil Photoysis	The purpose of this test is compliance with the proposed new guidelines for phototransformation of chemicals in soil surfaces. Man-made chemicals may reach soil directly via deliberate application or via indirect routes as chemicals can be transformed in soil by microbial, chemical and/or photochemical processes.

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