Agricultural Research Department

Estimation method for the volatilization of pesticides from fallow soil

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ABSTRACT

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Many pesticides partly volatilize from the soil surface after spray applications. These emissions need to be quantified in order to estimate net loads on the soil and subsequent leaching to surface and groundwater. Various publications provide measured flux densities of pesticides into the atmosphere. However, a general method was lacking to estimate the cumulative volatilization as a function of the pesticide's properties and the most relevant environmental parameters. By correlating volatilization data from the literature to the fraction of the pesticide in the gas phase of the topsoil, a number of easy-to-use regression equations were derived for greenhouse and field conditions.

Keywords: emission, environment, groundwater, surface water

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Contents

Preface

Within the framework of the Environmental Management Act (*Wet Milieubeheer*), the tasks of the Environmental Planning Bureau (*Milieuplanbureau, MPB*) are the responsibility of the National Institute of Public Health and the Environment (*Rijksinstituut voor Volksgezondheid en Milieu, RIVM*). An important task of the MPB is the annual publication of an Environmental Balance (*Milieubalans, MB*). In addition, it publishes the so-called National Environmental Outlook (*Milieuverkenningen*) every four years. The Agricultural Research Department DLO contributes to the MPB tasks by

* providing analyses for various aspects of environmental policy in rural areas;
* developing new models and databases for rural areas and improving existing ones;
* maintaining the level of DLO expertise and assuring its quality.

The cooperation between RIVM and DLO was formalized in an agreement signed in 1996, and implemented in the DLO research programme entitled `Development of expertise for the Environmental Planning Bureau'. On the basis of national and regional requirements, this programme aims to develop and operationalize the expertise required for the MPB tasks and for environmental policy analyses for the Ministry of Agriculture, Nature Management and Fisheries. Research in this programme is partially funded by RIVM.

The environmental balance includes information on the rate and extent of the emission of pesticides into the environment, and on their fate. Part of DLO's contribution to the Environmental Planning Bureau is realized in the project entitled `Emission of pesticides into environmental compartments'. The results of this project are reported below; they will be used to improve the quantification of emissions of pesticides into the air after their application to bare soil. A new method is presented for the quantification of the pesticide load at the soil surface, which will also allow improved assessment of the risk of leaching to the groundwater. The study discussed in this report was carried out in the period between the summer of 1996 and the spring of 1997. Its progress and findings have been regularly discussed within the project team, which consisted of

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Summary

Large-scale use of pesticides during the past decades has given rise to increasing public and political concern. In most cases pesticides are directly sprayed onto soils and crops from where they can volatilize. Once dispersed into the atmosphere, pesticides may precipitate elsewhere on water and soil surfaces. Soil deposits may go into solution and be leached to surface waters and the groundwater. Long range exposure of man and environment could pose serious health risks.

The volatilization of pesticides into the atmosphere after spraying onto agricultural soils is known to depend on their physico-chemical properties, their transformation in the soil and on the soil surface, and the soil and weather conditions. As a single factor cannot be expected to dominate the cumulative volatilization under all conditions, a general estimation method needed to be developed which would take account of the most relevant factors. By correlating volatilization data from the literature to the fraction of the pesticide in the gas phase of the topsoil, a number of regression equations were derived for greenhouse and field conditions. The cumulative volatilization values obtained in this way are stored in the ISBEST information system (Informatiesysteem Bestrijdingsmiddelen), a national database for the use of all pesticides approved in The Netherlands. These data are subsequently processed for estimating the net pesticide load on the soil as input for leaching models. The output of these models are presented in the national environmental balance publications (Milieubalans).

After spraying, the pesticide is distributed over the gas, liquid, and solid phases of the topsoil layer. The amounts present in the gas and liquid phases play an important role in the re-distribution of the pesticide over the soil profile by means of various convective and diffusive transport processes. The amount present in the gas phase is considered to determine the rate of volatilization from the soil surface. Pesticides sorbed to soil organic matter or clay minerals are (temporarily) immobilized, depending on the specific pesticide and soil properties.

Phase partitioning is a well-known method to describe the fractions of the pesticide in the gas, liquid, and solid phases. This method requires the vapour pressure, water solubility, sorption coefficient and a number of environmental variables as input. These environmental variables are ambient temperature, soil moisture and organic matter content, and the soil bulk density.

By correlating the cumulative volatilization (CV) values reported in the literature to the calculated fraction of the pesticide in the gas phase (FP_{gas}), regression equations were derived for various field and greenhouse conditions. Under average soil and weather conditions in the field, the equation reads $CV = a + b \cdot \log FP_{gas}$, with a = 71.9 and b = 11.6. For very dry soil and weather conditions, the coefficients found were a = 42.9 and b = 9.0, respectively. Greenhouse conditions yielded a = 51.1 and b = 7.2.

In a previous study, the DOW method (DOW Chemical USA) was recommended for estimating the cumulative volatilization. A comparison between both approaches

indicated that the DOW method gives systematically higher values, often approaching 100% of the dosage. Such values are not confirmed by the available literature. The method presented here shows results more in line with the reported data. Nonetheless, care should be exercised with the (current) validity of this approach, because only surface applications of non-granular pesticide formulations on fallow soils without residual plant litter were considered. Moreover, pesticides showing a high volatilization rate are usually soil incorporated and not surface sprayed.

It should be noted that the literature often reports large ranges for the physico-chemical properties of pesticides. This obviously affects the accuracy of any quantitative approach for estimating the volatilization. In addition, pesticide half-life values at the soil surface are frequently available, which is likely to result in inaccurate estimations for compounds susceptible to, for instance, photodegradation. The presented method may therefore overestimate the cumulative volatilization for pesticides showing a comparatively high transformation rate in the upper soil layer.

Finally, it is recommended to include physical modelling in order to obtain more accurate estimations for the emission of pesticides to the atmosphere. Such a model should comprise all relevant transport and pesticide transformation processes. Special attention should be given to the temporal variability of the moisture and temperature balance in the top few millimetres of the soil profile. The results of the models computations can be tested against the available measurements.

1 Introduction

Pesticide applications form an integral part of crop production worldwide. In the past decades, the large-scale use of pesticides has led to growing environmental concern. Traces have been detected at such remote places as the arctics. Since most pesticides are sprayed directly onto soils and crops, a substantial part may reach the atmosphere directly by drift of very fine spray droplets or indirectly through volatilization from plant and soil surfaces. Relatively little is known as yet concerning the fate of pesticides in the atmosphere, and consequently long range exposure of man and environment will be difficult to quantify. Terrestrial and aquatic organisms may also be endangered by deposition of pesticides from the air onto soil and water surfaces.

Tools for estimating pesticide emissions to the atmosphere or to the groundwater exist, but they still lack a reasonable degree of accuracy. This holds especially true for national or regional estimations, which cannot easily be verified.

The present report focuses on the volatilization of pesticides from fallow soils, a research activity coordinated by the office for environmental planning (Milieu-planbureau, MPB) of the National Institute of Public Health and Environment (Rijksinstituut voor Volksgezondheid en Milieu-hygiene, RIVM). This office initiates research into estimations of the net pesticide loads on soils, the atmospheric exposure to pesticides in the direct surroundings of the applications, and the long range deposition of pesticides.

Estimating the volatilization of pesticides is an essential element in determining the net deposition on the soil. Results of this study are stored in the ISBEST information system (Informatiesysteem Bestrijdingsmiddelen) developed as a national database for the use of pesticides (Lentjes and Denneboom, 1996). Subsequently, these data can be used for leaching calculations with the PESTLA model (Van den Berg and Boesten, 1997) or the PESTRAS model (Freijer et al., 1996). The output of these models are presented in the national environmental balance publications (Milieubalans 96, RIVM, 1996).

The volatilization rate of a pesticide into the air is largely influenced by its physico-chemical properties. Hence, emission rate and extent will differ considerably between various pesticides. In a previous study, the DOW method was recommended for estimating the cumulative volatilization (Jansma and Linders, 1995). This method directly relates a specific volatilization rate of a chemical to its physico-chemical properties. It is, however, poorly documented and has methodological shortcomings as important soil parameters and pesticide transformation are not taken into consideration.

Earlier studies indicated a possible relation between the volatilization rate and the concentration of the pesticide present in the gas phase of a thin topsoil layer (Bor et al., 1995a; 1995b). This idea is worked out into more detail in this report. The advantage of this approach is that, for a reference set of weather and soil data, the gas phase concentration of a pesticide can be directly calculated from vapour pressure, solubility in water and sorption coefficient. As information was needed on the total volatilization rather than on volatilization rates, an attempt was made to relate the cumulative volatilization data collected from the literature to the concentration of the pesticide in the gas phase.

In order to facilitate data entry and analyses, a spreadsheet program was developed for the approximately 350 pesticides approved in The Netherlands. The spreadsheet yields a table with an estimated value for the cumulative volatilization of each compound, provided that its physico-chemical properties are available or known with reasonable accuracy. More compounds can be easily added.

This report is subdivided into five chapters. After the introduction, Chapter 2 presents a general overview of the pesticide properties and the processes affecting the volatilization from the soil surface. Chapter 3 describes the developed estimation method. Chapter 4 presents a discussion of the results obtained with this method and its validity under various conditions. Finally, Chapter 5 provides the major conclusions and recommendations.

2 Factors and processes affecting volatilization

2.1 Introduction

Pesticides are most frequently applied with spraying machines. Although soils and plants are the only targets, a substantial amount may be lost directly into the air through drift and be deposited elsewhere. Another major pathway of pesticide loss to the environment is the volatilization from the soil and leaf surfaces after spraying. Wind erosion of contaminated soil particles may occur as well under dry conditions of the upper soil layer, thereby removing part of the pesticide load from the soil (Glotfelty et al., 1989).

A first indication of the volatilization tendency of pesticides can be obtained from data on their saturated vapour pressure. It can be expected that compounds with a low vapour pressure, such as atrazine, only modestly contribute to air pollution. The volatilization process, however, may continue for a considerable period until other dissipation processes have substantially reduced the residues. Compounds with a high vapour pressure, on the other hand, may volatilize rapidly within a relatively short period of time, thereby leading to high concentrations in the air. Usually, the more volatile compounds are directly incorporated into the soil, which reduces their escape into the atmosphere considerably.

The volatilization of pesticides from bare soils involves complex processes and mechanisms. The variation in the cumulative volatilization (CV) is large, ranging from 0.13% of the dosage (active ingredient) for a 3-day field experiment with diazinon (Majewski et al., 1989; 1990) to some 40% for a 5-day field experiment using trifluralin (Majewski et al., 1993). A prolonged time-scale may be expected to increase this range.

2.2 Physico-chemical properties of pesticides

The physico-chemical properties of a pesticide relevant for volatilization from the soil surface are molecular mass, vapour pressure, solubility in water, adsorption and half-life values. For a limited number of compounds, mainly weak acids and alkalis, also the dissociation constant plays a role.

The vapour pressure can be considered as the single most important factor in determining the volatilization rate from inert surfaces. Each chemical has its own specific, temperature dependent, saturation vapour pressure with a range extending over several orders of magnitude (Tomlin, 1994). In the soil matrix the pesticide will be partitioned over the solid, liquid and gas phases, resulting in an `effective' vapour pressure which is often much lower than the saturation pressure. The molecular mass is used to convert between pesticide concentration and vapour pressure.

The sorption coefficient controls which part of the pesticide dosage will be bound to organic matter or clay minerals in the soil. Figures in the range of 90% of the pesticide dosage are not unusual, but will obviously depend on the organic matter or clay content of the soil. The soil solution, with relatively low pesticide concentrations due to generally low solubilities, can be considered as a transition medium for pesticide exchange from the solid phase to the vapour phase and vice versa, rather than a storage medium.

Pesticide half-life values do not affect the phase partitioning. In the longer run, however, and depending on their actual values, they will influence the volatilization rate by lowering pesticide concentrations through their (assumed) first-order transformation processes.

Physico-chemical properties of pesticides can be retrieved from various manuals and databases (e.g. Tomlin, 1994, and Hornsby et al., 1996). Often, these authors made a selection from the available data, because of their high variability due to different determination methods or experimental conditions.

2.3 Processes

2.3.1 Introduction

Once a pesticide is sprayed onto the soil, various processes are involved in its distribution over the gas, liquid, and solid phases. In addition, the pesticide may be transported to other compartments such as the groundwater. The spatial distribution of the pesticide over the soil profile will therefore be influenced by parameters like soil properties, soil moisture content, weather conditions as well. Eventually, the resultant of all these processes may be expected to determine the cumulative loss by volatilization.

In this section a subdivision is made between transport, storage, and degradation processes, in which the relevant mechanisms will be briefly discussed.

2.3.2 Transport

Transport from surface to atmosphere

Taylor and Spencer (1990) describe the emission of pesticides into the atmosphere as two separate processes. The first one concerns a phase change from the liquid or solid state into vapour. The second process is the dispersion of the resulting vapour into the atmosphere through molecular diffusion and turbulent mixing. According to Hartley and Graham-Bryce (1980), the air layer with laminar flow characteristics, where diffusion controls the vapour transport, can only be defined in terms of an effective thickness. Its depth above the soil surface is not expected to exceed a few millimetres and will vary with wind speed and surface roughness. A transition zone will exist above this layer where the flow becomes increasingly turbulent.

Convective transport in soils
Convective transport of pesticides follows the water flux in the soil as dissolved constituents. In the upper soil layers this movement occurs mainly in a vertical plane. The magnitude of solute transport strongly depends on the partitioning of the applied chemical between the solid and the liquid phases (Jury et al., 1983).

Downward fluxes, usually referred to as leaching, will move the pesticides from the soil surface to deeper soil layers at a rate mainly determined by the water flux and the partitioning coefficient. Leaching will occur as a result of rain and/or irrigation events.

Upward water fluxes in the soil (capillary rise) are normally caused by evaporation at the soil surface or by water abstraction for plant transpiration. This may induce an upward pesticide transport, particularly in cases where they have been incorporated in the soil. Hartley (1969) has described this process in detail, calling it the `wick effect'. If the evaporation rate of water at the soil surface is higher than the corresponding volatilization rate of the chemical, an increase in concentration results which is likely to accelerate the volatilization for moderately volatile, moderately soluble compounds (Spencer and Cliath, 1973). Dried-out topsoils, however, will considerably reduce the rate of volatilization, due to increased adsorption of pesticides to soil organic matter.

According to Letey and Farmer (1974), the convective flow of pesticides by means of air fluxes in the soil can be considered negligible. Van den Berg (1992), however, comments that under certain conditions the convective flow cannot be neglected. Such conditions could be caused by pressure variations over the (top) soil profile due to meteorological instability, an infiltration front of rain or irrigation water moving downwards, a falling or rising groundwater table, or temperature gradients in the topsoil due to diurnal variations at the soil surface. More research on this subject is needed.

Diffusive transport in soils
Diffusive transport of pesticides occurs in both the gas and liquid phases of the soil matrix. Quantities of pesticides in the vapour phase are small compared to those in the liquid phase. However, since diffusion coefficients in air are several thousand times larger than those in water, mass transport may be in the same order of magnitude (Thomas, 1990).

Diffusion and convection usually occur together, although solute transport may affect the concentration gradient required for diffusive transport. Laboratory data show that for the insecticides lindane and dieldrin volatilization supported by upward convection can be up to five times higher than when controlled by diffusion alone (Taylor and Glotfelty, 1988; Spencer and Cliath, 1973). Similar experiments with trifluralin showed a much smaller difference, most likely due to the lower solubility of this chemical (Spencer and Cliath, 1974). Clearly, also the air-water ratio in the soil matrix and the soil structure itself will determine which process predominates.

Freijer et al. (1996) indicated that vapour transport in general plays an important role for those pesticides having a high or even intermediate ratio of vapour pressure over water solubility (Henry coefficient).

2.3.3 Sorption

Most pesticides are partly sorbed to the organic soil material. Sometimes also the mineral soil particles are involved in this process. Adsorption reduces the actual pesticide concentration in the gas phase considerably and, hence, their volatilization. Sorption of non- (or weakly) polar and nonionic pesticides is strongly related to the organic matter content present in the soil and the surface area of the soil particles (Guenzi and Beard, 1974). For the more polar or cationic chemicals, binding to clay minerals may occur. Adsorption and desorption are reversible processes in the distribution between the solid and the liquid phases. The solid-liquid partitioning of a pesticide is often described by the Freundlich equation, stating that the amount of chemical adsorbed per unit soil is a function of the equilibrium solution concentration to the power 1/N. Usually a value of N equal to 1 is taken, yielding a linear relation, although Glotfelty and Schomburg (1989) indicate that in most cases N varies between 1 and 2. Boesten and Van der Linden (1991) used a value of 1/N equal to 0.9 for their leaching model. This value was calculated as an average from a series of pesticide studies reviewed by Calvet et al. (1980).

Clearly, the amount of water present in the soil pores is an essential element in the sorption process. Glotfelty and Schomburg (1989) state that for a dried-out soil surface layer in equilibrium with air of a relative humidity of about 90%, mineral surfaces with high adsorptive capacities are exposed. At these sites chemicals may adsorb with highly nonlinear isotherms at a capacity of at least two orders of magnitude higher than that for moist soils (Chiou and Shoup, 1985). Spencer and Cliath (1974) reported a 3000 to 5000 greater adsorption capacity for trifluralin in dry soils. This process, however, is largely reversible. Rewetting of the soil leads to competition for `sorbing places' with the water molecules until the soil particles are covered by a monomolecular water layer, at which point desorption of the pesticide stabilizes (Spencer and Cliath, 1974).

2.3.4 Degradation

Pesticides applied to the soil are subject to various degradation processes. They can be transformed biologically, chemically, or photochemically into various metabolites. The type of process and the transformation rate obviously depend on the properties of the pesticide. Also the application technique, climatic conditions and various soil parameters play a role. Due to large scatter of individual reaction coefficients under field conditions, degradation processes are usually lumped as a first-order process and represented empirically by a value for the half-life time (Jury et al., 1983). The application method (surface applied vs. incorporated) determines whether photo-degradation may play an important role or not. Disappearance of pesticides by means of any of these processes is likely to reduce the (long-term) volatilization rate. A comprehensive summary of rate coefficients measured for a variety of pesticides is given by Nash (1988).

2.4 Environmental conditions

2.4.1 Introduction

When pesticides are applied to the soil, their behaviour will be (partially) controlled by this new environment. Generally, the factors influencing pesticide volatilization can be grouped into soil and weather variables. The most significant parameters belonging to each group are discussed in the following sections.

2.4.2 Soil

Important soil parameters are surface roughness, moisture content, organic matter content, bulk density and temperature. For some types of pesticides the soil pH may be of significance. Clay content is important for cationic chemicals, including the weak bases. A pesticide history of the soil may considerably enhance biodegradation when an adaptive microbial population still exists (Nash, 1988).

Surface roughness
The surface roughness largely depends on the shape of the soil surface or vegetation, assuming that no major obstacles or irregularities are present in the (close) proximity. Both the thickness of the laminar air layer just above the soil surface and the eddy diffusion coefficient in the transition zone with turbulent mixing are strongly influenced by the surface roughness (Section 2.3.2).

Moisture content
The pore space in the soil is usually divided between an air fraction and an aqueous fraction. These fractions, together with the liquid-gas partitioning coefficient, determine which part of the pesticide will be in the gas phase and which part in the liquid phase.

Both, soil water and air may also serve as convective and/or diffusive transport media for pesticides in the soil. The fractions of the total pore space occupied by water and air resolve the relative importance of these processes.

Especially the moisture content of the upper soil layer is of crucial importance for the volatilization process. A dried-out top layer may dramatically reduce the volatilization due to extreme adsorption, as discussed in Section 2.3.3. Under dry field conditions, the formation of dew during the evening and early morning and the capillary rise of soil water may restore the moisture content of this layer, thereby increasing volatilization (Glotfelty et al., 1984; Whang et al., 1993). Similar effects have been observed by many authors after irrigation and/or rainfall events (Glotfelty et al., 1984 and 1989; Majewski et al., 1990; Whang et al., 1993; Bor et al., 1995b).

Generally, dissipation processes in the soil are expected to be more rapid under moist conditions than under dry conditions (Nash, 1988).

Organic matter content
The organic material present in the soil is of prime importance for the adsorption and desorption of pesticides and has been discussed in Section 2.3.3.

Bulk density
The soil bulk density largely determines the pore space for air and water. Hence, high bulk densities put a limit on the space available to these media and reduce the rate of transport.

The bulk density is also a factor in the phase partitioning, i.e. in the amount of pesticide sorbed to the organic matter per unit soil volume.

Temperature
Soil temperature directly affects the values of the physico-chemical parameters of the pesticides. Especially the vapour pressure of the pesticides tends to increase sharply with increasing temperature (Spencer and Cliath, 1969; Grover et al., 1978; Grain, 1982; Glotfelty and Schomburg, 1989; Gueckel et al., 1982). Bowman and Sans (1985) reported a positive correlation between solubility and temperature for 28 insecticides, with diazinon en chlorfenvinphos as the two exceptions. In general, the effect of temperature on vapour pressure is larger than on solubility in water.

In the field, temperature in the top soil layer follows the energy balance and reaches its maximum value around solar noon or early afternoon. Volatilization rates will be at a maximum as well, provided that this layer still contains a minimum amount of moisture as to avert strong adsorption effects. Volatilization rates during the night are assumed to be small.

Temperature effects on transport processes are significant near the soil surface. Diffusion coefficients increase with increasing temperature (Letey and Farmer, 1974). Since temperature also affects vapour pressure, solubility in water and sorption, new concentration gradients may be established in the soil profile, thereby causing changes in the diffusion rate.

Convective flows are influenced by spatial and temporal variations in temperature as well. Mass transport may occur from locations with high temperatures to locations where lower temperatures prevail (Nielsen et al., 1972).

Various dissipation processes in the soil are affected by the temperature. Generally, a higher temperature results in a more rapid dissipation of pesticides. For practical purposes, Nash (1988) presumed dissipation to cease at temperatures below freezing point.

2.4.3 Weather

Important climatic parameters are temperature, wind speed, relative humidity, solar radiation, and rainfall (irrigation). Each parameter will be discussed in more detail below.

Temperature
Air temperatures are of direct importance for the volatilization process at the soil surface. As stated before, the temperature strongly affects the vapour pressure of the pesticide and thus the vapour concentration gradient over the laminar flow layer just above the soil surface. The air temperature is often taken as an estimation for the topsoil temperature.

Wind speed
The dispersion of pesticide vapours above the laminar layer into the atmosphere is largely controlled by wind speed and surface roughness. In fact, these two factors determine the eddy diffusivity coefficient to a large extent. Generally, volatilization increases with increasing air flow until a maximum volatilization rate is reached. Waymann and Rüdel (1995) reported for a wind tunnel experiment, in which lindane was sprayed onto bare soils, a cumulative volatilization during 24 hours after application of 12%, 31%, and 31% of the dosage at air flow rates of 0.4, 1.1, and 1.7 m/s respectively.

Relative humidity
A low relative humidity of the (atmospheric) air causes a high water evaporation rate from the bare soil surface, provided that sufficient moisture is available. In case capillary rise cannot replenish the amount of water lost, the soil surface will dry up and the volatilization rate may be reduced due to increased adsorption (Section 2.3.3).

Solar radiation
Effects of solar radiation can be twofold. A high light intensity, especially at the UV wavelengths, accelerates the photochemical breakdown for certain chemicals present at the soil surface. Solar radiation also increases the topsoil temperature as a result of the energy balance, which may affect various processes (Section 2.4.2).

Rainfall (irrigation)
Rainfall (or an irrigation event) may cause a downward flux of water in the soil, moving pesticides away from the soil surface. The magnitude of this solute transport depends on the rainfall quantity, soil characteristics and moisture status, and the pesticide properties. Fairly low amounts of rainfall on dry soils, however, may result in a large volatilization flux caused by desorption (Section 2.4.2).

3 Method for estimating volatilization

3.1 Introduction

In this chapter an attempt is made to estimate the atmospheric emission of the approximately 350 pesticides approved for use in The Netherlands. The approach includes data collected from the literature on the volatilization from pesticide-treated soils. A method using pesticide partitioning over the soil phases was suggested in Bor et al. (1995a) as a possible estimation procedure for the volatilization rate. However, due to the limited number of compounds in the field experiment, no definite conclusions could be drawn.

In order to keep the approach as simple as possible a few pre-conditions were set, namely:
– only fallow soils without plant litter were considered;
– only surface applications were included, ruling out the soil incorporations;
– granular and encapsulated formulations were excluded.

The advantage of the selected approach is that phase partitioning can be derived directly from the pesticide's physico-chemical properties and some of the most relevant environmental variables, for which seasonal averages can be taken. Curve fitting for the volatilization rates against their fraction in the gas phase may lead to an empirical relation required for estimating rates of other chemicals. Instead of using the volatilization rates, however, the cumulative volatilization per compound as dependent variable is used. This quite laborious task also necessitated the development of a spreadsheet program for the approximately 350 pesticides approved in The Netherlands.

3.2 Literature data

The literature search resulted in some 154 references to articles in which the combined keywords `volatilization', `pesticides', and `soils' occurred in titles or abstracts. Unfortunately only 20 articles could be qualified as useful field, greenhouse, and laboratory experiments. The others did not meet the pre-conditions as set out in Section 3.1, were lacking the required quality or quantity for the volatilization data, or missed vital information with respect to environmental variables. Especially the soil moisture content was found to be documented rather poorly in a number of articles, although it is considered to be a critical factor for the volatilization of pesticides.

The information collected from the 20 articles is compiled in Annex 1. The used format includes:

title	- name of author, year of publication, reference code for CardBox database;
compound	- name of compound with most relevant physico-chemical properties;
formulation	- in GIFAP codes or trademark description;

date/place	-	date and place of experiment;
duration	-	duration of experiment (in days);
application	-	mode of application (e.g. hand or machine sprayed, tools used, etc.);
dosage -	-	pesticide dosage (in kg ha^{-1}, sometimes given as backwards extrapolated soil residues);
method	-	experimental conditions (laboratory, greenhouse, field), method used for air sampling;
soil -	-	relevant soil parameters, such as soil composition, organic matter or organic carbon content (in %), moisture content at saturation (in %), dry bulk density (in kg m^{-3}), treated area, depth of soil (lab experiments), and temperature (in ^{o}C);
water regime	-	rainfall and/or irrigation events (in mm on specified day during experiment), actual soil moisture content (in % on specified day, average value between brackets unless mentioned otherwise);
micro-climate	-	air temperatures (in ^{o}C at given height on specified day and where possible as night-day averages), wind speed (in m s^{-1} at given height on specified day or given as a range with average value between brackets), relative humidity of the air (%);
volatilization	-	volatilization rate (in g h^{-1} ha^{-1}) after 2 hours, 24 hours, at the end of the measurement period, and sometimes at a number of intermediate intervals), cumulative volatilization (CV values in percent of dosage after 2 hours, 24 hours, at the end of the measurement period, and sometimes at a number of intermediate intervals).

Annex 2 presents the major physico-chemical properties of all pesticides referred to in Annex 1. Tabulated are the molecular mass, vapour pressure, solubility in water, sorption coefficients, and DT_{50} values. The coefficient for sorption to soil organic matter K_{om} is preferred. If not available, the coefficient for sorption to soil organic carbon K_{oc} or the octanol-water partitioning coefficient K_{ow} is used. Times for 50% dissipation (DT_{50}) refer primarily to the lumped dissipation processes in the soil. This is a more general parameter than half-life, which implies first order kinetics. For specific processes occurring at the soil surface, such as photochemical degradation, also other DT_{50} values may be useful. Where available, these are added. Preferably, sorption coefficients and DT_{50} values were retrieved from data of the National Institute of Public Health and Environment (Linders et al., 1994). Sources for molecular mass, vapour pressure, and solubility were obtained from Tomlin (1994) and Hornsby et al. (1996). Pertaining temperatures are added in parentheses behind vapour pressure and solubility and, where relevant, dissociation constants behind solubility values.

3.3 Pesticide partitioning between soil phases

The mathematical formulation of the post-application pesticide distribution over the gas, liquid, and solid phases is a well known method to estimate a pesticide's `effective' vapour pressure. In the methodology followed in this section (Van den Berg, 1992), the partitioning between the gas and liquid phases is expressed as:

$$C_{liquid} = K_{l/g}\, C_{vapour} \qquad (1)$$

with:
C_{liquid} = concentration of pesticide in the liquid phase (kg m^{-3} liquid)
C_{vapour} = concentration of the pesticide in the gas phase (kg m^{-3} gas)
$K_{l/g}$ = liquid-gas partitioning coefficient ((kg m^{-3} liquid) / (kg m^{-3} gas))

When assuming a linear sorption isotherm, the partitioning between the solid and liquid phases can be written as:

$$X = K_{s/l}\, C_{liquid} \qquad (2)$$

with:
$K_{s/l}$ = solid-liquid partitioning coefficient ((kg kg^{-1} solid) / (kg m^{-3} liquid))
X = mass of pesticide adsorbed to the soil particles (kg kg^{-1} solid)

The concentration of the pesticide in the soil system is described by:

$$C_{soil} = \theta_{gas}\, C_{vapour} + \theta_{liquid}\, C_{liquid} + \rho_{soil}\, X \qquad (3)$$

with:
C_{soil} = concentration of pesticide in the soil matrix (kg m^{-3} soil)
θ_{gas} = volume fraction of gas ((m^3 gas) (m^{-3} soil))
θ_{liquid} = volume fraction of moisture ((m^3 liquid) (m^{-3} soil))
ρ_{soil} = dry bulk density of the soil ((kg solid) (m^{-3} soil))

Equation (3) can also be written as:

$$C_{soil} = Q\, C_{vapour} \qquad (4)$$

with the capacity factor Q as:

$$Q = \theta_{gas} + \theta_{liquid}\, K_{l/g} + \rho_{soil}\, K_{l/g}\, K_{s/l} \qquad (5)$$

In principle, all variables in Equation (5) are known. $K_{s/l}$ can be set equal to the sorption coefficient K_{om} times the organic matter content of the soil. $K_{l/g}$ follows directly from Equation (1), where the vapour concentration can be derived from the vapour pressure using the ideal gas law. The dimensionless fraction of the pesticide in the gas phase then follows from:

$$FP_{gas} = \frac{\theta_{gas}}{Q} \qquad (6)$$

3.4 Temperature effects

Generally, ambient temperature during field experiments shows considerable variation. Average daily air temperatures ranged from 11.5 ^{o}C to 30 ^{o}C in the 14 field studies. As remarked before, physico-chemical parameters may highly depend on temperature. Atrazine, for example, has a vapour pressure of about 0.0076 mPa at 10 ^{o}C, but at a temperature of 30 ^{o}C this value may rise to 0.187 mPa (Hornsby, 1996). Corrections were made for the effect of temperature on the vapour pressure using the Clausius-Clapeyron equation (Klotz and Rosenberg, 1974):

$$\frac{d\,(\ln P)}{dT} = -\frac{\Delta H_v}{R\,T^2} \qquad (7)$$

where:

P = vapour pressure at temperature T (Pa)
ΔH_v = heat of vaporization (J mole^{-1})
R = universal gas constant (8.314 J mole^{-1} K^{-1})
T = temperature (K)

For a limited number of pesticides the heat of vaporization could be retrieved from the literature (Table 1). For some others, vapour pressures were available at two or more different temperatures, providing the opportunity to estimate the heat of vaporization using Equation (7) (Table 2). Care should be taken, however, not to cross melting points as to avoid a change from ΔH_v to the heat of sublimation ΔH_s (Glotfelty and Schomburg, 1989). Differences between vapour pressures at equal temperatures can be attributed in many cases to the different methods with which the vapour pressure was determined. For all remaining pesticides, a heat of vaporization of 95 kJ mole^{-1} was calculated as an average from Tables 1 and 2.

Table 1 Heat of vaporization for ten pesticides

Compound	Heat of vaporization (kJ mole^{-1})	Reference
dichlobenil	87	Humburg et al., 1989
dichlorvos	66	Gückel et al., 1982
EPTC	58	Hamaker, 1972
lindane	115	Gückel et al., 1982
parathion	96	Gückel et al., 1982
parathion-methyl	94	Gückel et al., 1982
tri-allate	84	Gückel et al., 1982
trifluralin	121.4	Spencer and Cliath, 1974
pp-DDT	117.9	Gückel et al., 1982
dieldrin	98.8	Spencer et al., 1969

Table 2 Calculated values for the heat of vaporization for nine pesticides

Compound	Heat of vaporization (kJ mole-1)
atrazine	146
chlorpyriphos-ethyl	83
diazinon	59
lindane[1]	91
oxamyl	66
parathion[1]	91
simazine	131
trifluralin[1]	116
prometon	91

[1] literature value of Table 1 used in spreadsheet

Also values for the differential heat of solution ΔH_{sol} can be obtained from the literature (Table 3). The effect of temperature on the solubility of a pesticide in a saturated solution can be calculated by substituting the vapour pressure P in Equation (7) with the solubility S and ΔH_v with ΔH_{sol} (Bowman and Sans, 1985). For pesticides with solubilities given at more than one temperature, values for ΔH_{sol} can be computed (Table 4). Generally, the temperature effect on solubility in water is smaller than on vapour pressure. Both Tables 3 and 4 show positive values for the majority of the chemicals, but negative values occur for diazinon and chlorfenvinphos. The literature did not reveal an explanation for this phenomenon. For all other pesticides, a differential heat of solution of 27 kJ mole^{-1} was calculated as an average from Tables 3 and 4.

Table 3 Differential heat of solution for 18 insecticides (source: Bowman and Sans, 1985)

Compound	Differential heat of solution (kJ mole^{-1})	Compound	Differential heat of solution (kJ mole^{-1})
azinphos-methyl	54.35	fenamiphos	11.14
bromophos-ethyl	49.28	malathion	5.36
carbaryl	20.94	parathion	13.90
carbofuran	9.00	parathion-methyl	35.25
carbophenothion	6.36	phosalone	40.32
chlorfenvinphos	-5.48	pirimephos-methyl	25.83
chlorpyrifos	37.81	propoxur	12.02
diazinon -	17.38	temephos	156.26
dieldrin	32.74	trichloronat	9.42

Table 4 Calculated values for the differential heat of solution for two pesticides

Compound	Differential heat of solution (kJ mole^{-1})
chlorpyrifos-ethyl[1]	27
lindane	27

[1] literature value of Table 3 used in spreadsheet

3.5 Results

3.5.1 Spreadsheet implementation

In order to handle the amount of data, various conversions and the data analyses, a spreadsheet was developed. The spreadsheet contains the 352 pesticides currently approved in The Netherlands, as well as a few (obsolete) others for which volatilization data were available in the literature. The approved compounds were classified according to the name of their active ingredient and were retrieved from the ISBEST information system, a national database for the use of pesticides (Lentjes and Denneboom, 1996).

First, an empirical relation was established between the calculated fraction of the pesticide in the gas phase of the soil top layer and the cumulative volatilization (CV in % of the dosage) for those pesticides found in the literature. Secondly, an estimation was made for all other compounds using their calculated fraction in the gas phase as entrance variable in the derived empirical relation. Each item is treated in more detail below.

Empirical relation between CV and fraction in gas phase

The literature search resulted in useful data on the volatilization from the soil surface in the field for 31 pesticides. Their names were added in the spreadsheet as far as they were not already listed among the approved 352 compounds. Some chemicals occurred more than once (Table 5). For each pesticide, its vapour pressure and solubility in water were modified for the ambient temperature, as described in Section 3.4. Then the partitioning of the pesticides over the three soil phases was calculated following the procedure presented in Section 3.3. Finally, the literature values for the cumulative volatilization were correlated against the fraction of the pesticide present in the gas phase.

Table 5 shows literature data for the cumulative volatilization under field conditions. A direct comparison is complicated by the different time scales of the various experiments. CV values in this study (see Annex 1) are recorded at 2 hours, 24 hours, at the end of the measurement period, and at some intermediate points. For each pesticide, a single logarithmic and a double logarithmic regression analysis was made for its CV values against time. It turned out that for the `low volatilizers', that is with CV values less than 10% of the dosage, the double logarithmic model in most cases produced the best correlation regression. For the `high volatilizers', with a volatilization above 10% of the dosage, the single logarithmic model usually gave a better fit. Table 5 also presents the cumulative volatilization values interpolated or extrapolated to a 21 day period.

The empirical relation between cumulative volatilization and the fraction of the pesticide in the gas phase of the top layer is given in Figure 1. Two studies, namely Majewski et al. (1989; 1990) and Bor et al. (1995b), were conducted under very dry conditions, without irrigation or rainfall. It may be assumed that adsorption to the completely dried-out topsoils was extremely high. A second empirical relation is therefore derived for dry field conditions.

Table 5 Cumulative volatilization (CV) values for 31 pesticides in 14 field studies at the end of the measurement period and estimated values at 21 days after application

Reference	Compound	Duration experiment (days)	CV at end of study (in % of dosage)	CV estimated at t = 21 days (in % of dosage)	Correlation coefficient (r^2)		Number of observations
					Single log model	Double log model	
Bor et al., 1995a	tri-allate	14	29	30	0.975[1]	0.993	4
	ethoprophos	14	24	25	1.000[1]	0.955	4
	parathion-ethyl	14	4	5	0.953	0.972[1]	4
Bor et al., 1995b	EPTC	14	26	28	0.923[1]	0.876	4
	tri-allate	14	19	20	0.971[1]	0.924	4
	parathion-ethyl	14	2.4	2.8	0.903	0.980[1]	4
Pattey et al., 1995	trifluralin	4.2	13	17	1.000[1]	0.972	3
	tri-allate	4.2	21	26	0.948[1]	0.998	3
Haenel and Siebers, 1995	lindane	2	15	23	0.997[1]	0.997	3
Wienhold and Gish, 1994	atrazine	35	8.6	7.7	0.976	0.964[1]	5
	alachlor	35	13.8	12.4	0.988[1]	0.844	5
Majewski et al., 1993	trifluralin	5	40	46	0.865[1]	0.956	3
	tri-allate	5	38	44	0.883[1]	0.980	3
Siebers et al., 1993 lindane		2	17.5	28	0.990[1]	0.979	3
	lindane	2	28	42	0.972[1]	1.000	3
Whang et al., 1993 fonofos		26	27	25	0.955[1]	0.957	4
	chlorpyrifos-methyl	26	12	11	0.920[1]	0.968	4
	atrazine	26	1.9	1.8	0.837	0.994[1]	4
Majewski et al., 1991	chlorthal-dimethyl	21	18	16	0.865[1]	0.935	5
Clendening et al., 1990	EPTC	3	32	45	0.996[1]	0.992	3
	atrazine	17	0.6	0.8	0.779	0.995[1]	3
Ross et al., 1990	chlorthal-dimethyl	21	10	7	0.630[1]	0.942	4
Majewski et al., 1989;1990	chlorpyrifos-ethyl	3.2	0.64	1.48	0.626	0.815[1]	3
	diazinon	3.2	0.13	0.27	0.626	0.796[1]	3
	lindane	3.2	9.9	11.8	0.662[1]	0.848	3
	nitrapyrin[2]	3.2	15	18	0.685[1]	0.844	3
Glotfelty et al., 1989	alachlor	21	19	16	0.836[1]	0.988	4
	toxaphene	21	31	26	0.849[1]	1.000	4
	atrazine	21	2.4	2.8	0.779	0.995[1]	4
	simazine	21	1.3	1.2	0.738	0.999[1]	4
Turner et al., 1978	chlorpropham	7	37	40	0.782[1]	0.973	3

[1] model selected in spreadsheet
[2] nitrapyrin is a nitrification inhibitor

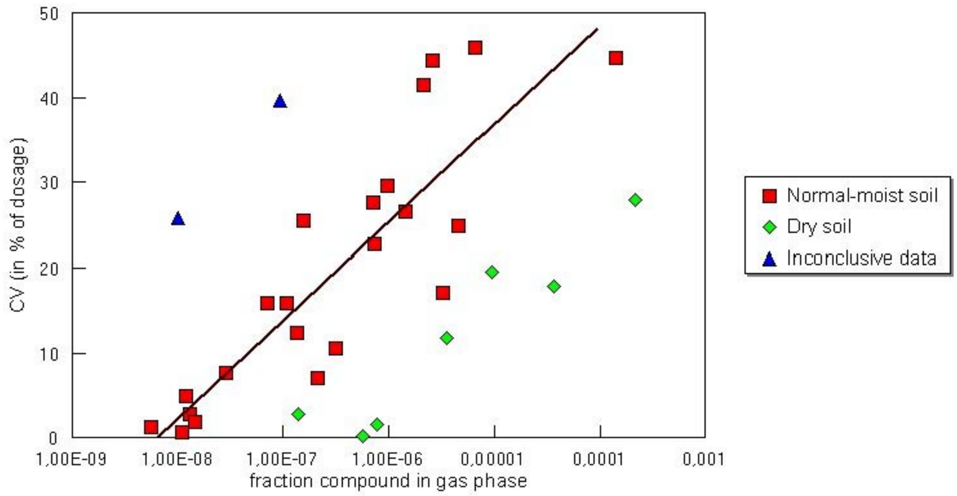

Fig. 1 Relation between cumulative volatilization at 21 days after application and fraction of compound in gas phase under various field conditions

The pesticides chlorpropham and toxaphene (left side) were not included in the regression analysis. In the literature, toxaphene is specified as a mixture of various compounds, making it difficult to establish single values for its physico-chemical properties. The high volatilization of chlorpropham could not be very well explained, but may be attributed to an incorrect vapour pressure used for calculating the fraction of this pesticide present in the gas phase (Leistra, Personal communication, 1997).

The empirical relation for normal to moist field conditions at 21 days after application reads ($n = 22$ and $r^2 = 0.76$):

$$CV_{normal-moist} = 71.9 + 11.6 \log [100\ FP_{gas}] \ ; \ 6.33\ 10^{-9} < FP_{gas} \leq 1 \quad (8)$$

where:

CV = cumulative volatilization (% of dosage active ingredient)

FP_{gas} = fraction of pesticide in the gas phase

For dry field conditions at 21 days after application, the following relation was established ($n = 7$ and $r^2 = 0.89$):

$$CV_{dry} = 42.3 + 9.0 \log [100\ FP_{gas}] \ ; \ 0.2\ 10^{-6} < FP_{gas} \leq 1 \quad (9)$$

Some of the in Figure 1 presented compounds are known to volatilize readily. Trifluralin, tri-allate, and EPTC pesticide applications may show losses in the order of magnitude of 40 to 50% and are therefore usually incorporated into the soil.

In a similar way as for the field experiments, a relation between cumulative volatilization and the fraction of the pesticide in the gas phase can be derived for greenhouse conditions. Volatilization data from the literature for six experiments, including 11 different compounds (see Annex 1), are presented against the calculated

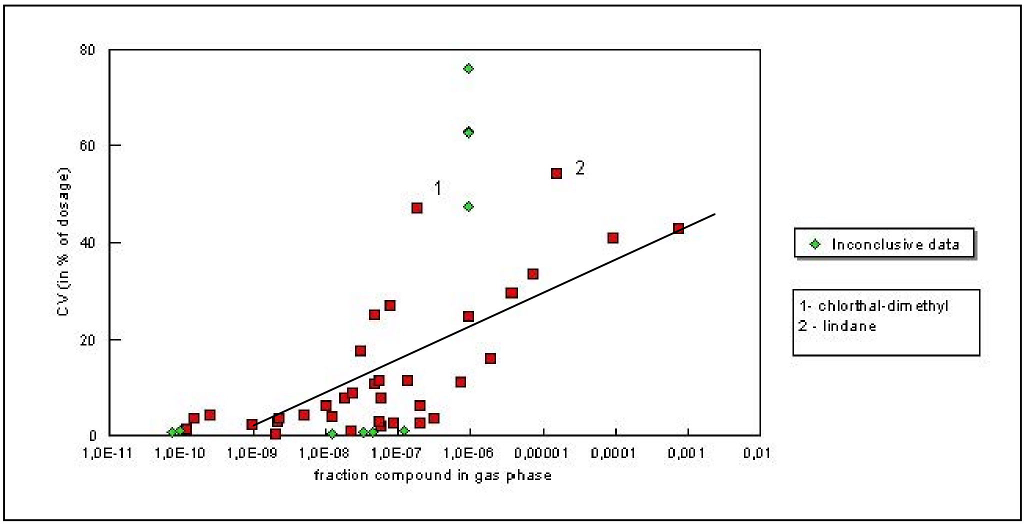

Fig. 2 Relation between cumulative volatilization at 21 days after application and fraction of compound in gas phase under various greenhouse and laboratory conditions

fraction in the gas phase in Figure 2. The regression equation for the cumulative volatilization at 21 days after application yields for this case (n = 35 and r^2 = 0.55):

$$CV = 51.1 + 7.2 \log [\, 100\, FP_{gas} \,] \;\; ; \;\; 0.8\ 10^{-9} < FP_{gas} \leq 1 \qquad (10)$$

A limited number of the presented data were derived from laboratory experiments. Four measurements using lindane were conducted in a wind tunnel with air velocities in excess of 1 m s^{-1}, which can be marked as unrealistic values for greenhouses (Waymann and Rüdel, 1995). They are depicted as inconclusive data in the upper part of Figure 2. Other laboratory data, however, fitted closely to the regression line.

Inconclusive data shown at the bottom half of Figure 2 concern experiments conducted under isothermal conditions, where the authors did not always succeed in maintaining low soil temperatures of 5 and 15 ^{o}C under warm and humid conditions. In most cases this also caused flooding of the soil surface (Nash and Gish, 1989, and Nash, 1989a).

The results for two greenhouse trials with the pesticides chlorthal-dimethyl (Nash and Gish, 1989) and lindane (Nash, 1983) show a distinct deviation from the regression line. The literature does not indicate an explanation for this anomaly, except that these experiments were carried out under relatively high temperatures of 27 and 35 ^{o}C respectively.

Estimating the cumulative volatilization for other pesticides

Cumulative volatilization values can be computed on basis of the calculated fraction of the pesticide in the gas phase and the regression equations (8), (9) or (10). In order to determine the fraction in the gas phase, all relevant physico-chemical properties of the pesticides such as vapour pressure, solubility in water, and sorption coefficient need to be known. Annex 3 presents a summary containing these properties for 279 out of the 352 compounds.

The fraction of the pesticide in the gas phase also depends on the soil organic matter content, dry bulk density, ambient temperature and soil moisture content. These parameters are user definable, where the temperature and soil moisture should be entered as average values over the selected period for volatilization.

Estimated cumulative volatilization values (in % of dosage) for both field and greenhouse conditions can be retrieved from Annex 4 for 279 compounds. This number is limited by the availability of physico-chemical properties. All results are based on the following input data:

– duration of volatilization period:	21	days
– dry bulk density of the topsoil:	1400	kg m^{-3}
– organic matter of the topsoil:	4.7	%
– volumetric moisture content of the topsoil:	10	%
– ambient temperature:	20	^{o}C

For comparison purposes, a third column was added to Annex 4 containing cumulative volatilization values using the DOW method as recommended by Jansma and Linders (1995). This method directly relates the pesticide's physico-chemical properties to a rate coefficient K_v (Eq. 11) in a first-order kinetics equation for the concentration of the pesticide at the soil surface.

$$K_v = \frac{Q\,P}{K_{om}\,S} \tag{11}$$

with:

K_v = volatilization rate coefficient (d^{-1})

P = vapour pressure at room temperature (Pa)

K_{om} = coefficient for sorption on soil organic matter at room temperature (dm^3 kg^{-1})

S = solubility in water at room temperature (mg l^{-1})

Q = empirical constant equal to 5.6 10^5 (mg Pa^{-1} kg^{-1} d^{-1})

It can be noted from Annex 4 that all values estimated with the DOW method for a 21 day period are systematically higher than those found with the method derived in this report. The rate coefficient K_v reaches particularly high values for cases where the product of solubility and sorption approaches zero. Some 70 out of the 279 pesticides show a cumulative volatilization of more than 90%, which is not supported by any study covered by this report.

Figure 3 presents the sensitivity of the estimated cumulative volatilization for chlorpyrifos-ethyl for (realistic) variations in four environmental input parameters. This insecticide is moderately volatile with an estimated cumulative volatilization of about 20% of the dosage under field conditions. The figure is based on the following reference data:

– duration of volatilization period:	21	days
– dry bulk density of the topsoil:	1300	kg m^{-3}
– organic matter content of the topsoil:	3	%
– volumetric moisture content of the topsoil:	20	%
– ambient temperature:	20	^{o}C

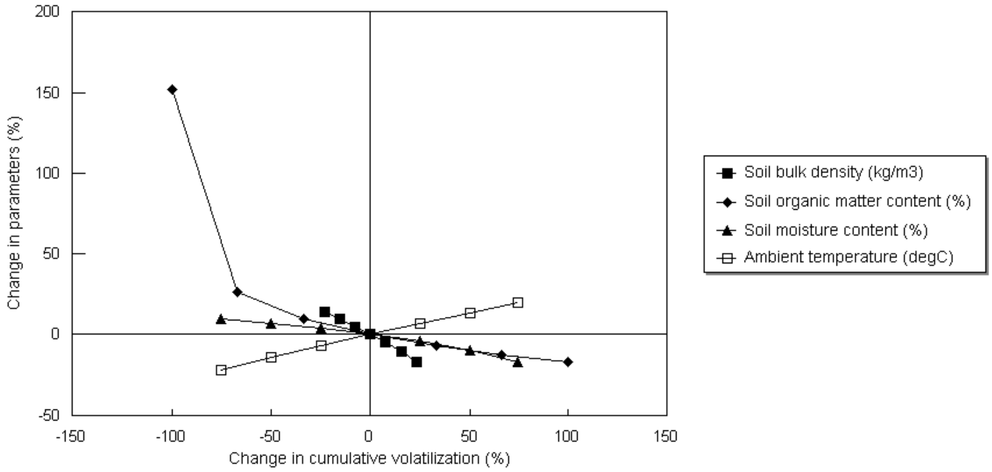

Fig. 3 Sensitivity of the calculated cumulative volatilization of chlorpyriphos-ethyl for changes in four environmental parameters

Apparently, a sharp reduction in volatilization occurs for low values of the soil organic matter content (Fig. 3). The other relations show a slightly non-linear behaviour, but do not affect the cumulative volatilization for more than 25% within the given ranges. It should be noted that a volumetric soil moisture content of less than the lower limit of 5% could lead to excessive binding of the pesticide to soil organic matter and thus greatly reduce the volatilization (see also Section 2.3.3).

3.5.2 Data requirements

The spreadsheet requires the following items as input data:

Physico-chemical properties of the pesticides

For each pesticide the vapour pressure in mPa, solubility in water in mg l^{-1}, and sorption coefficient in dm^3 kg^{-1}. The coefficients for sorption on organic matter (K_{om}) are preferred. Coefficients related to organic carbon (K_{oc}), however, can be converted to K_{om} by multiplication with the factor 0.57. Octanol-water partition coefficients (K_{ow}) are converted following Rao and Davidson, (1980):

$$\log(K_{oc}) = 1.029 \log(K_{ow}) - 0.18 \qquad (12)$$

Temperature

Average air temperature during daylight hours over the considered period in degrees Celsius. The volatilization is assumed to take place only during these hours.

Soil moisture content

Volume percentage of soil moisture in the top layer as an average value over the considered period. This parameter is a critical and highly variable factor in the volatilization of surface- applied pesticides. The moisture content is usually not very well documented (especially for the top few millimetres of the surface layer) and is difficult to estimate.

Soil bulk density
Dry soil bulk density in kg m^{-3}.

Soil organic matter content
Soil organic matter in percent. In cases where a value is given for organic carbon, multiplication with the factor 1.75 is required.

Some additional parameters were entered in the spreadsheet for future analysis. These are wind speed, pesticide dosage, and DT_{50} values for transformation processes in the soil and on the soil surface.

4 Discussion

Data on the volatilization of pesticides are not commonly available. The publications usually cover a small range of widely-used compounds. In many cases extrapolation to other pesticides is problematic due to highly different physico-chemical properties and environmental conditions. These difficulties, however, could be (partly) solved by correlating the cumulative emission values found in the literature to the pesticide's fraction in the gas phase, where it is readily available for volatilization.

The partitioning method provides the fractions of the pesticide distributed over the gas, liquid, and solid phases of the soil. These fractions depend on the pesticide's physico-chemical properties and a number of environmental variables, such as soil moisture and organic matter content and ambient temperature. According to its mathematical description, the pesticide distribution over the soil phases remains constant as long as the involved environmental conditions remain the same. In this study, constant values were taken for the temperature and soil moisture content during the measurement period.

The actual pesticide concentration at the soil surface varies with time, depending on various transport and/or transformation processes. The time related dependency of the volatilization is represented by the values retrieved from literature, in which other processes, such as transport to deeper soil layers and degradation, play a role. These values were interpolated or extrapolated to a standard period of 21 days for all compounds using single or double logarithmic regression analysis. In general, the double logarithmic model gave the best results for compounds with a cumulative volatilization of less than 10% of the dosage and the single logarithmic model for compounds with a cumulative volatilization higher than 10%.

Regression analysis was also used to obtain a relation between the cumulative volatilization values (CV in percent of the dosage) collected from the literature and the fraction of the pesticide in the gas phase (FP_{gas}). For 11 field experiments, including 12 different pesticides (eight pesticides occurred more than once) and carried out under average soil and weather conditions, a relation was found in the form of $CV = a + b \log FP_{gas}$, with a = 71.9 and b = 11.6 (n = 22 and $r^2 = 0.76$). For two field experiments, including seven pesticides and carried out under very dry soil and weather conditions, the coefficients were a = 42.9 and b = 9.0 respectively (n = 7 and $r^2 = 0.89$). Results for two chemicals, namely toxaphene and chlorpropham, were rejected as inconclusive. This was mainly attributed to their uncertain physico-chemical properties. Toxaphene is specified as a mixture of various compounds, making it difficult to establish single values for its physico-chemical properties. The origin of the vapour pressure quoted for chlorpropham is not clear.

In a similar way as for the field experiments, a regression equation can be derived for greenhouse conditions. The coefficients in the logarithmic equation for the cumulative volatilization are a = 51.1 and b = 7.2 (n = 35 and $r^2 = 0.55$). These values are based on six experiments, including two under laboratory conditions, with 11 different compounds (four pesticides occurred more than once). The relatively low correlation could be ascribed to two deviating measurements for volatilization losses of lindane and chlorthal-dimethyl (DCPA), for which no satisfactory explanation was found.

Although the cumulative volatilization of a pesticide was found to be reasonably correlated to its fraction in the gas phase, volatilization values quoted in the literature frequently show considerable variation for similar compounds. The various methods available for measuring pesticide volatilization rates are found to produce statistically comparable results. The scatter may therefore be explained by factors influencing the volatilization rate, such as wind speed, formulation type of the applied pesticide, dosage inaccuracy, and differences in the transport and degradation rates of the pesticides in or on the soil. Literature also indicates the soil moisture content as one of the key variables in the volatilization process. Recordings during field experiments, however, are frequently inaccurate and usually do not cover the upper millimetres of the soil where a cyclic process of wetting and drying takes place, thus strongly affecting the volatilization rate.

The equations derived in this study can be used to estimate the cumulative volatilization for any other compound using its fraction in the gas phase as input variable. The environmental conditions should be determined a priori and are assumed to remain constant during the selected period of volatilization.

Clearly, the presented approach has a number of limitations and/or shortcomings. Data collected from the literature were confined to surface-sprayed, fallow soils without (significant) plant litter. Also granular or encapsulated applications were not included. Separate relations, however, could be derived in a similar way as described in this study, provided that enough data can be made available for such conditions. Also the removal of pesticides from the soil surface by means of wind erosion was not covered by this study. This relocation depends on both the applied formulation and the wind speed, and could have a noticeable effect on the volatilization under dry meteorological conditions.

The overall accuracy of any quantitative approach depends on the availability and accuracy of the physico-chemical properties of the pesticides. Product development bulletins, literature, and various databases disclose a considerable range for many compounds. Moreover, the actual volatilization may also depend on specific properties of the chemical not directly covered by this study, such as its half-life in the soil or on the soil surface. Some compounds transform so rapidly that their emission to the atmosphere can only be a fraction of what is indicated by their principal physico-chemical properties (e.g. the insecticide heptenophos, Annex 3). This may not be the case for their metabolites, however. If the relevant metabolites, their physico-chemical properties, and the transformation kinetics of the parent compound are known, an estimation for the volatilization can be made using the method developed in this study.

Compared to other approaches, as for instance the DOW method, it can be concluded that coupling the cumulative volatilization to the phase partitioning of pesticides has the advantage of including important environmental parameters as soil moisture content and soil composition. Both methods allow for the influence of the ambient temperature by adjusting the vapour pressure and water solubility. Values for the cumulative volatilization obtained with the present approach are considered realistic when compared to the measured values cited in the literature (comparison Table 5 and Annex 4). Unlike results obtained with the DOW method, no unrealistically high volatilization is calculated for adsorption coefficients approaching zero.

More accurate estimations for the volatilization of pesticides from the soil surface can be achieved by developing a physical model describing all relevant processes. Existing field scale models are capable to provide the heat and moisture balance of the topsoil layer. Moreover, they can also describe the temporal variability of these parameters, which determine the volatilization process to a large extent. The physical structure and soil composition of the upper few millimetres of this layer probably deserves additional attention for both the moisture and heat balance and pesticide behaviour. Also the transformation of pesticides on the soil surface should be included. The incorporation of a volatilization module offers the possibility to include other important parameters influencing this process, such as wind speed and (land) surface roughness. Finally, the computational results obtained with the model can be validated against the available measurements collected from the literature.

5 Conclusions and recommendations

The method described in this report provides a number of easy-to-use regression equations for estimating the cumulative volatilization of pesticides from the bare soil surface. Once the physico-chemical properties of a given compound are known, such estimates can be made on the basis of a few environmental variables.

Results obtained with this method are certainly more in line with cumulative volatilization values reported in the literature, when compared to values obtained with the DOW method. Moreover, the DOW approach is poorly documented and has methodological shortcomings as important soil parameters and pesticide transformation are not taken into consideration.

Unfortunately, the literature reports wide ranges for the physico-chemical properties for a considerable number of pesticides. This obviously inhibits accurate estimates using any quantitative approach. The quality of the input data, therefore, requires careful analysis and where reliable information is missing, adequate measurements are needed.

This study did not investigate the effect of the wind speed on the volatilization of pesticides, but the 14 field experiments examined in this report probably show enough variation in wind speed to establish an average relation. For the single laboratory experiment carried out in a windtunnel, it was reported that the wind speed had a major influence on the volatilization. Further investigations are therefore recommended.

Data on the half-life values of pesticides at the soil surface are scarce. For a number of compounds hydrolysis and especially photochemical degradation play an important role. In case a pesticide transforms rapidly, the current calculations overestimate the cumulative volatilization. Additional information on these specific processes is needed.

Finally, it is recommended to build a physical model describing all relevant processes for the volatilization of pesticides from the soil surface. More accurate estimations for this loss route can be obtained once such a model has been validated against available measurements.

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Annex 1 Summaries of data retrieved from the literature

Guide:

Data regarding the volatilization of pesticides collected from 20 articles are compiled in this annex. Experimental conditions may widely vary between laboratory and field trials. The used format for each experiment is as follows:

title	-	name of author, year of publication, reference code for CardBox database (i.e. record number in LIT_1.FIL file containing literature references);
compound	-	name of compound with most relevant physico-chemical properties from different sources; references for unreferenced properties are found in Annex 2;
formulation	-	in GIFAP formulation codes or trademark description (e.g. GIFAP: WP = wettable powder, EC = emulsifiable concentrate, SC = suspension concentrate, CG = encapsulated granule);
date/place	-	date and place of experiment;
duration	-	duration of experiment (in days);
application	-	mode of application (e.g. hand or machine sprayed, used tools, etc.);
dosage	-	pesticide dosage (in kg ha^{-1}, sometimes given as backwards extrapolated soil residues);
method	-	experimental conditions (field, lab, or greenhouse) and method used for air sampling;
soil	-	relevant soil parameters, such as texture, organic matter or organic carbon content (in %), moisture content at saturation (in volume %), dry bulk density (in kg m^{-3}), treated area, depth of soil (lab experiments), and temperature (in ^oC);
water regime	-	rainfall and/or irrigation events (in mm on day N), actual soil moisture content (in volume % on day N, average value between brackets unless mentioned otherwise);
micro-climate	-	air temperatures (in ^oC at given height on day N and where possible as night-day averages), wind speed (in m s^{-1} at given height on day N or given as a range with average value between brackets), and relative humidity of the air (in %);
volatilization	-	volatilization rate (in g h^{-1} ha^{-1}) after 2 hours, 24 hours, at the end of the measurement period, and sometimes at a number of intermediate intervals), cumulative volatilization (CV values in percent of dosage after 2 hours, 24 hours, at the end of the measurement period, and sometimes at a number of intermediate intervals).

Where repetition in the experimental conditions occurs, an indication is given by the word `same'. This is the case if more than one compound was sampled or when some experimental conditions were changed while others remained the same. In some cases data sets were incomplete and, where strictly necessary, assumptions had to be made. Relevant information is added between brackets. Without further reference this information pertains to average values. The abbreviation MC stands for `Moisture Content', RH for `Relative Humidity' and NA for `Not Applicable'.

Haenel, 1995, cb41

compound: **lindane**
(insecticide, organochlorines group, γ-isomer, VP = 5.6 mPa (20 ^{o}C), $VP_{Hornsby, 1996}$ = 17.3 mPa (30 ^{o}C), $VP_{Spencer\ and\ Cliath,\ 1974}$ = 17.04 mPa (30 ^{o}C), S = 7.3 mg l^{-1} (25 ^{o}C), $S_{author?}$ = 12 mg l^{-1} (35 ^{o}C), K_{om} = 633 dm^{3} kg^{-1}, $K_{oc,Hornsby,\ 1996}$ = 1100 dm^{3} kg^{-1}, $DT_{50,soil}$ = 1406 d, $DT_{50,soil,Hornsby,\ 1996}$ = 400 d, $DT_{50,solution,pH9}$ = 0.5 d, $DT_{50,solution,pH7}$ = 191 d)

formulation: NEXIT STARK (80% lindane, no GIFAP formulation code given)

date/place: May '91, Braunschweig, FRG

duration: 2 d

application: hand-moved motor sprayer with four nozzles Teejet 11006

dosage: 0.76 kg ha^{-1} active ingredient

method: field measurements at 0.6 and 1.5 m height using Aerodynamic-Profile Approach (including newly developed correction method (for small experimental surfaces); residue method gave large scatter (not good applicable for cross-checks))

soil: sand = 49%, silt = 43%, clay = 8%, C_{org} = 1.3%, pH = 6.2, MC_{sat} = 27.7 dry_mass%, $\theta_{sat,\ estimated} \approx$ 42.0%, $\rho_{dry\ soil} \approx$1500 kg m^{-3}
area (L x W): 31.4 x 20.5 m depth: NA temperature: unknown

water regime: no rainfall; $MC_{(0-0.10\ m)}$ = 9.3-10.0 dry_mass% (9.7) or $\theta_{(0-0.10\ m)}$ = 14.1-15.2% (14.7)

micro-climate: air temperature (at 0.6 m): 10-16 ^{o}C (day 0), 10-16 ^{o}C (whole period), (all night-day averages); 5-21 ^{o}C (range) wind; speed (at 1.5 m): 0-2 m s^{-1} (0.7)

volatilization: $rate_{t\ =\ 0,\ estimated}$ = 13.0 g h^{-1} ha^{-1}
$rate_{t\ =\ 2h,\ estimated}$ = 11.5 g h^{-1} ha^{-1}
$rate_{t\ =\ 1d,\ estimated}$ = 2.1 g h^{-1} ha^{-1}
$rate_{t\ =\ 2d,\ estimated}$ = 0.6 g h^{-1} ha^{-1}
4% of applied dosage after 2 hours
12% of applied dosage after 1 day
15% of applied dosage after 2 days

Note: 3 similar experiments available in report (not present), CV < 30%

Gish, 1995, cb40

compound: **atrazine**
(herbicide, triazines group, VP = 0.039 mPa (25 ^{o}C), $VP_{Gueckel,\ 1995}$ = 0.026 mPa (20 ^{o}C), $VP_{Hornsby,\ 1996}$ = 0.187 mPa (30 ^{o}C), S = 33 mg l^{-1} (25 ^{o}C), K_{om} = 70 dm^{3} kg^{-1}, $K_{oc,\ Hornsby,\ 1996}$ = 100 dm^{3} kg^{-1}, $DT_{50,\ soil}$ = 50 d, $DT_{50,\ soil,\ Gish}$ = 71 d, $DT_{50,\ soil,\ Hornsby,\ 1996}$ = 60 d)

formulation: commercial Bullet, USA, diluted in water, GIFAP code unknown

date/place: unknown

duration: 35 d

application: sprayed on surface

dosage: 1.7 kg ha^{-1} a.i.

method: greenhouse measurements (under controlled conditions) using glass agroecosystem chambers (1.5 x 0.5 x 1.0 m)

soil: sandy loam: clay = 5.6%, OM = 1.1%, pH = 6.4, $\theta_{sat,\ estimated} \approx$ 46.0%, $\rho_{dry\ soil} \approx$1400 kg m^{-3} area (LxW): 1.5 x 0.5 m depth: 0.17 m
soil temperature: 25 ^{o}C (fixed)

water regime: 10 x 10 mm uniformly spaced over 35 days (sprayed)
$\Psi_{(0-0.05\ m)}$ = -/-0.3-4.0 kPa (-2.3), $\theta_{(0-0.05\ m)} \approx$40-46% (43)

micro-climate: air temperature: unknown; wind speed: 0.1 m s^{-1} (fixed)

volatilization:	$rate_{t = 0, estimated}$ = unknown $rate_{t = 2h, estimated}$ = unknown $rate_{t = 1d, estimated}$ = 0.3 g h^{-1} ha^{-1} $rate_{t = 35d, estimated}$ = 0.002 g h^{-1} ha^{-1} <0.5% of applied dosage after 2 hours <0.5% of applied dosage after 1 day 0.5% (± 0.1%) of applied dosage after 2 days 1.4% (± 0.3%) of applied dosage after 7 days 2.1% (± 0.0%) of applied dosage after 14 days 3.1% (± 0.0%) of applied dosage after 21 days 4% (± 0.25%) of applied dosage after 35 days

compound:	**atrazine**
formulation:	same
date/place:	same
duration:	same
application:	same
dosage:	same
method:	same
soil:	same soil temperature: 35 °C (fixed)
water regime:	same $\Psi_{(0\text{-}0.05\ m)}$ = -/-0.3-6.4 kPa (-4.0), $\Theta_{(0\text{-}0.05\ m)}$≈34-46% (40)
micro-climate:	same
volatilization:	$rate_{t = 0, estimated}$ = unknown $rate_{t = 2h, estimated}$ = unknown $rate_{t = 1d, estimated}$ = 0.6 g h^{-1} ha^{-1} $rate_{t = 35d, estimated}$ = 0.03 g h^{-1} ha^{-1} <0.3% of applied dosage after 2 hours <0.3% of applied dosage after 1 day 2.0% (± 0.3%) of applied dosage after 2 days 4.2% (± 0.9%) of applied dosage after 7 days 6.9% (± 0.7%) of applied dosage after 14 days 7.6% (± 1.1%) of applied dosage after 21 days 9.1% (± 1.0%) of applied dosage after 35 days

compound:	**alachlor** (herbicide, chloroacetanilides group, VP = 2.9 mPa (25 °C), S = 242 mg l^{-1} (25 °C), K_{om} = 117 dm^3 kg^{-1}, DT_{50} = 22 d)
formulation:	commercial Bullet, USA, diluted in water, GIFAP code unknown
date/place:	same
duration:	same
application:	same
dosage:	2.8 kg ha^{-1} a.i.
method:	same
soil:	same soil temperature: 25 °C (fixed)
water regime:	same $\Psi_{(0\text{-}0.05\ m)}$ = -/-0.3-4.0 kPa (-2.3), $\Theta_{(0\text{-}0.05\ m)}$≈40-46% (43)
micro-climate:	same
volatilization:	$rate_{t = 0, estimated}$ = unknown $rate_{t = 2h, estimated}$ = unknown

$rate_{t = 1d, estimated}$ = 0.7 g h^{-1} ha^{-1}
$rate_{t = 35d, estimated}$ = 0.12 g h^{-1} ha^{-1}
<0.4% of applied dosage after 2 hours
0.4% of applied dosage after 1 day
1.4% of applied dosage after 3 days
2.5% (± 0.6%) of applied dosage after 7 days
3.8% (± 0.7%) of applied dosage after 14 days
4.8% (± 0.9%) of applied dosage after 21 days
5.8% (± 1.2%) of applied dosage after 35 days

compound:	**alachlor**
formulation:	same
date/place:	same
duration:	same
application:	same
dosage:	same
method:	same
soil:	same soil temperature: 35 °C (fixed)
water regime:	same $\Psi_{(0\text{-}0.05\ m)}$ = -/-0.3-6.4 kPa (-4.0), $\theta_{(0\text{-}0.05\ m)}$≈34-46% (40)
micro-climate:	same
volatilization:	$rate_{t = 0, estimated}$ = unknown $rate_{t = 2h, estimated}$ = unknown $rate_{t = 1d, estimated}$ = 2.3 g h^{-1} ha^{-1} $rate_{t = 35d, estimated}$ = 0.05 g h^{-1} ha^{-1} <0.4% of applied dosage after 2 hours 0.4% of applied dosage after 1 day 2.9% (± 0.7%) of applied dosage after 3 days 6.4% (± 2.7%) of applied dosage after 7 days 10.7% (± 3.2%) of applied dosage after 14 days 12.3% (± 1.8%) of applied dosage after 21 days 13.6% (± 1.4%) of applied dosage after 35 days

Note: soil surface dried out a number of times (especially under 35 °C conditions), contrary to what was estimated for $\theta_{(0\text{-}0.05\ m)}$

Waymann, 1995, cb149

compound:	**lindane** (insecticide, organochlorines group, γ-isomer, VP = 5.6 mPa (20 °C), $VP_{Hornsby, 1996}$ = 17.3 mPa (30 °C), $VP_{Spencer\ and\ Cliath,\ 1974}$ = 17.04 mPa (30 °C), S = 7.3 mg l^{-1} (25 °C), $S_{author?}$ = 12 mg l^{-1} (35 °C), K_{om} = 633 dm^3 kg^{-1}, $K_{oc,Hornsby,\ 1996}$ = 1100 dm^3 kg^{-1}, $DT_{50,soil}$ = 1406 d, $DT_{50,soil,Hornsby,\ 1996}$ = 400 d, $DT_{50,solution,pH9}$ = 0.5 d, $DT_{50,solution,pH7}$ = 191 d)
formulation:	SC (NEXIT Fluessig, 80% lindane)
date/place:	unknown
duration:	1 d
application:	sprayed on surface with moving nozzle Teejet 8001EVS
dosage:	1.28 kg ha^{-1} a.i.
method:	lab measurements 2 bowls (A = 0.14 m^2 each) in wind tunnel

soil:	sieved silty sand: sand = 75-79%, C_{org} = 1.1-1.5% (1.3), $\theta_{sat,\ estimated} \approx 44\%$, $\rho_{dry\ soil} \approx 1450$ kg m^{-3}
	area (L x W): 0.28 m^2
	depth: 0.03 m
	temperature: unknown
water regime:	no supply
	$\theta_{(0\text{-}0.03\ m)} = 0.6\ \theta_{sat,\ estimated}$ = 26% (fixed)
micro-climate:	air temperature: 20 ^{o}C (fixed)
	wind speed: 0.4 m s^{-1} (fixed), RH = 50%
volatilization:	$rate_{t\,=\,0,\ estimated}$ = 9.0 g h^{-1} ha^{-1}
	$rate_{t\,=\,2h,\ estimated}$ = 7.7 g h^{-1} ha^{-1}
	$rate_{t\,=\,1d,\ estimated}$ = 5.9 g h^{-1} ha^{-1}
	1.3% of applied dosage after 2 hours
	12% of applied dosage after 1 day

compound:	**lindane**
formulation:	same
date/place:	same
duration:	same
application:	same
dosage:	1.12 kg ha^{-1} a.i.
method:	same
soil:	same
water regime:	same
micro-climate:	same
	wind speed: 1.1 m s^{-1} (fixed), RH = 49%
volatilization:	$rate_{t\,=\,0,\ estimated}$ = 16.8 g h^{-1} ha^{-1}
	$rate_{t\,=\,2h,\ estimated}$ = 15.7 g h^{-1} ha^{-1}
	$rate_{t\,=\,1d,\ estimated}$ = 12.0 g h^{-1} ha^{-1}
	2.9% of applied dosage after 2 hours
	31% of applied dosage after 1 day

compound:	**lindane**
formulation:	same
date/place:	same
duration:	same
application:	same
dosage:	1.39 kg ha^{-1} a.i.
method:	same
soil:	same
water regime:	same
micro-climate:	same
	wind speed: 1.7 m s^{-1} (fixed), RH = 49%
volatilization:	$rate_{t\,=\,0,\ estimated}$ = 26.4 g h^{-1} ha^{-1}
	$rate_{t\,=\,2h,\ estimated}$ = 24.3 g h^{-1} ha^{-1}
	$rate_{t\,=\,1d,\ estimated}$ = 13.3 g h^{-1} ha^{-1}
	3.7% of applied dosage after 2 hours
	31% of applied dosage after 1 day

compound:	**lindane**
formulation:	same
date/place:	same

duration:	same
application:	same
dosage:	1.17 kg ha^{-1} a.i.
method:	same
	6 bowls (A = 0.14 m^2 each) in wind tunnel
soil:	same
	area (LxW): 0.84 m^2
water regime:	same
micro-climate:	same
	wind speed: 1.1 m s^{-1} (fixed), RH = 52%
volatilization:	$rate_{t = 0, estimated}$ = 11.7 g h^{-1} ha^{-1}
	$rate_{t = 2h, estimated}$ = 12.3 g h^{-1} ha^{-1}
	$rate_{t = 1d, estimated}$ = 9.9 g h^{-1} ha^{-1}
	2.1% of applied dosage after 2 hours
	23% of applied dosage after 1 day

compound:	**lindane**
formulation:	same
date/place:	same
duration:	same
application:	same
dosage:	0.33 kg ha^{-1} a.i.
method:	same
	6 bowls (A = 0.14 m^2 each) in wind tunnel
soil:	same
	area (LxW): 0.84 m^2
water regime:	same
micro-climate:	same
	wind speed: 1.1 m s^{-1} (fixed), RH = 49%
volatilization:	$rate_{t = 0, estimated}$ = 10.9 g h^{-1} ha^{-1}
	$rate_{t = 2h, estimated}$ = 9.7 g h^{-1} ha^{-1}
	$rate_{t = 1d, estimated}$ = 2.4 g h^{-1} ha^{-1}
	6.3% of applied dosage after 2 hours
	39% of applied dosage after 1 day

Notes: (1) - set-up of experiment caused a rather laminar flow directly above soil surface limiting the volatilization through turbulent mixing; (2) - test area size appears to be important parameter; (3) - dosage appears to be important parameter

Wienhold, 1994, cb68

compound:	**atrazine**
	(herbicide, triazines group, VP = 0.039 mPa (25 ^oC), $VP_{Gueckel, 1995}$ = 0.026 mPa (20 ^oC), $VP_{Hornsby, 1996}$ = 0.187 mPa (30 ^oC), S = 33 mg l^{-1} (25 ^oC), K_{om} = 70 dm^3 kg^{-1}, $K_{oc,Hornsby, 1996}$ = 100 dm^3 kg^{-1}, $DT_{50,soil}$ = 50 d, $DT_{50,soil,Gish}$ = 71 d, $DT_{50,soil,Hornsby, 1996}$ = 60 d)
formulation:	WP (commercial Bullet, USA, and in mix with alachlor as CG)
date/place:	June '92, Central Maryland Research Center, Marlboro, MD, USA
duration:	35 d
application:	sprayed on surface
dosage:	1.7 kg ha^{-1} a.i. (= nominal rate; analysis soil residue: 1.55 kg ha^{-1} a.i.)
method:	field measurements using glass agroecosystem chambers (0.25 m^3)
	(chambers relocated after rain events)

soil:	sandy loam: clay = 5.6%, OM = 1.1%, pH = 6.4, $\theta_{sat,\ estimated} \approx$ 46%, $\rho_{dry\ soil} \approx$ 1400 kg m^{-3}; area (LxW): 0.5 m^2; depth: NA; soil temperature: 25 ^oC (day 0), 24 ^oC (day 1), 23 ^oC (day 2), (at noon and follows air temperature)
water regime:	total rainfall: 106 mm, distributed over days 2 (9 mm), 3 (14 mm), 6 (41 mm), 7 (0.5 mm), 16 (8 mm), 17 (0.5 mm), 18 (1 mm), 22 (2 mm), 23 (1 mm), 28 (10 mm), 29 (9 mm), and 31 (10 mm) $MC_{(0\text{-}0.03\ m)}$ = 15 dry_mass% or $\theta_{(0\text{-}0.03\ m)}$ = 21% (day 0), 14 dry_mass% or 20 vol% (day 1), 10 dry_mass% or 14 vol% (day 2), 13 dry_mass% or 18 vol% (whole period)
micro-climate:	air temperature: 13-22 ^oC (day 0), (night-day minimum and maximum); 15-27 ^oC (whole period night-day average minimum and maximum); 7-32 ^oC (range whole period); wind speed: 0.0022 m s^{-1} (in chamber)
volatilization:	$rate_{t\,=\,0,\ estimated}$ = unknown $rate_{t\,=\,2h,\ estimated}$ = unknown $rate_{t\,=\,1d,\ estimated}$ = 0.3 g h^{-1} ha^{-1} $rate_{t\,=\,35d,\ estimated}$ = 0.03 g h^{-1} ha^{-1} <0.4% of applied dosage after 2 hours 0.4% of applied dosage after 1 day 6.8% of applied dosage after 12 days 8.0% of applied dosage after 21 days 8.6% of applied dosage after 35 days
compound:	**alachlor** (herbicide, chloroacetanilides group, VP = 2.9 mPa (25 ^oC), S = 242 mg l^{-1} (25 ^oC), K_{om} = 117 dm^3 kg^{-1}, DT_{50} = 22 d)
formulation:	CG (commercial Bullet, USA, and in mix with atrazine as WP)
date/place:	same
duration:	same
application:	same
dosage:	2.8 kg ha^{-1} a.i. (= nominal rate; analysis soil residue: 2.15 kg ha^{-1} a.i.)
method:	same
soil:	same
water regime:	same
micro-climate:	same
volatilization:	$rate_{t\,=\,0,\ estimated}$ = unknown $rate_{t\,=\,2h,\ estimated}$ = unknown $rate_{t\,=\,1d,\ estimated}$ = 1.0 g h^{-1} ha^{-1} $rate_{t\,=\,35d,\ estimated}$ = 0.15 g h^{-1} ha^{-1} <1% of applied dosage after 2 hours 1% of applied dosage after 1 day 10.1% of applied dosage after 12 days 12.6% of applied dosage after 21 days 13.8 of applied dosage after 35 days

Note: (1) - refer to Gish, 1995, cb40, lab experiments (same compounds, procedures, and soils); (2) - after appr. 20 days corn crop canopy established

Whang, 1993, cb18

compound:	**fonofos**
	(insecticide, organophosphorus group, VP = 28 mPa (25 ^oC), $VP_{Hornsby, 1996}$ = 45.3 mPa (25 ^oC), S = 13 mg l^{-1} (22 ^oC), $S_{Hornsby, 1996}$ = 16.9 mg l^{-1} (25 ^oC), K_{om}>325 dm^3 kg^{-1}, $K_{oc,Hornsby, 1996}$ = 870 dm^3 kg^{-1}, $DT_{50,soil}$ = 99 d, $DT_{50,soil,Hornsby, 1996}$ = 40 d)
formulation:	EC (in single mix with chlorpyrifos and atrazine)
date/place:	April '90, Beltsville, MD, USA
duration:	26 d
application:	sprayed on surface
dosage:	5.3 kg ha^{-1} a.i. (= nominal rate; analysis soil residue: 5.64 kg ha^{-1} a.i.)
method:	field measurements at 0.98 m height using Theoretical Profile Shape Method
soil:	silt loam: sand = 23%, silt = 57%, clay = 20%, OM = 1.2% (after Glotfelty, cb55), $\theta_{sat, estimated}$≈ 51.0%, $\rho_{dry\ soil}$≈1300 kg m^{-3} area (LxW): 2827 m^2 (circle) depth: NA; soil temperature: unknown
water regime:	total rainfall: 86 mm, distributed over days 2 (28 mm), 4 (4.5 mm), 9 (5 mm), 17 (17 mm), 17 (14 mm), 18 (1 mm), 22 (1 mm), 22 (15 mm), 23 (0.5 mm); $MC_{(0\text{-}0.01\ m)}$ = 7 dry_mass% or $\theta_{(0\text{-}0.01\ m)}$ = 9% (day 0), 11 dry_mass% or 14 vol% (day 1), 25.5 dry_mass% or 32.5 vol% (day 2), 19.5 dry_mass% or 25 vol% (day 3), 16 dry_mass% or 20 vol% (day 4), 15 dry_mass% or 19 vol% (day 6), 14 dry_mass% or 18 vol% (day 10), 7 dry_mass% or 9 vol% (day 13), 14 dry_mass% or 18 vol% (whole period), (all day-averages); 5-29 dry_mass% (14) or 6-37 vol% (18) (range)
micro-climate:	air temperature: -/-3-13 ^oC (day 0), 5-18 ^oC (days 1-9), 12-29 ^oC (days 10-16), 9-21 ^oC (days 17-25), 8-22 ^oC (whole period), (night-day minima and maxima!); -/-3-33 ^oC (range) wind speed: measured but not tabulated
volatilization:	$rate_{t = 0, calculated}$ = 15 g h^{-1} ha^{-1} (T between 2 and 11 ^oC) $rate_{t = 2h, calculated}$ = 65 g h^{-1} ha^{-1} (T between 2 and 11 ^oC) $rate_{t = 1d, average\text{-}9:00\text{-}21:30}$ = 34 g h^{-1} ha^{-1} (T between 2 and 11 ^oC) $rate_{t = 26d, average\text{-}8:30\text{-}17:30}$ = 0.3 g h^{-1} ha^{-1} (T between 19 and 26 ^oC) 1.5% of applied dosage after 2 hours 7.5% of applied dosage after 1 day 18% of applied dosage after 4 days 27% of applied dosage after 26 days (estimated)

compound:	**chlorpyrifos-methyl**
	(insecticide, organophosphorus group, VP = 5.6 mPa (25 ^oC), $VP_{Worthing, 1987}$ = 2.5 mPa (? ^oC), S = 4 mg l^{-1} (24 ^oC), $S_{Worthing, 1987}$<2 mg l^{-1}, K_{ow} = 17 300 dm^3 kg^{-1}, $DT_{50,soil,Tomlin}$ = 1.5-33 d, $DT_{50,solution\ pH8}$ = 3 d)
formulation:	EC (in single mix with and atrazine and fonofos)
date/place:	same
duration:	same
application:	sprayed on surface
dosage:	5.6 kg ha^{-1} a.i. (= nominal rate; analysis soil residue: 5.60 kg ha^{-1} a.i.)
method:	same
soil:	same
water regime:	same
micro-climate:	same
volatilization:	$rate_{t = 0, calculated}$ = 3 g h^{-1} ha^{-1} (T between 2 and 11 ^oC) $rate_{t = 2h, calculated}$ = 18 g h^{-1} ha^{-1} (T between 2 and 11 ^oC) $rate_{t = 1d, average\text{-}9:00\text{-}21:30}$ = 10 g h^{-1} ha^{-1} (T between 2 and 11 ^oC) $rate_{t = 26d, average\text{-}8:30\text{-}17:30}$ = 0.2 g h^{-1} ha^{-1} (T between 19 and 26 ^oC) 0.4% of applied dosage after 2 hours

	2.3% of applied dosage after 1 day 7% of applied dosage after 4 days 12% of applied dosage after 26 days (estimated)
compound:	**atrazine** (herbicide, triazines group, VP = 0.039 mPa (25 ^oC), $VP_{Gueckel, 1995}$ = 0.026 mPa (20 ^oC), $VP_{Hornsby, 1996}$ = 0.187 mPa (30 ^oC), S = 33 mg l^{-1} (25 ^oC), K_{om} = 70 dm^3 kg^{-1}, $K_{oc,Hornsby, 1996}$ = 100 dm^3 kg^{-1}, $DT_{50,soil}$ = 50 d, $DT_{50,soil,Gish}$ = 71 d, $DT_{50,soil,Hornsby, 1996}$ = 60 d)
formulation:	EC (in single mix with and fonofos and chlorpyrifos)
date/place:	same
duration:	same
application:	sprayed on surface
dosage:	2.5 kg ha^{-1} a.i. (= nominal rate; analysis soil residue: 2.91 kg ha^{-1} a.i.)
method:	same
soil:	same
water regime:	same
micro-climate:	same
volatilization:	$rate_{t = 0, calculated}$ = 0.5 g h^{-1} ha^{-1} (T between 2 and 11 ^oC) $rate_{t = 2h, calculated}$ = 0.8 g h^{-1} ha^{-1} (T between 2 and 11 ^oC) $rate_{t = 1d, average-9:00-21:30}$ = 0.4 g h^{-1} ha^{-1} (T between 2 and 11 ^oC) $rate_{t = 26d, average-8:30-17:30}$ = 0.06 g h^{-1} ha^{-1} (T between 19 and 26 ^oC) 0.05% of applied dosage after 2 hours 0.3% of applied dosage after 1 day 0.7% of applied dosage after 4 days 1.9% of applied dosage after 26 days (estimated)

<u>Nash, 1983, cb92</u>

compound:	**heptachlor (with trans- and cis-chlordane)** (insecticide, organochlorines group, VP = 53 mPa (25 ^oC), $VP_{Bowery, 1964}$ = 40 mPa (30 ^oC), S = 0.056 mg l^{-1} (25-29 ^oC), $K_{oc,Hornsby, 1996}$ = 24 000 dm^3 kg^{-1}, $K_{ow,Calahan, 1979, from Stiver, 1990}$ = 25 119, $DT_{50,soil,Tomlin, 1991}$ = 289 d, $DT_{50,soil,Hornsby, 1996}$ = 250 d)
formulation:	EC (in single mix with trifluralin, lindane, trans- and cis-chlordane, heptachlor epoxide, DDT, dieldrin, and endrin)
date/place:	July'78, University of Maryland, Salisbury, MD, USA
duration:	11 d
application:	hand-sprayed on surface
dosage:	4.2 kg ha^{-1} a.i.
method:	greenhouse measurements using glass agroecosystem chambers (1.5x0.5x1.0 m)
soil:	sandy loam: sand = 79%, clay = 14%, silt = 7%, OM = 0.6%, pH = 6.8, MC = 16 dry_mass% at Ψ = 33kPa or θ = 22.5% at Ψ = 33kPa (data confusion: MC = 6 dry_mass% actually mentioned), $\theta_{sat, estimated} \approx 46\%$, $\rho_{dry soil} \approx 1400$ kg m^{-3} area (L x W): 1.5 x 0.5 m depth: 0.15 m soil surface temperature: 23-32 ^oC during experiment soil temperature: 24-30 ^oC during experiment soil temperature: 25.5-27.5 ^oC (26.5) on day 0 and 26-29 ^oC (27.5) on day 9
water regime:	sprinkle pre-irrigation: 4.4 mm 4 hrs before spraying and 4.4 mm on days 1 and 9 $MC_{(0-0.01 m)} \approx 5.5$-16 dry_mass% (9.5) or $\theta_{(0-0.01 m)}$ = 7.5-22.5% (13.5) on

	day 0 $MC_{(0\text{-}0.01\ m)}$≈1.5-16 dry_mass% (8) or $\theta_{(0\text{-}0.01\ m)}$ = 2-22.5% (11.5) on day 9
micro-climate:	air temperature: 22-33 ^{o}C during experiment 25.5-28.5 ^{o}C (27) on day 1 and RH = 50-80% (65) 26-29 ^{o}C (27.5) on day 9 and RH = 50-80% (65) wind speed: 0.08 m s^{-1} (fixed)
volatilization:	$rate_{t = 0,\ measured}$ = 7.2 g h^{-1} ha^{-1} $rate_{t = 2h,\ estimated}$ = 4.1 g h^{-1} ha^{-1} $rate_{t = 1d,\ measured}$ = 0.8 g h^{-1} ha^{-1} $rate_{t = 10d,\ measured}$ = 0.2 g h^{-1} ha^{-1} 3% of applied dosage after 2 hours (curve fit estimation) 14% of applied dosage after 1 day (curve fit estimation, see note 1) 60% of applied dosage after 11 days
compound:	**trifluralin** (herbicide, dinitroanalines group, VP = 9.5 mPa (25 ^{o}C), $VP_{Hornsby,\ 1996}$ = 14.7 mPa (25 ^{o}C), $VP_{Spencer\ and\ Cliath,\ 1973}$ = 32.2 mPa (30 ^{o}C), S = 0.343 mg l^{-1} (pH5), S = 0.395 mg l^{-1} (pH7), S = 0.383 mg l^{-1} (pH9), $S_{Hornsby,\ 1996}$ = 0.3 mg l^{-1} (25 ^{o}C), K_{om} = 3775 dm^3 kg^{-1}, $K_{oc,Hornsby,\ 1996}$ = 8000 dm^3 kg^{-1}, $DT_{50,soil}$ = 221 d, $DT_{50,soil,Hornsby,\ 1996}$ = 60 d)
formulation:	same
date/place:	same
duration:	same
application:	same
dosage:	2.8 kg ha^{-1} a.i.
method:	same
soil:	same
water regime:	same
micro-climate:	same
volatilization:	$rate_{t = 0,measured}$ = 3.1 g h^{-1} ha^{-1} $rate_{t = 2h,\ estimated}$ = 1.7 g h^{-1} ha^{-1} $rate_{t = 1d,measured}$ = 0.8 g h^{-1} ha^{-1} $rate_{t = 10d,measured}$ <0.1 g h^{-1} ha^{-1} 2% of applied dosage after 2 hours (curve fit estimation) 8% of applied dosage after 1 day (curve fit estimation, see note 1) 60% of applied dosage after 11 days
compound:	**lindane** (insecticide, organochlorines group, γ-isomer, VP = 5.6 mPa (20 ^{o}C), $VP_{Hornsby,\ 1996}$ = 17.3 mPa (30 ^{o}C), $VP_{Spencer\ and\ Cliath,\ 1974}$ = 17.04 mPa (30 ^{o}C), S = 7.3 mg l^{-1} (25 ^{o}C), $S_{author?}$ = 12 mg l^{-1} (35 ^{o}C), K_{om} = 633 dm^3 kg^{-1}, $K_{oc,Hornsby,\ 1996}$ = 1100 dm^3 kg^{-1}, $DT_{50,soil}$ = 1406 d, $DT_{50,soil,Hornsby,\ 1996}$ = 400 d, $DT_{50,solution,pH9}$ = 0.5 d, $DT_{50,solution,pH7}$ = 191 d)
formulation:	same
date/place:	same
duration:	same
application:	same
dosage:	0.87 kg ha^{-1} a.i.
method:	same
soil:	same
water regime:	same
micro-climate:	same
volatilization:	$rate_{t = 0,measured}$ = 1.4 g h^{-1} ha^{-1}

	$rate_{t = 2h, estimated}$ = 0.8 g h^{-1} ha^{-1}
	$rate_{t = 1d, measured}$ = 0.2 g h^{-1} ha^{-1}
	$rate_{t = 10d, measured}$<0.05 g h^{-1} ha^{-1}
	3% of applied dosage after 2 hours (curve fit estimation)
	13% of applied dosage after 1 day (curve fit estimation, see note 1)
	78% of applied dosage after 11 days

compound:	p,p^1**-DDT** (insecticide, organochlorines group, VP = 0.025 mPa (20 °C), $VP_{Orgill, 1976}$ = 0.096 mPa (30 °C), $S_{Hornsby, 1996}$ = 0.0055 mg l^{-1} (20 °C), $K_{oc,Hornsby, 1996}$ = 2 000 000 dm^3 kg^{-1}, $DT_{50,Hornsby, 1996}$ = 2000 d)
formulation:	same
date/place:	same
duration:	same
application:	same
dosage:	1.7 kg ha^{-1} a.i.
method:	same
soil:	same
water regime:	same
micro-climate:	same
volatilization:	$rate_{t = 0, measured}$ = 0.06 g h^{-1} ha^{-1} $rate_{t = 2h, estimated}$ = 0.03 g h^{-1} ha^{-1} $rate_{t = 1d, measured}$ = 0.02 g h^{-1} ha^{-1} $rate_{t = 10d, measured}$ = 0.02 g h^{-1} ha^{-1} 0.05% of applied dosage after 2 hours (curve fit estimation) 0.3% of applied dosage after 1 day (curve fit estimation, see note 1) 10.5% of applied dosage after 11 days

Notes: (1) - RCV values after day 1 are (strongly) influenced by irrigation of 4.4 mm a few hours earlier (fitted curve does not account for this phenomenon); (2) - volatilization decline rate during first few hours similar for many pesticides (k≈2); (3) - volatilization rates significantly depend on soil moisture and air/soil temperature; (4) - results for dieldrin and endrin not presented; (5) -results for a similar, second experiment in 1979 not used because no measurements were taken on first day and no RCV values were presented.

Nash, 1989a, cb87

compound:	**dicamba (dimethylammonium salt)** (herbicide, benzoic acids group, $VP_{Beste, 1983}$ = 0.0046 mPa (25 °C), $VP_{Hornsby, 1996}$ = 0 mPa, $S_{Hornsby, 1996}$ = 850 000 mg l^{-1} (25 °C), $K_{oc,Hornsby, 1996}$ = 2 dm^3 kg^{-1}, $K_{oc,Kenaga, 1980}$ = 0.42 dm^3 kg^{-1}, $DT_{50,soil,Hornsby, 1996}$ = 14 d; dicamba: VP = 4.5 mPa (25^0), S = 6500 mg l^{-1} (25 °C), K_{om} = 0 dm^3 kg^{-1}, $DT_{50,soil}$ = 48 d)
formulation:	EC
date/place:	unknown
duration:	154 d
application:	not given
dosage:	2.5 kg ha^{-1} a.i.
method:	greenhouse measurements (under controlled conditions) using glass agroecosystem chambers (1.5 x 0.5 x 1.0 m)
soil:	sandy loam: OM = 5.2%, pH = 6.7, MC = 15.6 dry_mass% or θ = 19.6% at Ψ = 33kPa, $\theta_{sat, estimated}$≈46%, $\rho_{dry soil}$≈1350 kg m^{-3} area (L x W): 1.5 x 0.5 m^2 depth: 0.15 m soil temperature: 5 °C (fixed)

water regime: soil kept moist by sprinkling, $\theta_{estimated}$ = 19.6% (field capacity at pF2.5)
micro-climate: air temperature: 5 ^oC (fixed)
wind speed: 0.08 m s^{-1} (fixed, in chamber)
volatilization: $rate_{t = 0, estimated}$ = unknown
$rate_{t = 2h, estimated}$ = 0.5 g h^{-1} ha^{-1} (curve fit)
$rate_{t = 1d, estimated}$ = 0.04 g h^{-1} ha^{-1} (curve fit)
$rate_{t = 154d, estimated}$ = 0.0002 g h^{-1} ha^{-1} (curve fit)
0.5% of applied dosage after 2 hours (integrated curve fit with t_0 = 1s)
0.6% of applied dosage after 1 day (integrated curve fit with t_0 = 1s)
0.6% of applied dosage after 154 days

compound: **dicamba**
formulation: same
date/place: same
duration: same
application: same
dosage: same
method: same
soil: same
soil temperature: 15 ^oC (fixed)
water regime: same
micro-climate: air temperature: 15 ^oC (fixed)
wind speed: same
volatilization: $rate_{t = 0, estimated}$ = unknown
$rate_{t = 2h, estimated}$ = 0.7 g h^{-1} ha^{-1} (curve fit)
$rate_{t = 1d, estimated}$ = 0.08 g h^{-1} ha^{-1} (curve fit)
$rate_{t = 154d, estimated}$ = 0.001 g h^{-1} ha^{-1} (curve fit)
0.4% of applied dosage after 2 hours (integrated curve fit)
0.6% of applied dosage after 1 day (integrated curve fit)
1.1% of applied dosage after 154 days

compound: **dicamba**
formulation: same
date/place: same
duration: same
application: same
dosage: same
method: same
soil: same
soil temperature: 20 ^oC (fixed)
water regime: same
micro-climate: air temperature: 20 ^oC (fixed)
wind speed: same
volatilization: $rate_{t = 0, estimated}$ = unknown
$rate_{t = 2h, estimated}$ = 1.9 g h^{-1} ha^{-1} (curve fit)
$rate_{t = 1d, estimated}$ = 0.3 g h^{-1} ha^{-1} (curve fit)
$rate_{t = 154d, estimated}$ = 0.01 g h^{-1} ha^{-1} (curve fit)
0.5% of applied dosage after 2 hours (integrated curve fit)
1.0% of applied dosage after 1 day (integrated curve fit)
6.3% of applied dosage after 154 days

compound: **dicamba**
formulation: same
date/place: same

duration: same
application: same
dosage: same
method: same
soil: same
soil temperature: 25 °C (fixed)
water regime: same
micro-climate: air temperature: 25 °C (fixed)
wind speed: same
volatilization: $rate_{t = 0, estimated}$ = unknown
$rate_{t = 2h, estimated}$ = 1.3 g h^{-1} ha^{-1} (curve fit)
$rate_{t = 1d, estimated}$ = 0.3 g h^{-1} ha^{-1} (curve fit)
$rate_{t = 154d, estimated}$ = 0.01 g h^{-1} ha^{-1} (curve fit)
0.3% of applied dosage after 2 hours (integrated curve fit)
0.7% of applied dosage after 1 day (integrated curve fit)
5.9% of applied dosage after 154 days

compound: **dicamba**
formulation: same
date/place: same
duration: same
application: same
dosage: same
method: same
soil: same
soil temperature: 35 °C (fixed)
water regime: same
micro-climate: air temperature: 35 °C (fixed)
wind speed: same
volatilization: $rate_{t = 0, estimated}$ = unknown
$rate_{t = 2h, estimated}$ = 5.8 g h^{-1} ha^{-1} (curve fit)
$rate_{t = 1d, estimated}$ = 0.6 g h^{-1} ha^{-1} (curve fit)
$rate_{t = 154d, estimated}$ = 0.005 g h^{-1} ha^{-1} (curve fit)
3.2% of applied dosage after 2 hours (integrated curve fit with t_0 = 1s)
4.4% of applied dosage after 1 day (integrated curve fit with t_0 = 1s)
7.9% of applied dosage after 154 days

compound: **2,4-D (propylene glycolbutyl ether esters of acetic acid)**
(herbicide, aryloxyalkanoic acids group, with fast hydrolysis to 2,4-D acid, $VP_{Beste, 1983, estimated}$ = 0.006 mPa (25 °C), $S_{Beste, 1983, estimated}$ = 1.2 mg l^{-1} (25 °C), $K_{oc,Hamaker, 1975}$ = 32 dm^3 kg^{-1}, $DT_{50,soil,Hornsby, 1996}$ = 60 d; 2,4-D acid: VP = 11 mPa (20 °C), S = 620 mg l^{-1} (25 °C), K_{om} = 8 dm^3 kg^{-1}, $DT_{50,soil}$ = 230 d (pH_{soil}<5), $DT_{50,soil}$ = 26 d (pH_{soil}>5))
formulation: same
date/place: same
duration: same
application: same
dosage: 2.5 kg ha^{-1} a.i.
method: same
soil: same
soil temperature: 5 °C (fixed)
water regime: same
micro-climate: air temperature: 5 °C (fixed)

	wind speed: same
volatilization:	$rate_{t = 0, estimated}$ = unknown
	$rate_{t = 2h, estimated}$ = 0.4 g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 1d, estimated}$ = 0.04 g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 154d, estimated}$ = 0.0004 g h^{-1} ha^{-1} (curve fit)
	0.4% of applied dosage after 2 hours (integrated curve fit)
	0.4% of applied dosage after 1 day (integrated curve fit)
	0.9% of applied dosage after 154 days

compound:	**2,4-D**
formulation:	same
date/place:	same
duration:	same
application:	same
dosage:	same
method:	same
soil:	same
	soil temperature: 15 ^{o}C (fixed)
water regime:	same
micro-climate:	air temperature: 15 ^{o}C (fixed)
	wind speed: same
volatilization:	$rate_{t = 0, estimated}$ = unknown
	$rate_{t = 2h, estimated}$ = 1.2 g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 1d, estimated}$ = 0.12 g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 154d, estimated}$ = 0.001 g h^{-1} ha^{-1} (curve fit)
	0.6% of applied dosage after 2 hours (integrated curve fit with t_0 = 1s)
	0.9% of applied dosage after 1 day (integrated curve fit with t_0 = 1s)
	1.4% of applied dosage after 154 days

compound:	**2,4-D**
formulation:	same
date/place:	same
duration:	same
application:	same
dosage:	same
method:	same
soil:	same
	soil temperature: 20 ^{o}C (fixed)
water regime:	same
micro-climate:	air temperature: 20 ^{o}C (fixed)
	wind speed: same
volatilization:	$rate_{t = 0, estimated}$ = unknown
	$rate_{t = 2h, estimated}$ = 2.4 g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 1d, estimated}$ = 0.2 g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 154d, estimated}$ = 0.003 g h^{-1} ha^{-1} (curve fit)
	1.2% of applied dosage after 2 hours (integrated curve fit with t_0 = 1s)
	1.7% of applied dosage after 1 day (integrated curve fit with t_0 = 1s)
	3.6% of applied dosage after 154 days

compound:	**2,4-D**
formulation:	same
date/place:	same
duration:	same
application:	same

dosage: same
method: same
soil: same
soil temperature: 25 ^{o}C (fixed)
water regime: same
micro-climate: air temperature: 25 ^{o}C (fixed)
wind speed: same
volatilization: $rate_{t = 0, estimated}$ = unknown
$rate_{t = 2h, estimated}$ = 3.6 g h^{-1} ha^{-1} (curve fit)
$rate_{t = 1d, estimated}$ = 0.3 g h^{-1} ha^{-1} (curve fit)
$rate_{t = 154d, estimated}$ = 0.003 g h^{-1} ha^{-1} (curve fit)
2.1% of applied dosage after 2 hours (integrated curve fit with t_0 = 1s)
2.8% of applied dosage after 1 day (integrated curve fit with t_0 = 1s)
4.3% of applied dosage after 154 days

compound: **2,4-D**
formulation: same
date/place: same
duration: same
application: same
dosage: same
method: same
soil: same
soil temperature: 35 ^{o}C (fixed)
water regime: same
micro-climate: air temperature: 35 ^{o}C (fixed)
wind speed: same
volatilization: $rate_{t = 0, estimated}$ = unknown
$rate_{t = 2h, estimated}$ = 7.8 g h^{-1} ha^{-1} (curve fit)
$rate_{t = 1d, estimated}$ = 5.2 g h^{-1} ha^{-1} (curve fit)
$rate_{t = 154d, estimated}$ = 0.002 g h^{-1} ha^{-1} (curve fit)
8.5% of applied dosage after 2 hours (integrated curve fit with t_0 = 1s)
9.8% of applied dosage after 1 day (integrated curve fit with t_0 = 1s)
12.1% of applied dosage after 154 days

compound: **2,4,5-T (propylene glycolbutyl ether esters of acetic acid)**
(herbicide, aryloxyalkanoic acids group with fast hydrolysis to 2,4-D acid) $VP_{Nash, 1989b, estimated}$ = 0.00086 mPa (25 ^{o}C), $S_{Nash, 1989, estimated}$ = 235 mg l^{-1} (25 ^{o}C), $K_{oc,Kenaga, 1980}$ = 80 dm^3 kg^{-1}, $DT_{50,soil}$ = unknown; 2,4,5-T acid: VP = 0.0007 mPa (25 ^{o}C), S = 150 mg l^{-1} (25 ^{o}C), K_{oc} = 80 dm^3 kg^{-1}, $DT_{50,soil,Hornsby, 1996}$ = 30 d)
formulation: same
date/place: same
duration: same
application: same
dosage: 2.5 kg ha^{-1} a.i.
method: same
soil: same
soil temperature: 5 ^{o}C (fixed)
water regime: same
micro-climate: air temperature: 5 ^{o}C (fixed)
wind speed: same
volatilization: $rate_{t = 0, estimated}$ = unknown
$rate_{t = 2h, estimated}$ = 0.02 g h^{-1} ha^{-1} (curve fit)

rate$_{t = 1d, estimated}$ = 0.002 g h^{-1} ha^{-1} (curve fit)
rate$_{t = 154d, estimated}$ = 0.00002 g h^{-1} ha^{-1} (curve fit)
unknown % of applied dosage after 2 hours (integrated curve fit)
unknown % of applied dosage after 1 day (integrated curve fit)
0.6% of applied dosage after 154 days

compound:	**2,4,5-T**
formulation:	same
date/place:	same
duration:	same
application:	same
dosage:	same
method:	same
soil:	same
	soil temperature: 15 ^oC (fixed)
water regime:	same
micro-climate:	air temperature: 15 ^oC (fixed)
	wind speed: same
volatilization:	rate$_{t = 0, estimated}$ = unknown
	rate$_{t = 2h, estimated}$ = 0.5 g h^{-1} ha^{-1} (curve fit)
	rate$_{t = 1d, estimated}$ = 0.05 g h^{-1} ha^{-1} (curve fit)
	rate$_{t = 154d, estimated}$ = 0.0006 g h^{-1} ha^{-1} (curve fit)
	0.3% of applied dosage after 2 hours (integrated curve fit)
	0.4% of applied dosage after 1 day (integrated curve fit)
	0.8% of applied dosage after 154 days

compound:	**2,4,5-T**
formulation:	same
date/place:	same
duration:	same
application:	same
dosage:	same
method:	same
soil:	same
	soil temperature: 20 ^oC (fixed)
water regime:	same
micro-climate:	air temperature: 20 ^oC (fixed)
	wind speed: same
volatilization:	rate$_{t = 0, estimated}$ = unknown
	rate$_{t = 2h, estimated}$ = 0.9 g h^{-1} ha^{-1} (curve fit)
	rate$_{t = 1d, estimated}$ = 0.1 g h^{-1} ha^{-1} (curve fit)
	rate$_{t = 154d, estimated}$ = 0.002 g h^{-1} ha^{-1} (curve fit)
	0.4% of applied dosage after 2 hours (integrated curve fit)
	0.6% of applied dosage after 1 day (integrated curve fit)
	2.5% of applied dosage after 154 days

compound:	**2,4,5-T**
formulation:	same
date/place:	same
duration:	same
application:	same
dosage:	same
method:	same
soil:	same

	soil temperature: 25 ^{o}C (fixed)
water regime:	same
micro-climate:	air temperature: 25 ^{o}C (fixed)
	wind speed: same
volatilization:	$rate_{t = 0, estimated}$ = unknown
	$rate_{t = 2h, estimated}$ = 3.6 g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 1d, estimated}$ = 0.3 g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 154d, estimated}$ = 0.003 g h^{-1} ha^{-1} (curve fit)
	unknown % of applied dosage after 2 hours (integrated curve fit with t_0 = 1s); unknown % of applied dosage after 1 day (integrated curve fit with t_0 = 1s); 5.5% of applied dosage after 154 days

compound:	**2,4,5-T**
formulation:	same
date/place:	same
duration:	same
application:	same
dosage:	same
method:	same
soil:	same
	soil temperature: 35 ^{o}C (fixed)
water regime:	same
micro-climate:	air temperature: 35 ^{o}C (fixed)
	wind speed: same
volatilization:	$rate_{t = 0, estimated}$ = unknown
	$rate_{t = 2h, estimated}$ = 5.7 g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 1d, estimated}$ = 0.2 g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 154d, estimated}$ = 0.0004 g h^{-1} ha^{-1} (curve fit)
	unknown % of applied dosage after 2 hours (integrated curve fit)
	unknown % of applied dosage after 1 day (integrated curve fit)
	5.5% of applied dosage after 154 days

compound:	**fenoprop (or silvex or 2,4,5-TP, butoxypropyl ester)**
	(herbicide, aryloxyalkanoic acids group, $VP_{Nash, 1989, estimated}$ = 0.0007 mPa (25 ^{o}C), $VP_{Hornsby, 1996}$<0.013 mPa, $S_{Nash, 1989, estimated}$ = 188.7 mg l^{-1} (25 ^{o}C), $S_{Hornsby, 1996}$ = 140 mg l^{-1} (25 ^{o}C), $K_{oc,Kenaga, 1980}$ = 500 dm^3 kg^{-1}, $K_{oc,Hornsby, 1996}$ = 300 dm^3 kg^{-1}, $DT_{50,soil,Hornsby, 1996}$ = 21 d)
formulation:	same
date/place:	same
duration:	same
application:	same
dosage:	2.5 kg ha^{-1} a.i.
method:	same
soil:	same
	soil temperature: 5 ^{o}C (fixed)
water regime:	same
micro-climate:	air temperature: 5 ^{o}C (fixed)
	wind speed: same
volatilization:	$rate_{t = 0, estimated}$ = unknown
	$rate_{t = 2h, estimated}$ = 0.1 g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 1d, estimated}$ = 0.05 g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 154d, estimated}$ = 0.006 g h^{-1} ha^{-1} (curve fit)
	unknown % of applied dosage after 2 hours (integrated curve fit)
	unknown % of applied dosage after 1 day (integrated curve fit)

3.8% of applied dosage after 154 days

compound: **fenoprop (silvex)**
formulation: same
date/place: same
duration: same
application: same
dosage: same
method: same
soil: same
soil temperature: 15 ^{o}C (fixed)
water regime: same
micro-climate: air temperature: 15 ^{o}C (fixed)
wind speed: same
volatilization: $rate_{t = 0, estimated}$ = unknown
$rate_{t = 2h, estimated}$ = 0.5 g h^{-1} ha^{-1} (curve fit)
$rate_{t = 1d, estimated}$ = 0.1 g h^{-1} ha^{-1} (curve fit)
$rate_{t = 154d, estimated}$ = 0.006 g h^{-1} ha^{-1} (curve fit)
0.1% of applied dosage after 2 hours (integrated curve fit)
0.3% of applied dosage after 1 day (integrated curve fit)
3.1% of applied dosage after 154 days

compound: **fenoprop (silvex)**
formulation: same
date/place: same
duration: same
application: same
dosage: same
method: same
soil: same
soil temperature: 20 ^{o}C (fixed)
water regime: same
micro-climate: air temperature: 20 ^{o}C (fixed)
wind speed: same
volatilization: $rate_{t = 0, estimated}$ = unknown
$rate_{t = 2h, estimated}$ = 1.5 g h^{-1} ha^{-1} (curve fit)
$rate_{t = 1d, estimated}$ = 0.3 g h^{-1} ha^{-1} (curve fit)
$rate_{t = 154d, estimated}$ = 0.02 g h^{-1} ha^{-1} (curve fit)
0.3% of applied dosage after 2 hours (integrated curve fit)
0.8% of applied dosage after 1 day (integrated curve fit)
9.1% of applied dosage after 154 days

compound: **fenoprop (silvex)**
formulation: same
date/place: same
duration: same
application: same
dosage: same
method: same
soil: same
soil temperature: 25 ^{o}C (fixed)
water regime: same
micro-climate: air temperature: 25 ^{o}C (fixed)
wind speed: same

volatilization: $rate_{t = 0, estimated}$ = unknown
$rate_{t = 2h, estimated}$ = 1.4 g h^{-1} ha^{-1} (curve fit)
$rate_{t = 1d, estimated}$ = 0.4 g h^{-1} ha^{-1} (curve fit)
$rate_{t = 154d, estimated}$ = 0.02 g h^{-1} ha^{-1} (curve fit)
0.2% of applied dosage after 2 hours (integrated curve fit)
0.8% of applied dosage after 1 day (integrated curve fit)
13% of applied dosage after 154 days

compound: **fenoprop (silvex)**
formulation: same
date/place: same
duration: same
application: same
dosage: same
method: same
soil: same
soil temperature: 35 ^{o}C (fixed)
water regime: same
micro-climate: air temperature: 35 ^{o}C (fixed)
wind speed: same
volatilization: $rate_{t = 0, estimated}$ = unknown
$rate_{t = 2h, estimated}$ = 6.9 g h^{-1} ha^{-1} (curve fit)
$rate_{t = 1d, estimated}$ = 0.6 g h^{-1} ha^{-1} (curve fit)
$rate_{t = 154d, estimated}$ = 0.004 g h^{-1} ha^{-1} (curve fit)
unknown % of applied dosage after 2 hours (integrated curve fit)
unknown % of applied dosage after 1 day (integrated curve fit)
10% of applied dosage after 154 days

compound: **picloram (potassium salt)**
(herbicide, pyridinecarboxylic acids group, $VP_{Beste, 1983, estimated}$ = 0.000045 mPa (25 ^{o}C), $VP_{Hornsby, 1996}$ = 0, $S_{Beste, 1983, estimated}$ = 503.3 mg l^{-1} (25 ^{o}C), $S_{Hornsby, 1996}$ = 200 000 mg l^{-1} (25 ^{o}C), $K_{oc,Kenaga, 1980}$ = 75 dm^3 kg^{-1}, $K_{oc,Hornsby, 1996}$ = 16 dm^3 kg^{-1},$DT_{50,soil,Hornsby, 1996}$ = 90 d; picloram: VP = 0.082 mPa (35 ^{o}C), S = 430 mg l^{-1} (25 ^{o}C), $DT_{50,soil}$ = 30-330d, $DT_{50,UV-25 0C}$ = 2.6 d)
formulation: same
date/place: same
duration: same
application: same
dosage: 2.5 kg ha^{-1} a.i.
method: same
soil: same
soil temperature: 5 ^{o}C (fixed)
water regime: same
micro-climate: air temperature: 5 ^{o}C (fixed)
wind speed: same
volatilization: $rate_{t = 0, estimated}$ = unknown
$rate_{t = 2h, estimated}$ = 0.05 g h^{-1} ha^{-1} (curve fit)
$rate_{t = 1d, estimated}$ = 0.01 g h^{-1} ha^{-1} (curve fit)
$rate_{t = 154d, estimated}$ = 0.0004 g h^{-1} ha^{-1} (curve fit)
0.01% of applied dosage after 2 hours (integrated curve fit)
0.03% of applied dosage after 1 day (integrated curve fit)
0.1% of applied dosage after 154 days

compound: **picloram**
formulation: same
date/place: same
duration: same
application: same
dosage: same
method: same
soil: same
soil temperature: 15 ^{o}C (fixed)
water regime: same
micro-climate: air temperature: 15 ^{o}C (fixed)
wind speed: same
volatilization: rate$_{t = 0, \text{estimated}}$ = unknown
rate$_{t = 2h, \text{estimated}}$ = 0.07 g h^{-1} ha^{-1} (curve fit)
rate$_{t = 1d, \text{estimated}}$ = 0.02 g h^{-1} ha^{-1} (curve fit)
rate$_{t = 154d, \text{estimated}}$ = 0.0008 g h^{-1} ha^{-1} (curve fit)
unknown % of applied dosage after 2 hours (integrated curve fit)
unknown % of applied dosage after 1 day (integrated curve fit)
0.1% of applied dosage after 154 days

compound: **picloram**
formulation: same
date/place: same
duration: same
application: same
dosage: same
method: same
soil: same
soil temperature: 20 ^{o}C (fixed)
water regime: same
micro-climate: air temperature: 20 ^{o}C (fixed)
wind speed: same
volatilization: rate$_{t = 0, \text{estimated}}$ = unknown
rate$_{t = 2h, \text{estimated}}$ = 0.07 g h^{-1} ha^{-1} (curve fit)
rate$_{t = 1d, \text{estimated}}$ = 0.03 g h^{-1} ha^{-1} (curve fit)
rate$_{t = 154d, \text{estimated}}$ = 0.003 g h^{-1} ha^{-1} (curve fit)
unknown % of applied dosage after 2 hours (integrated curve fit)
unknown % of applied dosage after 1 day (integrated curve fit)
0.2% of applied dosage after 154 days

compound: **picloram**
formulation: same
date/place: same
duration: same
application: same
dosage: same
method: same
soil: same
soil temperature: 25 ^{o}C (fixed)
water regime: same
micro-climate: air temperature: 25 ^{o}C (fixed)
wind speed: same
volatilization: rate$_{t = 0, \text{estimated}}$ = unknown
rate$_{t = 2h, \text{estimated}}$ = 0.08 g h^{-1} ha^{-1} (curve fit)

rate$_{t = 1d, estimated}$ = 0.02 g h^{-1} ha^{-1} (curve fit)
rate$_{t = 154d, estimated}$ = 0.002 g h^{-1} ha^{-1} (curve fit)
unknown % of applied dosage after 2 hours (integrated curve fit)
unknown % of applied dosage after 1 day (integrated curve fit)
0.2% of applied dosage after 154 days

compound:	**picloram**
formulation:	same
date/place:	same
duration:	same
application:	same
dosage:	same
method:	same
soil:	same soil temperature: 35 ^{o}C (fixed)
water regime:	same
micro-climate:	air temperature: 35 ^{o}C (fixed) wind speed: same
volatilization:	rate$_{t = 0, estimated}$ = unknown rate$_{t = 2h, estimated}$ = 0.07 g h^{-1} ha^{-1} (curve fit) rate$_{t = 1d, estimated}$ = 0.02 g h^{-1} ha^{-1} (curve fit) rate$_{t = 154d, estimated}$ = 0.002 g h^{-1} ha^{-1} (curve fit) 0.01% of applied dosage after 2 hours (integrated curve fit) 0.04% of applied dosage after 1 day (integrated curve fit) 0.5% of applied dosage after 154 days

Note: (1) - values presented give a probable upper-limit for the volatilization with respect to soil moisture conditions (upper layer kept wet); (2) - fixed temperatures at 5 and 15 ^{o}C could not be maintained during experiment causing inaccuracies

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compound:	**trifluralin** (herbicide, dinitroanalines group, VP = 9.5 mPa (25 ^{o}C), VP$_{Hornsby, 1996}$ = 14.7 mPa (25 ^{o}C), VP$_{Spencer\ and\ Cliath,\ 1973}$ = 32.2 mPa (30 ^{o}C), S = 0.343 mg l^{-1} (pH5), S = 0.395 mg l^{-1} (pH7), S = 0.383 mg l^{-1} (pH9), S$_{Hornsby, 1996}$ = 0.3 mg l^{-1} (25 ^{o}C), K_{om} = 3775 dm^3 kg^{-1}, $K_{oc,Hornsby, 1996}$ = 8000 dm^3 kg^{-1}, $DT_{50,soil}$ = 221 d, $DT_{50,soil,Hornsby, 1996}$ = 60 d)
formulation:	unknown (in single mix with quintozene, dieldrin, chlorthal-dimethyl, and atrazine)
date/place:	unknown
duration:	154 d
application:	hand-sprayed on surface
dosage:	2.5 kg ha^{-1} a.i.
method:	greenhouse measurements (under controlled conditions) using glass agroecosystem chambers (1.5 x 0.5 x 1.0 m)
soil:	sandy loam: OM = 5.2%, pH = 6.7, MC = 15.6 dry_mass% or θ = 19.6% at Ψ = 33kPa, $\theta_{sat, estimated}$≈46%, $\rho_{dry\ soil}$≈1350 kg m^{-3} area (L x W): 1.5 x 0.5 m^2 depth: 0.15 m soil temperature: 5 ^{o}C (fixed)
water regime:	soil kept moist by sprinkling, $\theta_{estimated}$ = 19.6% (field capacity assumption at pF2.5)

micro-climate:	air temperature: 5 ^oC (fixed)
	wind speed: 0.08 m s^{-1} (fixed, in chamber)
volatilization:	$rate_{t = 0, estimated}$ = unknown
	$rate_{t = 2h, estimated}$ = 3.6 g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 1d, estimated}$ = 0.5 g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 154d, estimated}$ = 0.009 g h^{-1} ha^{-1} (curve fit)
	unknown % of applied dosage after 2 hours (integrated curve fit)
	unknown % of applied dosage after 1 day (integrated curve fit)
	17% of applied dosage after 154 days (incl. metabolite MPT: 5.5%)

compound:	**trifluralin**
formulation:	same
date/place:	same
duration:	same
application:	same
dosage:	same
method:	same
soil:	same
	soil temperature: 15 ^oC (fixed)
water regime:	same
micro-climate:	air temperature: 15 ^oC (fixed)
	wind speed: same
volatilization:	$rate_{t = 0, estimated}$ = unknown
	$rate_{t = 2h, estimated}$ = 10.3 g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 1d, estimated}$ = 1.0 g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 154d, estimated}$ = 0.01 g h^{-1} ha^{-1} (curve fit)
	10.3% of applied dosage after 2 hours (integrated curve fit)
	12.5% of applied dosage after 1 day (integrated curve fit)
	18% of applied dosage after 154 days (incl. metabolite MPT: 2.3%)

compound:	**trifluralin**
formulation:	same
date/place:	same
duration:	same
application:	same
dosage:	same
method:	same
soil:	same
	soil temperature: 20 ^oC (fixed)
water regime:	same
micro-climate:	air temperature: 20 ^oC (fixed)
	wind speed: same
volatilization:	$rate_{t = 0, estimated}$ = unknown
	$rate_{t = 2h, estimated}$ = 66.1 g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 1d, estimated}$ = 2.6 g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 154d, estimated}$ = 0.004 g h^{-1} ha^{-1} (curve fit)
	18% of applied dosage after 2 hours (integrated curve fit with t_0 = 30 m)
	27% of applied dosage after 1 day (integrated curve fit with t_0 = 30 m)
	32% of applied dosage after 154 days (incl. metabolite MPT: 4.1%)

compound:	**trifluralin**
formulation:	same
date/place:	same
duration:	same

application:	same
dosage:	same
method:	same
soil:	same
	soil temperature: 25 ^oC (fixed)
water regime:	same
micro-climate:	air temperature: 25 ^oC (fixed)
	wind speed: same
volatilization:	$rate_{t = 0, estimated}$ = unknown
	$rate_{t = 2h, estimated}$ = 75.8 g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 1d, estimated}$ = 2.4 g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 154d, estimated}$ = 0.002 g h^{-1} ha^{-1} (curve fit)
	21% of applied dosage after 2 hours (integrated curve fit with t_0 = 3 m)
	31% of applied dosage after 1 day (integrated curve fit with t_0 = 3 m)
	36% of applied dosage after 154 days (incl. metabolite MPT: 2.3%)

compound:	**trifluralin**
formulation:	same
date/place:	same
duration:	same
application:	same
dosage:	same
method:	same
soil:	same
	soil temperature: 35 ^oC (fixed)
water regime:	same
micro-climate:	air temperature: 35 ^oC (fixed)
	wind speed: same
volatilization:	$rate_{t = 0, estimated}$ = unknown
	$rate_{t = 2h, estimated}$ = 222.9 g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 1d, estimated}$ = 3.5 g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 154d, estimated}$ = 0.0008 g h^{-1} ha^{-1} (curve fit)
	unknown % of applied dosage after 2 hours (integrated curve fit)
	unknown % of applied dosage after 1 day (integrated curve fit)
	49% of applied dosage after 154 days (incl. metabolite MPT: 4.4%)

compound:	**chlorthal-dimethyl (DCPA)**
	(herbicide, benzoic acids group, VP = 0.21 mPa (25 ^oC), S = 0.343 mg l^{-1} (pH5), S = 0.5 mg l^{-1} (25 ^oC), K_{ow} = 1.9 10^4, $DT_{50,soil,Tomlin}$ = 100 d)
formulation:	unknown (in single mix with trifluralin, quintozene, dieldrin, and atrazine)
date/place:	same
duration:	same
application:	same
dosage:	2.5 kg ha^{-1} a.i.
method:	same
soil:	same
	soil temperature: 5 ^oC (fixed)
water regime:	same
micro-climate:	air temperature: 5 ^oC (fixed)
	wind speed: same
volatilization:	$rate_{t = 0, estimated}$ = unknown
	$rate_{t = 2h, estimated}$ = 0.3 g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 1d, estimated}$ = 0.2 g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 154d, estimated}$ = 0.04 g h^{-1} ha^{-1} (curve fit)

	unknown % of applied dosage after 2 hours (integrated curve fit)
	unknown % of applied dosage after 1 day (integrated curve fit)
	17% of applied dosage after 154 days
compound:	**chlorthal-dimethyl (DCPA)**
formulation:	same
date/place:	same
duration:	same
application:	same
dosage:	same
method:	same
soil:	same
	soil temperature: 15 ^{o}C (fixed)
water regime:	same
micro-climate:	air temperature: 15 ^{o}C (fixed)
	wind speed: same
volatilization:	$rate_{t = 0, estimated}$ = unknown
	$rate_{t = 2h, estimated}$ = 1.0 g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 1d, estimated}$ = 0.5 g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 154d, estimated}$ = 0.1 g h^{-1} ha^{-1} (curve fit)
	0.1% of applied dosage after 2 hours (integrated curve fit)
	0.6% of applied dosage after 1 day (integrated curve fit)
	27% of applied dosage after 154 days
compound:	**chlorthal-dimethyl (DCPA**)
formulation:	same
date/place:	same
duration:	same
application:	same
dosage:	same
method:	same
soil:	same
	soil temperature: 20 ^{o}C (fixed)
water regime:	same
micro-climate:	air temperature: 20 ^{o}C (fixed)
	wind speed: same
volatilization:	$rate_{t = 0, estimated}$ = unknown
	$rate_{t = 2h, estimated}$ = 3.3 g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 1d, estimated}$ = 1.0 g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 154d, estimated}$ = 0.1 g h^{-1} ha^{-1} (curve fit)
	0.5 % of applied dosage after 2 hours (integrated curve fit)
	1.9 % of applied dosage after 1 day (integrated curve fit)
	38% of applied dosage after 154 days
compound:	**chlorthal-dimethyl (DCPA)**
formulation:	same
date/place:	same
duration:	same
application:	same
dosage:	same
method:	same
soil:	same
	soil temperature: 25 ^{o}C (fixed)
water regime:	same

micro-climate:	air temperature: 25 ^{o}C (fixed)
	wind speed: same
volatilization:	$rate_{t = 0, estimated}$ = unknown
	$rate_{t = 2h, estimated}$ = 7.2 g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 1d, estimated}$ = 1.5 g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 154d, estimated}$ = 0.06 g h^{-1} ha^{-1} (curve fit)
	1.6% of applied dosage after 2 hours (integrated curve fit)
	3.9% of applied dosage after 1 day (integrated curve fit)
	40% of applied dosage after 154 days

compound:	**chlorthal-dimethyl (DCPA)**
formulation:	same
date/place:	same
duration:	same
application:	same
dosage:	same
method:	same
soil:	same
	soil temperature: 35 ^{o}C (fixed)
water regime:	same
micro-climate:	air temperature: 35 ^{o}C (fixed)
	wind speed: same
volatilization:	$rate_{t = 0, estimated}$ = unknown
	$rate_{t = 2h, estimated}$ = 27.7 g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 1d, estimated}$ = 3.4 g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 154d, estimated}$ = 0.05 g h^{-1} ha^{-1} (curve fit)
	15% of applied dosage after 2 hours (integrated curve fit)
	22% of applied dosage after 1 day (integrated curve fit)
	62% of applied dosage after 154 days

compound:	**atrazine**
	(herbicide, triazines group, VP = 0.039 mPa (25 ^{o}C), $VP_{Gueckel, 1995}$ = 0.026 mPa (20 ^{o}C), $VP_{Hornsby, 1996}$ = 0.187 mPa (30 ^{o}C), S = 33 mg l^{-1} (25 ^{o}C), K_{om} = 70 dm^3 kg^{-1}, $K_{oc,Hornsby, 1996}$ = 100 dm^3 kg^{-1}, $DT_{50,soil}$ = 50 d, $DT_{50,soil,Gish}$ = 71 d, $DT_{50,soil,Hornsby, 1996}$ = 60 d)
formulation:	unknown (in single mix with trifluralin, quintozene, dieldrin, and chlorthal-dimethyl)
date/place:	same
duration:	same
application:	same
dosage:	2.5 kg ha^{-1} a.i.
method:	same
soil:	same
	soil temperature: 5 ^{o}C (fixed)
water regime:	same
micro-climate:	air temperature: 5 ^{o}C (fixed)
	wind speed: same
volatilization:	$rate_{t = 0, estimated}$ = unknown
	$rate_{t = 2h, estimated}$ = 0.09 g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 1d, estimated}$ = 0.06 g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 154d, estimated}$ = 0.02 g h^{-1} ha^{-1} (curve fit)
	unknown % of applied dosage after 2 hours (integrated curve fit)
	unknown % of applied dosage after 1 day (integrated curve fit)
	9% of applied dosage after 154 days

compound:	**atrazine**
formulation:	same
date/place:	same
duration:	same
application:	same
dosage:	same
method:	same
soil:	same
	soil temperature: 15 ^{o}C (fixed)
water regime:	same
micro-climate:	air temperature: 15 ^{o}C (fixed)
	wind speed: same
volatilization:	$rate_{t = 0, estimated}$ = unknown
	$rate_{t = 2h, estimated} = 0.2$ g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 1d, estimated} = 0.2$ g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 154d, estimated} = 0.06$ g h^{-1} ha^{-1} (curve fit)
	0.02 of applied dosage after 2 hours (integrated curve fit)
	0.2% of applied dosage after 1 day (integrated curve fit)
	12% of applied dosage after 154 days

compound:	**atrazine**
formulation:	same
date/place:	same
duration:	same
application:	same
dosage:	same
method:	same
soil:	same
	soil temperature: 20 ^{o}C (fixed)
water regime:	same
micro-climate:	air temperature: 20 ^{o}C (fixed)
	wind speed: same
volatilization:	$rate_{t = 0, estimated}$ = unknown
	$rate_{t = 2h, estimated} = 0.3$ g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 1d, estimated} = 0.2$ g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 154d, estimated} = 0.1$ g h^{-1} ha^{-1} (curve fit)
	0.03 % of applied dosage after 2 hours (integrated curve fit)
	0.3 % of applied dosage after 1 day (integrated curve fit)
	20% of applied dosage after 154 days

compound:	**atrazine**
formulation:	same
date/place:	same
duration:	same
application:	same
dosage:	same
method:	same
soil:	same
	soil temperature: 25 ^{o}C (fixed)
water regime:	same
micro-climate:	air temperature: 25 ^{o}C (fixed)
	wind speed: same
volatilization:	$rate_{t = 0, estimated}$ = unknown

	$rate_{t = 2h, estimated}$ = 0.5 g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 1d, estimated}$ = 0.3 g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 154d, estimated}$ = 0.08 g h^{-1} ha^{-1} (curve fit)
	0.06% of applied dosage after 2 hours (integrated curve fit)
	0.4% of applied dosage after 1 day (integrated curve fit)
	21% of applied dosage after 154 days

compound:	**atrazine**
formulation:	same
date/place:	same
duration:	same
application:	same
dosage:	same
method:	same
soil:	same
	soil temperature: 35 ^{o}C (fixed)
water regime:	same
micro-climate:	air temperature: 35 ^{o}C (fixed)
	wind speed: same
volatilization:	$rate_{t = 0, estimated}$ = unknown
	$rate_{t = 2h, estimated}$ = 3.2 g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 1d, estimated}$ = 0.8 g h^{-1} ha^{-1} (curve fit)
	$rate_{t = 154d, estimated}$ = 0.05 g h^{-1} ha^{-1} (curve fit)
	0.6 % of applied dosage after 2 hours (integrated curve fit)
	1.7 % of applied dosage after 1 day (integrated curve fit)
	25% of applied dosage after 154 days

Note: (1) - values presented give a probable upper-limit for the volatilization with respect to soil moisture conditions (upper layer kept wet); (2) - fixed temperatures at 5 and 15 ^{o}C could not be maintained during experiment causing inaccuracies; (3) - values for trifluralin include metabolite MPT (needs correction in data!)

Glotfelty, 1989, cb1

compound:	**alachlor**
	(herbicide, chloroacetanilides group, VP = 2.9 mPa (25 ^{o}C), S = 242 mg l^{-1} (25 ^{o}C), K_{om} = 117 dm^3 kg^{-1}, DT_{50} = 22 d)
formulation:	EC (in single mix with toxaphene, atrazine and simazine)
date/place:	May '81, University of Maryland, Salisbury, MD, USA
duration:	24 d
application:	sprayed on surface (tractor mounted)
dosage:	2.24 kg ha^{-1} a.i.
method:	field measurements at 0.2, 0.3, 0.5, 0.8, 1.2, and 1.90 m heights using Aerodynamic Balance Method
soil:	silt loam: OM = 1.5%, $\theta_{sat, estimated} \approx 51.0\%$, $\rho_{dry\ soil} \approx 1300$ kg m^{-3}
	area (L x W): 2827 m^2 (circle)
	depth: NA
	soil temperature: unknown
water regime:	total rainfall: 86 mm, distributed over days 3 (15.5 mm), 8 (23 mm), 11 (16 mm), 16 (15 mm), and 6 days prior to application 16.5 mm
	$\theta_{(0-0.03\ m)}$ = not measured, but surface moist on days 4, 9, 12, 17 and during

measurements on days 5, 10, 11, and 18; $\theta_{estimated} \approx 27\%$ (average wilting point and field capacity)

micro-climate: air temperature: 30.5 ^oC (day 0, sunny), 27.5 ^oC (day 1, cloud-clear), 27.5 ^oC (day 2, sunny), (all average day temperatures); 23-32 ^oC (range); wind speed: 0.5-5.5 m s^{-1} (2.3) with 1.75 m s^{-1} (day 0), 2.0 m s^{-1} (day 1), and 3.75 m s^{-1} (day 2)

volatilization: $rate_{t = 0,measured}$ = 3 g h^{-1} ha^{-1}
$rate_{t = 2h,measured}$ = 1.7 g h^{-1} ha^{-1}
$rate_{t = 1d,measured}$ = 2.1 g h^{-1} ha^{-1}
$rate_{t = 24d,measured}$ = 0.24 g h^{-1} ha^{-1}
0.3% of applied dosage after 2 hours
1.3% of applied dosage after 1 day
12% of applied dosage after 10 days (estimated)
19% of applied dosage after 21 days (estimated)

compound: **toxaphene (camphechlor)**
(insecticide, organochlorines group, $VP_{Hornsby,\ 1996}$ = 0.533 mPa (20 ^oC), $VP_{Seiber,\ 1981}$ = 0.15 mPa, $S_{Hornsby,\ 1996}$ = 3 mg l^{-1} (20 ^oC), $S_{Sanborn,\ 1976}$ = 0.4 mg l^{-1}, $K_{oc,Hornsby,\ 1996}$ = 100 000 dm^3 kg^{-1}, $K_{oc,\ McDowell,\ 1981}$ = 9.9 10^4 dm^3 kg^{-1}, $DT_{50,Hornsby,\ 1996}$ = 9 d)

formulation: EC (in single mix with alachlor, atrazine and simazine)
date/place: same
duration: same
application: same
dosage: 2.52 kg ha^{-1} a.i.
method: same
soil: same
water regime: same
micro-climate: same
volatilization: $rate_{t = 0,\ measured}$ = 5.9 g h^{-1} ha^{-1}
$rate_{t = 2h,\ measured}$ = 1.9 g h^{-1} ha^{-1}
$rate_{t = 1d,\ measured}$ = 7.8 g h^{-1} ha^{-1}
$rate_{t = 24d,\ measured}$ = 1.2 g h^{-1} ha^{-1}
0.5% of applied dosage after 2 hours
3.3% of applied dosage after 1 day
19% of applied dosage after 10 days (estimated)
31% of applied dosage after 21 days (estimated)

compound: **atrazine**
(herbicide, triazines group, VP = 0.039 mPa (25 ^oC), $VP_{Gueckel,\ 1995}$ = 0.026 mPa (20 ^oC), $VP_{Hornsby,\ 1996}$ = 0.187 mPa (30 ^oC), S = 33 mg l^{-1} (25 ^oC), K_{om} = 70 dm^3 kg^{-1}, $K_{oc,Hornsby,\ 1996}$ = 100 dm^3 kg^{-1}, $DT_{50,soil}$ = 50 d, $DT_{50,soil,Gish}$ = 71 d, $DT_{50,soil,Hornsby,\ 1996}$ = 60 d)

formulation: WP (in single mix with alachlor, toxaphene and simazine)
date/place: same
duration: same
application: same
dosage: 1.68 kg ha^{-1} a.i.
method: same
soil: same
water regime: same
micro-climate: same
volatilization: $rate_{t = 0,\ measured}$ = 0.11 g h^{-1} ha^{-1}
$rate_{t = 2h,\ measured}$ = 0.087 g h^{-1} ha^{-1}

	$rate_{t = 1d, measured}$ = 0.46 g h^{-1} ha^{-1} $rate_{t = 24d, measured}$ = 0.017 g h^{-1} ha^{-1} 0.01% of applied dosage after 2 hours 0.2% of applied dosage after 1 day 1.3% of applied dosage after 10 days (estimated) 2.4% of applied dosage after 21 days (estimated)
compound:	**simazine** (herbicide, triazines group, VP = 0.00294 mPa (25 °C), $VP_{Worthing, 1987}$ = 0.00081 mPa (20 °C), $VP_{Hornsby, 1996}$ = 0.0048 mPa (30 °C), S = 6.2 mg l^{-1} (20 °C), $S_{Worthing, 1987}$ = 5 mg l^{-1} (20 °C), K_{om} = 70 dm^3 kg^{-1}, $DT_{50,soil}$ = 50 d)
formulation:	WP (in single mix with alachlor, toxaphene and atrazine)
date/place:	same
duration:	same
application:	same
dosage:	1.68 kg ha^{-1} a.i.
method:	same
soil:	same
water regime:	same
micro-climate:	same
volatilization:	$rate_{t = 0, measured}$ = 0.042 g h^{-1} ha^{-1} $rate_{t = 2h, measured}$ = 0.018 g h^{-1} ha^{-1} $rate_{t = 1d, measured}$ = 0.11 g h^{-1} ha^{-1} $rate_{t = 24d, measured}$ = 0.021 g h^{-1} ha^{-1} 0.005% of applied dosage after 2 hours 0.06% of applied dosage after 1 day (estimated) 0.57% of applied dosage after 10 days (estimated) 1.3% of applied dosage after 21 days (estimated)

Note: (1) - for WP formulations dried soils are liable to wind erosion of the compound; (2) - on day 24 corn up at 40 cm, thereby affecting the volatilization rate

Glotfelty, 1984, cb55

compound:	**heptachlor, trifluralin, lindane, chlordane, dacthal** interesting article, but missing a complete overview of volatilization data, soil moisture and temperature, etc.

Wienhold, 1993, cb55

compound:	**atrazine** (herbicide, triazines group, VP = 0.039 mPa (25 °C), $VP_{Gueckel, 1995}$ = 0.026 mPa (20 °C), $VP_{Hornsby, 1996}$ = 0.187 mPa (30 °C), S = 33 mg l^{-1} (25 °C), K_{om} = 70 dm^3 kg^{-1}, $K_{oc,Hornsby, 1996}$ = 100 dm^3 kg^{-1}, $DT_{50,soil}$ = 50 d, $DT_{50,soil,Gish}$ = 71 d, $DT_{50,soil,Hornsby, 1996}$ = 60 d)
formulation:	commercial Bullet, USA, GIFAP unknown
date/place:	unknown
duration:	35 d
application:	hand-sprayed on surface
dosage:	1.7 kg ha^{-1} a.i.
method:	lab measurements using glass agroecosystem chambers (1.5 x 0.5 x 1.0 m)
soil:	loamy fine sand: clay = 5.6%, OM = 1.1%, pH = 6.4, $\theta_{sat, estimated} \approx 44.0\%$, $\rho_{dry\ soil} \approx 1450$ kg m^{-3}

	area (L x W): 0.75 m^2
	depth: 0.15 m
	soil temperature: 15 ^oC (fixed)
water regime:	$MC_{(0-0.03\ m)} \approx 20$ dry_mass% or $\theta_{(0-0.03\ m)} \approx 29\%$
micro-climate:	air temperature: unknown
	wind speed: 0.097 m s^{-1} (in chamber)
volatilization:	$rate_{t=0}$ = unknown
	$rate_{t=2h}$ = unknown
	$rate_{t=1d,\ estimated}$ = 0.01 g h^{-1} ha^{-1}
	$rate_{t=35d,\ estimated}$ = 0.01 g h^{-1} ha^{-1}
	<0.05% of applied dosage after 2 hours
	0.05% of applied dosage after 1 day
	0.53% of applied dosage after 35 days
compound:	**atrazine**
formulation:	same
date/place:	same
duration:	same
application:	same
dosage:	same
method:	same
soil:	same
water regime:	same
micro-climate:	same
	soil temperature: 25 ^oC (fixed)
volatilization:	$rate_{t=0}$ = unknown
	$rate_{t=2h}$ = unknown
	$rate_{t=1d,\ estimated}$ = 0.18 g h^{-1} ha^{-1}
	$rate_{t=35d,\ estimated}$ = 0.16 g h^{-1} ha^{-1}
	<0.9% of applied dosage after 2 hours
	0.9% of applied dosage after 1 day
	8.3% of applied dosage after 35 days
compound:	**atrazine**
formulation:	same
date/place:	same
duration:	same
application:	same
dosage:	same
method:	same
soil:	same
water regime:	same
micro-climate:	same
	soil temperature: 35 ^oC (fixed)
volatilization:	$rate_{t=0}$ = unknown
	$rate_{t=2h}$ = unknown
	$rate_{t=1d,\ estimated}$ = 0.31 g h^{-1} ha^{-1}
	$rate_{t=35d,\ estimated}$ = 0.27 g h^{-1} ha^{-1}
	<1.5% of applied dosage after 2 hours
	1.5% of applied dosage after 1 day
	14% of applied dosage after 35 days
compound:	**alachlor**
	(herbicide, chloroacetanilides group, VP = 2.9 mPa (25 ^oC), S = 242 mg l^{-1}

	(25 ^oC), K_{om} = 117 $dm^3\ kg^{-1}$, DT_{50} = 22 d)
formulation:	commercial Bullet, USA, GIFAP unknown
date/place:	same
duration:	same
application:	2.8 kg ha^{-1} a.i.
dosage:	same
method:	same
soil:	same
water regime:	same
micro-climate:	same soil temperature: 15 ^oC (fixed)
volatilization:	$rate_{t=0}$ = unknown $rate_{t=2h}$ = unknown $rate_{t=1d,\ estimated}$ = 0.05 g $h^{-1}\ ha^{-1}$ $rate_{t=35d,\ estimated}$ = 0.05 g $h^{-1}\ ha^{-1}$ <0.2% of applied dosage after 2 hours 0.2% of applied dosage after 1 day 1.6% of applied dosage after 35 days

compound:	**alachlor**
formulation:	commercial Bullet, USA, GIFAP unknown
date/place:	same
duration:	same
application:	same
dosage:	same
method:	same
soil:	same
water regime:	same
micro-climate:	same soil temperature: 25 ^oC (fixed)
volatilization:	$rate_{t=0}$ = unknown $rate_{t=2h}$ = unknown $rate_{t=1d,\ estimated}$ = 0.33 g $h^{-1}\ ha^{-1}$ $rate_{t=35d,\ estimated}$ = 0.3 g $h^{-1}\ ha^{-1}$ <1.3% of applied dosage after 2 hours 1.3% of applied dosage after 1 day 9.5% of applied dosage after 35 days

compound:	**alachlor**
formulation:	commercial Bullet, USA, GIFAP unknown
date/place:	same
duration:	same
application:	same
dosage:	same
method:	same
soil:	same
water regime:	same
micro-climate:	same soil temperature: 35 ^oC (fixed)
volatilization:	$rate_{t=0}$ = unknown $rate_{t=2h}$ = unknown $rate_{t=1d,\ estimated}$ = 0.5 g $h^{-1}\ ha^{-1}$ $rate_{t=35d,\ estimated}$ = 0.4 g $h^{-1}\ ha^{-1}$ <2.9% of applied dosage after 2 hours

2.9% of applied dosage after 1 day
14% of applied dosage after 35 days

Note: two metabolites of atrazine detected at 25 °C and 35 °C, namely deethylatrazine and deisopropylatrazine

Krasel, 1993, cb90

compound: chlortoluron/ethofumesate/isoproturon/lindane/methabenzthiazuron/metamitron/simazine/tri-allate/trifluralin Cumulative volatilization losses only available after 6 hours period.

Clendening, 1990, cb14

compound: **EPTC**
(herbicide, thiocarbamates group, VP = 2626 mPa (25 °C), S = 375 mg l^{-1} (25 °C), $S_{Freed, 1976, from Baker, 1996}$ = 636 mg l^{-1} (3 °C), K_{om} = 61 dm^3 kg^{-1}, $DT_{50,soil}$ = 47 d)

formulation: GIFAP unknown (in mix with bromacil, tri-allate, atrazine, and prometon)

date/place: October/November '86, Southern California, USA

duration: 17 d

application: hand-sprayed on surface

dosage: 1.85 kg ha^{-1} a.i. (see note)

method: field measurements using acrylic portable flux chambers (size unknown)

soil: sandy loam: OM = low and estimated at 1.0%, $\theta_{sat, estimated}$≈46.0%, $\rho_{dry soil}$≈1400 kg m^{-3}
area (L x W): 4 x 4 m^2
depth: unknown
soil temperature: unknown

water regime: total irrigation: 55 mm, distributed over days 2 (18.3 mm), 9 (17.5 mm), 16 (19 mm), and 2 days prior to application with unknown (large) quantity
$\theta_{(0-0.03\ m)}$ = not measured, $\theta_{estimated\ average}$≈16% (average field capacity and wilting point)

micro-climate: air temperature: unknown and estimated at 20 °C (November '86 Southern California)
wind speed: unknown (in chamber: low)

volatilization: $rate_{t=0}$ = 33 g h^{-1} ha^{-1}
$rate_{t=2h, estimated}$ = 1.9 g h^{-1} ha^{-1}
$rate_{t=1d}$ = 0.5 g h^{-1} ha^{-1}
$rate_{t=17d}$ = 0.0 g h^{-1} ha^{-1}
7.2% of applied dosage after 2 hours (estimated and see note)
23% of applied dosage after 1 day (estimated and see also note)
32% of applied dosage after 3 days
23.5 (± 9.3)% of applied dosage after 17 days (unclear result)

compound: **atrazine**
(herbicide, triazines group, VP = 0.039 mPa (25 °C), $VP_{Gueckel, 1995}$ = 0.026 mPa (20 °C), $VP_{Hornsby, 1996}$ = 0.187 mPa (30 °C), S = 33 mg l^{-1} (25 °C), K_{om} = 70 dm^3 kg^{-1}, $K_{oc,Hornsby, 1996}$ = 100 dm^3 kg^{-1}, $DT_{50,soil}$ = 50 d, $DT_{50,soil,Gish}$ = 71 d, $DT_{50,soil,Hornsby, 1996}$ = 60 d)

formulation: GIFAP unknown (in mix with bromacil, tri-allate, EPTC, and prometon)

date/place: same

duration: same

application: same

dosage:	0.16 kg ha^{-1} a.i.
method:	same
soil:	same
water regime:	same
micro-climate:	same
volatilization:	$rate_{t = 0} = 0.002$ g h^{-1} ha^{-1} $rate_{t = 2h, estimated} = 0.015$ g h^{-1} ha^{-1} $rate_{t = 1d, estimated} = 0.0$ g h^{-1} ha^{-1} $rate_{t = 17d} = 0.002$ g h^{-1} ha^{-1} 0.008% of applied dosage after 2 hours (estimated) 0.07% of applied dosage after 1 day (estimated) 0.16% of applied dosage after 3 days 0.6 (± 0.2)% of applied dosage after 17 days

compound:	**tri-allate** (herbicide, thiocarbamates group, VP = 16 mPa (25 °C), S = 4 mg l^{-1} (25 °C), $K_{om} = 1164$ dm^3 kg^{-1}, $DT_{50,soil} = 103$ d)
formulation:	GIFAP unknown (in mix with bromacil, atrazine, EPTC, and prometon)
date/place:	same
duration:	same
application:	same
dosage:	0.02 kg ha^{-1} a.i.
method:	same
soil:	same
water regime:	same
micro-climate:	same
volatilization:	$rate_{t = 0}$ = unknown $rate_{t = 2h}$ = unknown $rate_{t = 1d,}$ = unknown $rate_{t = 17d}$ = unknown unknown% of applied dosage after 2 hours unknown% of applied dosage after 1 day 4.4% of applied dosage after 3 days 2.7 (± 2.5)% of applied dosage after 17 days (unclear result)

compound:	**bromacil** (herbicide, uracils group, VP = 0.041 mPa (25 °C), S = 700 mg l^{-1} (25 °C), $K_{oc,Hornsby, 1996} = 32$ dm^4/kg, $K_{ow} = 74.5$, $DT_{50,soil,Jury, 1984} = 350$ d, $DT_{50,Hornsby, 1996} = 60$ d)
formulation:	GIFAP unknown (in mix with tri-allate, atrazine, EPTC, and prometon)
date/place:	same
duration:	same
application:	same
dosage:	2.04 kg ha^{-1} a.i.
method:	same
soil:	same
water regime:	same
micro-climate:	same
volatilization:	$rate_{t = 0}$ = unknown $rate_{t = 2h}$ = unknown $rate_{t = 1d,}$ = unknown $rate_{t = 17d}$ = unknown unknown% of applied dosage after 2 hours unknown% of applied dosage after 1 day

0.0% of applied dosage after 3 days
0.0% of applied dosage after 17 days

compound: **prometon**
(herbicide, triazines group, VP = 0.306 mPa (20 ^oC), $VP_{Hornsby, 1996}$ = 1.03 mPa (25 ^oC), S = 750 mg l^{-1} (20 ^oC), $S_{Hornsby, 1996}$ = 720 mg l^{-1} (22 ^oC), $K_{oc,Jury, 1984}$ = 408 dm^3 kg^{-1}, $K_{oc,Hornsby, 1996}$ = 150 dm^3 kg^{-1}, $DT_{50,soil,Jury, 1984}$ = 100 d, $DT_{50,soil,Hornsby, 1996}$ = 500 d)
formulation: GIFAP unknown (in mix with bromacil, atrazine, EPTC, and tri-allate)
date/place: same
duration: same
application: same
dosage: 1.875 kg ha^{-1} a.i.
method: same
soil: same
water regime: same
micro-climate: same
volatilization: $rate_{t = 0}$ = unknown
$rate_{t = 2h}$ = unknown
$rate_{t = 1d,}$ = unknown
$rate_{t = 17d}$ = unknown
unknown% of applied dosage after 2 hours
unknown% of applied dosage after 1 day
0.13% of applied dosage after 3 days
0.31 (± 0.08)% of applied dosage after 17 days

Note: a significant part of EPTC volatilized in the air as aerosol during application (estimated at 61%), CV values therefore based on amount which actually reached the soil (39%)

Baker, 1996, cb67
compound: **EPTC** (incorporated in soil, well described experiment and theory)

Majewski, 1989, cb130 / Majewski, 1990, cb72
compound: **chlorpyrifos-ethyl**
(insecticide, organophosphorus group, VP = 2.7 mPa (25 ^oC), $VP_{Hornsby, 1996}$ = 2.27 mPa (20 ^oC), $VP_{Hornsby, 1996}$ = 12.0 mPa (20 ^oC), S = 1.4 mg l^{-1} (25 ^oC), $S_{Hornsby, 1996}$ = 0.4 mg l^{-1} (25 ^oC), S = 2.0 mg l^{-1} (35 ^oC), K_{om} = 293 dm^3 kg^{-1}, $K_{oc,Hornsby, 1996}$ = 6070 dm^3 kg^{-1}, $DT_{50,soil,Tomlin}$ = 94 d, $DT_{50,soil,Hornsby, 1996}$ = 30 d, $DT_{50,water-pH8}$ = 1.5 d)
formulation: EC (in mix with diazinon, lindane, and nitrapyrin)
date/place: September '85, Davis Campus, CA, USA
duration: 4 d
application: spray rigs
dosage: 1.7 kg ha^{-1} a.i.
method: field measurements at 0.2, 0.35, 0.55, 0.90, and 1.5m height using Aerodynamic Method (Pruitt)
soil: type unknown: C_{org} = 1.1%, $\theta_{sat, estimated}$≈40%, $\rho_{dry soil}$≈1550 kg m^{-3} (from Majewski, 1991)
area (L x W): 100 x 100 m^2
depth: NA
soil temperature: unknown
water regime: very light rainfall on day 2 (20 min. duration), 50 mm sprinkle 8 days prior to application

	$MC_{(0-0.07\ m)}$ = 11.7 dry_mass% or $\theta_{(0-0.07\ m)}$ = 18.6% (day 0), 11.1 dry_mass% or 17.7 vol% (day 1), 11.3 dry_mass% or 18.0 vol% (day 2), 9.6 dry_mass% or 15.3 vol% (day 3), 10.9 dry_mass% or 17.4 vol% (whole period), (all day averages; volumetric or mass % could not be established, mass % taken)
micro-climate:	air temperature: unknown, but generally sunny and hot with low clouds on day 2; assume: 30 °C (average day temperature) and 20 °C (average night temperature) wind speed: 0.84-6.87 m s^{-1} (5.3 m s^{-1} on day 0, 1.1 m s^{-1} on day 1, 2.0 m s^{-1} on day 2, and 1.8 m s^{-1} on day 3, average values)
volatilization:	$rate_{t=0}$ = unknown $rate_{t=2h}$ = 0.23 g h^{-1} ha^{-1} $rate_{t=1d}$ = 0.31 g h^{-1} ha^{-1} $rate_{t=3.15d}$ = 0.065 g h^{-1} ha^{-1} 0.04% of applied dosage after 2 hours (estimated) 0.44% of applied dosage after 1 day (estimated) 0.64% of applied dosage after 3.15 days (estimated)
compound:	**diazinon** (insecticide, organophosphorus group, VP = 12 mPa (25 °C), $VP_{Hornsby,\ 1996}$ = 8 mPa (20 °C), S = 60 mg l^{-1} (20 °C), K_{om} = 159 dm^3 kg^{-1}, $K_{oc,Hornsby,\ 1996}$ = 1000 dm^3 kg^{-1}, DT_{50} = 21 d, $DT_{50,Hornsby,\ 1996}$ = 40 d)
formulation:	EC (in mix with chlorpyrifos-ethyl, lindane, and nitrapyrin)
date/place:	same
duration:	same
application:	spray rigs
dosage:	1.7 kg ha^{-1} a.i.
method:	same
soil:	same
water regime:	same
micro-climate:	same
volatilization:	$rate_{t=0}$ = unknown $rate_{t=2h}$ = 0.06 g h^{-1} ha^{-1} $rate_{t=1d}$ = 0.05 g h^{-1} ha^{-1} $rate_{t=3.15d}$ = 0.002 g h^{-1} ha^{-1} 0.01% of applied dosage after 2 hours (estimated) 0.02% of applied dosage after 1 day (estimated) 0.13% of applied dosage after 3.15 days (estimated)
compound:	**lindane** (insecticide, organochlorines group, γ-isomer, VP = 5.6 mPa (20 °C), $VP_{Hornsby,\ 1996}$ = 17.3 mPa (30 °C), $VP_{Spencer\ and\ Cliath,\ 1974}$ = 17.04 mPa (30 °C), S = 7.3 mg l^{-1} (25 °C), $S_{author?}$ = 12 mg l^{-1} (35 °C), K_{om} = 633 dm^3 kg^{-1}, $K_{oc,Hornsby,\ 1996}$ = 1100 dm^3 kg^{-1}, $DT_{50,soil}$ = 1406 d, $DT_{50,soil,Hornsby,\ 1996}$ = 400 d, $DT_{50,solution,pH9}$ = 0.5 d, $DT_{50,solution,pH7}$ = 191 d)
formulation:	EC (in mix with chlorpyrifos-ethyl, diazinon, and nitrapyrin)
date/place:	same
duration:	same
application:	spray rigs
dosage:	0.8 kg ha^{-1} a.i.
method:	same
soil:	same
water regime:	same
micro-climate:	same

volatilization:	$rate_{t=0}$ = unknown $rate_{t=2h}$ = 4.79 g h^{-1} ha^{-1} $rate_{t=1d}$ = 5.27 g h^{-1} ha^{-1} $rate_{t=3.15d}$ = 0.45 g h^{-1} ha^{-1} 0.9% of applied dosage after 2 hours (estimated) 2.0% of applied dosage after 1 day (estimated) 9.9% of applied dosage after 3.15 days (estimated)
compound:	**nitrapyrin** (bactericide, pyridines group, VP = 370 mPa (23 °C), S = 40 mg l^{-1} (22 °C), K_{ow} = 2112, K_{oc} = 250-9100 dm^3 kg^{-1}, $K_{oc,Hornsby,\ 1996}$ = 570 dm^3 kg^{-1}, $DT_{50,soil-aeroob,Tomlin}$ = 6.42 d, $DT_{50,soil-anaeroob,Tomlin}$ = 0.1 d, $DT_{50,water-photol.}$ = 0.5 d, $DT_{50,water-hydrolysis-pH7}$ = 2.0 d, $DT_{50,soil,Hornsby,\ 1996}$ = 10 d)
formulation:	EC (in mix with chlorpyrifos-ethyl, diazinon, and lindane)
date/place:	same
duration:	same
application:	spray rigs
dosage:	1.5 kg ha^{-1} a.i.
method:	same
soil:	same
water regime:	same
micro-climate:	same
volatilization:	$rate_{t=0}$ = unknown $rate_{t=2h}$ = 11.63 g h^{-1} ha^{-1} $rate_{t=1d}$ = 6.75 g h^{-1} ha^{-1} $rate_{t=3.15d}$ = 0.25 g h^{-1} ha^{-1} 2.1% of applied dosage after 2 hours (estimated) 4.0% of applied dosage after 1 day (estimated) 15% of applied dosage after 3.15 days (estimated)

Note: (1) - no significant difference between various methods at 95% confidence level; (2) - detailed application rates in Majewski et al., 1989; (3) - water solubility data in Majewski et al., 1989; (4) - moisture status of the upper soil layer is not correctly represented by the core samples of 70 mm depth; and (5) - initial fluxes missed due to installation procedures taking 2 hours

Majewski, 1991, cb74

compound:	**chlorthal-dimethyl (DCPA)** (herbicide, benzoic acids group, VP = 0.21 mPa (25 °C), $VP_{Hornsby,\ 1996}$ = 0.33 mPa (25 °C), S = 0.343 mg l^{-1} (pH5), S = 0.5 mg l^{-1} (25 °C), K_{ow} = 1.9 10^4, $K_{oc,Hornsby,\ 1996}$ = 5000 dm^3 kg^{-1}, $DT_{50,soil,Tomlin}$ = 100 d)
formulation:	WP
date/place:	April '87, Davis Campus, CA, USA
duration:	21 d
application:	not given
dosage:	5.9 kg ha^{-1} a.i. (= analysis soil residue; given rate appr. 7 kg ha^{-1} a.i.)
method:	field measurements at 0.2 m, 0.35 m, 0.55 m, 0.90 m, and 1.50 m height using Theoretical Profile Shape Method
soil:	unknown: C_{org} = 1.1%, $\theta_{sat,\ estimated}$≈40%, $\rho_{dry\ soil}$≈1550 kg m^{-3} (from Majewski, 1991, or use data Ross, 1990, cb9) area (L x W): 7900 m^2 (circle r = 50 m) depth: NA soil temperature: unknown
water regime:	total irrigation: 164mm, distributed over days 1 (17 mm), 3 (13 mm), 4 (8.5 mm), 5 (6 mm), 6 (16.5 mm), 7 (10 mm), 8 (7.5 mm), 9 (8 mm), 11 (4.5

	mm), 12 (7.5 mm), 13 (8.5 mm), 14 (6.5 mm), 15 (7.5 mm), 16 (12 mm), 18 (8 mm), 19 (11 mm), and 20 (12 mm) (supply rate at appr. 6.6 mm/h mostly in morning before flux measurements)
	$MC_{(0\text{-}0.076\ m)}$ = 15.7 ± 2.3 dry_mass% (volumetric or mass % could not be established, mass % assumed), $\theta_{(0\text{-}0.076\ m)}$ = 25 ± 3.7%
micro-climate:	air temperature (at 0.5 m): 14-22 ^oC (day 0), 10-27 ^oC (day 1), 11.5-22.5 ^oC (day 2), 11.5-26 ^oC (whole period), (all averages night-day); 10-29 ^oC (min. and max. whole period); wind speed (at 1.5 m): 0.7-1.1m s^{-1} (day 0), 0.9-5.6 m s^{-1} (day 1), 2.0-7.3 m s^{-1} (day 2), 0.7-8.8 m s^{-1} (whole period with average of 4.5 m s^{-1})
volatilization:	$rate_{t=0}$ = unknown
	$rate_{t=2h}$ = unknown
	$rate_{t=1d,\ estimated}$ = 5.4 g h^{-1} ha^{-1}
	$rate_{t=21d}$ = 1.6 g h^{-1} ha^{-1}
	unknown % of applied dosage after 2 hours
	1.9% of applied dosage after 1 day (estimated)
	3.0% of applied dosage after 4 days
	11.0% of applied dosage after 10 days
	14.5% of applied dosage after 15 days
	18% of applied dosage after 21 days

Note: (1) - dacthal applied to dry soil; (2) - no measurements of volatilization during first 9 hours available; (3) - volatilization fluxes with TP method about 20% higher than those with AD method; (4) - upwind fetch inadequate for AD method; (5) - as a result of points (3) and (4) TP method selected for presentation; (6) - volatilization during first day calculated from total loss during 21 days; (7) - white Lisbon onion planted

Majewski, 1993, cb17

compound:	**trifluralin**
	(herbicide, dinitroanalines group, VP = 9.5 mPa (25 ^oC), $VP_{Hornsby,\ 1996}$ = 14.7 mPa (25 ^oC), $VP_{Spencer\ and\ Cliath,\ 1973}$ = 32.2 mPa (30 ^oC), S = 0.343 mg l^{-1} (pH5), S = 0.395 mg l^{-1} (pH7), S = 0.383 mg l^{-1} (pH9), $S_{Hornsby,\ 1996}$ = 0.3 mg l^{-1} (25 ^oC), K_{om} = 3775 dm^3 kg^{-1}, $K_{oc,Hornsby,\ 1996}$ = 8000 dm^3 kg^{-1}, $DT_{50,soil}$ = 221 d, $DT_{50,soil,Hornsby,\ 1996}$ = 60 d)
formulation:	emulsified aqueous suspension
date/place:	September '89, Animal Research Centre, Ottawa, Canada
duration:	5 d
application:	not given
dosage:	2.1 kg ha^{-1} a.i. (= analysis soil residue; given rate appr. 2.5 kg ha^{-1} a.i.)
method:	duration experiment: 5 d
	field measurements at 0.25 m, 0.40 m, 0.70 m, 0.90 m, 1.10 m, 1.60 m, and 2.26 m height using Aerodynamic Method
soil:	clay (dalhousie): C_{org} = 1%, $\theta_{sat,\ estimated}$≈45%, $\rho_{dry\ soil}$≈1450 kg m^{-3} (all values estimated)
	area (L x W): 71 000 m^2 (circle with r = 150 m)
	depth: NA
	soil temperature: unknown
water regime:	field moist at time of application due to light rainfall night before; last 2 days soil permanently moist; rainfall: 50 mm (day 2)
	$\theta_{surface}$ = 15.7% (day 0), 13.1% (day 1), 18.3% (day 2), 30.3% (day 3), 24.5% (day 4)
	$\theta_{surface}$ = 20% (day-average period)
micro-climate:	air temperature (at 0.75 m): 14-26 ^oC (day 0), 13-28 ^oC (day 1), 13-24 ^oC (day 2), 6-24 ^oC (day 3), 4-12 ^oC (day 4), 18-23 ^oC (first 3 days), 6-10 ^oC

	(average night-day last 2 days), 13.2-17.8 ^{o}C (night-day whole period), (all averages night-day); 2-28 ^{o}C (min. and max. whole period); wind speed (at 1.75 m): 0.5-4 m s^{-1} (day 0), 0.5-4 m s^{-1} (day 1), 0.5-9.5 m s^{-1} (day 2), 7-10 m s^{-1} (day 3), 1-9 m s^{-1} (day 4), 0.5-10 m s^{-1} (whole period with average of 5 m s^{-1})
volatilization:	$rate_{t=0}$ = unknown $rate_{t=2h}$ = 14.4 g h^{-1} ha^{-1} $rate_{t=1d}$ = 5.4 g h^{-1} ha^{-1} $rate_{t=5d}$ = 2.3 g h^{-1} ha^{-1} 11 % of applied dosage after 2 hours 19% of applied dosage after 1 day 40% of applied dosage after 5 days

compound:	**tri-allate** (herbicide, thiocarbamates group, VP = 16 mPa (25 ^{o}C), S = 4 mg l^{-1} (25 ^{o}C), K_{om} = 1164 dm^3 kg^{-1}, $DT_{50,soil}$ = 103 d)
formulation:	same
date/place:	same
duration:	same
application:	not given
dosage:	3.0 kg ha^{-1} a.i. (= analysis soil residue; given rate appr. 2.5 kg ha^{-1} a.i.)
method:	same
soil:	same
water regime:	same
micro-climate:	same
volatilization:	$rate_{t=0}$ = unknown $rate_{t=2h}$ = 16.2 g h^{-1} ha^{-1} $rate_{t=1d}$ = 5.4 g h^{-1} ha^{-1} $rate_{t=21d}$ = 2.3 g h^{-1} ha^{-1} 8% of applied dosage after 2 hours 17% of applied dosage after 1 day 38% of applied dosage after 5 days

Note: mass balance indicates losses due to photolysis may have occurred for trifluralin

Bor, 1995, cb142

compound:	**tri-allate** (herbicide, thiocarbamates group, VP = 16 mPa (25 ^{o}C), S = 4 mg l^{-1} (25 ^{o}C), K_{om} = 1164 dm^3 kg^{-1}, $DT_{50,soil}$ = 103 d)
formulation:	EC
date/place:	April '93, Vredepeel, NL
duration:	14 d
application:	Douven spraying machine with Teejet spray nozzles
dosage:	1.48 kg ha^{-1} a.i.
method:	field measurements using: Aerodynamic Method (AD) with sampling heights at 0.3, 0.5, 0.8, and 1.5m Theoretical Profile Shape Method (TP) with sampling height at 1.3m Bowen-ratio (BR) Method (for sampling heights see AD Method)
soil:	sand: OM = 3.7%, $\theta_{sat, estimated} \approx 45\%$, $\rho_{dry\ soil} \approx 1400$ kg m^{-3} area (L x W): 1260 m^2 (circle with r = 20m for TP Method) area (L x W): 80 x 122 m (AD and BR Methods) depth: NA soil temperature: known but not reported

water regime:	total rainfall: 20 mm, distributed over days 0 (1.7 mm), 1 (4.5 mm), 5 (1.2 m), 6 (0.2 mm), 9 (0.8 mm), 11 (0.4 mm), 12 (6.4 mm), and 13 (5.2 mm) $MC_{(0-0.005\ m)}$ = 13.0 dry_mass% or $\theta_{(0-0.005\ m)}$ = 18.3% (day 2), 5.0 dry_mass% or 7.0 vol% (day 7), and 4.7 dry_mass% or 6.6 vol% (day 14); on average 7.6 dry_mass% or 10.7 vol% $MC_{(0-0.03\ m)}$ = 16 dry_mass% or $\theta_{(0-0.03\ m)}$ = 22.5% (day 0), 16 dry_mass% or 22.5 vol% (day 1), 8.5 dry_mass% or 12 vol% (day 7), and 11 dry_mass% or 15.5 vol% (day 14); $\theta_{surface}$ = 15.4% (average top layer and lower layer where data missing)
micro-climate:	air temperature (at 0.3 m): 8-10 ^{o}C (day 0), 7.5-8.5 ^{o}C (day 1), 5-8.5 ^{o}C (day 2), 5-11 ^{o}C (day 3), 9.5-12.5 ^{o}C (day 4), 7-11 ^{o}C (days 5-10), 10-12.5 ^{o}C (days 11-13), 10-18 ^{o}C (day 14), 8-11.5 ^{o}C (whole period), (all average night-day temperatures); 1.5-22.5 ^{o}C (range period) with average of 10 ^{o}C wind speed (at 0.3 m): 4.2 m s^{-1} (day 0), 2.5 m s^{-1} (day 1), 1.0 m s^{-1} (day 2), 3.0 m s^{-1} (day 3), 1.5 m s^{-1} (days 4-10), 3 m s^{-1} (days 11-14); 0.2-5 m s^{-1} (range) with average of 2.2 m s^{-1}
volatilization:	$rate_{t=0}$ = unknown $rate_{t=2h}$ = 35.5 g h^{-1} ha^{-1} $rate_{t=1d}$ = 4.8 g h^{-1} ha^{-1} $rate_{t=14d}$ = 0.34 g h^{-1} ha^{-1} 4.1% of applied dosage after 2 hours (calculated) 12.4% of applied dosage after 1 day (calculated) 24% of applied dosage after 7 days (calculated) 29% of applied dosage after 14 days (calculated)
compound:	**ethoprophos** (insecticide, organophosphorus group, VP = 46.5 mPa (26 ^{o}C), S = 700 mg l^{-1} (20 ^{o}C), K_{om} = 60 dm^3 kg^{-1}, $DT_{50,soil}$ = 32 d)
formulation:	EC
date/place:	same
duration:	same
application:	same
dosage:	1.66 kg ha^{-1} a.i.
method:	same
soil:	same
water regime:	same
micro-climate:	same
volatilization:	$rate_{t=0}$ = unknown $rate_{t=2h}$ = 41 g h^{-1} ha^{-1} $rate_{t=1d}$ = 2.1 g h^{-1} ha^{-1} $rate_{t=14d}$ = 0.13 g h^{-1} ha^{-1} 3.5% of applied dosage after 2 hours (calculated) 13.2% of applied dosage after 1 day (calculated) 21% of applied dosage after 7 days (calculated) 24% of applied dosage after 14 days (calculated)
compound:	**parathion-ethyl** (insecticide, organophosphorus group, VP = 0.89 mPa (20 ^{o}C), S = 11 mg l^{-1} (25 ^{o}C), K_{om} = 1746 dm^3 kg^{-1}, $DT_{50,soil}$ = 49 d)
formulation:	EC
date/place:	same
duration:	same
application:	same
dosage:	1.72 kg ha^{-1} a.i.

method:	same
soil:	same
water regime:	same
micro-climate:	same
volatilization:	$rate_{t=0}$ = unknown $rate_{t=2h}$ = 4.3 g h^{-1} ha^{-1} $rate_{t=1d}$ = 0.4 g h^{-1} ha^{-1} $rate_{t=14d}$ = 0.03 g h^{-1} ha^{-1} 0.4% of applied dosage after 2 hours (calculated) 1.7% of applied dosage after 1 day (calculated) 2.8% of applied dosage after 7 days (calculated) 4% of applied dosage after 14 days (calculated)

Note: all values presented determined as averages of the three agrometeorological methods

Bor, 1995, cb141

compound:	**EPTC** (herbicide, thiocarbamates group, VP = 2626 mPa (25 °C), S = 375 mg l^{-1} (25 °C), $S_{Freed, 1976}$ = 636 mg l^{-1} (3 °C), K_{om} = 61 dm^3 kg^{-1}, $DT_{50,soil}$ = 47 d)
formulation:	EC
date/place:	September '92, Randwijk, NL
duration:	14 d
application:	Douven spraying machine
dosage:	4.95 kg ha^{-1} a.i.
method:	field measurements using: Theoretical Profile Shape Method (TP) with sampling height at 1.3 m
soil:	clay: OM = 1.1%, $\theta_{sat, estimated}$≈56%, $\rho_{dry\ soil}$≈1160 kg m^{-3} area (L x W): 1260 m^2 (circle with r = 20 m) depth: NA soil temperature (at 0.025 m): 17-18.5 °C (day 0), 15-17 °C (day 1), 13.5-16 °C (day 2), 15-18.5 °C (day 3), 16-20 °C (day 4-6), 15.5-17 °C (day 7-9), 13-16 °C (day 10-12), 10.5-11.5 °C (day 13-14), 14.5-17 °C (whole period), (all average night-day temperatures); 10-22.5 °C (range) with average of 16 °C
water regime:	total rainfall: 8.6 mm, distributed over days 8 (0.3 mm) and 14 (8.3 mm) $MC_{(0-0.05\ m)}$ = 12.0 dry_mass% or $\theta_{(0-0.05\ m)}$ = 14% (day 1) $MC_{(0.05-0.10\ m)}$ = 18.0 dry_mass% or $\theta_{(0.05-0.10\ m)}$ = 21% (day 1) $MC_{(0.10-0.15\ m)}$ = 20.0 dry_mass% or $\theta_{(0.10-0.15\ m)}$ = 23% (day 1) $MC_{(0.15-0.20\ m)}$ = 20.0 dry_mass% or $\theta_{(0.15-0.20\ m)}$ = 23% (day 1) $\theta_{estimated\ average}$≈ 10% (dry conditions)
micro-climate:	air temperature (at 0.3 m): 19-21 °C (day 0), 14.5-17 °C (day 1), 12.5-16 °C (day 2), 16.5-20.5 °C (day 3), 15-22 °C (days 4-6), 14.5-18 °C (days 7-8), 11.5-15.5 °C (days 9-12), 8-10 °C (days 13-14), 13-17 °C (whole period), (all average night-day temperatures); 6.5-28 °C (range period) with average of 16.5 °C wind speed (at 0.3 m): 2 m s^{-1} (day 0), 3.5 m s^{-1} (days 1-2), 2.0 m s^{-1} (days 3-6), 1.4 m s^{-1} (days 7-10), 4.8 m s^{-1} (days 11-14); 0.4-7.7m s^{-1} (range) with average of 2.8 m s^{-1}
volatilization:	$rate_{t=0}$ = unknown $rate_{t=2h, estimated}$ = 111 g h^{-1} ha^{-1} $rate_{t=1d}$ = 1.5 g h^{-1} ha^{-1} $rate_{t=14d}$ = 0.03 g h^{-1} ha^{-1} 8% of applied dosage after 2 hours (calculated on basis of Box Method)

21% of applied dosage after 1 day (calculated on basis of Box Method)
23% of applied dosage after 7 days (calculated on basis of Box Method)
26% of applied dosage after 14 days (calculated on basis of Box Method)

compound: **tri-allate**
(herbicide, thiocarbamates group, VP = 16 mPa (25 ^oC), S = 4 mg l^{-1} (25 ^oC), K_{om} = 1164 dm^3 kg^{-1}, $DT_{50,soil}$ = 103 d)
formulation: EC
date/place: same
duration: same
application: same
dosage: 1.10 kg ha^{-1} a.i.
method: same
soil: same
water regime: same
micro-climate: same
volatilization: $rate_{t = 0}$ = unknown
$rate_{t = 2h, estimated}$ = 12.4 g h^{-1} ha^{-1}
$rate_{t = 1d}$ = 1.3 g h^{-1} ha^{-1}
$rate_{t = 14d}$ = 1.2 g h^{-1} ha^{-1}
3.4% of applied dosage after 2 hours (calculated on basis of Box Method)
12% of applied dosage after 1 day (calculated on basis of Box Method)
15% of applied dosage after 7 days (calculated on basis of Box Method)
19% of applied dosage after 14 days (calculated on basis of Box Method)
compound: **parathion-ethyl**
(insecticide, organophosphorus group, VP = 0.89 mPa (20 ^oC), S = 11 mg l^{-1} (25 ^oC), K_{om} = 1746 dm^3 kg^{-1}, $DT_{50,soil}$ = 49 d)
formulation: EC
date/place: same
duration: same
application: same
dosage: 1.27 kg ha^{-1} a.i.
method: same
soil: same
water regime: same
micro-climate: same
volatilization: $rate_{t = 0}$ = unknown
$rate_{t = 2h, estimated}$ = 1.3 g h^{-1} ha^{-1}
$rate_{t = 1d}$ = 0.2 g h^{-1} ha^{-1}
$rate_{t = 14d}$ = 0.4 g h^{-1} ha^{-1}
0.24% of applied dosage after 2 hours (calculated on basis of Box Method)
0.9% of applied dosage after 1 day (calculated of basis of Box Method)
1.5% of applied dosage after 7 days (calculated on basis of Box Method)
2.4% of applied dosage after 14 days (calculated on basis of Box Method)

Note: rainfall data and soil moisture status indicate very dry conditions

Siebers, 1993, cb104
compound: **lindane**
(insecticide, organochlorines group, γ-isomer, VP = 5.6 mPa (20 ^oC), $VP_{Hornsby, 1996}$ = 17.3 mPa (30 ^oC), $VP_{Spencer\ and\ Cliath,\ 1974}$ = 17.04 mPa (30 ^oC), S = 7.3 mg l^{-1} (25 ^oC), $S_{author?}$ = 12 mg l^{-1} (35 ^oC), K_{om} = 633 dm^3 kg^{-1}, $K_{oc,Hornsby, 1996}$ = 1100 dm^3 kg^{-1}, $DT_{50,soil}$ = 1406 d, $DT_{50,soil,Hornsby, 1996}$ = 400 d,

	$DT_{50,solution,pH9}$ = 0.5 d, $DT_{50,solution,pH7}$ = 191 d)
formulation:	NEXIT STARK (80% lindane, no GIFAP formulation code given)
date/place:	May '91, Braunschweig, FRG
duration:	2 d
application:	spraying machine with Teejet nozzles
dosage:	0.76 kg ha^{-1} a.i.
method:	field measurements using: Aerodynamic Method (AD) with measuring heights: 0.60 m and 1.50 m; correction factor for small surface areas included
soil:	sandy clay loam: C_{org} = 1.3%, $MC_{sat, estimated} \approx 27.7$ dry_mass% or $\theta_{sat, estimated}$ = 42%, $\rho_{dry soil} \approx 1500$ kg m^{-3} area (L x W): 20.5 x 31.4 m depth: NA soil temperature: unknown
water regime:	total rainfall: not given MC = 9.3-10 dry_mass% (9.7) or θ = 14.1-15.2% (14.7)
micro-climate:	air temperature (at 0.6m(?)): NA-15 ^oC (day 0), 8-17.5 ^oC (day 1), 9-15 ^oC (day 2), 8.5-15.8 ^oC (whole period), (all average night-day temperatures); 6-20 ^oC (range period) relative humidity (RH): 81% with range 54-99% (days 0-1) wind speed (at 1.5 m): 1.2 m s^{-1} with range <0.5-1.8 m s^{-1} (day 0), 0.8 m s^{-1} with range <0.5-2.7 m s^{-1} (day 1), 0.2 m s^{-1} with range <0.5-1.6 m s^{-1}
volatilization:	$rate_{t = 0}$ = unknown $rate_{t = 2h, estimated}$ = 15.5 g h^{-1} ha^{-1} $rate_{t = 1d}$ = 0.43 g h^{-1} ha^{-1} $rate_{t = 2d}$ = 0.05 g h^{-1} ha^{-1} 5% of applied dosage after 2 hours 16% of applied dosage after 1 day 17.5% of applied dosage after 2 days

compound:	**lindane**
formulation:	same
date/place:	September '91, Braunschweig, FRG
duration:	2 d
application:	same
dosage:	1.07 kg ha^{-1} a.i.
method:	same
soil:	same
water regime:	same MC = 3.0-4.2 dry_mass% (3.6) or θ = 4.5-6.4% (5.5)
micro-climate:	air temperature (at 0.5m(?)): NA-25 ^oC (day 0), 18-25 ^oC (day 1), 14-17.5 ^oC (day 2), 16-22.5 ^oC (all average night-day temperatures); 10.6-27.4 ^oC (range period) relative humidity (RH): 61% with range 30-94% (days 0-1) wind speed (at 1.4 m): 2 m s^{-1} with range 1.2-2.8 m s^{-1} (day 0), 1.2 m s^{-1} with range <0.5-2.6 m s^{-1} (day 1), 2.4 m s^{-1} with range 1.8-3.2 m s^{-1}
volatilization:	$rate_{t = 0}$ = unknown $rate_{t = 2h, estimated}$ = 29 g h^{-1} ha^{-1} $rate_{t = 1d}$ = 0.25 g h^{-1} ha^{-1} $rate_{t = 2d}$ = 0.29 g h^{-1} ha^{-1} 6.5% of applied dosage after 2 hours 20% of applied dosage after 1 day

28% of applied dosage after 2 days

Turner, 1978, cb138

compound: **chlorpropham**
(herbicide, carbamates group, VP = 1.07 mPa (20 ^oC), S = 89 mg l^{-1} (25 ^oC), K_{om} = 251 dm^3 kg^{-1}, $K_{oc,Hornsby,\ 1996}$ = 400 dm^3 kg^{-1}, $DT_{50,soil}$ = 40 d, $DT_{50,soil,Hornsby,\ 1996}$ = 30 d)

formulation: EC

date/place: May '76, Frederick, Maryland, USA

duration: 50 d (see note)

application: sprayed

dosage: 2.61 kg ha^{-1} a.i. (from residue analysis; given application dosage 3.0 kg ha^{-1} a.i.)

method: field measurements using: Aerodynamic Method (AD) with measuring heights: 0.15 m, 0.30 m, 0.50 m, 0.75 m, and 1.0 m

soil: silt loam: OM = 2%, $\theta_{sat,\ estimated}$≈51%, $\rho_{dry\ soil}$≈1250 kg m^{-3}
area (L x W): 77.46 x 77.46 m
depth: NA
soil temperature: unknown

water regime: rainfall: light rainfall (day 0), thunder (day 7)
$MC_{0\text{-}0.05m}$ = 10.3 dry_mass% or $\theta_{0\text{-}0.05m}$ = 11.5% (day 0, soil dry and powdery)
$MC_{0\text{-}0.05m}$ = 18.3 dry_mass% or $\theta_{0\text{-}0.05m}$ = 20.4% (day 2)
$MC_{0\text{-}0.05m}$ = 20.3 dry_mass% or $\theta_{0\text{-}0.05m}$ = 22.7% (day 7)
$MC_{0\text{-}0.05m}$ = 13.3 dry_mass% or $\theta_{0\text{-}0.05m}$ = 14.8% (day 14)
$MC_{0\text{-}0.05m}$ = 15.9 dry_mass% or $\theta_{0\text{-}0.05m}$ = 17.7% (day 24)
$MC_{0\text{-}0.05m}$ = 15.6 dry_mass% or $\theta_{0\text{-}0.05m}$ = 17.4% (average period)

micro-climate: air temperature (at 0.46 m): 18.7 ^oC (day 0, fair, light rain), 21.3 ^oC (day 2, fair), 26.8 ^oC (day 7, fair, thunder), 26.7 ^oC (day 14, fair, light wind), 28.9 ^oC (day 24, fair, steady wind), 24.5 ^oC (whole period), (all average day temperatures);
wind speed: 0.1 m s^{-1} (day 0)

volatilization: $rate_{t\,=\,0}$ = unknown
$rate_{t\,=\,2h}$ = 29.4 g h^{-1} ha^{-1}
$rate_{t\,=\,1d}$ = unknown
$rate_{t\,=\,7d}$ = 3.0 g h^{-1} ha^{-1}
$rate_{t\,=\,24d}$ = 0.71 g h^{-1} ha^{-1}
1.5% of applied dosage after 2 hours (estimated)
5.7% of applied dosage after 1 day (estimated)
37% of applied dosage after 7 days (estimated)
unknown % of applied dosage after 24 days

Note: soy-beans were sowed and crop height must have influenced volatilization after day 24, therefore no values given

Pattey, 1995, cb38

compound: **tri-allate**
(herbicide, thiocarbamates group, VP = 16 mPa (25 ^oC), S = 4 mg l^{-1} (25 ^oC), K_{om} = 1164 dm^3 kg^{-1}

formulation: aqueous emulsion mix

date/place: September '92, Greenbelt Farm, Ottawa, Canada

duration: 4.2 d

application: unknown

dosage:	1.7 kg ha^{-1} a.i.
method:	field measurements using Relaxed Eddy Accumulation System
soil:	fine sandy loam: OM = 2.36%, $\theta_{sat, estimated} \approx 50\%$, $\rho_{dry\ soil} \approx 1300$ kg m^{-3} area (L x W): 70 686 m^2 (circle with r = 150 m) depth: NA soil temperature: not given
water regime:	total rainfall: 5.7 mm, distributed over days 2 (1.0 mm) and 3 (4.7 mm) $\theta_{(0\text{-}0.05\ m)}$ = 27.8-33.3% (30.6)
micro-climate:	air temperature (at 7.0 m): 5-15 ^oC (days 0-1), 8.5-12 ^oC (day 2), 15-18 ^oC (day 3), 11.5-16.5 ^oC (day 4), 9-15.5 ^oC (whole period), (all average night-day temperatures); 0-21.5 ^oC (range period); relative humidity (RH) (at 7.0 m): 25-100% (80) wind speed (at 1.5 m): 2 m s^{-1} (days 0-2 and 4), 6 m s^{-1} (day 3), (during day time, during night time nil)
volatilization:	$rate_{t=0}$ = unknown $rate_{t=2h}$ = 30.3 g h^{-1} ha^{-1} $rate_{t=1d}$ = 8.3 g h^{-1} ha^{-1} $rate_{t=5d}$ = 1.4 g h^{-1} ha^{-1} 2.8% of applied dosage after 2 hours 10.2% of applied dosage after 1 day 21% of applied dosage after 4.2 days
compound:	**trifluralin** (herbicide, dinitroanalines group, VP = 9.5 mPa (25 ^oC), $VP_{Hornsby,\ 1996}$ = 14.7 mPa (25 ^oC), $VP_{Spencer\ and\ Cliath,\ 1973}$ = 32.2 mPa (30 ^oC), S = 0.343 mg l^{-1} (pH5), S = 0.395 mg l^{-1} (pH7), S = 0.383 mg l^{-1} (pH9), $S_{Hornsby,\ 1996}$ = 0.3 mg l^{-1} (25 ^oC), K_{om} = 3775 dm^3 kg^{-1}, $K_{oc,Hornsby,\ 1996}$ = 8000 dm^3 kg^{-1}, $DT_{50,soil}$ = 221 d, $DT_{50,soil,Hornsby,\ 1996}$ = 60 d)
formulation:	same
date/place:	same
duration:	same
application:	same
dosage:	1.15 kg ha^{-1} a.i.
method:	same
soil:	same
water regime:	same
micro-climate:	same
volatilization:	$rate_{t=0}$ = unknown $rate_{t=2h}$ = 15.8 g h^{-1} ha^{-1} $rate_{t=1d}$ = 2.3 g h^{-1} ha^{-1} $rate_{t=5d}$ = 0.5 g h^{-1} ha^{-1} 2.8% of applied dosage after 2 hours 9.0% of applied dosage after 1 day 13% of applied dosage after 4.2 days

Note: (1) - mass balance indicates losses due to photolysis may have occurred for trifluralin; (2) - presence of straw during pesticide application may have affected results due to interception; (3) - author claims agreement with results of Majewski (1993, cb17), which cannot be confirmed here

Ross, 1990, cb9

compound:	**chlorthal-dimethyl (DCPA)** (herbicide, benzoic acids group, VP = 0.21 mPa (25 ^oC), $VP_{Hornsby,\ 1996}$ = 0.33 mPa (25 ^oC), S = 0.343 mg l^{-1} (pH5), S = 0.5 mg l^{-1} (25 ^oC), K_{ow} = 1.9 10^4, $K_{oc,Hornsby,\ 1996}$ = 5000 dm^3 kg^{-1}, $DT_{50,soil,Tomlin}$ = 100 d)

formulation:	WP
date/place:	April '87, Davis Campus, CA, USA
duration:	21 d
application:	tractor mounted boom sprayer
dosage:	7.08 kg ha^{-1} a.i. (= given rate; analysis soil residue: 4.4 kg ha^{-1} a.i.)
method:	field measurements with Aerodynamic Method at 0.2 m, 0.35 m, 0.55 m, 0.90 m, and 1.50 m height
soil:	silty loam: C_{org} = 0.75%, $\theta_{sat, estimated} \approx 51\%$, $\rho_{dry\ soil} \approx 1300$ kg m^{-3} area (L x W): 7900 m^2 (circle r = 50 m) depth: NA soil temperature: unknown
water regime:	total irrigation: 44.7mm, distributed over days 1 (11.4 mm), 3 (8.9 mm), 4 (5.6 mm), 5 (4.1 mm), 8 (4.8 mm), 11 (5.6 mm), 14 (4.3 mm) (supply rate at appr. 4.3 mm/h mostly in morning before flux measurements) total rainfall: 0.4mm, distributed over days 1 (0.2 mm) and 21 (0.2 mm) $\theta_{estimated}$ = 28% (average field capacity and wilting point)
micro-climate:	air temperature (at 0.5 m): 18-25.5 ^oC (day 0), 12-24 ^oC (day 1), 11-17.7 ^oC (day 2), na-24 ^oC (day 5), na-24 ^oC (day 8), na-26.5 ^oC (day 11), na-25 ^oC (day 14), na-20 ^oC (day 21), 14-23 ^oC (whole period), (all averages night-day); 9-29 ^oC (min. and max. whole period); relative humidity (RH): 19-91% (day 0), 21-85% (remaining period) wind speed (at 0.8 m): 0.75-3.65 m s^{-1} (day 0), 1.27-4.74 m s^{-1} (day 1), 1.71-5.56 m s^{-1} (day 2), na-1.64 m s^{-1} (day 5), na-5.85 m s^{-1} (day 8), na-1.58 m s^{-1} (day 11), na-3.96 m s^{-1} (day 14), na-6.03 m s^{-1} (day 21), 1.39-4.13 m s^{-1} (whole period), (all averages night-day); <1-8 m s^{-1} (min. and max. whole period)
volatilization:	$rate_{t=0}$ = unknown $rate_{t=2h, estimated}$ = 5.5 g h^{-1} ha^{-1} $rate_{t=1d, estimated}$ = 0.03 g h^{-1} ha^{-1} $rate_{t=21d}$ = 1.3 g h^{-1} ha^{-1} 0.15% of applied dosage after 2 hours (estimated) 0.45% of applied dosage after 1 day (estimated) 1.4% of applied dosage after 4 days (estimated) 10% of applied dosage after 21 days (estimated)

Note: (1) - planted with onions during 2 days before application day; (2) - off-target deposition measured of 0.2% of application within 23 m wide ring around treated circle

Annex 2 Physico-chemical properties of pesticides used for regression analysis

Chemical group and compound name	Molecular mass $(g\ mole^{-1})$	Vapour pressure at room temp. (mPa)	Water solubility at room temp. $(mg\ l^{-1})$	Sorption coeff. K_{om} $(dm^3\ kg^{-1})$	DT_{50} soil (days)
aryloxyalkanoic acids					
2,4-D acid (H)	221.04[3] (4)	1 (4)	890 (4)	26[2] (3)	8 (3)
2,4-D propylene glycolbutyl ether ester of acid (H)	277.1 (1)	1 (4)	100 (4)	32[1] (6)	60 (4)
2,4,5-T propylene glycolbutyl ether ester of acid (H)	367.7 (4)	0.00086[4] (7)	50 (4)	80[1] (8)	30 (4)
fenoprop butoxypropyl ester (H) (silvex or 2,4,5-TP)	269.5 (4)	0.01 (4)	140 (4)	300[1] (4)	21 (4)
benzoic acids					
dicamba (H)	221.0 (1)	4.5 (1)	6500 (1)	2[1] (1)	48 (3)
dicamba dimethylammonium salt (H)	266.1 (1)	0.0046 (5)	850 000 (4)	2[1] (4)	14 (4)
chlorthal-dimethyl/DCPA (H)	332.0 (1)	0.21 (1)	0.5 (4)	5000[1] (4)	100 (1)
carbamates					
chlorpropham (H)	213.67 (4)	1 (4)	89 (4)	251 (3)	40 (3)
chloroacetanilides					
alachlor (H)	269.77 (4)	1.9 (4)	240 (4)	117 (3)	22 (3)
dinitroanilines					
trifluralin (H)	335.28 (4)	15 (4)	0.3 (4)	3775 (3)	221 (3)
organochlorines					
lindane/HCH (I)	290.85 (4)	5.6 (1)	7 (1)	633 (3)	1406 (3)
pp-DDT (I)	354.5 (4)	0.025 (4)	0.0055 (4)	2 000 000[1] (4)	2000 (4)
camphechlor/toxapheen (I)	413.8 (4)	0.5 (4)	3 (4)	100 000[1] (4)	9 (4)
organophosphorus					
parathion-ethyl (I)	291.27 (4)	0.89 (1)	11 (1)	1746 (3)	49 (3)
parath.-methyl (I)	263.21 (4)	2 (4)	60 (4)	141 (3)	19 (3)
diazinon (I)	304.3 (4)	8 (4)	60 (4)	1000[1] (4)	21 (3)
ethoprophos (I)	242.3 (4)	51 (4)	750 (4)	60 (3)	32 (3)
chlorpyrifos-ethyl (I)	350.62 (4)	2.7 (1)	1.4 (1)	6070[1] (4)	94 (3)
chlorpyrifos-methyl (I)	322.5 (1)	5.6 (1)	4 (1)	3000[1] (4)	17 (1)
fonofos (I)	246.32 (4)	28 (1)	16.9 (4)	870[1] (4)	99 (3)
pyridinecarboxylic acids					
picloram-potassium salt (H)	279.6 (1)	0.000045[4] (5)	400 000 (1)	75[1] (8)	90 (4)
thiocarbamates					
EPTC (H)	189.3 (4)	2626 (4)	344 (4)	61 (3)	47 (3)
tri-allate (H)	304.66 (4)	15 (4)	4 (4)	1164 (3)	103 (3)
triazines					
atrazine (H)	215.69 (4)	0.0385 (4)	33 (4)	70 (3)	50 (3)
simazine (H)	201.66 (4)	0.00295 (4)	6.2 (4)	59 (3)	58 (3)
prometon (H)	225.3 (1)	0.306 (1)	750 (1)	150[1] (4)	500 (4)
uracils					
bromacil (H)	261.1 (1)	0.041 (1)	700 (1)	32[1] (4)	60 (4)
nitrapyrin (B)	230.9 (4)	370 (4)	40 (4)	570[1] (4)	10 (4)

References:
(1) - Tomlin, 1994
(2) - Worthing, 1987
(3) - Linders et al., 1994
(4) - Hornsby et al., 1996
(5) - Beste, 1983
(6) - Hamaker, 1975
(7) - Nash, 1989b
(8) - Kenaga, 1980

Abbreviations:
H – herbi cide
I - insecticide
B - bactericide
[3]value of parent acid
[4]estimation Nash, 1989b

Remarks:
[1]value for K_{oc}
[2]pH>5

Annex 3 Physico-chemical properties of pesticides approved in The Netherlands

Active ingredient names from Pandoras' box (Linders et al.,1994)	Molecular Mass		Vapour Pressure			Solubility in water			Kom		DT50-soil	
				at temp			at temp				mean/med	
	(g/mole)	Reference	(mPa)	(degC)	Reference	(mg/l)	(degC)	Reference	(dm3/kg)	Reference	(days)	Reference
1-naphtylacetamide	185.2	Tomlin'94	0.01	25	Tomlin'94	39	40	Tomlin'94	-	-	-	-
1-naphtylacetic acid	186.2	Tomlin'94	0.01	25	Tomlin'94	420	20	Tomlin'94	-	-	-	-
abamectine 1a	873.1	Hornsby'96	2E-04	22.5	Hornsby'96	5	20	Hornsby'96	2857	Hornsby'96	28	Hornsby'96
acephate	183.16	Hornsby'96	0.23	22.5	Hornsby'96	818000	20	Hornsby'96	33	Linders'94	8	Linders'94
aclonifen	264.7	Tomlin'94	0.016	20	Tomlin'94	1.4	20	Tomlin'94	3484	Linders'94	71	Linders'94
acrinathrin (acrinate)	541.4	Tomlin'94	3.9E-04	25	Tomlin'94	0.02	25	Tomlin'94	43000	Linders'94	23	Linders'94
alachlor	269.77	Hornsby'96	1.9	25	Hornsby'96	240	22.5	Hornsby'96	117	Linders'94	22	Linders'94
aldicarb	190.3	Tomlin'94	13	20	Tomlin'94	4930	20	Tomlin'94	4.7	Linders'94	2.4	Linders'94
alloxydim-sodium	345.4	Tomlin'94	0.133	25	Tomlin'94	2E+06	30	Tomlin'94	4	Linders'94	20	Linders'94
Al-fosfide	-	-	-	-	-	-	-	-	-	-	-	-
amitraz	293.4	Hornsby'96	0.35	25	Hornsby'96	1	22.5	Hornsby'96	571.4	Hornsby'96	2	Hornsby'96
amitrol	84.08	Hornsby'96	0.059	22.5	Hornsby'96	360000	22.5	Hornsby'96	75	Linders'94	0.7	Linders'94
(NH4)2SO4	-	-	-	-	-	-	-	-	-	-	-	-
amm-thiocyanaat	-	-	-	-	-	-	-	-	-	-	-	-
ancymidol	256.31	Hornsby'96	0.03	25	Hornsby'96	650	22.5	Hornsby'96	68.6	Hornsby'96	120	Hornsby'96
anilazine	275.54	Hornsby'96	8.3E-04	20	Hornsby'96	8	22.5	Hornsby'96	95	Linders'94	1	Linders'94
antrachinon	-	-	-	-	-	-	-	-	-	-	-	-
asulam	230.2	Tomlin'94	1	20	Tomlin'94	5000	22.5	Tomlin'94	64	Linders'94	24	Linders'94
atrazine	215.69	Hornsby'96	0.0385	25	Hornsby'96	33	22.5	Hornsby'96	70	Linders'94	50	Linders'94
azaconazole	300.1	Tomlin'94	0.0086	20	Tomlin'94	300	20	Tomlin'94	64.6	Tomlin'94	-	-
azamethifos	324.7	Tomlin'94	0.0049	20	Tomlin'94	1100	20	Tomlin'94	-	-	-	-
azinphos-methyl	317.3	Hornsby'96	0.03	20	Hornsby'96	29	25	Hornsby'96	862	Linders'94	52	Linders'94
azocyclotin	436.2	Tomlin'94	6.00E-08	25	Tomlin'94	0.12	20	Tomlin'94	0	Linders'94	200	Linders'94
Bacillus thuringiensis	-	-	-	-	-	-	-	-	-	-	-	-
Bacillus thuringiensis (combi)	-	-	-	-	-	-	-	-	-	-	-	-
benazolin	243.7	Tomlin'94	1E-04	20	Tomlin'94	500	20	Tomlin'94	13	Linders'94	80	Linders'94
benazolin-ethyl	271.7	Tomlin'94	0.37	25	Tomlin'94	47	20	Tomlin'94	13	Linders'94	80	Linders'94
bendiocarb	223.23	Hornsby'96	4.7	25	Hornsby'96	40	25	Hornsby'96	28	Linders'94	28	Linders'94
benfuracarb	410.5	Tomlin'94	0.0266	20	Tomlin'94	8	20	Tomlin'94	10063	Tomlin'94	1	Tomlin'94
benodanil	323.1	Hornsby'96	1.0E-05	20	Hornsby'96	20	20	Hornsby'96	400	Hornsby'96	25	Hornsby'96
benomyl	290.3	Hornsby'96	1E-05	25	Hornsby'96	2	25	Hornsby'96	1000	Linders'94	14	Linders'94
bensultap	431.6	Tomlin'94	0.21	22	Tomlin'94	0.75	30	Tomlin'94	650	Linders'94	7	Linders'94
bentazone	240.3	Tomlin'94	0.46	20	Tomlin'94	570	20	Tomlin'94	0.4	Linders'94	48	Linders'94
benzalkoniumchloride	-	-	-	-	-	-	-	-	-	-	-	-
benzoylprop	-	-	-	-	-	-	-	-	-	-	-	-
benzyladenine	-	-	-	-	-	-	-	-	-	-	-	-
bifenox	342.14	Hornsby'96	0.32	30	Hornsby'96	0.398	25	Hornsby'96	1420	Linders'94	5	Linders'94
bifenthrin	422.88	Hornsby'96	0.024	22.5	Hornsby'96	0.1	22.5	Hornsby'96	111000	Linders'94	219	Linders'94
bitertanol-A	337.4	Tomlin'94	2.20E-07	20	Tomlin'94	2.9	20	Tomlin'94	6459.7	Tomlin'94		
boraten	-	-	-	-	-	-	-	-	-	-	-	-
borax	-	-	-	-	-	-	-	-	-	-	-	-
brodifacoum	523.4	Tomlin'94	0.04	25	Tomlin'94	10	20	Tomlin'94	2.1E+08	Tomlin'94	-	-
bromacil	261.1	Tomlin'94	0.041	25	Tomlin'94	700	25	Tomlin'94	18	Hornsby'96	60	Hornsby'96
bromadiolone	-	-	-	-	-	-	-	-	-	-	-	-
bromofenoxim	461	Tomlin'94	1E-03	22.5	Linders'94	0.6	20	Tomlin'94	565	Linders'94	73	Linders'94
bromophos-ethyl	394	Worthing'87	6.1	30	Worthing'87	0.14	20	Worthing'87	10	Linders'94	8	Linders'94
bromopropylate	428.1	Tomlin'94	0.011	20	Tomlin'94	0.5	20	Tomlin'94	95	Linders'94	59	Linders'94
bromoxynil	276.9	Tomlin'94	1	20	Tomlin'94	130	25	Tomlin'94	109	Hornsby'96	10	Tomlin'94
buminaphos	347	Tomlin'94	100	22.5	Linders'94	170	22.5	Linders'94	85	Linders'94	9	Linders'94
bupirimate	316.4	Tomlin'94	0.1	25	Tomlin'94	22	25	Tomlin'94	300	Linders'94	79	Linders'94
buprofezin	305.4	Tomlin'94	1.25	25	Tomlin'94	0.9	20	Tomlin'94	10063	Tomlin'94	-	-
butocarboxim	190.3	Tomlin'94	10.6	20	Tomlin'94	35000	20	Tomlin'94	5.25	Tomlin'94	4.5	Tomlin'94
butoxycarboxim	222.3	Tomlin'94	0.266	20	Tomlin'94	209000	20	Tomlin'94	5.25	Tomlin'94	43	Tomlin'94
calciumcyanide	-	-	-	-	-	-	-	-	-	-	-	-
Ca(NO3)2	-	-	-	-	-	-	-	-	-	-	-	-
captafol	349.1	Hornsby'96	0.001	22.5	Hornsby'96	1.4	22.5	Hornsby'96	1714	Hornsby'96	7	Hornsby'96
captan	300.61	Hornsby'96	0.011	25	Hornsby'96	5.1	22.5	Hornsby'96	75	Linders'94	1	Linders'94
carbaryl	201.23	Hornsby'96	0.16	24	Hornsby'96	120	30	Hornsby'96	34	Linders'94	14	Linders'94
carbendazim	191.19	Hornsby'96	6.5E-05	20	Hornsby'96	8	20	Hornsby'96	76	Linders'94	52	Linders'94
carbetamide	236.3	Hornsby'96	0	25	estimated	3500	20	Hornsby'96	52	Linders'94	10	Linders'94
carbophenothion	342.9	Hornsby'96	1.1	25	Hornsby'96	0.34	20	Hornsby'96	28571	Hornsby'96	30	Hornsby'96
carbofuran	221.25	Hornsby'96	0.08	22.5	Hornsby'96	351	25	Hornsby'96	13	Hornsby'96	50	Hornsby'96
carboxin	235.31	Hornsby'96	0.024	25	Hornsby'96	195	20	Hornsby'96	12.7	Linders'94	7	Linders'94
chlorbromuron	293.5	Hornsby'96	0.053	22.5	Hornsby'96	35	20	Hornsby'96	440	Linders'94	39	Linders'94
chlorbufam	-	-	-	-	-	-	-	-	-	-	-	-
chlorfacinon	-	-	-	-	-	-	-	-	-	-	-	-
chlorfenvinphos	359.6	Tomlin'94	1	25	Tomlin'94	145	23	Tomlin'94	539	Linders'94	36	Linders'94
chloralhydrate	-	-	-	-	-	-	-	-	-	-	-	-
chloridazon	221.6	Tomlin'94	0.01	20	Tomlin'94	340	20	Tomlin'94	64	Linders'94	31	Linders'94
chlormequat	158.1	Tomlin'94	0.01	20	Tomlin'94	1E+06	20	Tomlin'94	48	Linders'94	1.3	Linders'94
chloroflurenol	-	-	-	-	-	-	-	-	-	-	-	-
chlorothalonil	265.9	Tomlin'94	0.076	25	Tomlin'94	0.9	25	Tomlin'94	5031	Linders'94	10	Linders'94
chlorotoluron	212.7	Tomlin'94	0.017	25	Tomlin'94	74	25	Tomlin'94	133	Linders'94	63	Linders'94
chloroxuron	290.75	Hornsby'96	5.2E-04	25	Hornsby'96	2.5	22	Hornsby'96	1048	Linders'94	36	Linders'94
chlorpropham	213.67	Hornsby'96	1	20	Hornsby'96	89	25	Hornsby'96	251	Linders'94	40	Linders'94
chlorpyriphos-ethyl	350.62	Hornsby'96	2.7	25	Tomlin'94	1.4	25	Tomlin'94	3469	Hornsby'96	94	Linders'94
chlorthal-dimethyl (DCPA)	331.99	Hornsby'96	0.21	25	Tomlin'94	0.5	25	Hornsby'96	2857	Hornsby'96	100	Tomlin'94
chlorthiamid	-	-	-	-	-	-	-	-	- will degrade very fast to dichlobenil			
clodinafop-propargyl	349.8	Tomlin'94	0.00319	25	Tomlin'94	4	25	Tomlin'94	816	Linders'94	0.6	Linders'94
clofentezine	303.1	Tomlin'94	1.3E-04	25	Tomlin'94	0.0025	25	Tomlin'94	139	Linders'94	39	Linders'94
cloquintoceet-mexyl (CGA 185072)	335.8	Tomlin'94	0.00531	25	Tomlin'94	0.59	25	Tomlin'94	56519.4	Tomlin'94	1.5	Tomlin'94
copper oxychloride	-	-	-	-	-	-	-	-	-	-	-	-
creosote	-	-	-	-	-	-	-	-	-	-	-	-
cresol	-	-	-	-	-	-	-	-	-	-	-	-
chlorcresol	-	-	-	-	-	-	-	-	-	-	-	-
coumatetralyl	292.3	Tomlin'94	8.5E-06	20	Tomlin'94	425	20	Tomlin'94	1370	Tomlin'94	90	Tomlin'94
cyanamide	42	Tomlin'94	500	20	Tomlin'94	4.59E+06	20	Tomlin'94	0	Linders'94	3.5	Linders'94
cyanazine	240.7	Hornsby'96	2.1E-04	20	Hornsby'96	170	25	Hornsby'96	55	Linders'94	16	Linders'94
cycloate	215.37	Hornsby'96	213	25	Hornsby'96	95	25	Hornsby'96	23	Linders'94	61	Linders'94
cycloxydim	325.5	Tomlin'94	0.01	20	Tomlin'94	40	20	Tomlin'94	61	Linders'94	1	Linders'94
cyfluthrin	434.3	Hornsby'96	0.0021	22.5	Hornsby'96	0.002	20	Hornsby'96	33750	Linders'94	116	Linders'94
cyhexatin	385.2	Hornsby'96	0	25	estimated	1	25	Hornsby'96	200	Linders'94	100	Linders'94
cymiazole	-	-	-	-	-	-	-	-	-	-	-	-
cymoxanil	198.2	Tomlin'94	0.08	25	Tomlin'94	890	20	Tomlin'94	10	Linders'94	0.7	Linders'94
cypermethrin (cis)	416.3	Hornsby'96	1.9E-04	20	Hornsby'96	0.004	20	Hornsby'96	2137	Linders'94	90	Linders'94
cypermethrin (trans)	416.3	Hornsby'96	1.9E-04	20	Hornsby'96	0.004	20	Hornsby'96	2137	Linders'94	32	Linders'94
alpha-cypermethrin	416.3	Tomlin'94	2.3E-02	20	Tomlin'94	0.01	25	Tomlin'94	2137	Linders'94	91	Tomlin'94
cyproconazole	291.8	Tomlin'94	0.0346	20	Tomlin'94	140	25	Tomlin'94	219	Linders'94	110	Linders'94
cyprofuram	279.7	Worthing'87	0.0066	25	Worthing'87	574	22.5	Worthing'87	186	Linders'94	43	Linders'94
cyromazine	166.19	Hornsby'96	4.48E-04	25	Hornsby'96	13600	22	Hornsby'96	58	Linders'94	93	Linders'94
dalapon	143	Tomlin'94	0.01	20	Tomlin'94	900000	25	Tomlin'94	0.5	Linders'94	3.6	Linders'94
daminozide	160.2	Hornsby'96	0.001	22.5	Hornsby'96	100000	25	Hornsby'96	1.8	Linders'94	4.5	Linders'94
dazomet	162.3	Hornsby'96	0.4	20	Hornsby'96	3000	20	Hornsby'96	5.7	Hornsby'96	0.01	Linders'94
deltamethrin	505.2	Tomlin'94	0.0133	25	Tomlin'94	2E-04	25	Tomlin'94	600000	Tomlin'94	25	Linders'94
demeton-S-methylsulfon	262.3	Worthing'87	0.005	22.5	Linders'94	3300	22.5	Linders'94	0	Linders'94	2.7	Linders'94
desmedipham	300.32	Hornsby'96	4E-04	25	Hornsby'96	8	20	Hornsby'96	208	Linders'94	49	Linders'94
desmetryn	213.3	Tomlin'94	0.133	20	Tomlin'94	580	20	Tomlin'94	119	Linders'94	9	Linders'94
diallate	270.2	Hornsby'96	20	25	Hornsby'96	14	25	Hornsby'96	286	Hornsby'96	30	Hornsby'96
dial.dichl.aceetamid(cdaa)	173.6	Hornsby'96	1300	20	Hornsby'96	20000	22.5	Hornsby'96	11	Hornsby'96	10	Hornsby'96
diazinon	304.3	Hornsby'96	8	20	Hornsby'96	60	22	Hornsby'96	571.4	Hornsby'96	21	Linders'94
dicamba	221	Tomlin'94	4.5	25	Tomlin'94	6500	25	Tomlin'94	0	Linders'94	48	Linders'94
dichlobenil	172.02	Hornsby'96	133	25	Hornsby'96	21.2	25	Hornsby'96	125	Linders'94	70	Linders'94
dichlofenthion	-	-	-	-	-	-	-	-	11	Linders'94	6	Linders'94
dichlofluanid	333.2	Tomlin'94	0.021	20	Tomlin'94	1.3	20	Tomlin'94	14	Linders'94	2.9	Linders'94
dichloromethane	-	-	-	-	-	-	-	-	-	-	-	-
dichlorprop	235.1	Tomlin'94	0.01	20	Tomlin'94	350	20	Tomlin'94	0	Linders'94	15	Linders'94
dichlorprop-P	235.1	Tomlin'94	0.062	20	Tomlin'94	590	20	Tomlin'94	38	Tomlin'94	-	-
dichlorvos	221	Hornsby'96	2666	25	Hornsby'96	10000	20	Hornsby'96	87	Linders'94	2	Linders'94

Active ingredient names from Pandoras' box (Linders et al.,1994)	Molecular Mass		Vapour Pressure			Solubility in water			Kom		DT50-soil	
				at temp			at temp				mean/med	
	(g/mole)	Reference	(mPa)	(degC)	Reference	(mg/l)	(degC)	Reference	(dm3/kg)	Reference	(days)	Reference
dicloran	207	Tomlin'94	0.16	20	Tomlin'94	6.3	20	Tomlin'94	428	Linders'94	282	Linders'94
dicofol (op)	370.51	Hornsby'96	0.053	22.5	Hornsby'96	0.8	25	Hornsby'96	201	Linders'94	15	Linders'94
dicofol (pp)	370.51	Hornsby'96	0.053	22.5	Hornsby'96	0.8	25	Hornsby'96	201	Linders'94	45	Hornsby'96
didecyldimethylammoniumchloride	-	-	-	-	-	-	-	-	-	-	23	Linders'94
dienochlor	474.6	Hornsby'96	1.3	25	Hornsby'96	25	20	Hornsby'96	115	Linders'94	18	Linders'94
diethatyl-ethyl	311.8	Hornsby'96	0.43	30	Hornsby'96	105	25	Hornsby'96	99	Linders'94	114	Linders'94
diethofencarb	267.3	Tomlin'94	8.4	20	Tomlin'94	26.6	20	Tomlin'94	158	Linders'94	5.4	Linders'94
difenacoum	-	-	-	-	-	-	-	-	-	-	-	-
difenoconazole	406.3	Tomlin'94	3.3E-05	25	Tomlin'94	16	25	Tomlin'94	1840	Linders'94	140	Linders'94
difenoxuron	286.3	Worthing'87	1.24E-06	20	Worthing'87	20	20	Worthing'87	343	Linders'94	18	Linders'94
difenzoquat	-	-	-	-	-	-	-	-	-	-	720	Linders'94
difethialon	-	-	-	-	-	-	-	-	-	-	-	-
diflubenzuron	310.69	Hornsby'96	1.2E-04	25	Hornsby'96	0.08	25	Hornsby'96	104	Linders'94	3	Linders'94
diflufenican	394.3	Tomlin'94	0.07	30	Tomlin'94	0.05	25	Tomlin'94	1150	Linders'94	192	Linders'94
dikegulac-sodium	296.3	Tomlin'94	0.0013	25	Tomlin'94	590000	25	Tomlin'94	0	Linders'94	195	Linders'94
dimefuron	338.8	Tomlin'94	0.1	20	Tomlin'94	16	20	Tomlin'94	410	Linders'94	170	Linders'94
dimethachlor	255.7	Tomlin'94	2.1	20	Tomlin'94	2100	20	Tomlin'94	70	Tomlin'94	37	Tomlin'94
dimethoate	229.2	Tomlin'94	1.1	25	Tomlin'94	23800	20	Tomlin'94	17	Linders'94	16	Linders'94
dimethomorph (E-isomer)	387.9	Tomlin'94	9.7E-04	25	Tomlin'94	50	21.5	Tomlin'94	252	Linders'94	41	Linders'94
dimethomorph (Z-isomer)	387.9	Tomlin'94	1E-03	25	Tomlin'94	50	21.5	Tomlin'94	252	Linders'94	78	Linders'94
dinocap	364.41	Hornsby'96	0.0053	20	Hornsby'96	4	22.5	Hornsby'96	314	Hornsby'96	5.3	Tomlin'94
dinoseb	240.2	Hornsby'96	6.7	25	Hornsby'96	52	22.5	Hornsby'96	23	Linders'94	50	Linders'94
dinoseb-acetate	282.2	Worthing'87	0	25	estimated	2200	22.5	Hornsby'96	36	Hornsby'96	5	Linders'94
dinoterb	240.2	Tomlin'94	20	20	Tomlin'94	4.5	20	Tomlin'94	72	Linders'94	9.8	Linders'94
diquat-dibromide	344.06	Hornsby'96	0	25	estimated	718000	20	Hornsby'96	5840	Linders'94	1000	Hornsby'96
dithianon	296.3	Tomlin'94	0.066	25	Tomlin'94	0.5	20	Tomlin'94	103	Linders'94	5	Linders'94
diuron	233.1	Hornsby'96	0.0092	25	Hornsby'96	42	25	Hornsby'96	232	Linders'94	94	Linders'94
DNOC	198.1	Tomlin'94	14	25	Tomlin'94	130	15	Tomlin'94	20.6	Linders'94	8.5	Linders'94
dodemorph	281.5	Tomlin'94	0.48	20	Tomlin'94	100	20	Tomlin'94	5400	Linders'94	190	Linders'94
dodine	-	-	-	-	-	-	-	-	1340	Linders'94	19	Linders'94
endosulfan	406.91	Hornsby'96	0.023	25	Hornsby'96	0.32	22	Hornsby'96	7085.7	Hornsby'96	50	Hornsby'96
endothal-sodium	-	-	-	-	-	-	-	-	-	-	-	-
EPTC	189.3	Hornsby'96	2626	24	Hornsby'96	344	22.5	Hornsby'96	61	Linders'94	47	Linders'94
esfenvalerate	419.9	Hornsby'96	0.0015	25	Hornsby'96	0.002	25	Hornsby'96	10300	Linders'94	32	Linders'94
ethephon	144.5	Hornsby'96	0.01	20	Hornsby'96	1.239E+06	22.5	Hornsby'96	61	Linders'94	1.1	Linders'94
ethiofencarb	225.3	Tomlin'94	0.45	20	Tomlin'94	1800	20	Tomlin'94	11	Linders'94	37	Linders'94
ethofumesate	286.3	Hornsby'96	0.65	25	Hornsby'96	50	25	Hornsby'96	84	Linders'94	37	Linders'94
ethoprophos	242.3	Hornsby'96	51	25	Hornsby'96	750	22.5	Hornsby'96	60	Linders'94	32	Linders'94
ethoxylated fatty amines	-	-	-	-	-	-	-	-	-	-	-	-
ethyleneglycol	-	-	-	-	-	-	-	-	-	-	-	-
ethylkwikbromide	-	-	-	-	-	-	-	-	-	-	-	-
etofenprox	376.5	Tomlin'94	32	100	Tomlin'94	1E-06	25	Tomlin'94	6.77E+06	Tomlin'94	11	Linders'94
etridiazole	247.53	Hornsby'96	13	20	Hornsby'96	50	25	Hornsby'96	140	Linders'94	23	Linders'94
etrimfos	292.3	Worthing'87	8.6	20	Worthing'87	40	23	Worthing'87	17	Linders'94	12.5	Linders'94
fenaminosulf	251.2	Hornsby'96	0	25	estimated	20000	25	Hornsby'96	11	Linders'94	17	Linders'94
fenamiphos	303.4	Hornsby'96	0.1	30	Hornsby'96	400	22.5	Hornsby'96	171	Linders'94	21	Linders'94
fenarimol	331.2	Hornsby'96	0.029	25	Hornsby'96	14	25	Hornsby'96	343	Hornsby'96	360	Hornsby'96
fenbutatinoxide	1052.7	Hornsby'96	2.4E-06	25	Hornsby'96	0.0127	20	Hornsby'96	1314	Hornsby'96	90	Hornsby'96
fenchlorazole-ethyl	403.5	Tomlin'94	8.9E-04	20	Tomlin'94	0.9	20	Tomlin'94	215	Linders'94	2.4	Linders'94
fenfuram	201.2	Hornsby'96	0.02	20	Hornsby'96	100	20	Hornsby'96	171	Hornsby'96	42	Hornsby'96
fenitrothion	277.2	Tomlin'94	0.8	22.5	Linders'94	21	20	Tomlin'94	111	Linders'94	28	Linders'94
fenoxaprop-ethyl	361.8	Hornsby'96	0.0043	25	Hornsby'96	0.8	22.5	Hornsby'96	15	Linders'94	0.65	Linders'94
fenoxaprop-P-ethyl	361.8	Tomlin'94	5.3E-04	20	Tomlin'94	0.9	25	Tomlin'94	8.7	Linders'94	0.65	Linders'94
fenoxycarb	301.3	Hornsby'96	0.0017	25	Hornsby'96	6	22.5	Hornsby'96	571.4	Hornsby'96	16	Tomlin'94
fenpiclonil	237.1	Tomlin'94	1.1E-06	25	Tomlin'94	4.8	25	Tomlin'94	1150	Linders'94	308	Linders'94
fenpropathrin	349.41	Hornsby'96	0.73	22.5	Hornsby'96	0.33	25	Hornsby'96	616	Linders'94	34	Linders'94
fenpropidin	273.5	Tomlin'94	17	25	Tomlin'94	530	25	Tomlin'94	1500	Linders'94	111	Linders'94
fenpropimorph	303.5	Tomlin'94	2.3	20	Tomlin'94	4.3	20	Tomlin'94	2075	Linders'94	67	Linders'94
fentin-acetate	409	Tomlin'94	1.9	60	Tomlin'94	9	20	Tomlin'94	1300	Linders'94	46	Linders'94
fentin-hydroxide	367	Tomlin'94	0.047	50	Tomlin'94	1	20	Tomlin'94	1300	Linders'94	26	Linders'94
fenvalerate	419.9	Hornsby'96	0.0015	25	Hornsby'96	0.002	25	Hornsby'96	1350	Linders'94	83	Linders'94
ferbam	416.5	Tomlin'94	0	25	estimated	130	22.5	Tomlin'94	171	Hornsby'96	17	Hornsby'96
FeSO4	-	-	-	-	-	-	-	-	-	-	-	-
fluazifop-butyl	327.3	Hornsby'96	0.055	20	Hornsby'96	2	20	Hornsby'96	1714	Hornsby'96	<7	Tomlin'94
fluazifop-p-butyl	383.4	Hornsby'96	0.033	20	Hornsby'96	2	20	Hornsby'96	3257	Hornsby'96	<7	Tomlin'94
fluazinam	-	-	-	-	-	-	-	-	5330	Linders'94	107	Linders'94
flucycloxuron	483.9	Tomlin'94	4.4	20	Tomlin'94	0.001	20	Tomlin'94	1972	Linders'94	208	Linders'94
flurenol(-butyl)	282.3	Tomlin'94	0.13	25	Tomlin'94	36.5	20	Tomlin'94	120	Tomlin'94	1.5	Tomlin'94
flurochloridon	312.1	Tomlin'94	0.75	50	Tomlin'94	28	20	Tomlin'94	75	Linders'94	24	Linders'94
fluroxypyr	255	Tomlin'94	3.78E-06	20	Tomlin'94	91	20	Tomlin'94	35	Linders'94	27	Linders'94
fluroxypyr 1-methylheptylester	-	-	-	-	-	-	-	-	9400	Linders'94	2.4	Linders'94
flusilazole	315.4	Tomlin'94	0.039	25	Tomlin'94	54	20	Tomlin'94	963	Linders'94	600	Linders'94
flutolanil	323.3	Tomlin'94	1.77	20	Tomlin'94	9.6	20	Tomlin'94	402	Linders'94	601	Linders'94
fluvalinate	502.93	Hornsby'96	0.01	25	Hornsby'96	0.001	20	Tomlin'94	78857.1	Tomlin'94	7	Linders'94
folpet	296.6	Tomlin'94	1.3	20	Tomlin'94	1	22.5	Tomlin'94	594.2	Tomlin'94	-	-
fonofos	246.32	Hornsby'96	28	25	Tomlin'94	16.9	22.5	Hornsby'96	497	Hornsby'96	99	Linders'94
formaldehyde	-	-	-	-	-	-	-	-	-	-	-	-
formothion	257.3	Tomlin'94	0.133	20	Tomlin'94	2600	24	Tomlin'94	4	Linders'94	<1	Linders'94
fosetyl-aluminium	354.1	Hornsby'96	0.01	22.5	Hornsby'96	120000	20	Hornsby'96	12.7	Linders'94	0.07	Linders'94
foxim	-	-	-	-	-	-	-	-	-	-	-	-
fuberidazol	184.2	Tomlin'94	2E-06	20	Tomlin'94	71	25	Tomlin'94	211	Tomlin'94	1.8	Tomlin'94
furalaxyl	301.3	Tomlin'94	0.07	20	Tomlin'94	230	20	Tomlin'94	40	Linders'94	49	Linders'94
furathiocarb	382.5	Tomlin'94	0.0039	25	Tomlin'94	11	25	Tomlin'94	375	Linders'94	1	Linders'94
gibberellin	-	-	-	-	-	-	-	-	-	-	-	-
gluphosinate-amm.	198.19	Hornsby'96	0	25	estimated	1.37E+06	22.5	Hornsby'96	95	Linders'94	23	Linders'94
glyphosate	169.1	Tomlin'94	0	25	estimated	12000	25	Tomlin'94	3200	Linders'94	38	Linders'94
glyphosate-trimesium (glyph,part)	245.2	Tomlin'94	0.04	25	Tomlin'94	1E+06	25	estimated	6533	Linders'94	8	Linders'94
glyphosate-trimesium (trim,part)	245.2	Tomlin'94	0.04	25	Tomlin'94	1E+06	25	estimated	893	Linders'94	4	Linders'94
guazatine	-	-	-	-	-	-	-	-	9.5	Linders'94	20	Linders'94
haloxyfop ethoxyethyl	433.8	Tomlin'94	1.64E-05	20	Tomlin'94	1.91	20	Tomlin'94	113	Linders'94	1.5	Linders'94
heptenophos	250.6	Tomlin'94	65	15	Tomlin'94	2200	20	Tomlin'94	92.1	Tomlin'94	0.7	Linders'94
hexaconazole	314.2	Tomlin'94	0.01	20	Tomlin'94	17	20	Tomlin'94	605	Linders'94	122	Linders'94
hexazinone	252.3	Hornsby'96	0.027	25	Hornsby'96	33000	25	Hornsby'96	16	Linders'94	62	Linders'94
hexythiazox	352.9	Hornsby'96	0.0031	25	Hornsby'96	0.5	25	Hornsby'96	2100	Linders'94	14	Linders'94
hymexazol	99.1	Tomlin'94	133	25	Tomlin'94	85000	25	Tomlin'94	0.079	Tomlin'94	13.5	Tomlin'94
imazalil	297.2	Tomlin'94	0.158	20	Tomlin'94	180	20	Tomlin'94	2286	Hornsby'96	100	Tomlin'94
imazamethabenz-methyl (m-isomer)	288.35	Hornsby'96	0.0015	22.5	Hornsby'96	1370	22.5	Hornsby'96	64	Linders'94	51	Linders'94
imazamethabenz-methyl (p-isomer)	288.35	Hornsby'96	0.0015	22.5	Hornsby'96	857	22.5	Hornsby'96	56	Linders'94	43	Linders'94
imazapyr	261.3	Tomlin'94	0.013	60	Tomlin'94	11300	25	Tomlin'94	6	Linders'94	510	Linders'94
imidacloprid	255.7	Tomlin'94	2E-04	20	Tomlin'94	510	20	Tomlin'94	144	Linders'94	180	Linders'94
ioxynil	370.9	Tomlin'94	1	20	Tomlin'94	50	25	Tomlin'94	118	Linders'94	10	Linders'94
iprodione	330.2	Tomlin'94	5E-04	25	Tomlin'94	13	20	Tomlin'94	281	Linders'94	41	Linders'94
isofenphos	345.4	Hornsby'96	0.4	20	Hornsby'96	24	20	Hornsby'96	155	Linders'94	64	Linders'94
iso-octylphenolpolyglycolether	-	-	-	-	-	-	-	-	-	-	-	-
isoproturon	206.3	Tomlin'94	0.0033	20	Tomlin'94	65	22	Tomlin'94	63	Linders'94	46	Linders'94
isoxaben	332.4	Hornsby'96	0.053	25	Hornsby'96	1	22.5	Hornsby'96	500	Linders'94	262	Linders'94
kasugamycine	379.4	Tomlin'94	1E-05	25	Tomlin'94	125000	25	Tomlin'94	39	Tomlin'94	-	-
lambda-cyhalothrin	449.9	Hornsby'96	2.0E-04	20	Hornsby'96	0.005	22.5	Hornsby'96	180000	Linders'94	41	Linders'94
coppernaphtanate	-	-	-	-	-	-	-	-	-	-	-	-
copperhydroxide	-	-	-	-	-	-	-	-	-	-	-	-
copperoxychinolate	-	-	-	-	-	-	-	-	-	-	-	-
copperoxychloride	-	-	-	-	-	-	-	-	-	-	-	-
HgO	-	-	-	-	-	-	-	-	-	-	-	-
lenacil	234.3	Tomlin'94	2E-04	25	Tomlin'94	6	25	Tomlin'94	20	Linders'94	179	Linders'94
lindane	290.85	Hornsby'96	5.6	20	Tomlin'94	7	20	Hornsby'96	633	Linders'94	1406	Linders'94
linuron	249.11	Hornsby'96	2.3	22.5	Hornsby'96	75	25	Hornsby'96	233	Linders'94	131	Linders'94
MgO	-	-	-	-	-	-	-	-	-	-	-	-
malathion	330.3	Hornsby'96	1	20	Hornsby'96	130	22.5	Hornsby'96	79	Linders'94	1	Hornsby'96

Active ingredient names from Pandoras' box (Linders et al.,1994)	Molecular Mass (g/mole)	Reference	Vapour Pressure (mPa)	at temp (degC)	Reference	Solubility in water (mg/l)	at temp (degC)	Reference	Kom (dm3/kg)	Reference	DT50-soil mean/med (days)	Reference
maleine-hydrazide	112.1	Hornsby'96	0	25	estimated	6000	25	Hornsby'96	143	Hornsby'96	4.9	Linders'94
mancozeb	330	estimated	0	25	estimated	6	25	Hornsby'96	1143	Hornsby'96	5	Linders'94
maneb	265.29	Hornsby'96	0	25	estimated	6	25	Hornsby'96	1143	Hornsby'96	56	Linders'94
MCPA	200.6	Tomlin'94	0.023	20	Tomlin'94	734	25	Tomlin'94	29	Linders'94	15	Linders'94
mecoprop	214.6	Tomlin'94	0.31	20	Tomlin'94	734	25	Tomlin'94	0	Linders'94	11	Linders'94
mecoprop-P	214.6	Tomlin'94	0.4	20	Tomlin'94	860	20	Tomlin'94	0.491	Tomlin'94	-	-
mefluidide	310.3	Hornsby'96	0	25	estimated	180	25	Hornsby'96	114	Hornsby'96	4	Hornsby'96
mepiquat.chloride	149.7	Hornsby'96	0	25	estimated	1E+06	20	Hornsby'96	600000	Hornsby'96	54	Tomlin'94
mercaptodimethur	-	-	-	-	-	-	-	-	-	-	-	-
metalaxyl	279.3	Hornsby'96	0.7498	25	Hornsby'96	8400	22	Hornsby'96	27	Linders'94	42	Linders'94
metaldehyde	176.2	Hornsby'96	0	25	estimated	230	22.5	Hornsby'96	10	Linders'94	10	Linders'94
metam-sodium	129.18	Hornsby'96	0	25	estimated	963000	22.5	Hornsby'96	228	Linders'94	0.009	Linders'94
metamitron	202.2	Tomlin'94	8.6E-04	20	Tomlin'94	1700	20	Tomlin'94	100	Linders'94	30	Linders'94
metazachlor	277.8	Tomlin'94	0.049	20	Tomlin'94	430	20	Tomlin'94	81	Linders'94	18	Linders'94
methabenzthiazuron	221.3	Tomlin'94	0.0059	20	Tomlin'94	59	20	Tomlin'94	405	Linders'94	135	Linders'94
methamidophos	141.1	Tomlin'94	2.3	20	Tomlin'94	2E+05	20	Hornsby'96	5	Linders'94	2.6	Linders'94
methidathion	302.3	Hornsby'96	0.449	25	Hornsby'96	220	22	Hornsby'96	96	Linders'94	4.5	Linders'94
methiocarb	225.3	Tomlin'94	0.015	20	Tomlin'94	27	20	Tomlin'94	506	Linders'94	61	Linders'94
methomyl	162.2	Hornsby'96	6.7	25	Hornsby'96	58000	25	Hornsby'96	12	Linders'94	8	Linders'94
methylbromide	94.94	Hornsby'96	2.4E+08	25	Hornsby'96	13400	25	Hornsby'96	2.4	Linders'94	15	Linders'94
methyldodecylbenzyltrimethyl...	-	-	-	-	-	-	-	-	-	-	-	-
methyldodecylxylyleen-bis...	-	-	-	-	-	-	-	-	-	-	-	-
methylisothiocyanate	73.11	Hornsby'96	2.7E+06	20	Hornsby'96	7600	20	Hornsby'96	3	Linders'94	6	Linders'94
methylkwikbenzoate	-	-	-	-	-	-	-	-	-	-	-	-
metiram	1088.7	Hornsby'96	0	25	estimated	0.1	22.5	Hornsby'96	285714	Hornsby'96	6	Linders'94
metobromuron	259.1	Tomlin'94	0.4	20	Tomlin'94	330	20	Tomlin'94	125	Linders'94	33	Linders'94
metolachlor	283.8	Hornsby'96	4.179	25	Hornsby'96	530	20	Hornsby'96	103	Linders'94	101	Linders'94
metoxuron	228.7	Tomlin'94	4.3	20	Tomlin'94	678	24	Tomlin'94	166	Linders'94	18.5	Linders'94
metribuzin	214.3	Tomlin'94	0.058	20	Tomlin'94	1050	20	Tomlin'94	32	Linders'94	34	Linders'94
metsulfuron-methyl	381.4	Hornsby'96	3.3E-07	25	Hornsby'96	9500	22.5	Hornsby'96	28	Linders'94	31	Linders'94
mevinphos	224.15	Hornsby'96	17	20	Hornsby'96	600000	22.5	Hornsby'96	17	Linders'94	1.2	Linders'94
mineral oil	-	-	-	-	-	-	-	-	-	-	-	-
mineral oil (herbicide)	-	-	-	-	-	-	-	-	-	-	-	-
monolinuron ·	214.6	Hornsby'96	20	21	Hornsby'96	735	25	Hornsby'96	193	Linders'94	50	Linders'94
myclobutanil	288.78	Hornsby'96	0.21	25	Hornsby'96	142	25	Hornsby'96	355	Linders'94	282	Linders'94
nitrothal-isopropyl	295.3	Tomlin'94	0.01	20	Tomlin'94	0.39	20	Tomlin'94	919	Linders'94	4	Linders'94
nonylphenolp.glycol.eth	-	-	-	-	-	-	-	-	-	-	-	-
nonylphenol-eth.glyc.	-	-	-	-	-	-	-	-	-	-	-	-
n-propyl-3t-butylphenoxy acetic acid	-	-	-	-	-	-	-	-	-	-	-	-
nuarimol	314.7	Tomlin'94	0.0027	25	Tomlin'94	26	25	Tomlin'94	344	Linders'94	306	Linders'94
omethoate	213.2	Tomlin'94	3.3	20	Tomlin'94	1E+06	25	estimated	13.3	Linders'94	1	Linders'94
oxamyl	219.3	Hornsby'96	31	25	Hornsby'96	282000	25	Hornsby'96	2	Linders'94	18	Linders'94
oxycarboxim	267.3	Tomlin'94	0.0056	25	Tomlin'94	1000	25	Tomlin'94	54	Hornsby'96	37	Tomlin'94
oxydemeton-methyl	246.29	Hornsby'96	3.9	20	Hornsby'96	1E+06	22.5	Hornsby'96	44	Linders'94	0.5	Linders'94
paclobutrazol	293.8	Hornsby'96	0.001	20	Hornsby'96	35	22.5	Hornsby'96	229	Hornsby'96	274	Tomlin'94
paraformaldehyde	-	-	-	-	-	-	-	-	-	-	-	-
paraquat	257.2	Tomlin'94	0	25	estimated	700000	20	Tomlin'94	100000	Linders'94	11000	Linders'94
parathion	291.27	Hornsby'96	0.89	20	Tomlin'94	11	20	Tomlin'94	1746	Linders'94	49	Linders'94
parathion-methyl	263.21	Hornsby'96	2	20	Hornsby'96	60	25	Hornsby'96	141	Linders'94	19	Linders'94
penconazole	284.2	Tomlin'94	0.21	20	Tomlin'94	73	20	Tomlin'94	1166	Linders'94	197	Linders'94
pencycuron	328.8	Tomlin'94	5E-07	20	Tomlin'94	0.3	20	Tomlin'94	1000	Linders'94	64	Linders'94
pendimethalin	281.3	Tomlin'94	4	25	Tomlin'94	0.3	20	Tomlin'94	111	Linders'94	171	Linders'94
pentachlorophenol	266.3	Tomlin'94	16000	100	Tomlin'94	80	30	Tomlin'94	17	Hornsby'96	48	Hornsby'96
permethrin	391.3	Hornsby'96	0.0017	25	Hornsby'96	0.006	20	Hornsby'96	340	Linders'94	13	Linders'94
phenmedipham	300.32	Hornsby'96	1E-06	25	Hornsby'96	4.7	20	Hornsby'96	464	Linders'94	45	Linders'94
phosalone	367.82	Hornsby'96	0.07	22.5	Hornsby'96	3	22.5	Hornsby'96	1345	Linders'94	7	Linders'94
phosmet	317.33	Hornsby'96	0.065	25	Hornsby'96	20	22.5	Hornsby'96	208	Linders'94	5.6	Linders'94
phosphamidon	299.7	Hornsby'96	2.2	25	Hornsby'96	1E+06	22.5	Hornsby'96	5	Linders'94	4.5	Linders'94
piperonylbutoxide	338.4	Tomlin'94	0.117	20	Tomlin'94	0.001	22.5	estimated	11	Linders'94	13	Linders'94
pirimicarb	238.3	Hornsby'96	4	30	Hornsby'96	2700	25	Hornsby'96	461	Linders'94	108	Linders'94
pirimiphos-methyl	305.34	Hornsby'96	2	20	Hornsby'96	9	20	Hornsby'96	202	Linders'94	12.5	Linders'94
prochloraz	376.7	Hornsby'96	0.15	20	Hornsby'96	34	25	Hornsby'96	286	Hornsby'96	21	Tomlin'94
procymidon	284.1	Hornsby'96	19	22.5	Hornsby'96	4.5	25	Hornsby'96	857.1	Hornsby'96	7	Hornsby'96
propham	179.2	Tomlin'94	-	-	-	250	20	Tomlin'94	11	Linders'94	11	Linders'94
prometryn	241.4	Hornsby'96	0.165	25	Hornsby'96	33	20	Hornsby'96	221	Linders'94	41	Linders'94
propachlor	211.69	Hornsby'96	31	22.5	Hornsby'96	613	25	Hornsby'96	40	Linders'94	5.2	Linders'94
propamocarb	224.7	Tomlin'94	0.8	25	Tomlin'94	867000	25	Tomlin'94	179	Linders'94	25	Linders'94
propaquizafop	443.9	Tomlin'94	4.4E-08	25	Tomlin'94	0.63	25	Tomlin'94	242	Linders'94	3	Tomlin'94
propazine	229.7	Tomlin'94	0.0039	20	Tomlin'94	5	20	Tomlin'94	58	Linders'94	132	Linders'94
propetamphos	281.3	Tomlin'94	1.9	20	Tomlin'94	110	24	Tomlin'94	3216	Tomlin'94	-	-
profenofos	373.6	Tomlin'94	0.124	25	Tomlin'94	28	25	Tomlin'94	13965	Tomlin'94	7	Tomlin'94
propiconazole	342.2	Tomlin'94	0.056	25	Hornsby'96	110	20	Hornsby'96	717	Linders'94	96	Linders'94
propoxur	209.25	Hornsby'96	1.3	20	Hornsby'96	1800	20	Hornsby'96	16	Linders'94	79	Linders'94
propylbutylphenoxyac.	-	-	-	-	-	-	-	-	-	-	-	-
propyzamide	256.1	Tomlin'94	0.058	25	Tomlin'94	15	25	Tomlin'94	117	Linders'94	25	Linders'94
prosulfocarb	251.4	Tomlin'94	0.069	25	Tomlin'94	13.2	20	Tomlin'94	996	Linders'94	24	Linders'94
pyrazophos	373.4	Tomlin'94	0.1	22.5	Linders'94	4.2	25	Tomlin'94	376	Linders'94	39	Linders'94
pyrethrins	328.43	Hornsby'96	0.001	22.5	Hornsby'96	0.001	22.5	Hornsby'96	8.3	Linders'94	8	Linders'94
pyridate	378.9	Tomlin'94	1.3E-04	20	Tomlin'94	1.5	20	Tomlin'94	461.3	Tomlin'94	5	Linders'94
pyridathioben (pyridaben)	364.9	Tomlin'94	0.25	20	Tomlin'94	0.012	20	Tomlin'94	6200	Linders'94	55	Linders'94
pyrifenox	295.2	Tomlin'94	1.7	25	Tomlin'94	150	25	Tomlin'94	263	Linders'94	66	Linders'94
quatern.ammonium..	-	-	-	-	-	-	-	-	-	-	-	-
quinmerac	221.6	Tomlin'94	0.01	20	Tomlin'94	240000	20	Tomlin'94	5.1	Linders'94	68	Linders'94
quintozeen	295.3	Tomlin'94	12.7	25	Tomlin'94	0.1	20	Tomlin'94	3123	Tomlin'94	-	-
quizalofop-ethyl	372.8	Tomlin'94	8.66E-07	20	Tomlin'94	0.3	20	Tomlin'94	1069	Linders'94	0.3	Linders'94
quizalofop-P-ethyl	372.8	Tomlin'94	1.1E-04	20	Tomlin'94	0.4	20	Tomlin'94	1069	Linders'94	2	Linders'94
rimsulfuron	431.4	Tomlin'94	0.0015	25	Tomlin'94	7300	25	Tomlin'94	35	Linders'94	3	Tomlin'94
sethoxydim	327.5	Hornsby'96	0.021	25	Hornsby'96	4390	20	Hornsby'96	29	Linders'94	1.2	Linders'94
silicone	-	-	-	-	-	-	-	-	-	-	-	-
simazine	201.66	Hornsby'96	0.00295	25	Hornsby'96	6.2	22	Hornsby'96	59	Linders'94	58	Linders'94
sodiumdimethyldithiocarbamate	-	-	-	-	-	-	-	-	-	-	-	-
streptomycine	-	-	-	-	-	-	-	-	-	-	-	-
strychnine	-	-	-	-	-	-	-	-	-	-	-	-
sulpher	-	-	-	-	-	-	-	-	-	-	-	-
sulfotep	322.3	Tomlin'94	14	20	Tomlin'94	10	20	Tomlin'94	4830	Tomlin'94	28	Linders'94
TCA	185.4	Hornsby'96	0	25	estimated	1.2E+06	25	Hornsby'96	0	Linders'94	25	Linders'94
tar acids and oils	-	-	-	-	-	-	-	-	-	-	-	-
tebuconazole	307.8	Tomlin'94	0.0013	20	Tomlin'94	32	20	Tomlin'94	613	Linders'94	652	Linders'94
teflubenzuron	381.1	Tomlin'94	8E-07	20	Tomlin'94	0.019	23	Tomlin'94	10063	Tomlin'94	49	Tomlin'94
tefluthrin	418.7	Tomlin'94	8	20	Tomlin'94	0.02	20	Tomlin'94	115000	Linders'94	13	Linders'94
temephos	-	-	-	-	-	-	-	-	-	Linders'94	2	Linders'94
terbufos	288.43	Tomlin'94	34.6	25	Tomlin'94	4.5	27	Tomlin'94	630	Linders'94	8	Linders'94
terbutryn	241.4	Hornsby'96	0.28	25	Hornsby'96	22	22	Hornsby'96	390	Linders'94	74	Linders'94
terbutylazine	229.7	Tomlin'94	0.15	25	Tomlin'94	8.5	20	Tomlin'94	180	Linders'94	114	Linders'94
tetrachloorvinphos	366	Hornsby'96	0.0056	20	Hornsby'96	11	20	Hornsby'96	514	Hornsby'96	2	Hornsby'96
tetradifon	356	Tomlin'94	3.2E-05	20	Tomlin'94	0.08	20	Tomlin'94	455	Linders'94	52	Linders'94
thiabendazole	201.2	Hornsby'96	0	25	estimated	50	22.5	Hornsby'96	1429	Hornsby'96	403	Hornsby'96
thifensulfuron-methyl	387.4	Hornsby'96	1.7E-05	25	Hornsby'96	2400	25	Hornsby'96	19	Linders'94	6	Linders'94
thiocyclam hydrogen oxalate	271.4	Tomlin'94	0.545	20	Tomlin'94	16300	20	Tomlin'94	12	Linders'94	2.2	Linders'94
thiodicarb	354.5	Tomlin'94	5.7	20	Tomlin'94	35	25	Tomlin'94	88	Linders'94	2	Linders'94
thiofanate-methyl	342.4	Hornsby'96	0.01	20	Hornsby'96	3.5	20	Hornsby'96	230	Linders'94	3.3	Linders'94
thiofanox	218.3	Tomlin'94	22.6	25	Tomlin'94	5200	22	Tomlin'94	10	Linders'94	4	Linders'94
thiometon	246.3	Tomlin'94	23	20	Tomlin'94	200	25	Tomlin'94	442	Linders'94	2	Linders'94
thiram	240.4	Tomlin'94	2.3	25	Tomlin'94	18	22.5	Tomlin'94	4.2	Linders'94	18	Linders'94
tolclofos-methyl	301.1	Hornsby'96	57	22.5	Hornsby'96	0.3	23	Hornsby'96	1558	Linders'94	66	Linders'94
tolylfluanid	347.2	Tomlin'94	0.016	20	Tomlin'94	0.9	22.5	Tomlin'94	11	Linders'94	1	Linders'94
tri-allate	304.66	Hornsby'96	15	22.5	Hornsby'96	4	22.5	Hornsby'96	1164	Linders'94	103	Linders'94
triadimefon	293.76	Hornsby'96	0.002	20	Hornsby'96	71.5	20	Hornsby'96	171	Hornsby'96	12	Tomlin'94

Active ingredient names from Pandoras' box (Linders et al.,1994)	Molecular Mass		Vapour Pressure			Solubility in water			Kom		DT50-soil	
				at temp			at temp				mean/med	
	(g/mole)	Reference	(mPa)	(degC)	Reference	(mg/l)	(degC)	Reference	(dm3/kg)	Reference	(days)	Reference
triadimenol	295.8	Hornsby'96	4.1E-05	20	Hornsby'96	47	20	Hornsby'96	134	Linders'94	114	Linders'94
triapenthenol	-	-	-	-	-	-	-	-	86	Linders'94	81	Linders'94
triazophos	313.3	Tomlin'94	0.39	30	Tomlin'94	35	20	Tomlin'94	208	Linders'94	65	Linders'94
trichlorfon	257.4	Tomlin'94	0.21	20	Tomlin'94	120000	20	Tomlin'94	11	Linders'94	18	Linders'94
trichloronaat	333.6	Hornsby'96	2	20	Hornsby'96	50	20	Hornsby'96	229	Hornsby'96	139	Hornsby'96
triclopyr	256.5	Tomlin'94	0.2	25	Tomlin'94	8100	20	Tomlin'94	32	Linders'94	20	Linders'94
tridemorph	297.5	Tomlin'94	6.4	20	Tomlin'94	11.7	20	Tomlin'94	985	Linders'94	34	Linders'94
triflumizole	345.7	Tomlin'94	0.186	25	Tomlin'94	12500	20	Tomlin'94	25	Linders'94	13	Linders'94
trifluralin	335.28	Hornsby'96	15	25	Hornsby'96	0.3	25	Hornsby'96	3775	Linders'94	221	Linders'94
triforine	435	Tomlin'94	0.027	25	Tomlin'94	9	20	Tomlin'94	184	Linders'94	20	Linders'94
validamycine	-	-	-	-	-	-	-	-	-	-	-	-
vamidothion	-	-	-	-	-	-	-	-	-	-	1.8	Linders'94
vinclozolin	286.1	Tomlin'94	0.016	20	Tomlin'94	3.4	20	Tomlin'94	157	Linders'94	23	Linders'94
warfarin	-	-	-	-	-	-	-	-	-	-	5	Linders'94
zineb	275.8	Hornsby'96	0.01	20	Hornsby'96	10	22.5	Hornsby'96	571.4	Hornsby'96	1	Linders'94
ziram	305.8	Hornsby'96	0.013	22.5	Hornsby'96	65	25	Hornsby'96	8	Linders'94	40	Linders'94
1,3-dichloropropene	111	Tomlin'94	2.9E+06	20	Tomlin'94	2250	25	Tomlin'94	15	Linders'94	13	Linders'94
cis-dichloropropene	111	Tomlin'94	3.5E+06	20	Tomlin'94	2180	25	Tomlin'94	15	estimated	10	Hornsby'96
2,4-D (pH soil < 5)	-	-	-	-	-	-	-	-	230	Linders'94	8	Linders'94
2,4-D (pH soil > 5)	221.04	Hornsby'96	1	20	Hornsby'96	890	25	Hornsby'96	26	Linders'94	8	Linders'94

Annex 4 Cumulative volatilization from soil surface estimated with new method

Active ingredient name from Pandoras' Box (Linders et al.,1994)	Field CumulVolat (in % dosage) after day: 21	Greenhouse CumulVolat (in % dosage) after day: 21	Field/Grh._Dow CumulVolat (in % dosage) after day: 21	Remarks
1- naphtylacetamide	-	-	-	{1}
1- naphtylacetic acid	-	-	-	{1}
abamectine 1a	0	0	0	{2}
acephate	0	0	0	-
aclonifen	0	3	4	-
acrinathrin (acrinate)	-	-	-	-
alachlor	7	10	55	-
aldicarb	17	17	100	{8},{11}
alloxydim-sodium	0	0	0	{5}
Al-fosfide	-	-	-	{1}
amitraz	18	18	100	{7},{8},{9},{11}
amitrol	0	0	0	{11}
(NH4)2SO4	-	-	-	-
amm-thiocyanaat	-	-	-	{1}
ancymidol	0	0	1	-
anilazine	0	0	1	{11}
antrachinon	-	-	-	{1}
asulam	0	2	4	{2},{8}
atrazine	0	4	18	-
azaconazole	0	0	1	{7},{8}
azamethifos	-	-	-	{1}
azinphos-methyl	0	1	1	{8},{10}
azocyclotin	0	0	na	{8}
Bacillus thuringiensis	-	-	-	{1}
Bacillus thuringiensis (combi)	-	-	-	{1}
benazolin	0	0	0	{7},{8}
benazolin-ethyl	17	17	100	{7}
bendiocarb	27	23	100	{8},{9}
benfuracarb	0	0	0	{7},{8},{10},{11}
benodanil	0	0	0	{7}
benomyl	0	0	0	{2},{8}
bensultap	-	-	-	-
bentazone	18	18	100	{8}
benzalkoniumchloride	-	-	-	-
benzoylprop	-	-	-	{1}
benzyladenine	-	-	-	{1}
bifenox	16	16	100	{10},{11}
bifenthrin	0	2	3	-
bitertanol-A	0	0	0	{7},{15}
boraten	-	-	-	{1}
borax	-	-	-	{1}
brodifacoum	0	0	0	{4},{7},{8}
bromacil	0	1	4	{8},{12}
bromadiolone	-	-	-	{1}
bromofenoxim	0	4	4	{2},{8}
bromophos-ethyl	60	44	100	{8}
bromopropylate	18	17	93	{4}
bromoxynil	11	13	57	{2},{7},{13}
buminaphos	33	27	100	-
bupirimate	0	6	16	{8}
buprofezin	10	13	80	{7}
butocarboxim	6	10	49	{7},{11}
butoxycarboxim	0	0	0	{7},{8}
calciumcyanide	-	-	-	{1}
Ca(NO3)2	-	-	-	{1}
captafol	0	0	0	{3},{7},{8}
captan	3	8	29	{11}
carbaryl	4	9	37	{8}
carbendazim	0	0	0	{8}
carbetamide	0	0	0	-
carbophenothion	10	12	74	-
carbofuran	0	6	19	-
carboxin	0	3	11	{8},{10},{11}
chlorbromuron	0	2	4	-
chlorbufam	-	-	-	{1}
chlorfacinon	-	-	-	{1}
chlorfenvinphos	0	6	14	-
chloralhydrate	-	-	-	{1}
chloridazon	0	0	1	{2},{8},{10)
chlormequat	0	0	0	{2},{5},{8},{11}
chloroflurenol	-	-	-	{1}
chlorothalonil	0	6	18	-
chlorotoluron	0	0	2	-
chloroxuron	0	0	0	-
chlorpropham	7	11	41	-
chlorpyriphos-ethyl	20	19	100	{8}
chlorthal-dimethyl (DCPA)	12	14	82	{8}
chlorthiamid	-	-	-	{1}
clodinafop-propargyl	0	0	1	{8},{9},{11}
clofentezine	16	16	99	{8},{9}
cloquintoceet-mexyl (CGA 185072)	0	0	0	{7},{8},{9},{11}
copper oxychloride	-	-	-	{1}
creosote	-	-	-	{1}
cresol	-	-	-	{1}
chlorcresol	-	-	-	{1}
coumatetralyl	0	0	0	{7},{8},{10}
cyanamide	-	-	-	-
cyanazine	0	0	0	-
cycloate	42	33	100	-
cycloxydim	0	4	5	{2},{8},{10},{11}

Active ingredient name from Pandoras' Box (Linders et al.,1994)	Field CumulVolat (in % dosage) after day: 21	Greenhouse CumulVolat (in % dosage) after day: 21	Field/Grh._Dow CumulVolat (in % dosage) after day: 21	Remarks
cyfluthrin	6	10	31	{8},{21}
cyhexatin	0	0	0	{4}
cymiazole	-	-	-	{1}
cymoxanil	0	2	10	{3},{8},{11}
cypermethrin (cis)	6	10	23	{20}
cypermethrin (trans)	-	-	-	-
alpha-cypermethrin	26	23	100	{7},{20}
cyproconazole	0	0	1	{8}
cyprofuram	0	0	0	{8}
cyromazine	0	0	0	{8}
dalapon	0	0	0	{6},{8},{14}
daminozide	0	0	0	{8},{11}
dazomet	0	6	24	{7},{8},{11}
deltamethrin	13	14	75	{2},{4},{10}
demeton-S-methylsulfon	0	0	na	-
desmedipham	0	0	0	{8},{9},{11}
desmetryn	0	0	2	-
diallate	29	24	100	{20}
dial.dichl.aceetamid(cdaa)	29	25	100	{7}
diazinon	16	16	94	{8}
dicamba	16	16	na	{8},{12}
dichlobenil	38	30	100	{10}
dichlofenthion	-	-	-	{1}
dichlofluanid	24	21	100	{8},{11}
dichloromethane	-	-	-	{1}
dichlorprop	2	8	na	{2},{8},{12}
dichlorprop-P	0	2	3	{7},{8}
dichlorvos	25	22	100	{6},{8},{9},{11}
dicloran	7	11	50	{8},{10}
dicofol (op)	18	18	98	{8},{9},{20}
dicofol (pp)	-	-	-	-
didecyldimethylammoniumchloride	-	-	-	{1}
dienochlor	18	18	100	{3},{8},{10}
diethatyl-ethyl	-	-	-	-
diethofencarb	26	23	100	{11}
difenacoum	-	-	-	{1}
difenoconazole	0	0	0	-
difenoxuron	0	0	0	-
difenzoquat	-	-	-	{1}
difethialon	-	-	-	{1}
diflubenzuron	0	6	16	{8},{11}
diflufenican	20	19	100	-
dikegulac-sodium	0	0	na	{2},{8}
dimefuron	-	-	-	-
dimethachlor	1	7	15	{7}
dimethoate	0	0	3	{8},{10}
dimethomorph (E-isomer)	-	-	-	-
dimethomorph (Z-isomer)	0	0	0	{4},{16}
dinocap	0	5	5	{7},{8},{9},{11}
dinoseb	28	24	100	{8}
dinoseb-acetate	0	0	0	{8},{11}
dinoterb	43	33	100	{8}
diquat-dibromide	0	0	0	{14}
dithianon	21	20	100	{10},{11}
diuron	0	0	1	{8}
DNOC	25	22	100	{12}
dodemorph	0	0	1	{4},{19}
dodine	-	-	-	{1}
endosulfan	0	6	11	{20}
endothal-sodium	-	-	-	{1}
EPTC	44	34	100	-
esfenvalerate	10	12	58	-
ethephon	0	0	0	{2},{8},{11}
ethiofencarb	2	8	23	-
ethofumesate	11	13	84	-
ethoprophos	20	19	100	-
ethoxylated fatty amines	-	-	-	{1}
ethyleneglycol	-	-	-	{1}
ethylkwikbromide	-	-	-	{1}
etofenprox	-	-	-	-
etridiazole	27	23	100	-
etrimfos	36	29	100	{8}
fenaminosulf	0	0	0	-
fenamiphos	0	0	2	-
fenarimol	0	4	7	{8}
fenbutatinoxide	0	0	0	-
fenchlorazole-ethyl	0	5	5	{8}
fenfuram	0	0	1	{7}
fenitrothion	16	16	98	-
fenoxaprop-ethyl	-	-	-	-
fenoxaprop-P-ethyl	11	13	55	{8},{11}
fenoxycarb	0	0	1	{7}
fenpiclonil	0	0	0	-
fenpropathrin	30	25	100	{10},{11}
fenpropidin	-	-	-	-
fenpropimorph	17	17	95	{8}
fentin-acetate	0	1	85	{8},{9}
fentin-hydroxide	0	0	35	{8}
fenvalerate	20	19	100	-
ferbam	0	0	0	-

Active ingredient name from Pandoras' Box (Linders et al.,1994)	Field CumulVolat (in % dosage) after day: 21	Greenhouse CumulVolat (in % dosage) after day: 21	Field/Grh._Dow CumulVolat (in % dosage) after day: 21	Remarks
FeSO4	-	-	-	{1}
fluazifop-butyl	3	8	17	{7},{8},{11}
fluazifop-p-butyl	0	5	6	{11}
fluazinam	-	-	-	{1}
flucycloxuron	65	47	100	{2},{4},{10}
flurenol(-butyl)	2	8	29	{11},{22}
flurochloridon	0	6	99	-
fluroxypyr	0	0	0	-
fluroxypyr 1-methylheptylester	-	-	-	-
flusilazole	-	-	-	-
flutolanil	20	19	100	-
fluvalinate	12	14	77	{2},{8},{10},{23}
folpet	28	24	100	{7}
fonofos	26	22	100	{8},{10}
formaldehyde	-	-	-	{1}
formothion	0	6	14	{7},{8},{9},{11}
fosetyl-aluminium	0	0	0	{2},{11}
foxim	-	-	-	{1}
fuberidazol	0	0	0	{11}
furalaxyl	0	6	9	-
furathiocarb	0	0	1	{11}
gibberellin	-	-	-	{1}
gluphosinate-amm.	0	0	0	-
glyphosate	0	0	0	-
glyphosate-trimesium (glyph,part)	0	0	0	{11}
glyphosate-trimesium (trim,part)	-	-	-	-
guazatine	-	-	-	{1}
haloxyfop ethoxyethyl	0	0	0	{8},{9},{11},{24}
heptenophos	20	19	98	{7},{11}
hexaconazole	-	-	-	-
hexazinone	0	0	0	-
hexythiazox	0	2	3	{10}
hymexazol	15	16	100	{2},{7},{8}
imazalil	0	0	0	{8}
imazamethabenz-methyl (m-isomer)	-	-	-	-
imazamethabenz-methyl (p-isomer)	0	0	0	{8},{17}
imazapyr	-	-	-	-
imidacloprid	0	0	0	-
ioxynil	17	17	86	{2},{8},{12}
iprodione	0	0	0	{8},{9},{10}
isofenphos	13	14	72	-
iso-octylphenolpolyglycolether	-	-	-	{1}
isoproturon	0	0	1	-
isoxaben	-	-	-	-
kasugamycine	0	0	0	{2},{7}
lambda-cyhalothrin	0	0	0	{8},{10}
copper naphtanate	-	-	-	{1}
copperhydroxide	-	-	-	{1}
copperoxychinolate	-	-	-	{1}
copperoxychloride	-	-	-	{1}
HgO	-	-	-	{1}
lenacil	0	0	2	-
lindane	25	22	100	{18}
linuron	12	14	79	-
MgO	-	-	-	{1}
malathion	12	14	68	{11}
maleine-hydrazide	0	0	0	{6},{7},{8},{11},{12}
mancozeb	0	0	0	{7},{8},{9},{11}
maneb	0	0	0	{6},{7},{8},{9}
MCPA	0	0	1	{8},{12}
mecoprop	16	16	na	{8},{12}
mecoprop-P	15	15	100	{8},{12}
mefluidide	0	0	0	{7},{8},{11},{12}
mepiquat.chloride	0	0	0	{7},{14}
mercaptodimethur	-	-	-	-
metalaxyl	0	1	4	-
metaldehyde	0	0	0	-
metam-sodium	0	0	0	{8},{9},{10},{11},{14},{25}
metamitron	0	0	0	{8},{10}
metazachlor	0	0	2	-
methabenzthiazuron	0	0	0	-
methamidophos	0	0	3	{5},{8},{9},{11}
methidathion	1	7	22	{11}
methiocarb	0	0	1	{8},{10}
methomyl	0	3	11	-
methylbromide	90	62	100	-
methyldodecylbenzyltrimethyl...	-	-	-	{1}
methyldodecylxylyleen-bis...	-	-	-	{1}
methylisothiocyanate	73	52	100	{8},{9},{11}
methylkwikbenzoate	-	-	-	{1}
metiram	0	0	0	{6},{7}
metobromuron	0	6	11	-
metolachlor	7	11	59	-
metoxuron	6	10	36	-
metribuzin	0	0	2	{10}
metsulfuron-methyl	0	0	0	-
mevinphos	0	0	2	{11}
mineral oil	-	-	-	{1}
mineral oil (herbicide)	-	-	-	{1}
monolinuron	12	14	81	-

Active ingredient name from Pandoras' Box (Linders et al.,1994)	Field CumulVolat (in % dosage) after day: 21	Greenhouse CumulVolat (in % dosage) after day: 21	Field/Grh._Dow CumulVolat (in % dosage) after day: 21	Remarks
myclobutanil	0	2	5	-
nitrothal-isopropyl	5	10	28	{2},{11}
nonylphenolp.glycol.eth	-	-	-	{1}
nonylphenol-eth.glyc.	-	-	-	{1}
n-propyl-3t-butylphenoxy acetic acid	-	-	-	{1}
nuarimol	0	0	0	{2},{8}
omethoate	0	0	0	{6},{8},{9},{11}
oxamyl	3	8	48	{8}
oxycarboxim	0	0	0	{7}
oxydemeton-methyl	0	0	0	{11}
paclobutrazol	0	0	0	{7}
paraformaldehyde	-	-	-	{1}
paraquat	0	0	0	-
parathion	8	11	42	-
parathion-methyl	17	17	94	-
penconazole	0	2	3	-
pencycuron	0	0	0	{3}
pendimethalin	44	34	100	{10}
pentachlorophenol	29	24	100	{3},{7},{8}
permethrin	21	19	100	{20}
phenmedipham	0	0	0	{8},{9},{10}
phosalone	3	8	18	{2},{11}
phosmet	0	6	17	{8},{9},{11}
phosphamidon	0	0	1	{6},{11}
piperonylbutoxide	70	50	100	-
pirimicarb	0	0	4	{8},{10}
pirimiphos-methyl	24	21	100	{8},{10}
prochloraz	5	9	17	{7}
procymidon	31	25	100	{7}
propham	-	-	-	{1}
prometryn	0	6	23	-
propachlor	22	20	100	{11}
propamocarb	0	0	0	-
propaquizafop	0	0	0	{11}
propazine	0	7	15	-
propetamphos	0	5	6	{7}
profenofos	0	3	4	{8},{9}
propiconazole	0	0	1	{8}
propoxur	6	10	41	{10}
propylbutylphenoxyac.	-	-	-	{1}
propyzamide	3	8	32	-
prosulfocarb	0	2	6	-
pyrazophos	10	12	53	-
pyrethrins	46	35	100	{3},{6},{20}
pyridate	0	0	0	{7},{11}
pyridathioben (pyridaben)	31	25	100	-
pyrifenox	5	10	40	{8}
quatern.ammonium..	-	-	-	-
quinmerac	0	0	0	{2},{6},{8}
quintozeen	39	30	100	{7}
quizalofop-ethyl	0	0	0	{11}
quizalofop-P-ethyl	0	0	0	{11}
rimsulfuron	0	0	0	{8},{11}
sethoxydim	0	0	0	{8},{11}
silicone	-	-	-	{1}
simazine	0	2	9	-
sodiumdimethyldithiocarbamate	-	-	-	{1}
streptomycine	-	-	-	{1}
strychnine	-	-	-	{1}
sulpher	-	-	-	{1}
sulfotep	18	17	97	{7},{8}
TCA	0	0	na	{14}
tar acids and oils	-	-	-	{1}
tebuconazole	0	0	0	{8}
teflubenzuron	0	0	0	{7}
tefluthrin	31	26	100	-
temephos	-	-	-	{1}
terbufos	34	27	100	-
terbutryn	2	8	32	-
terbutylazine	7	11	68	-
tetrachloorvinphos	0	0	1	{7},{11}
tetradifon	0	0	1	-
thiabendazole	0	0	0	{8}
thifensulfuron-methyl	0	0	0	{8},{11},{26}
thiocyclam hydrogen oxalate	0	2	3	{8},{11}
thiodicarb	28	24	100	{11}
thiofanate-methyl	2	8	14	{2},{11}
thiofanox	14	15	99	{11}
thiometon	17	17	95	{11}
thiram	35	28	100	{8},{9}
tolclofos-methyl	47	35	100	-
tolylfluanid	26	23	100	{8},{11}
tri-allate	28	24	100	-
triadimefon	0	0	0	-
triadimenol	0	0	0	{6},{20}
triapenthenol	-	-	-	-
triazophos	3	8	47	-
trichlorfon	0	0	0	{8},{9},{20}
trichloronaat	15	16	87	{7}
triclopyr	0	0	1	{12}

Active ingredient name from Pandoras' Box (Linders et al.,1994)	**Field CumulVolat (in % dosage)** after day: 21	**Greenhouse CumulVolat (in % dosage)** after day: 21	**Field/Grh._Dow CumulVolat (in % dosage)** after day: 21	**Remarks**
tridemorph	21	19	100	{8}
triflumizole	0	0	1	-
trifluralin	34	27	100	{8}
triforine	1	7	17	-
validamycine	-	-	-	{1}
vamidothion	-	-	-	{1}
vinclozolin	6	10	30	-
warfarin	-	-	-	{1}
zineb	0	1	2	{2},{7},{11}
ziram	3	8	25	-
1,3-dichloropropene	76	54	100	-
cis-dichloropropene	77	54	100	-
2,4-D (pH soil < 5)	-	-	-	-
2,4-D (pH soil > 5)	7	11	40	{8},{12}

Basic data field application:

Period:	21	days
Dry Bulk Density soil:	1400	kg/m3
Org. Matter Content soil	4.7	%
Moisture Content soil:	10	vol%
Av. Daily Temperature:	20	degree Celsius

Basic data greenhouse application:

Period:	21	days
Dry Bulk Density soil:	1400	kg/m3
Org. Matter Content soil	4.7	%
Moisture Content soil:	10	vol%
Av. Daily Temperature:	20	degree Celsius

Statistics:

Number compounds:	352
Number CV values:	279
Score CV/compounds:	0.79
Regression_field (R2):	0.758624
Regression_grh (R2):	0.549295

Legend remarks

{1}	no or insufficient data
{2}	vapour pressure overestimated
{3}	vapour pressure estimated
{4}	solubility in water overestimated
{5}	solubility in water underestimated
{6}	solubility in water estimated
{7}	Kom estimated
{8}	pH dependent
{9}	hydrolyses (DT50 < 3 weeks)
{10}	fotolyses (DT50 < 3 weeks)
{11}	transforms rapidly (DT50 < few days)
{12}	acid
{13}	base
{14}	salt
{15}	A-isomer
{16}	z-isomer
{17}	p-isomer
{18}	gamma-isomer
{19}	cis-isomer
{20}	isomer or enantiomer mixture
{21}	see dichlobenil
{22}	butyl
{23}	tau
{24}	etotyl
{25}	see also methylisothiocyanate
{26}	methyl
na	not applicable

Annex 5 List of reports published in the Environmental Planning Bureau series

The reports can be ordered from the publishing institute while stocks last. Prices are in Dutch guilders (*f*).

1. Kruijne, R en R.C.M. Merkelbach. 1997. *Ontwikkeling van het prototype instrumentarium PEGASUS; Pesticide Emission to Groundwater And SUrface waterS*. DLO-Staring Centrum, Wageningen (*f* 25,--).
2. Smit, A.A.M.F.R., F. van den Berg en M. Leistra. 1997. *Estimation method for the volatilization of pesticides from fallow soil*. DLO Winand Staring Centre, Wageningen, The Netherlands (*f* 25,--)