Miljøministeriet
Miljøstyrelsen

The Agricultural Pesticide Load in Denmark 2007-2010

Environmental review no. 2, 2012
Orientering fra Miljøstyrelsen nr. 2, 2012

Title:

The Agricultural Pesticide Load in Denmark 2007-2010

Contributors/Editors:

Institute of Food and Resource Economics (Fødevareøkonomisk Institut), KU LIFE, Det Jordbrugsvidenskabelige Fakultet (DJF Århus Universitet) and The Danish Environmental Protection Agency (Miljøstyrelsen)

Publisher:

Miljøstyrelsen
Strandgade 29
1401 København K
www.mst.dk

Foto:

Illustrations:

Year:

2012

Map:

ISBN no.

978-87-92779-96-0

Foreword

The Danish "Pesticide Statistics 2010", which form the basis of the load calculations, are based on sales data reported to the Danish Environmental Protection Agency by companies holding approvals for active substances and authorisations for pesticidal products in Denmark.

"Pesticide Statistics 2010" was released as Environmental Review no 5 2011 (http://www2.mst.dk/udgiv/publikationer/2011/10/978-87-92779-45-8.pdf). Its focus is the use of plant protection products (pesticides) in agriculture. The Treatment Frequency Index (TFI) is calculated as in previous years.

This report describes how a so-called pesticide load can be calculated to reflect the properties of pesticides with respect to human health and the environment. The methods and scientific basis have been developed, refined and documented in close cooperation between the University of Copenhagen's Institute of Food and Resource Economics and staff at the Environmental Protection Agency. The work has been ongoing for several years as part of the development of a new pesticide tax and has been funded by the Environmental Protection Agency, the Ministry of Food, Agriculture and Fisheries and the Institute of Food and Resource Economics.

The project generating "Pesticide Statistics 2010" and "Pesticide Load 2007-2010" was linked to a monitoring group whose members were: Lise Samsøe-Petersen, Christina Bøje, Lea Frimann Hansen (Danish Environmental Protection Agency), Jesper Kjølholt (COWI), Lise Nistrup Jørgensen, Per Kudsk (Århus University, Department of Agroecology (DJF), Flakkebjerg) and Jens Erik Ørum (Institute of Food and Resource Economics, Copenhagen University, LIFE (Faculty of Life Sciences)).

We extend our thanks to the members of the monitoring group for their participation in the project and to the holders of approvals for active substances and authorisations for plant protection products on the Danish market for reviewing the data on the properties of the active substances and the products, which have formed the basis of the calculations.

The Danish Environmental Protection Agency

March 2012

Contents

1 Summary and conclusions

A new indicator for the load on the environment and health as a result of the use of pesticides has been developed, **the Pesticide Load Indicator (PLI).** This can in turn be converted to describe the **Area Load (AL)** (load per area unit). The load figures supplement previously published pesticide statistics with calculations of the Treatment Frequency Index (**TFI**). The load calculations also provide a basis for developing a ***guidance/point system*** to allow farmers and other users of pesticides to make an informed selection among pesticides based on their properties.

Where the TFI mainly reflects the intensity of pesticide use, the PLI is a better indicator of the load on the environment and human health resulting from the actual use (sales) of pesticides.

In the report, the data and principles on which the load calculations are based are described. The load figures (PLI and AL) for the years 2007-2010 are presented and discussed.

The figures for the period 2007-2010 show that the general pattern is the same across sales figures, TFI and PLI. A sharp rise between 2007 and 2008 is followed by a fall in 2009 and then a renewed increase, though not enough for 2010 values to exceed the 2008 record year, when the TFI was 3.2. When examining the 2007 to 2010 trend in detail, however, it emerges that AL and PLI increased by approximately 30 percent compared to an increase in TFI of only 11 percent. This indicates an increase in load per standard dose (the Load Index) during the period. Several factors may be involved here. A closer analysis of the data is needed to provide an explanation. The example illustrates the way in which load figures can be used in new ways of evaluating the use of pesticides.

The new indicator can also be used to analyse the distribution of the load. For instance, the figures show that while in the 2007 reference year the distribution of the three main indicators, human health, environmental fate and environmental toxicity, on the total load was equal, by 2010 the environmental toxicity load accounted for around 50 percent of the overall load. Products sold now represent a higher environmental load than in 2007, whilst the load in relation to health, accumulation in the food chain and/or leaching into ground water has generally speaking not changed in the period.

A breakdown of the PLI by crop can show the crops that contribute most to the overall load in Denmark. This has been found to be cereals, which also account for the largest area.

A breakdown of area load (AL) on crops, on the other hand, can show which areas suffer the highest load, and these are orchards and areas where potatoes are grown.

2 Introduction

The concept of the treatment frequency index (TFI) as an expression of the spraying intensity of pesticides in Danish agriculture was introduced 25 years ago. Annual TFI calculations have been published by the Environmental Protection Agency together with annual statistics based on amounts. The calculation of the Treatment Frequency Index is based on product sales figures that are reported to the Environmental Protection Agency every year.

The Treatment Frequency Index is the number of times the total area under conventional agriculture can be treated during the course of one growth season with the sold amount of plant protection products, applied in standard doses.

The Treatment Frequency Index is seen as a general indicator of the toxicity load on plants and animals living on open fields or adjacent areas, which is caused by the use of pesticides. The assumption is that pesticides are seldom so specific as to be toxic only to the target organism; to a greater or lesser extent they are also toxic to other organisms.

But the Treatment Frequency Index does not reveal details of the pesticide load on, for example, the environment or the health of the spray operator, much less the potential contamination of ground water. For this reason, there has long been a wish to develop an indicator that is a better gauge of the total load on humans and the environment and which at the same time is more specific and detailed than the Treatment Frequency Index.

A new indicator has been developed, the Pesticide Load Indicator (PLI).

The new indicator does not provide a measure of possible effects, including harmful effects, which may result from the use of pesticides. It is based on the quantities and properties of pesticides sold, but does not give any information on actual effects resulting from their application, nor indeed damage inflicted, on humans or the environment. It is thus a load indicator, not an indicator of harmful effects.

The pesticide load, with the unit "L" ("B" in Danish), is calculated on the basis of existing information on the environmental properties of the active substances in the plant protection products and the properties of the products with respect to human health. All plant protection products are evaluated and are only authorised if they do not represent an unacceptable risk and thus are not expected to cause undesirable effects on humans or the environment. Although products are authorised, differences exist in their environmental and health-related properties. This means that some cause a lower load than others and that by substituting (changing to) products with a lower load, an improvement in total load can be achieved.

The calculation of pesticide load is a significant precondition for the differentiated pesticide tax proposed by the government. The pesticide load is intended to be included in the Environmental Protection Agency's annual pesticide statistics. Thus the Treatment Frequency Index ("how much is being sprayed?") can be supplemented by pesticide load ("how toxic are the pesticides being sprayed?") when assessing pesticide consumption in the future.

The new indicator can over time be used for determining national objectives or for instance for highlighting certain parts of the environment such as the aquatic environment. It also enables a further indicator, the Area Load (AL) to be calculated. This can be used for determining objectives for certain crops.

3 Calculating load

3.1 Load

The pesticide load, with the unit "L", gives a measure of the load on the environment and health resulting from the use (sales) of pesticides.

The pesticide load is calculated for each of the three main categories of load. The three categories, also termed main indicators, are:

- ***Human health:*** measures the load to which the spray operator is exposed when handling and applying pesticides.
- ***Environmental fate:*** is a measure of the degradation time of the pesticides in soil and their potential for accumulation in food chains and for transport through soil to ground water.
- ***Environmental toxicity:*** is a measure of the toxicity of pesticides to non target organisms in the field and the surrounding nature.

3.2 Terminology

3.2.1 Pesticide, product and active substance

In this report pesticides are referred to as "plant protection products" or simply "products". The term "product" means the formulated product as it is sold to farmers. A product can contain several active substances and various additives which may for instance enhance the effect of the active substances or enable their dissolution in water.

The load of pesticides on human health is evaluated and calculated on the basis of the properties of the products, whilst measures of environmental fate and environmental toxicity are derived solely from the active substances in the products. When calculating load it is thus important that terminology is used consistently. In the following, pesticides will be referred to as either "products" or "active substances". The total environmental fate and environmental toxicity load are calculated by adding the loads of all the active substances in the product.

3.2.2 Loads

For the main indicator human health it can be useful to combine the words "health" and "load" in terms like "health load of pesticides" or simply the "health load".

Many of the other concepts are not so straightforward. To avoid awkward or unhelpful terms such as "environmental fate load" and "environmental toxicity load" it has been decided to refer to a given pesticide load by the name of the relevant indicator, preferably with the preceding term "pesticide" or a relevant unit such as "L" or "L per ha".

Thus the terms, "pesticide environmental fate load", "environmental fate load (L)", "environmental toxicity", "pesticide environmental toxicity", "environmental toxicity (L pr ha)", "bioaccumulation (L)", or "environmental toxicity on bees", all refer to a load resulting from the use of a given pesticide for a given indicator, expressed as the calculated load and the unit "L" or "L per ha".

Some terms such as "human health" and "environmental toxicity" can give rise to misunderstandings and confusion. It is thus important when using these terms in the context of pesticide load that they are not used unless in the context of "pesticides" and "load".

It should be stressed again that none of the three indicators – despite their names – give a measure of potential consequences of pesticide use. It should be noted in particular that the term "environmental toxicity" is used here as a short version of "environmental toxicity load" and thus not as a measure of toxic effects.

3.2.3 Main and sub indicators

The pesticide load on human health (spray operators) and the environment is, as mentioned, divided into three main categories or indicators, each of which is composed of several sub indicators.

Calculating the load for each of the three main indicators (human health, environmental fate and environmental toxicity) involves computation of the sub indicators. Human health is based on the risk phrases of the product and environmental fate is composed of three sub indicators: degradation, accumulation and leaching; whilst environmental toxicity has 11 sub indicators: short and some long term effects on mammals, birds, bees, earthworms, fish, aquatic arthropods (e.g. daphnia), aquatic plants and algae.

3.3 Basis of calculating the pesticide load

The following sections provide an overview of the data base and the calculation methods and load weightings for the three main indicators, human health, environmental fate and environmental toxicity.

3.3.1 Data base

Pesticides based on microorganisms and pesticides for seed treatment applied to imported seed are not included in load calculations in this report.

Table 3.1 shows main and sub indicators used to calculate pesticide load and the basis of the calculations.

Table 3.1. Main and sub indicators for calculation of pesticide loads

Main indicator	Sub indicator and unit	Data basis
Human health	*L pr kg product*	
		Risk phrases for product
Environmental fate	*L pr kg active substance (a.s.)*	
	Degradation (persistence)	A.s. degradability
	Bioaccumulation	A.s. potential for bioaccumulation (BCF)
	Leaching (mobility)	A.s. potential for leaching to ground water
Environmental toxicity	*L pr kg active substance (a.s.)*	
	Mammals	A.s. short-term effects
	Birds	A.s. short-term effects
	Bees	A.s. short-term effects
	Earthworms	A.s. short-term and long-term effects
	Aquatic environment	
	Fish	A.s. short-term and long-term effects
	Daphnia	A.s. short-term and long-term effects
	Aquatic plants	A.s. short-term effects
	Algae	A.s. short-term effects

The calculation of the product's load on the environment (environmental fate and toxicity) is based on the properties of the active substance, derived from the EU database entitled "PPDB"[1]. The database is based on the data applied for the EU assessment undertaken in connection with the evaluation and inclusion of the substances in the EU positive list[2] of active substances that are permitted as ingredients of plant protection products.

It should also be noted that the calculated pesticide load is based on our knowledge of sold volumes (the Treatment Frequency Index) and of the inherent properties of the product and the active substance, expressed as load pr kg product.

When calculating load, available data on the effect of the pesticides on each of the sub indicators is used in as far as is possible. Where a relevant parameter is not available for all active substances, such as information on the long-term effects on mammals and birds, this parameter is left out of the calculations.

Calculation of pesticide load on human (the operator's) **health** is based on the hazard classification of the product expressed as its risk phrase (R-phrase). R-phrases are allocated a score depending on their toxicity and a common load factor as well as a factor used to reflect the risk of exposure.

The calculation of pesticides' **environmental fate** is based on information on the properties of the active substance for each sub indicator. The measurements in question are bioconcentration factor (BCF) (**accumulation** in food chains), half-life in soil (**degradation**) and mobility in soil (**leaching** to

1 PPDB (2009). The Pesticide Properties Database (PPDB) developed by the Agriculture & Environment Research Unit (AERU) based at the University of Hertfordshire, financed by UK national funds and the EU-financed FOOTPRINT project (FP6-SSP-022704). http://sitem.herts.ac.uk/aeru/footprint/en/index.htm

2 Previously these substances were included in Annex I of Directive 91/414/EEC but with the entry into force on 14 June 2011 of a new EU Pesticide Regulation (1107/2009/EC), the active substances will be included in an approval regulation.

ground water) for the active substance and its degradation products (metabolites).

Calculations of pesticides' environmental toxicities are based on the acute and chronic toxicity[3] of the active substance for each sub indicator, defined as e.g. LC_{50} and EC_{50} values[4]. When calculating long-term (chronic) load for earthworms, fish and aquatic arthropods, degradation times for active substances in soil and water, respectively, are also included.

The calculation does not include information on the possible exposure of humans or environment as it does not take account of the requirements to use the risk reduction measures that are stated on the product label and/or user instructions and which are a precondition of the authorisation of a product. These may for example prescribe personal protection such as gloves and face masks when handling the pesticide or stipulate a 10 metre distance to aquatic environments. The indicator cannot therefore be used to evaluate whether undesired effects may arise if the product is used according to the rules – only to produce a measure with respect to load.

Where the pesticide is applied in a closed facility such as greenhouses or industrial premises, it is assumed that there will be no load on the external environment. The calculation does not compute any effect from such uses on environmental fate and environmental toxicity (it applies a factor of 0). Similarly, other load factors are used for pesticides for seed treatment than for products applied in the usual way.

3.3.2 Principles

Reference values

With regard to the environmental properties (fate and toxicity) of the active substance, the fundamental principle has been to determine the weighting and calculation of load for each indicator on the basis of a reference value and a reference load. The reference value is based on a "worst case" load in 2007 of an approved active substance with regard to the relevant factor, for example the value for the most toxic substance for mammals or the substance with the longest half-life.

The reference load expresses the level of the load emitted by this (most toxic) active substance per kg of the active substance. Thus, for each active substance, the ratio between each sub indicator value and the corresponding value in the case of the reference substance is calculated. This ratio is always less than 1. An active substance that is for example half as toxic as the most toxic active substance (double the dose would be required to achieve the same toxicity) is assigned half the load per kg as the most toxic active substance. And so on.

By using a reference substance and reference load to define the load for a sub indicator, one avoids having to define load as for example "xx mg active substance per litre per L" and it is also possible to add results for various organisms, which were originally measured in different units.

---

[3] Acute and chronic toxicity are investigated as effects measured by short-term and long-term exposure respectively of the trial organisms to the substances.

[4] LC_{50} and EC_{50} are concentrations at which 50 percent of trial organisms respectively die or there is an effect as for example reduced reproduction.

Weighting of pesticide load for main and sub indicators

Naturally, several preconditions and calculations are required to convert the above R-phrases, LC_{50} values and half-lives etc. to a load for the individual sub indicators.

The loads for the various indicators and sub indicators must be able to be added to express a total load – one figure that is a kind of national average, just as the consumption of pesticides is expressed by one figure – the Treatment Frequency Index. This addition requires that weights be assigned to the various indicators and sub indicators.

When computing the load for the three main indicators, efforts were made to assign weightings that resulted in the total load in the reference year 2007 being equally distributed between human health, environmental fate and environmental toxicity.

Similarly, efforts were made to ensure that the total load in 2007 as far as possible corresponded to a load of 1 (L per ha) for each of the corresponding main indicators. The year 2007 was chosen as the reference year on which to standardise the load for the main indicators as it was the reference year for evaluating the 2004-2009 Pesticide Plan. The standard was thus set based on data for active substances and products that were approved and authorised in 2007, and on the consumption.

In order to arrive at an area load of one L per ha in 2007 for the main indicators, the calculation was made backwards (from total load to load per kg active substance) and in this way, a load was determined (and thus also a weighting) per kg product for the most toxic products and active substances, with regard to each sub indicator. The load factors in use are thus the result of the wish to commence with a value of 1 L per ha in the reference year.

Combined pesticide load for main and sub indicators

The principles and preconditions outlined above allow for the pesticide load (L) to be calculated for all contexts as the sum of the loads for the underlying indicators:

Total L = L human health + L environmental fate + L environmental toxicity

It is also possible to run more detailed calculations on the load on individual crops. For example, to calculate environmental fate of herbicides in spring barley, this is done by combining the loads for the underlying indicators:

L environmental fate = L degradation + L bioaccumulation + B mobility

In the following section "L" (without specification) is used to refer to the load at several different levels. In each case the level in question will be made clear.

3.4 Human health load

Calculation of pesticide load on human health is based on the risk phrases (R-phrases) of the product, which reflect the classification in relation to health. The authorisation process involves evaluation of each product and allocation of a classification stipulating the risk phrases to be included on the product label.

The product classification depends either on the properties of the formulated product or on the classification of active substances and co-formulants as determined by EU classification criteria (Directive 67/548/EEC). Later it will be necessary to alter the criteria to take account of the new regulation on classification and labelling of chemical substances and mixtures (Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures).

Every risk phrase carries a score. The various risk phrases are numbered in accordance with EU rules. The lowest score of 10 points is awarded for example to products that are harmful if swallowed. The highest score of 100 points is given to products that are highly toxic or can cause irreversible damage. The ratio of highest to lowest scores is 10:1.

The conversion from points (score) to a load per kg of product involves multiplying the points by a load factor of 1/300. A product with a score of 30 points is thus given a load on human health of 0.1 L per kg product. The factor produces a total load on human health for 2007 which is close to 1 L per ha.

Table 3.2 shows the points and load on human health for the current R-phrases (first column) and for the hazard statements according to the aforementioned new regulation – as well as corresponding load figures.

Table 3.2. Calculation of load on human health

Risk phrases relating to human health[1]	Hazard statements with respect to human health[2]	Risk points, inherent properties	Load (L pr kg product)
R22 Harmful if swallowed	Acute Tox. 4, H302: Harmful if swallowed	Score 10	0.033
R37 Irritating to respiratory system	STOT SE 3, H335: May cause respiratory irritation		
R38 Irritating to skin	Skin Irrit. 2 H315: Causes skin irritation		
R65 Harmful: may cause lung damage if swallowed	Asp. Tox. 1, H304: may be fatal if swallowed and enters airways		
R66 Repeated exposure may cause skin dryness or cracking	EUH066: Repeated exposure may cause skin dryness or cracking		
R20 Harmful by inhalation	Acute Tox. 4, H332: Harmful if inhaled	Score 15	0.050
R21 Harmful in contact with skin	Acute Tox. 4, H312: Harmful in contact with skin		
R36 Irritating to eyes	Eye Irrit.2 H319: Causes serious eye irritation		
R43 May cause sensitisation by skin contact	Skin sens. 1 H317: May cause an allergic skin reaction.	Score 20	0.066
R33 Danger of cumulative effects		Score 30	0.100
R67 Vapours may cause drowsiness and dizziness	STOT SE 3, H336: May cause drowsiness or dizziness		
R25 Toxic if swallowed	Acute Tox. 3, H301: Toxic if swallowed	Score 50	0.166
R42 May cause sensitisation by inhalation	Resp. Sens. 1 H334: May cause allergy or asthma symptoms or breathing difficulties if inhaled		
R64 May cause harm to breastfed babies	Lact., H362: May cause harm to breast-fed children		
R23 Toxic by inhalation	Acute Tox. 3, H331: Toxic if inhaled	Score 70	0.233
R24 Toxic in contact with skin	Acute Tox. 3, H311: Toxic in contact with skin		
R28 Very toxic if swallowed	Acute Tox. 2, H300: Fatal if swallowed		
R34 Causes burns	Skin Corr. 1B H314: Causes severe skin burns and eye damage		
Carc. Cat. 3: R40 Limited evidence of a carcinogenic effect	Carc. 2, H351: Suspected of causing cancer (possible route of exposure)		
R41 Risk of serious damage to eyes	Eye Dam. 1 H318: Causes serious eye damage		
Xn; R48 Harmful: danger of serious damage to health by prolonged exposure	STOT RE 2, H373: May cause damage to organs through prolonged or repeated exposure (possible specific organs/route of exposure)		
Rep. 3; R62 Possible risk of impaired fertility Rep. 3; R63 Possible risk of harm to the unborn child	Repr. 2, H361 (possibly f and/or d): Suspected of damaging fertility or the unborn child (possible specific effect/exposure route)	Score 70	0.233
Xn; R68 Harmful: possible risk of irreversible effects	STOT SE 2, H371: May cause damage to organs (possible specific organs/route of exposure)		
Mut. 3; R68 Possible risk of irreversible effects	Mut. 2, H341: Suspected of causing genetic defects (possible route of exposure)		
	Acute Tox. 2, H330: Fatal if inhaled	Score 85	0.283
	Acute Tox. 2, H310 Fatal in contact with skin		
	Acute Tox. 1, H300: Fatal if swallowed		
R26 Very toxic by inhalation	Acute Tox. 1, H330: Fatal if inhaled	Score 100	0.330
R27 Very toxic in contact with skin	Acute Tox. 1, H310 Fatal in contact with skin		
R35 Causes severe burns	Skin Corr. 1A, H314: Causes severe skin burns and eye damage		
R39 Danger of very serious irreversible effects	STOT SE 1, H370: Causes damage to organs (possible specific organs/route of exposure)		
Carc. 1/2; R45 May cause cancer	Carc. 1A/B, H350 (poss. i): May cause cancer (possible route of exposure)		
Mut. 1/2; R46 May cause heritable genetic damage	Mut. 1A/B; H340: May cause genetic defects (possible route of exposure)		
T; R48 Toxic: Danger of serious damage to health by prolonged exposure	STOT RE 1, H372: Causes damage to organs through prolonged or repeated exposure (possible specific organs/route of exposure)		
R49 May cause cancer by inhalation			
Rep. 1/2; R60 May impair fertility Rep. 1/2; R61 May cause harm to the unborn child	Repr. 1A/B, H360 (poss. F/f and/or D/d): May damage fertility or the unborn child (possible specific effect/route of exposure)		

1) Current – under Directive 67/548/EC
2) Future – under Regulation no 1272/2008 (EC) of the European Parliament and of the Council

A total number of points (the score) is calculated for each product with regard to human health, based on the risk phrases which state the dangers associated with the product. This is done by summing points for all risk phrases (whether individual or combined) as stated in the authorisation and as appearing on the product label. A product can therefore receive a score of over 100 points if it has several possible effects.

To convert points relating to human health to a load per kg of product a factor of 1/300 is used, as mentioned. A product with two risk phrases, for example "R25 Toxic if swallowed", which represents 50 points, and "R26 Very toxic by inhalation", which represents 100 points, has a total score of 150 points corresponding to a load on human health of 0.5 L per kg product.

3.4.1 The risk of exposure is partially accounted for in the human health load

The calculation of load on human health is limited to the load to which the spray operator (and any assistants) may be subjected during handling and application of pesticides. It should further be stressed that the calculations are based solely on the inherent properties of the products. This means that for example directions to use personal protection as stated on the label are not considered. The calculated load, therefore, does not reflect the risk of poisoning for the spray operator in the case of correct use of the product.

There are, however, some general conditions that apply to the risk of exposure during use, because the formulation of the product is of significance. The risk of exposure is dependent on the way in which the product is mixed, in that for example the exposure risk is greater if the product is mixed as a powder in water (emitting dust) than if it is a tablet dissolved in water.

Table 3.3 shows exposure factors for users of pesticides.

Table 3.3. Exposure factors for users of pesticides

Formulation	Exposure factor
Powders that must be dissolved in water before use, and liquids (high exposure on mixing)	1.5
Other formulations, including: Ready-to-use solutions, granules, pellets, water-soluble tablets, insecticide sticks or other solid formulae, water-soluble bags, pesticides for seed treatments for industrial use, gas cartridges, etc.	1.0

This means that the load on human health for a plant protection product in powder or liquid form that has to be dissolved or diluted in water before use must be multiplied by a factor of 1.5.

3.5 Environmental fate load

The environmental fate of pesticides is determined using three sub indicators: degradation in soil, potential for bioaccumulation (accumulation in the food chain) and mobility in soil (potential for contamination of ground water).

Pesticide degradation is determined on the basis of the half-lives of the active substances in the soil (soil DT_{50}). The longer the half-life, the greater the load.

The load relating to bioaccumulation is calculated on the basis of the bioconcentration factor (BCF) of the active substances. Where no BCF has been reported, the factor is estimated from the log Pow value (an expression of the tendency of the substance to accumulate in fatty tissue) using a Pow model based on the relation between Pow and BCF for a series of substances.

Finally, the mobility of pesticides in soil (which indicates their potential for migrating to ground water) is calculated on the basis of the reported half-lives of the active substance and possible degradation products (metabolites) and the Koc value (degree of sorption to organic material) using the so-called SCI-GROW model, where the estimated concentration of a substance in ground water (U) is calculated using the formula below and the subsequent U values for the active substance and any degradation products are summed.

The calculations can be summarised in the equation:

$$U = 0.89\ 10^{-2.24+0.61\ [log_{10}(DT_{50}-5)(4-log_{10}(Koc+5))]}$$

For each of the three sub indicators, the ratio between the resulting value and the reference value (value for the most toxic substance) is calculated and multiplied by a load factor as described above. Table 3.4 shows the specific reference values and load factors.

Table 3.4 Parameters for calculation of environmental fate load

Sub indicator	Code	Unit	Reference value	Load factor (L pr kg active substance)
Degradation (persistence)	P	Half-life in soil (DT50) in days	354	2.5
Accumulation (bioaccumulation)	B	Bioconcentration factor (BCF)	5,100	2.5
Leaching (mobility)	U	SCI-GROW index	10.91	20

The reference substance, i.e., the active substance with the longest half-life in soil (354 days) results in a load of 2.5 L per kg active substance. An active substance with half this DT_{50} (177 days) results in a load of 1.25 L per kg active substance.

The reference substance, that is, the approved active substance with the highest L value (5,100), results in a load of 2.5 L per kg active substance.

The active substance (and its metabolites) with the highest U value (10.91) is assigned a load of 20 L per kg active substance.

Total environmental fate load = P + L + U

3.6 Environmental toxicity load

As mentioned, the environmental toxicity of pesticides is determined using several sub indicators. The load for the individual sub indicators is based for example on LC_{50} values and the score is calculated with respect to the most toxic active substances (reference substances), and subsequently multiplied with a load factor to arrive at the load for the individual sub indicator.

When calculating the environmental toxicity load of pesticides for surface treatment, the exposure of organisms to pesticides is to some degree accounted for. Birds that live on seeds and grains are particularly exposed to pesticides for seed treatment of seed and grain and less exposed to pesticides for surface treatment of beet seed, potatoes, onions and tubers compared with traditional field spraying. Different load factors are therefore used for pesticides for seed treatment than for other products.

When calculating the environmental toxicity load for the individual sub indicators, the sub indicators, reference values and load factors shown in

Table 3.5 are used for the majority of products and the two types of pesticides for surface treatment:

Table 3.5 Reference values and load factors for calculating parameters for the environmental toxicity of pesticides

Indicator	Unit for reference value	Reference value	Load factor for ord. products	Load factor for pesticides for seed treatments Seed/grain	Load factor for pesticides for surface treatment Tubers and similar
			L pr kg active substance	L pr kg active substance	L pr kg active substance
Short-term effect					
Birds	LD50 mg per kg body weight	49	1	10	0.1
Mammals	LD50 mg per kg body weight	20	1	10	0.1
Fish	LC50 mg per litre water	0.00021	30	1	1
Daphnia	EC50 mg per litre water	0.0003	30	1	1
Algae	EC50 mg per litre water	0.000025	3	0.1	0.1
Aquatic plants	EC50 mg per litre water	0.00036	3	0.1	0.1
Earthworms	LC50 mg per kg soil	3.4	2	1	1
Bees	LD50 microgram per bee	0.02	100	1	1
Long-term effect					
Fish	NOEC mg per litre water	0.000115	3	0.1	0.1
Daphnia	NOEC mg per litre water	0.000115	3	0.1	0.1
Earthworms	NOEC mg per kg soil	0.2	2	1	1

As an example, the most toxic active substance for bees has an LD_{50} value of 0.020 microgram per bee, which produces a load of 100 L per kg active substance. Another active substance (not shown in the table) with an LD_{50} value of 40 micrograms per bee is far less toxic to bees. It is 40/0.02 corresponding to 2,000 times less toxic to bees than the reference substance. This substance therefore produces a load for bees of 100 x 0.0005 L per kg (0.05 L per kg active substance) for bees. Many active substances are toxic to many different organisms. For example, the reference substance, which results in an environmental toxicity of 100 L per kg active substance for bees, has an overall environmental toxicity of approximately 170 L per kg.

The calculations underlying load factors for environmental toxicity are detailed in Annex 2.

3.6.1 Export and import of pesticides for seed treatment

The import and export of pesticides for seed treatment (surface treatment) represent a particular problem in the calculation of the extent of load and area load.

This is not the technical issue of calculating frequency and load for pesticides for seed treatment that are imported and exported as treated seed, but the fact that the Pesticide Statistics 2010 concern only those pesticides sold as pesticides in Denmark. Pesticides that are otherwise imported and exported in goods, e.g. in the form of treated seed, are not included in the statistics.

When calculating total load account is taken of the fact that some of the pesticides sold for seed treatment are not applied in Denmark, but are used exclusively to produce treated seed for export to other countries. The calculations thus include neither pesticides for seed treatment sold in Denmark but exported to other countries (and thus not an environmental load in Denmark) nor the pesticides for seed treatment imported with seed and used in Denmark (which may constitute an environmental load in Denmark).

4 Load, Area Load and the Pesticide Load Indicator

4.1 Defining load and area load

Using the product formulation and use as well as active substance content, a load per kg product can be calculated. The load for each product is measured in the unit L per kg. By multiplying the used (sold) amount of product, the total **load (measured in unit L)** for the respective product can be deduced. Load (L) is thus mainly dependent on the size of the area and the crops on which the product is used. This can be expressed as follows (units are given in brackets):

Load (L) = load per kg product (L per kg) x amount (kg)

On the basis of the values for the individual product load, L, a figure for the total national load can be deduced.

When the total load is divided by a given area, this produces a so-called **Area Load (AL, measured in L per ha)**:

Area Load (AL) (L per ha) = Load (L) / Area (ha)

Area Load for the year thus depends on the amount of pesticide sold and the properties of the pesticides as well as the size of the area over which the product is estimated to have been applied.

The calculation of the **Treatment Frequency Index (TFI)**, which reflects pesticide use nationally, is based on the standard dose of each product[5] for each crop and the annual sales of pesticides. At farm level, on the other hand, **the Treatment Index (TI)** reflects the number of times the farmer has treated his land with pesticides in a growing season if standard doses were used. TI and TFI are in many ways one and the same term; application and substitution are done by the farmer whilst the TFI is a statistical average calculation at national level. The calculation of TI is used for individual farms for advisory purposes and to decide on the use of pesticides in a given crop.

Equations, units and definitions in connection with the new term load (L) relate predominantly to TI and not TFI.

As the Treatment Frequency Index (TFI) is calculated by means of standard doses, the impact of the choice of product on the total load (L) as well as on the Area Load (AL) are expressed as the load per standard dose (L per standard dose). It has been decided to refer to the product's load per standard dose as the product's **Load Index**, with the unit L per TI.

[5] Standard dose is the dosage, at which a given pesticide is evaluated to be applied to a crop in order to achieve a sufficient effect. The standard dose can therefore vary depending on which crop the pesticide is being used in. It is this dose for each product in each crop, which is used as a basis for calculation of the TFI.

The Load Index is therefore an important tool in making a choice between pesticides with the same desired effect based on their load on human health and/or the environment.

The load from a given use of pesticides (i.e. for a given crop) can thus be calculated at farm level from the use expressed as number of standard doses (TI) x Load Index (L per TI). And the Area Load (L per ha) can be calculated as the number of standard doses (TI) per ha x the Load Index (L per TI).

At farm level/crop level the calculation is as follows:

Area Load (AL) (L per ha) =
Number of standard doses used (TI) per Area Unit (ha) x Load Index (L per TI)

For the national average, the calculation is as follows:

Area Load (AL) (L per ha) =
Treatment Frequency Index (TFI) (TI per ha) x Load Index (L per TI)

The process is such that, for example, halving the use of a given product, and with all other conditions equal, will have the same effect on Area Load as will changing to a product that for example has a Load Index of half the value. If current products can be replaced by products that are just as effective but have lower loads, the total load can in principle be reduced without reducing pesticide consumption.

4.2 Load indicators in environmental policy and the definition of PLI

The new measurements of load are relative indicators, which can reflect **the development** over time in both the **specific** (e.g. per crop or type of environment) and the **total**, general load.

Both total and specific loads are thus suited to environmental policy analyses and for determining objectives.

In practice (i.e. in the context of consultancy) it is likely that the Area Load (AL) (L per ha) will be used rather than total load. For the purposes of environmental policy, however, it can be less helpful that the Area Load – in contrast to total load – is not affected by the size of the area being sprayed. The Area Load is thus well suited for consultancy purposes and for determining objectives for the specific crops that are sprayed but less suited for setting a general environmental policy national objective for the overall agricultural area.

PLI
For environment policy analyses and the setting of objectives for overall agricultural pesticide use, total load can be converted to a so-called Pesticide Load Indicator (PLI), which uses as a benchmark pesticide consumption in the 2007 reference year. PLI is calculated in exactly the same way as Area Load, but while Area Load is calculated as the total load for the year divided by the area under conventional agriculture in the year, the **PLI is the total load for the year divided by the area under conventional agriculture in 2007 (which is 2.17 million ha)**. It is thus possible to follow the development in

total load, if for example there is a marked change in the area under organic cultivation or large agricultural areas are converted to nature reserves. This would not be reflected in Area Load, but it would be reflected in PLI.

In contrast to the term Area Load, which will in practice be used in many contexts and at many levels, the PLI is relevant only to general environmental policy purposes with respect to agriculture as a whole - not for example at field level. And thus as one superordinate PLI or broken down as PLIs with respect to for example the three main indicators: human health, environmental fate and environmental toxicity.

Up to now, pesticide policy has focussed on reducing consumption in general and not on the properties of pesticides. The load calculations allow more detailed analysis of the development in consumption and thus also provide a basis for more targeted efforts. In the following, further and more detailed examples of such analyses will be given.

5 The Pesticide Load 2007-2010

5.1 The Pesticide Load Indicator and Area Load 2007-2010

The load for the period 2007-2010 is calculated as described above, for both agricultural and non-agricultural applications. On the one hand a total load (L), that is, load on the basis of sold amounts of pesticides is calculated; and on the other PLI and Area Load (AL) (that is load per ha agricultural land under crop rotation) are calculated.

5.1.1 The main trends

An overview of the key figures for the load on agricultural crops in the years 2007-2010 is shown in Table 5.1 and illustrated in the graphs in Figures 5.1, 5.2 and 5.3. The detailed breakdown of Area Load by crop type can be found in Annex 1.

Table 5.1. Key figures for load and pesticide use 2007-2010 for total pesticide sales for agricultural crops, which may be treated.

	2007	2008	2009	2010
Total load agriculture (millions L)				
Human health	2.22	3.20	2.01	2.45
Environmental fate	2.19	2.90	1.55	2.28
Environmental toxicity	2.00	4.11	3.69	3.89
Total L in millions	***6.41***	***10.22***	***7.25***	***8.61***
Agricultural area under crop rotation (millions ha)				
Total ha in millions	***2.17***	***2.25***	***2.21***	***2.22***
Area Load (AL) (L per ha)				
Human health	1.02	1.42	0.91	1.10
Environmental fate	1.01	1.29	0.70	1.03
Environmental toxicity	0.92	1.83	1.67	1.75
Total Area Load	***2.95***	***4.54***	***3.28***	***3.89***
Treatment Frequency Index (TFI) (T per ha)				
Herbicides	1.56	1.71	1.28	1.63
Growth regulators	0.11	0.15	0.14	0.12
Fungicides	0.54	0.83	0.52	0.60
Insecticides	0.30	0.50	0.63	0.46
Total TFI	***2.51***	***3.19***	***2.58***	***2.80***
Load Index (L per TFI)				
Total	***1.18***	***1.42***	***1.27***	***1.39***
The Pesticide Load Indicator (PLI)				
Human health	1.02	1.48	0.93	1.13
Environmental fate	1.01	1.34	0.71	1.05
Environmental toxicity	0.92	1.89	1.70	1.79
Total PLI	***2.95***	***4.71***	***3.34***	***3.97***

Figures 5.1 and 5.2 show the absolute and relative development, respectively, for the three parameters, TFI, AL and PLI.

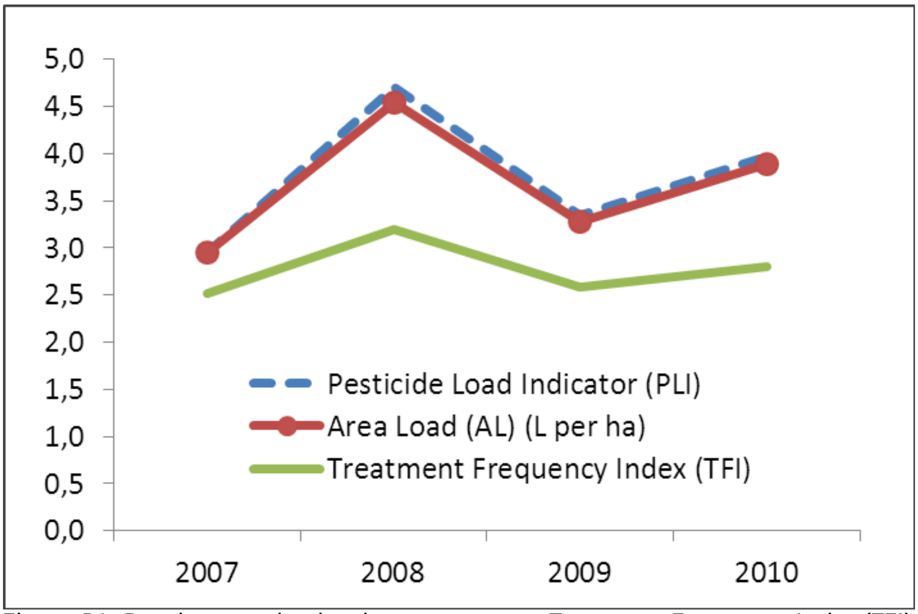

Figure 5.1 Development in the three parameters Treatment Frequency Index (TFI), Area Load (AL) and Pesticide Load Indicator (PLI) 2007-2010.

Figure 5.1 shows that the measurement of pesticide consumption (TFI) used up to now follows the same general pattern as the two new indicators AL and PLI. There was an increase between 2007 and 2008, followed by a decrease in 2009 and a new increase in 2010. The change in the TFI over the period is in large measure due to significant fluctuations in the purchase of products containing glyphosate. Certain years saw the building of stocks. This significant fluctuation in purchases over the years also affects the load indicators. When future calculations are made for several years, it will be possible to calculate a three year average of the load figures (as is done for the TFI), taking this fluctuation into account. Alternatively, the calculations can be based not only on sales figures but on reported data from spray logs. It also emerges that the PLI and the AL (by definition) are identical in 2007 and thereafter still almost identical, but the PLI is however slightly above the AL. This is because the area of land under crop rotation has increased slightly during the period.

Figure 5.2 shows that Area Load and the Pesticide Load Indicator increased between 2007 and 2010 by approximately 30 percent compared to an increase in the Treatment Frequency Index of only 11 percent in the same period. This indicates an increase in the load per standard dose (the Load Index) during the period. Several factors may be involved here. A closer analysis of the data is needed to provide an explanation.

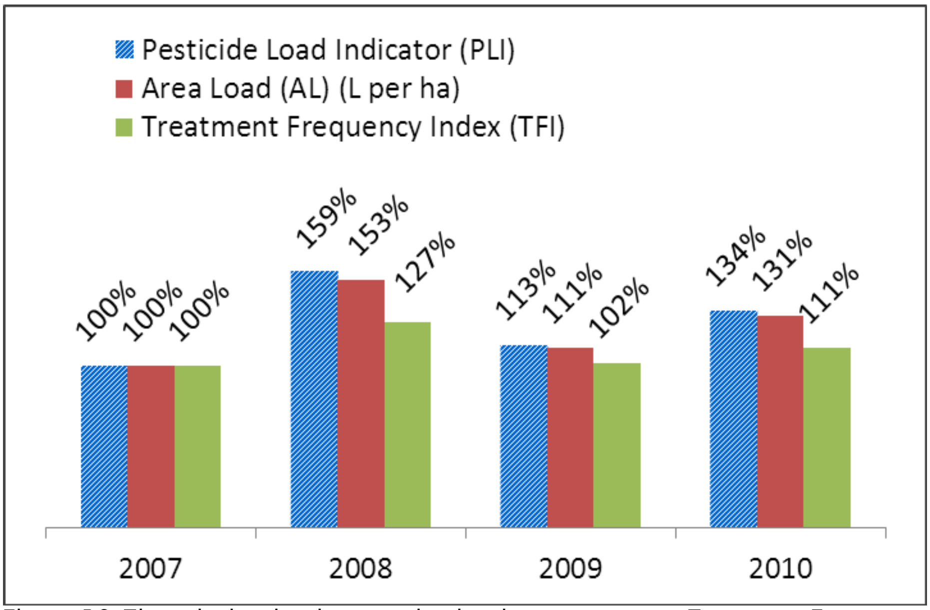

Figure 5.2 The relative development in the three parameters Treatment Frequency Index (TFI), Area Load (AL) and the Pesticide Load Indicator (PLI) 2007-2010.

Figure 5.3 shows the Area Load (AL) broken down into the three main indicators and PLI.

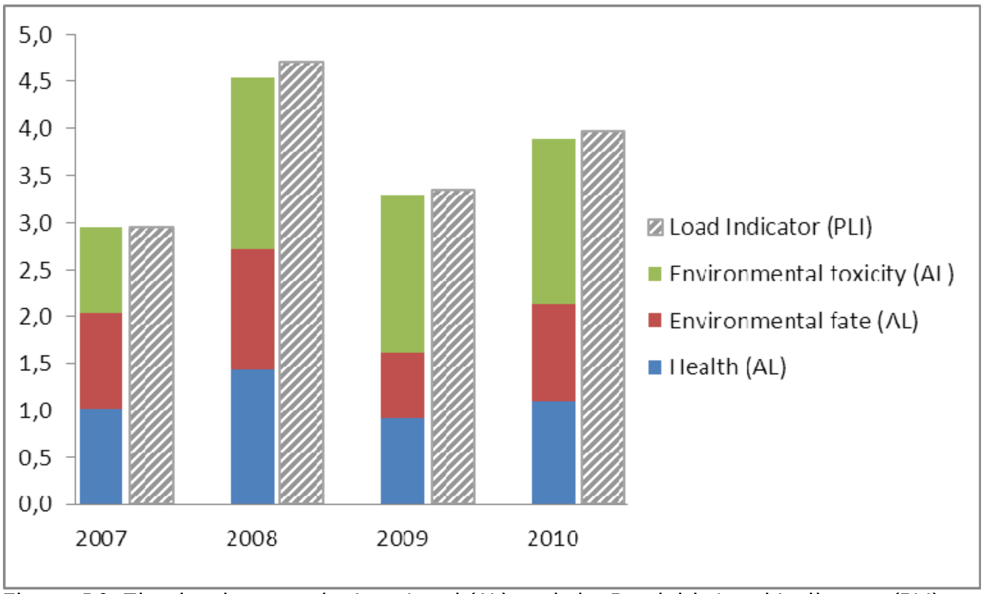

Figure 5.3 The development in Area Load (AL) and the Pesticide Load Indicator (PLI) 2007-2010. Miljøeffekt = Environmental toxicity, Miljøadfærd = Environmental fate, Sundhed = Health.

It can be seen from Table 5.1 and Figure 5.3 that a change in the distribution of the load occurred between 2007 and 2010. While in the 2007 reference year the load by definition was in general equally distributed across the three main indicators, human health, environmental fate and environmental toxicity,[6], the environmental toxicity load accounted for almost 50 percent of the overall load in 2010. At the same time, the load also increased a little for

[6] The weighting is based on the knowledge available in 2007, and with updated information on the properties of the active substances and the products' classifications in 2010 the value changes slightly.

the other indicators. When the environmental toxicity load grew during the period to approximately 50 percent of the load, this is due to a series of factors, the evaluation of which requires closer analysis of the data, but changes in choice of products during the period without doubt play an important role.

5.1.2 Details – examples

Annex 1 provides a detailed description of the development in Area Load for the main indicators, human health, environmental fate and environmental toxicity, for the main agricultural crops and for orchards, broken down by pesticide types for the years 2007-2010. To illustrate the possible uses of the load calculations, selected results and issues are presented below, primarily based on the data in Annex 1.

The following framework has been used: A) load distributed by crop 2010; L) load distributed by pesticide type 2007-2010; C) Load Index for selected products; D) an analysis of the use of pesticides resulting in the highest load in 2010; and E) a hypothetical substitution of insecticides in spring-sown cereals.

A. LOAD AND AREA LOAD ON CROPS 2010

Figure 5.4 shows the relative distribution of the total agricultural crop rotation (grey columns) and pesticide load (stacked columns) for the main agricultural crops and orchards together with other uses.

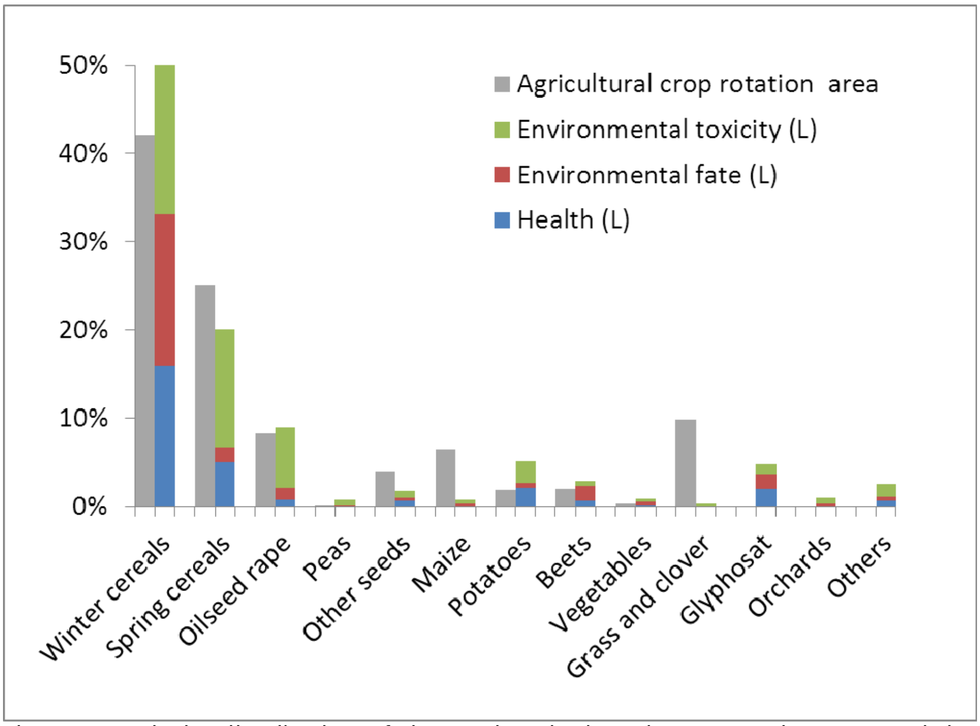

Figure 5.4 Relative distribution of the total agricultural crop rotation area and the pesticide load for the main agricultural crops, orchards and other uses in 2010. "Glyphosate" shows the use of glyphosate between two consecutive crops. The agricultural area is not shown for Glyphosate, orchards and “Other”. "Other" includes greenhouses, forestry, nurseries, domestic and garden use, public parks, golf courses, etc.

In this and subsequent figures, "Vegetables" means fieldgrown vegetables while "Glyphosate" shows the sales of glyphosate primarily destined for spraying weeds between two consecutive crops and which cannot therefore be calculated under a single crop. "Other" covers all other uses of plant protection products including in private gardens, public areas, recreational areas, sports facilities, parks, golf courses, forestry, Christmas tree production, ornamental plants and greenhouses. For further details, please refer to Annex 1.

The figure shows that the two major categories of cereals, winter cereals and spring-sown cereals, account for a total of 68 percent (48 percent and 20 percent respectively) of the total load in 2010, which roughly corresponds to the portion of the crop rotation area, which these two types of crop represented together (67 percent) (42 percent and 25 percent respectively).

The other pesticide uses do not take up much space. The almost 3 percent of the load not related to agriculture or orchards can be attributed to private gardens (approx. 2 percent), public areas, recreational areas, sports facilities, parks, golf courses, forestry (approx. 1 percent), floriculture, Christmas tree production, greenhouse vegetables and ornamental plants etc. Even if some of these show high application rates per ha, they are such small areas that their contribution to the total national load is negligible. Please refer to Annex 1 for more detail.

Winter cereals, oilseed rape and potatoes account for a larger portion of the total load than their share of the total area immediately entitles them to. For spring-sown cereals and "other seed crops", primarily seed grass, the share of the total load is by contrast lower than the corresponding share in area.

Figure 5.5 shows the Area Load for the main agricultural crops and orchards in 2010.

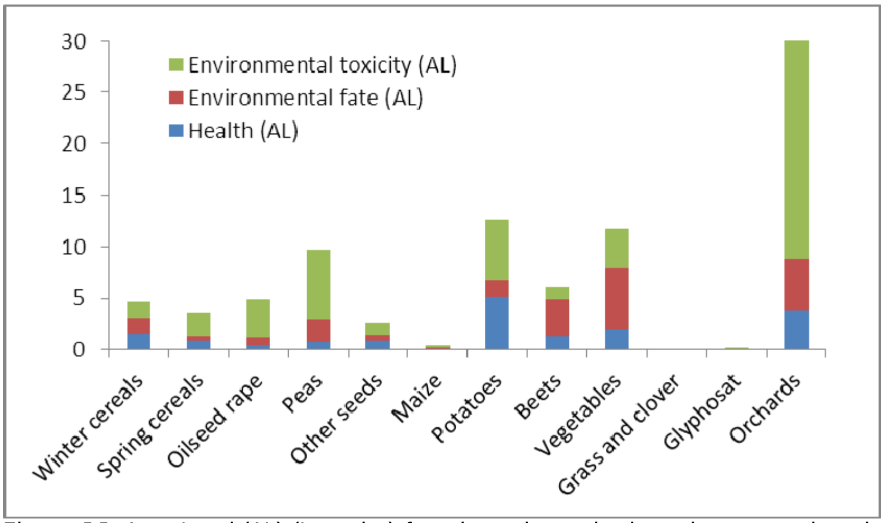

Figure 5.5 Area Load (AL) (L per ha) for the main agricultural crops and orchards in 2010.

As Figure 5.5 makes clear, the picture looks quite different when looking at the Area Load (load per ha) of various crop types than when looking at total load by crop, which does not take account of the size of the area to which the pesticides are applied (Figure 5.4). The largest Area Load can be found for orchards, potatoes, peas and vegetables with loads of 30, 13, 10 and 12 L per ha, respectively. The Area Load of these crops is thus three to six times greater than the average for crop rotation areas, which (cf. Table 5.1) had an Area Load of 4.3 L per ha in 2010.

Whilst the distribution of Area Load on winter cereals for example is roughly equal for human health, environmental fate and environmental toxicity, respectively, for spring-sown cereals, oilseed rape, peas, potatoes and orchards the environmental toxicity is dominating the total Area Load. For these crops, environmental toxicity accounts for more than 50 percent of the crop's total Area Load.

B. AREA LOAD FOR PESTICIDE TYPES 2007-2010

Table 5.2 and Figures 5.6 and 5.7 show the development in Area Load, the Treatment Frequency Index and the Load Index for agricultural use of pesticides between 2007 and 2010.

Table 5.2. Development in Area Load (AL) (L per ha), Treatment Frequency Index (TFI) and the Load Index (L per TI) for agriculture 2007-2010 by pesticide type.

Indicator	Pesticide type	2007	2008	2009	2010
Human health (AL)	Herbicides	0.52	0.50	0.44	0.48
	Fungicides	0.46	0.89	0.44	0.61
	Insecticides	0.02	0.03	0.03	0.01
	Growth regulatiors	0.02	0.01	0.01	0.01
	Total human health	*1.02*	*1.43*	*0.91*	*1.11*
Environmental fate (AL)	Herbicides	0.78	0.88	0.44	0.74
	Fungicides	0.18	0.37	0.19	0.24
	Insecticides	0.02	0.03	0.03	0.02
	Growth regulators	0.01	0.02	0.01	0.01
	Total environmental fate	*0.99*	*1.30*	*0.68*	*1.02*
Environmental toxicity (AL)	Herbicides	0.30	0.30	0.25	0.27
	Fungicides	0.16	0.25	0.13	0.15
	Insecticides	0.50	1.16	1.41	1.34
	Growth regulators	0.02	0.05	0.04	0.03
	Total environmental toxicity	*0.97*	*1.75*	*1.82*	*1.79*
Total Area Load (AL)	Herbicides	1.61	1.67	1.12	1.50
	Fungicides	0.80	1.52	0.75	1.00
	Insecticides	0.54	1.21	1.47	1.37
	Growth regulators	0.05	0.08	0.06	0.05
	Total Area Load for all types	*2.99*	*4.48*	*3.41*	*3.92*
Treatment Frequency Index (TFI)	Herbicides	1.56	1.71	1.28	1.62
	Fungicides	0.54	0.83	0.52	0.60
	Insecticides	0.30	0.50	0.63	0.46
	Growth regulators	0.11	0.15	0.14	0.12
	Total Treatment Frequency Index	*2.51*	*3.19*	*2.57*	*2.80*
Load Index (L per TI)	Herbicides	1.03	0.98	0.88	0.93
	Fungicides	1.48	1.83	1.45	1.66
	Insecticides	1.80	2.43	2.34	2.99
	Growth regulators	0.42	0.51	0.42	0.39
	Total Load Index	*1.19*	*1.40*	*1.33*	*1.40*

Based on an Area Load (AL) of 3.92 per ha and a total Treatment Frequency Index (TFI) of 2.80 for 2010, an average Load Index for the agricultural use of pesticides in 2010 of 1.40 L per TI can be calculated.

The above table and Figure 5.6 show that the Area Load as well as the Load Index showed the highest increase in the environmental toxicity of insecticides. The Area Load of insecticides thus increased from 0.54 to 1.37 L per ha and the Load Index increased from 1.80 to 2.99 L per TI. It is thus a matter of both increased use of insecticides and a change to insecticides with a greater load. This is illustrated in more detail in Example D below.

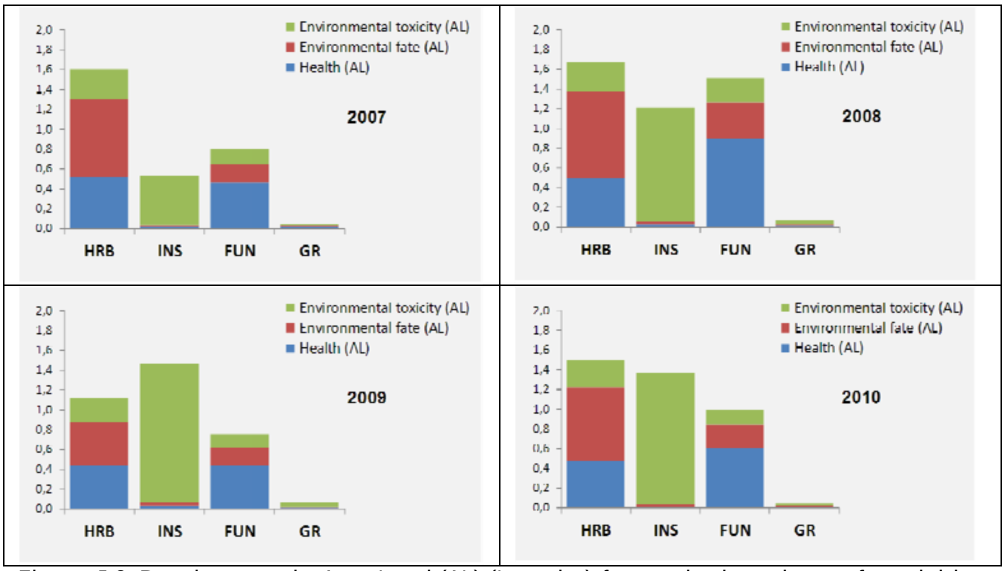

Figure 5.6 Development in Area Load (AL) (L per ha) for agricultural use of pesticides 2007-2010 by pesticide type (HRB: Herbicides, INS: Insecticides, FUN: Fungicides, GR: Growth regulators). ..

Figure 5.6 shows that between 2007 and 2010 significant shifts occurred in the dominating types of products and which of the main indicators contributed most to total load.

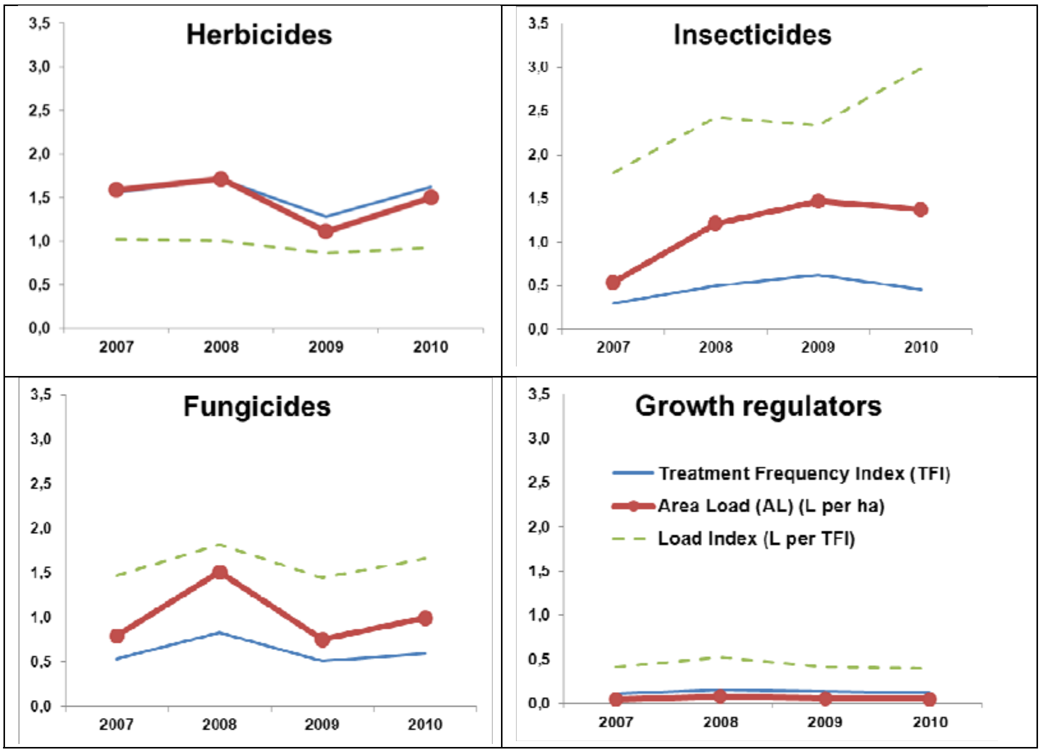

Figure 5.7 Development in the Treatment Frequency Index (TFI), Area Load (AL) (L per ha) and Load Index (L per TFI) for tha agricultural use of pesticides 2007-2010 by pesticide type.

It is clear from Figure 5.7, which shows the development in the Treatment Frequency Index (TFI), the Area Load (AL) (L per ha) and the Load Index (L per TI) for agricultural use of pesticides between 2007 and 2010 by pesticide type, that a significant increase in the Load Index (L per TI) (dashed line) occurred for insecticides from less than 2 L per TI in 2007 to more than 3 L per TI in 2010. This increase has, moreover, brought with it a significant increase in the Area Load from approx. 0.5 L per ha in 2007 to approx. 1.5 L per ha in 2010 (where an understanding of the fluctuations in the intervening period will require a detailed analysis of the data).

C. The Load Index for selected products

In connection to advice of farmers aiming at achieving a lower load from the use of pesticides, it may be relevant to focus on the load per standard dose. Based on the contribution of the pesticides and the active substances to the total load, a so-called Load Index (L per TI) can - as previously mentioned, be calculated for each individual pesticide; which is a reflection of the load per standard dose.

In Table 5.3, relevant key figures and the Load Index for a series of products are presented. For each of the four main types of pesticides, the products are sorted by descending total Load Index.

Table 5.3 Load data and Load Index for selected products. Red and green indicate the highest and lowest load, respectively. For products, which may be applied to several crops, efficacy and load index for winter cereals are used.

Regnr.	Product	Efficacy (TFI per kg)	Active ingrid. (kg per kg)	Load (L per kg)	IN TOTAL	Health	Environmental fate	Environmental toxicity
		-- (per kg of product) --			-- Load index (L per TFI) --			
FUNGICIDES								
19-144	Opera	0,93	0,18	1,75	1,88	1,24	0,24	0,41
11-29	Rubric	1,00	0,13	1,78	1,78	1,13	0,35	0,30
19-87	Opus	1,00	0,13	1,70	1,70	1,05	0,35	0,30
19-173	Bell	1,20	0,30	1,89	1,57	0,94	0,44	0,19
64-60	Dithane NT	0,50	0,75	0,52	1,04	0,60	0,02	0,42
19-143	Comet	1,00	0,25	0,79	0,79	0,15	0,15	0,49
18-391	Folicur EC 250	1,00	0,25	0,73	0,73	0,58	0,12	0,04
1-4	Tilt 250 EC	2,00	0,25	0,89	0,44	0,21	0,22	0,01
18-473	Proline EC 250	1,25	0,25	0,46	0,37	0,34	0,01	0,02
1-172	Amistar	1,00	0,25	0,24	0,24	0,00	0,18	0,06
HERBICIDES								
19-138	Stomp	0,25	0,40	1,48	5,90	0,40	5,02	0,48
1-211	Boxer	0,29	0,80	0,63	2,22	0,53	1,20	0,50
347-12	M-750	0,50	0,75	0,69	1,38	0,80	0,16	0,42
18-428	Oxitril CM	1,00	0,40	1,31	1,31	0,82	0,01	0,47
396-12	Agil 100 EC	0,67	0,10	0,61	0,92	0,82	0,07	0,03
347-5	Metaxon	0,50	0,75	0,42	0,83	0,25	0,16	0,42
48-29	Roundup Max	0,54	0,68	0,36	0,66	0,43	0,14	0,09
19-74	Basagran M 75	0,40	0,33	0,22	0,55	0,25	0,18	0,11
19-179	Fighter 480	0,67	0,48	0,27	0,41	0,15	0,19	0,07
19-109	Command CS	3,00	0,36	0,90	0,30	0,12	0,14	0,05
48-15	Roundup 3000	0,32	0,48	0,09	0,28	0,00	0,17	0,10
48-16	Roundup Bio	0,24	0,36	0,07	0,27	0,00	0,17	0,10
64-68	Starane XL	1,56	0,10	0,40	0,26	0,24	0,01	0,01
3-168	Ally ST	83,30	0,50	20,99	0,25	0,00	0,23	0,02
18-416	DFF	5,00	0,50	1,20	0,24	0,00	0,19	0,05
64-70	Mustang forte	1,32	0,20	0,25	0,19	0,11	0,04	0,03
3-156	Harmony Plus ST	51,80	0,50	9,55	0,18	0,00	0,17	0,01
1-185	Callisto	0,67	0,10	0,10	0,15	0,00	0,10	0,05
19-93	Focus Ultra	0,50	0,10	0,06	0,12	0,10	0,01	0,01
18-505	Atlantis OD	1,11	0,01	0,14	0,12	0,11	0,01	0,00
3-164	Express ST	66,67	0,50	7,34	0,11	0,00	0,11	0,00
18-442	MaisTer	6,70	0,31	0,63	0,09	0,01	0,01	0,08
48-28	Monitor	45,70	0,80	3,58	0,08	0,00	0,05	0,03
18-493	Hussar OD	10,00	0,10	0,48	0,05	0,01	0,02	0,01
64-69	Broadway	8,20	0,09	0,28	0,03	0,01	0,02	0,01
INSECTICIDES								
579-2	Cyperb 100	4,00	0,10	14,71	3,68	0,09	0,03	3,56
396-13	Mavrik 2F	5,00	0,24	12,85	2,57	0,00	0,05	2,52
11-40	Nexide CS	20,00	0,06	34,51	1,73	0,01	0,00	1,71
19-139	Fastac 50	4,00	0,05	5,26	1,31	0,06	0,01	1,24
1-163	Karate 2,5 WG	3,33	0,03	2,92	0,88	0,05	0,01	0,82
1-168	Pirimor G	4,00	0,50	2,87	0,72	0,14	0,08	0,50
18-501	Biscaya OD 240	3,33	0,24	0,94	0,28	0,16	0,04	0,09
GROWTH REGULATORS								
19-22	Cycocel 750	0,82	0,75	0,35	0,43	0,06	0,06	0,31
19-4	Terpal	0,58	0,46	0,19	0,34	0,09	0,13	0,12
1-154	Moddus M	2,00	0,25	0,14	0,07	0,05	0,01	0,01

Table 5.3 shows that Express is the most "effective" product measured in TI per kg product. Thus only 1/66 kg of Express is required per ha, corresponding to a standard dose of approx. 17 grams per ha to control relevant weeds. At the same time, Express is the herbicide that incurs both the highest load per kg product (2,81 L per kg) and the lowest load per treatment with a standard dose (0,04 L per TI) of all the herbicides in the table. The fact that Express has a high load per kg product is offset by the fact that it only requires a very small dose in order to control relevant weeds.

This example shows that with regard to consultancy purposes it will be more appropriate to focus on the pesticide load per standard dose than to focus on the more theoretical load per kg product.

There are also many examples of pesticides that have almost the same effect on the pests but which result in very different levels of load per standard dose. For example it emerges that Cyperb results in a total load approximately three times as high as the load for Fastac. It also emerges that for example Cyperb has a total Load Index which is nearly eight times as high as the total Load Index for Pirimor, which is the insecticide with the lowest load shown in the table. Conversely Pirimor has a slightly higher Load Index for human health and environmental fate than the other insecticides. This indicates on the one hand that there may be a significant potential for reducing the load by replacing (substituting) the pesticides with the highest loads with pesticides which having lower loads but are equally effective, and on the other that it can be difficult to reduce the total load without increasing the load for individual sub indicators. With the current weighting, substitution makes god sense.

It can be seen that Stomp is the product with the highest Load Index in the table (5.91 L per TI). The high Load Index is partly due to the fact that 4 kg product are used per treatment (0.25 TI per kg), and partly that the active substances in Stomp have a high load with respect to environmental fate.

Substitution can also be simply using a product with a different formula – even though the active substance is the same. In this regard the three Roundup (glyphosate-based) products are an example. Their toxicity and load profiles are very different. With a Load Index of 0.64 L per TI, Roundup Max has more than three times the load of Roundup Bio, which has a Load Index of 0.24 L per TI. The difference between Roundup Max and Roundup Bio is primarily the lower health load due to the formulation of Roundup Bio.

Again, tt must be stressed that the load calculations are based exclusively on the inherent properties of active substances and they do not take account of risk-reducing measures – like bee hazard labelling or rules on observing distances from water courses during application and similar on the label. A high load figure for environmental toxicity does not necessarily mean, therefore, that the use will result in effects on non-target organisms, provided that the product has been used as prescribed. But any application of environmentally alien substances in nature, whose purpose is to control living organisms, will have the potential to affect other organisms and exert undesired harm to these organisms, which is why it is important to reduce the risk of this happening – for instance by replacing the pesticides whose properties have the highest load.

D. Analysis of the use of pesticides resulting in the highest load

The following will examine some examples of ways in which the use of pesticides resulting in the highest load can be identified.

Generally speaking it is a matter of reducing the total load (L) on for example a spray operator, a ground water area or a bird. In order to identify the change of approach that can most effectively reduce the total load, it is thus an obvious step to identify the use of pesticides resulting in the highest load. As the load is additive on all crops and pests, however, the use of pesticides that contributes most to the total load is only interesting because a given, relative reduction in the load for this pesticide use will have a more pronounced effect on the total load than a corresponding reduction in another pesticide use with a lower load.

From a production and environmental policy point of view, however, it will be economically rational to prioritise a reduced load where this can be done as cheaply as possible and with the least possible marginal loss of production per load unit (i.e. per L), where the marginal reduction cost is measured in DKK per L. This prioritisation should moreover be undertaken without regard to the extent of areas or the intensity of the load of the pesticide use in question.

In the present report, such an analysis of the possibilities of an economically prioritised reduction of the pesticide load for relevant load indicators has not been carried out. The analyses here focus on the uses of pesticides that have the highest Area Load and thus – everything else being equal – the greatest potential for reduction, as well as the use of pesticides that contributes most to the total load for a given load indicator.

In Table 5.4, the Treatment Frequency Index, Area Load and Load Index for the main crops and pesticide types in 2010 are shown.

As already mentioned, for a complete overview of Area Load for all combinations of main crops, pesticide types and main indicators for all years between 2007 and 2010, please refer to Annex 1.

Table 5.4 The Treatment Frequency Index (TFI), Area Load (AL) (L per ha) and Load Index (L per TFI) for main crops and pesticide types in 2010. Glyphosate is the use between two consecutive crops. Red and green indicate the highest and lowest load, respectively.

	Treatment Frequency Index (TFI)					Area Load (AL) (L per ha)					Load Index (L per TFI)				
	HRB	GR	FUN	INS	Total	HRB	GR	FUN	INS	Total	HRB	GR	FUN	INS	Total
Winter cereals	1,27	0,18	0,77	0,38	2,60	1,83	0,08	1,67	1,06	4,65	1,44	0,43	2,16	2,82	1,78
Spring cereals	0,85	0,09	0,54	0,69	2,18	0,87	0,02	0,65	2,00	3,54	1,02	0,20	1,20	2,88	1,62
Oilseed rape	1,36		0,33	1,30	2,99	0,93		0,19	3,76	4,88	0,68		0,58	2,89	1,63
Peas	3,02			3,07	6,08	2,85			6,83	9,68	0,94			2,23	1,59
Other seeds	1,22	0,56	0,28	0,13	2,19	1,40	0,23	0,30	0,64	2,57	1,15	0,42	1,09	4,85	1,18
Maize	3,83		0,27	0,27	4,36	0,29		0,00	0,12	0,41	0,07		0,00	0,46	0,09
Potatoes	1,58		6,14	0,75	8,47	3,34		5,23	4,08	12,65	2,11		0,85	5,47	1,49
Beets	0,95			0,03	0,97	4,80			0,62	5,43	5,08			24,16	5,59
Vegetables	1,51	0,08	1,30	0,91	3,80	7,64	0,01	1,20	2,86	11,71	5,07	0,14	0,92	3,14	3,08
Grass and clover	0,02			0,01	0,04	0,03			0,06	0,09	1,43			4,75	2,68
Glyphosat	0,14				0,14	0,19				0,19	1,39				1,39
Orchards						1,60	0,29	7,75	20,50						

Explanation HRB: Herbicides, GR: Growth regulators, FUN Fungicides, INS: Insecticides

Table 5.4 shows that the highest Treatment Frequency Index, 6.14, was calculated for fungicides in potatoes. Thereafter follow herbicides in maize with TFI 3.83, and insecticides and herbicides on peas with TFI 3.07 and 3.02, respectively. A series of crops, e.g. grass and clover, are sprayed very little or not at all. For orchards, no earlier calculation of the Treatment Frequency Index has been carried out (as information on standard doses and distribution volumes between crops is missing), which is why the Treatment Frequency Index and Load Index are omitted for these crops in the table.

With regard to Area Load, it is insecticides in orchards, peas, potatoes and oilseed rape as well as herbicides in vegetables that have the highest scores with an Area Load of between 20.5 and 3.78 L per ha. Generally speaking it is orchards and potatoes that record the highest pesticide load, measured as Area Load.

Figure 5.8 shows total load for agriculture broken down by main crops and pesticide types in 2010.

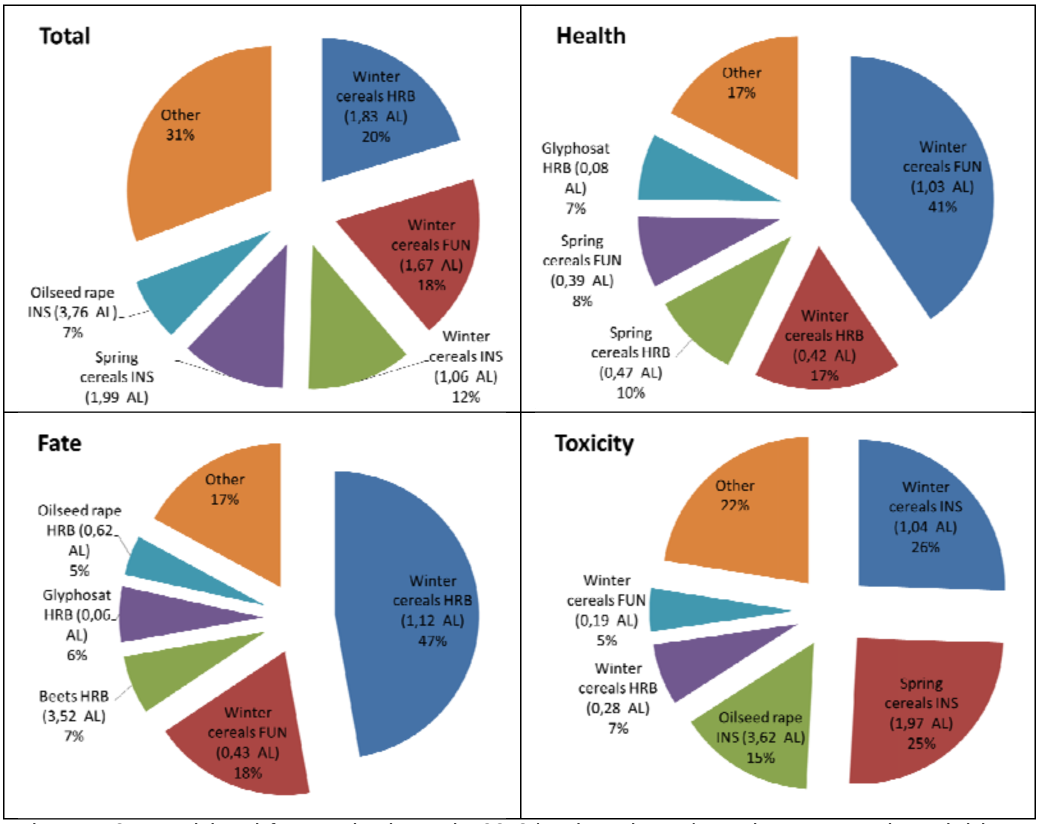

Figure 5.8 Total load for agriculture in 2010 broken down by main crops and pesticide types (HRB: Herbicides, INS: Insecticides, FUN: Fungicides, GR: Growth regulators). Toxicity = Environmental toxicity, Fate = Environmental fate,. "BF" = Area Load.

It can be seen from Figure 5.8 that the use of herbicides and fungicides in winter cereals accounts for 20 and 18 percent, respectively, of the total load in 2010. For the indicators human health, environmental fate and environmental toxicity, it is fungicides in winter cereals, herbicides in winter cereals and insecticides in spring-sown cereals that account for 41, 47 and 26 percent, respectively, of the respective load. It is thus no single type of pesticide use in a single crop that is responsible for the total load, but it is clear that fungicides on winter cereals incur a particularly large load on the health of the spray operators, whilst herbicides on winter cereals exert a particularly high environmental fate load (measured by potential for accumulating in the environment, biodegradability in soil and leaching to ground water).

Insecticides result in a particularly high environmental toxicity load but here the load cannot be attributed to a single crop in the same way.

This analysis has shown that a large part of the specific pesticide load can be attributed to specific crops and pests, but that the total general load can only be reduced by making efforts with respect to several crops and by substituting products against many different pests.

D. EXAMPLE OF SUBSTITUTION OF INSECTICIDES IN SPRING-SOWN CEREALS

Replacing products resulting in a high load with others resulting in a lower load is a possibility to reduce the load. With such a substitution of products, it will in theory be possible to simultaneously reduce the load and to maintain the Treatment Frequency Index unchanged, and thus have the same effect on the relevant pest.

The following example is provided to illustrate the potential for load reduction through substitution. It includes a completely hypothetical replacement of all insecticides in spring-sown cereals with the insecticide Pirimor, which has a significantly lower (total) Load Index than the other insecticides. It should be noted that Pirimor primarily has an effect on aphids; that insecticides in spring-sown cereals can also be used against pests other than aphids; and that Pirimor is currently more expensive to use than the other insecticides.

Table 5.5 Area Load (AL) (L per ha), Treatment Frequency Index (TFI) and Load Index (L per TI) for insecticides in spring-sown cereals in 2010

Product	Human health (AL)	Environmental fate (AL)	Environmental toxicity (AL)	Total (AL)	Share of total AL for insecticides	Treatments (TFI)	Load Index (L per TI)
Cyperb 100	0,023	0,010	1,423	1,456	73%	0,40	3,64
Mavrik 2F	0	0,002	0,076	0,077	3,8%	0,03	2,57
Nexide CS	0,001	0,001	0,311	0,313	16%	0,15	2,13
Fastac 50	0,005	0,001	0,102	0,108	5,4%	0,08	1,31
Karate 2,5 WG	0,002	0,0004	0,039	0,042	2,1%	0,05	0,88
Pirimor G	0,003	0,002	0,005	0,009	0,5%	0,02	0,53
LFS Pirimicarb	0,00004	0,00004	0,0001	0,0002	0,0%	0,0003	0,53
I alt 2010	0,033	0,016	1,956	2,005	100%	0,72	3,17
Substitution of all to Pirimor	0,069	0,064	0,124	0,257		0,49	0,53
Reduction	-0,036	-0,048	1,831	1,748		0,23	
Relative reduction	~ 0 %	~ 0 %	94%	87%		32%	

The table shows that the insecticides used on spring-sown cereals result in a high Area Load of 2.00 L per ha. Cyperb, which accounts for 73 percent of the Area Load, thus has a Load Index of 3.64 L per TI, whilst the pirimicarb products (Pirimor G and LFS Pirimicarb), have a Load Index of only 0.53 L per TI. A theoretical replacement of the insecticides currently used in spring-sown cereals with pirimicarb products will therefore enable a considerable reduction of the total load on spring-sown cereals.

If – based on an expert evaluation – an exchange rate of 0.75 TI of the current products in relation to 0.5 TI of Pirimor is assumed, the total load for insecticides in spring-sown cereals, cf. Table 5.5, can be reduced from 2.00 L per ha to 0.26 L per ha. At the same time, however, the loads on human health and environmental fate are increased by 0.04 and 0.05 L per ha, respectively, but all in all the substitution has resulted in a reduction in total load of 87 percent.

As mentioned this is a hypothetical example to illustrate the great potential for significant reductions in the pesticide load, which substitution in combination with the new load indicator can achieve.

Annex A - Load 2007-2010

This Annex provides more detail than Chapter 5 of the report. Besides the well-known agricultural crops, the following main crops (corresponding to footnote 1 in the following tables) have been used: "Vegetables" means field-scale vegetables, "Other seed" is dominated by grass and clover seed, whilst "Glyphosate" shows the sales of glyphosate (i.e. Roundup), which is primarily used for spraying weeds between crops and outside the growth season. Sales of glyphosate cannot therefore be computed under a single crop but are distributed over the entire crop rotation area. "Other" covers all other uses of plant protection products including house and garden, public areas, recreational areas, sports facilities, parks and golf courses. The term "Forestry" covers forests and nurseries, "House and garden" covers house and garden, public areas, recreational areas, sports facilities, parks and golf courses, whilst "Rest" covers all other, undistributed uses of pesticides.

For the period 2007-2010 the estimated areas are approx. 3,000 ha orchards, 300 ha greenhouses, 4,000 ha forest, Christmas tree cultivation and nurseries, and 300,000 ha urban areas (covering houses, gardens, parks, roads, sports facilities, golf courses and other recreational purposes).

Table A.1 The development in Area Load (AL) (L per ha) for the main agricultural crops and orchards1) for pesticide types 2007-2010.

	HEALTH (L per ha)				FATE (L per ha)				TOXICITY (L per ha)				TOTAL (L per ha)			
	2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010
FUNGICIDES																
Winter cereals	0,80	1,53	0,72	1,04	0,29	0,64	0,35	0,44	0,19	0,32	0,15	0,20	1,27	2,49	1,22	1,67
Spring cereals	0,14	0,36	0,24	0,39	0,12	0,25	0,12	0,16	0,09	0,12	0,08	0,10	0,35	0,74	0,45	0,65
Oilseed rape	0,02	0,07	0,06	0,09	0,03	0,10	0,07	0,08	0,01	0,01	0,01	0,02	0,06	0,18	0,13	0,19
Peas	0,03	0,11	0,12	0,00	0,04	0,05	0,02	0,00	0,02	0,04	0,03	0,00	0,08	0,21	0,17	0,00
Other seeds	0,04	0,17	0,13	0,14	0,08	0,13	0,08	0,11	0,02	0,07	0,05	0,05	0,14	0,36	0,27	0,30
Potatoes	4,99	6,27	3,69	3,07	1,05	0,77	0,43	0,26	2,73	3,83	2,28	1,90	8,77	10,87	6,40	5,23
Beets	0,41	0,90	0,27	0,45	0,12	0,20	0,07	0,10	0,10	0,20	0,06	0,09	0,63	1,30	0,40	0,64
Vegetables	0,45	1,30	1,22	0,26	0,85	1,21	0,70	0,61	0,42	0,87	0,54	0,33	1,72	3,38	2,47	1,20
Orchards	6,31	6,62	8,64	2,57	3,17	3,76	3,42	2,74	4,08	3,59	3,98	2,44	13,57	13,97	16,04	7,75
Average	0,48	0,82	0,45	0,61	0,18	0,35	0,20	0,25	0,16	0,24	0,13	0,15	0,83	1,41	0,78	1,01
HERBICIDES																
Winter cereals	0,54	0,49	0,45	0,43	1,01	1,14	0,73	1,13	0,29	0,30	0,25	0,28	1,84	1,93	1,42	1,83
Spring cereals	0,49	0,45	0,55	0,48	0,14	0,08	0,11	0,12	0,30	0,25	0,31	0,27	0,94	0,79	0,97	0,87
Oilseed rape	0,23	0,22	0,11	0,24	0,48	0,51	0,35	0,63	0,03	0,18	0,05	0,06	0,75	0,92	0,50	0,93
Peas	1,19	0,87	0,72	0,63	1,53	1,45	2,61	1,94	0,20	0,28	0,35	0,28	2,92	2,61	3,68	2,85
Other seeds	0,91	0,85	0,62	0,73	0,46	0,36	0,19	0,30	0,42	0,40	0,32	0,36	1,78	1,61	1,13	1,40
Maize	0,25	0,25	0,08	0,04	2,31	2,95	0,05	0,15	0,29	0,36	0,11	0,10	2,85	3,56	0,25	0,29
Potatoes	1,39	1,63	1,85	2,01	1,31	1,61	1,51	1,01	0,28	0,34	0,38	0,32	2,98	3,58	3,73	3,34
Beets	0,79	1,07	0,21	0,78	2,31	2,73	0,94	3,53	0,28	0,37	0,15	0,49	3,38	4,17	1,30	4,80
Vegetables	1,89	1,41	1,39	1,62	3,82	4,32	5,75	5,30	0,56	0,64	0,78	0,72	6,26	6,36	7,92	7,64
Grass and clover	0,04	0,00	0,01	0,01	0,02	0,01	0,01	0,01	0,02	0,01	0,01	0,01	0,08	0,02	0,03	0,03
Glyphosat	0,04	0,05	0,03	0,08	0,05	0,06	0,03	0,06	0,04	0,04	0,02	0,05	0,12	0,16	0,08	0,19
Orchards	1,46	0,57	0,50	0,46	5,13	0,91	0,65	0,99	1,72	0,27	0,06	0,15	8,31	1,75	1,22	1,60
Average	0,51	0,49	0,43	0,47	0,81	0,86	0,47	0,76	0,29	0,30	0,24	0,27	1,61	1,65	1,13	1,50
INSECTICIDES																
Winter cereals	0,01	0,01	0,02	0,01	0,00	0,01	0,01	0,01	0,28	0,82	1,03	1,05	0,29	0,84	1,06	1,06
Spring cereals	0,01	0,02	0,04	0,01	0,01	0,01	0,02	0,02	0,48	1,20	1,85	1,97	0,50	1,23	1,91	2,00
Oilseed rape	0,08	0,09	0,09	0,06	0,05	0,07	0,06	0,07	1,95	3,16	3,21	3,63	2,09	3,31	3,37	3,76
Peas	0,14	0,45	0,34	0,16	0,12	0,40	0,28	0,19	4,05	10,44	7,13	6,48	4,31	11,29	7,76	6,83
Other seeds	0,01	0,01	0,01	0,00	0,00	0,01	0,00	0,00	0,17	0,72	0,54	0,63	0,17	0,74	0,56	0,64
Maize	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,03	0,13	0,15	0,12	0,04	0,13	0,15	0,12
Potatoes	0,14	0,21	0,18	0,09	0,34	0,48	0,37	0,27	1,69	5,40	4,38	3,72	2,17	6,08	4,93	4,08
Beets	0,02	0,06	0,05	0,03	0,10	0,09	0,11	0,05	0,42	1,12	0,78	0,55	0,54	1,27	0,94	0,62
Vegetables	0,09	0,19	0,18	0,09	0,04	0,15	0,13	0,09	1,68	3,59	3,28	2,67	1,81	3,93	3,58	2,86
Grass and clover	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,02	0,08	0,08	0,06	0,02	0,08	0,08	0,06
Orchards	0,92	0,94	1,14	0,38	5,42	3,10	4,88	1,36	46,07	37,30	51,33	18,76	52,41	41,33	57,35	20,50
Average	0,02	0,03	0,03	0,01	0,02	0,03	0,03	0,02	0,53	1,15	1,34	1,33	0,57	1,20	1,40	1,37
GROWTH REGULATORS																
Winter cereals	0,04	0,02	0,02	0,01	0,02	0,04	0,03	0,02	0,04	0,10	0,08	0,05	0,10	0,15	0,13	0,08
Spring cereals	0,01	0,00	0,00	0,01	0,00	0,00	0,00	0,01	0,00	0,00	0,00	0,01	0,01	0,01	0,01	0,02
Other seeds	0,03	0,07	0,06	0,05	0,02	0,07	0,06	0,05	0,06	0,18	0,15	0,14	0,11	0,32	0,27	0,23
Vegetables	0,00	0,00	0,00	0,00	0,01	0,00	0,01	0,00	0,01	0,00	0,01	0,01	0,02	0,00	0,02	0,01
Orchards	0,29	0,26	0,24	0,29	0,01	0,01	0,00	0,01	0,00	0,00	0,00	0,00	0,29	0,27	0,24	0,29
Average	0,02	0,01	0,01	0,01	0,01	0,02	0,02	0,01	0,02	0,04	0,04	0,03	0,05	0,07	0,07	0,05
ALL PESTICIDES																
Winter cereals	1,38	2,06	1,21	1,48	1,32	1,83	1,12	1,59	0,79	1,53	1,50	1,57	3,49	5,42	3,83	4,65
Spring cereals	0,66	0,83	0,84	0,89	0,27	0,35	0,25	0,30	0,87	1,58	2,25	2,35	1,79	2,77	3,33	3,54
Oilseed rape	0,34	0,38	0,26	0,40	0,57	0,68	0,47	0,78	1,99	3,35	3,27	3,71	2,90	4,41	4,00	4,88
Peas	1,36	1,43	1,18	0,80	1,68	1,90	2,91	2,13	4,28	10,77	7,52	6,75	7,32	14,10	11,61	9,68
Other seeds	0,99	1,10	0,82	0,93	0,56	0,56	0,34	0,46	0,66	1,38	1,07	1,19	2,20	3,03	2,23	2,57
Maize	0,25	0,25	0,09	0,04	2,31	2,95	0,05	0,16	0,32	0,48	0,26	0,22	2,89	3,68	0,40	0,41
Potatoes	6,52	8,10	5,71	5,17	2,70	2,86	2,31	1,54	4,70	9,58	7,03	5,94	13,92	20,54	15,06	12,65
Beets	1,22	2,03	0,53	1,26	2,52	3,02	1,12	3,67	0,81	1,68	0,99	1,13	4,55	6,74	2,64	6,06
Vegetables	2,43	2,90	2,79	1,97	4,72	5,68	6,59	6,00	2,67	5,09	4,61	3,73	9,81	13,67	13,99	11,71
Grass and clover	0,04	0,01	0,01	0,01	0,02	0,01	0,01	0,01	0,04	0,08	0,09	0,07	0,10	0,10	0,11	0,09
Glyphosat	0,04	0,05	0,03	0,08	0,05	0,06	0,03	0,06	0,04	0,04	0,02	0,05	0,12	0,16	0,08	0,19
Orchards	8,98	8,38	10,52	3,70	13,72	7,77	8,95	5,09	51,87	41,16	55,37	21,35	74,6	57,3	74,8	30,14
Average	1,04	1,35	0,92	1,11	1,02	1,25	0,71	1,04	0,99	1,73	1,74	1,78	3,05	4,33	3,38	3,92

1) "Glyphosate" shows the use of glyphosate to control weeds between two consecutive crops and consequently cannot be assigned to a single crop.

Table A.2. Pesticide load (1000 L) for main agricultural crops and other uses in 20071)

Application	Human health	Environmental fate	Environmental toxicity	Total
Winter cereals	1,259	1,204	724	3,187
Spring-sown cereals	359	145	475	979
Oilseed rape	60	102	357	519
Peas	7	8	21	36
Other seed	84	47	56	187
Maize	36	324	45	404
Potatoes	261	108	188	557
Beets	52	108	35	196
Vegetables	14	28	16	58
Grass and clover	9	4	9	21
Glyphosate	83	106	78	266
Total agriculture	2,223	2,185	2,002	6,411
Orchards	27	41	156	224
Greenhouses	8	0	0	8
Forestry	20	26	27	74
Industry and stores	21	0	0	21
House and garden	73	25	265	363
Rest	25	21	89	135
Total	2,398	2,298	2,539	7,234

1: "Glyphosate" shows the sales of glyphosate, which is primarily used for spraying weeds between two consecutive crops and consequently cannot be assigned to a single crop.

Table A.3. Pesticide load (1000 L) for main agricultural crops and other uses in 20081)

Application	Human health	Environmental fate	Environmental toxicity	Total
Winter cereals	1,703	1,515	1,270	4,488
Spring-sown cereals	562	238	1,064	1,865
Oilseed rape	66	117	580	763
Peas	7	9	53	69
Other seed	88	45	110	243
Maize	39	454	74	567
Potatoes	332	117	393	842
Beet	83	124	69	276
Vegetables	17	34	31	82
Grass and clover	1	2	21	24
Glyphosate	123	137	101	361
Total agriculture	3,022	2,794	3,765	9,581
Orchards	25	23	123	172
Greenhouses	18	0	0	18
Forestry	2	11	64	77
Industry and stores	2	0	0	2
House and garden	92	25	63	181
Rest	43	50	98	190
Total	3,204	2,903	4,113	10,221

1: "Glyphosate" shows the sales of glyphosate, which is primarily used for spraying weeds between two consecutive crops and consequently cannot be assigned to a single crop.

Table A.4. Pesticide load (1000 L) for main agricultural crops and other uses in 2009[1)]

Application	Human health	Environmental fate	Environmental toxicity	Total
Winter cereals	1,126	1,038	1,397	3,561
Spring-sown cereals	442	134	1,188	1,764
Oilseed rape	41	76	527	644
Peas	7	18	46	71
Other seed	72	29	93	194
Maize	14	9	42	65
Potatoes	211	86	260	557
Beet	23	48	43	114
Vegetables	17	41	29	87
Grass and clover	2	3	21	27
Glyphosate	56	65	48	169
Total agriculture	2,012	1,547	3,694	7,252
Orchards	32	27	166	225
Greenhouses	4	0	0	4
Forestry	3	13	67	83
Industry and stores	6	0	0	6
House and garden	57	21	37	116
Rest	20	27	38	85
Total	2,134	1,635	4,003	7,771

1: "Glyphosate" shows the sales of glyphosate, which is primarily used for spraying weeds between two consecutive crops and consequently cannot be assigned to a single crop.

Table A.5. Pesticide load (1000 L) for main agricultural crops and other uses in 2010[1)]

Application	Human health	Environmental fate	Environmental toxicity	Total
Winter cereals	1,423	1,534	1,513	4,470
Spring-sown cereals	450	152	1,193	1,795
Oilseed rape	65	127	608	801
Peas	6	16	49	71
Other seed	58	29	75	162
Maize	6	26	36	67
Potatoes	186	56	214	456
Beet	54	158	49	261
Vegetables	13	38	24	75
Grass and clover	2	3	19	24
Glyphosate	182	144	105	432
Total agriculture	2,446	2,282	3,885	8,613
Orchards	11	15	64	90
Greenhouses	5	0	0	5
Forestry	2	17	77	96
Industry and stores	4	0	0	4
House and garden	44	13	23	79
Rest	5	14	31	50
Total	2,515	2,341	4,080	8,937

1: "Glyphosate" shows the sales of glyphosate, which is primarily used for spraying weeds between two consecutive crops and consequently cannot be assigned to a single crop.

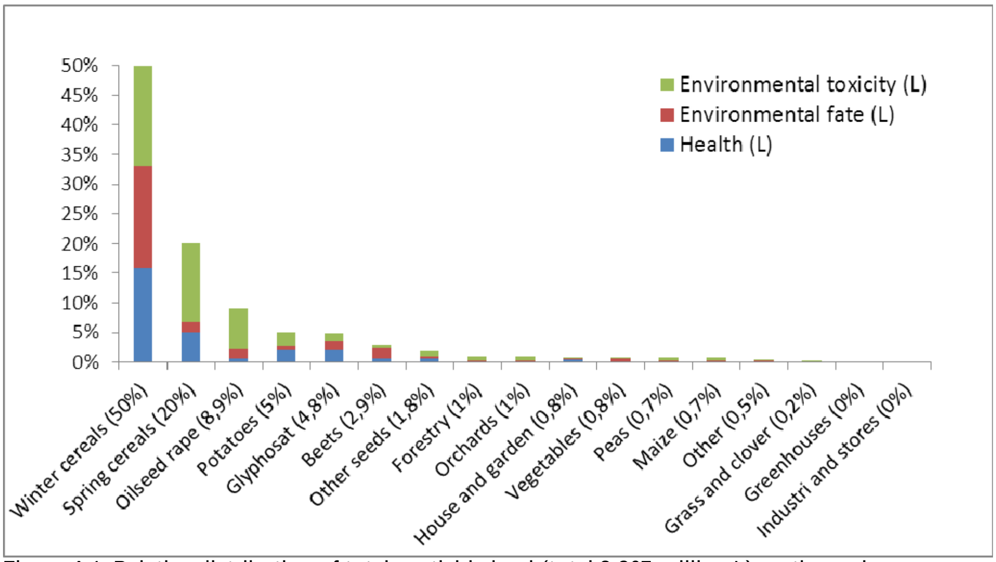

Figure A.1. Relative distribution of total pesticide load (total 8.937 million L) on the major agricultural crops and other uses in 2010. "Glyphosate" shows sales of glyphosate, which is primarily used for spraying weeds between two consecutive crops and consequently cannot be assigned to a single crop.. The term "Other" covers all other uses of plant protection products including private gardens, public areas, recreational areas, sports facilities, parks, golf courses, forestry, Christmas tree production, ornamental plants and greenhouses.

Annex B – Load factors for calculations of environmental load

1. General environmental toxicity load factors

The load factors for environmental toxicity in Table 3.5 are based on the general load factors below (Table B.1).

Table B.1 General load factors (L per kg reference active substance) for environmental toxicity

Sub indicator	General load factor (L pr kg active substance)
Mammals, acute	1
Birds, acute	1
Bees, acute	100
Earthworms, acute	2
Earthworms, chronic	2
Fish, acute	30
Fish, chronic	3
Daphnia, acute	30
Daphnia, chronic	3
Aquatic plants, acute	3
Aquatic plants, chronic	3

2. Exposure factors for long term environmental toxicity

The possible environmental impact due to long term exposure, is dependent on the biodegradability of the substances. At low biodegradability of the active substance – corresponding to a high DT_{50} value – the active substance will be present in the environment for a longer time and at a higher concentration, whereby it can result in a higher load on plants and animals, than a substance, which is rapidly degraded. For the load calculation for long term environmental toxicity, an exposure factor is, therefore, used to correct for the biodegradability. It is between 1 – for very slowly degradable active substances – and 0 for rapidly degraded substances.

The exposure factor , k , which depends on whether the degradation takes place in water (k_{W}) or soil (k_S) is calculated by means of the below equations, provided that there are available values for the half life in water (for fish and daphnia) or soil (earth worms).

If there is no value available for DT_{50} water or soil, respectively, the effect concentration is multiplied by 1.

The calculations are carried out before addition of the sub indicators to result in the total, long term environmental toxicity load for the active substance in question.

$$k_S = \left[1 - \frac{1}{\exp\left(180 * \frac{ln(2)}{DT_{50\,Soil}}\right)}\right] \Big/ \left(180 * \frac{ln(2)}{DT_{50\,Soil}}\right)$$

$$k_W = \left[1 - \frac{1}{\exp\left(7 * \frac{ln(2)}{DT_{50 Water}}\right)}\right] \Big/ \left(7 * \frac{ln(2)}{DT_{50 Water}}\right)$$

Figure B.1 shows the two exposure factors as a function of DT_{50}.

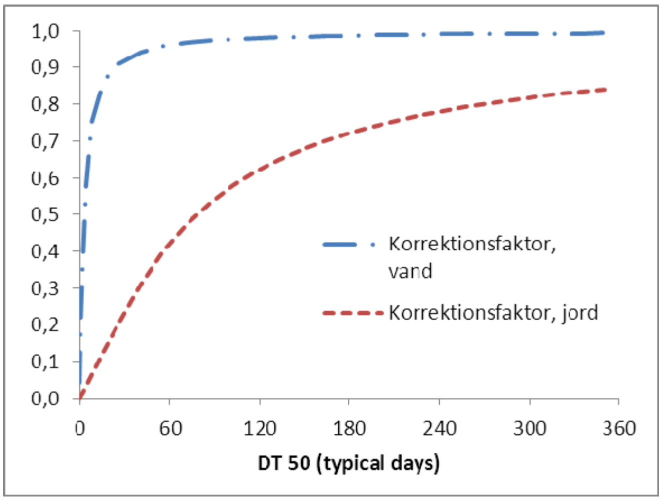

Figure B.1. Exposure factors (korrektionsfaktor), k_W og k_S, as based on the biodegradability of the active substances in water (vand) and soil (jord).

3. Exposure factors for surface treatment products

The load factors in Table 3.5 in the report are for pesticides for surface treatments corrected for exposure factors (Table B.2).

Table B.2 Exposure factors for correction of environmental toxicity load for pesticides for seed treatments

	Mammals	Birds	Bees	Earthworms	Aquatic environ-ment
Non seed treatment	1	1	1	1	1
Pesticide for seed treatment of seed/cereal	10	10	1/100	1/2	1/30
Pesticide for surface treatment of tubers/bulbs/pellets	1/10	1/10	1/100	1/2	1/30

It is clear from Table B.2 that the environmental toxicity load for treated cereals, for example, can be increased by a factor of 10 for birds and mammals but reduced by a factor of 100 for bees.

4. Biodegradability, P

For active substances, which are described as ”stable” in the PPDB, the DT_{50} is set to 2 years, when the environmental fate load is calculated. (Typically for historical calculations of the development of load.)

For the elements iron and sulphur, DT_{50} is considered to be missing, resulting in no load.

5. Estimated bioconcentration factor, BCF

In case there is no BCF value available, it is estimated from the logP by means of one of the following equations:

$$logP < 6: \quad BCF = 10^{0.85 \cdot logP - 0.7}$$

$$logP \geq 6: \quad BCF = 10^{-0.2 \cdot logP^2 + 2.74 \cdot logP - 4.72}$$

In case neither BCF nor logP is available, BCF is set to 0, equivalent to no load.

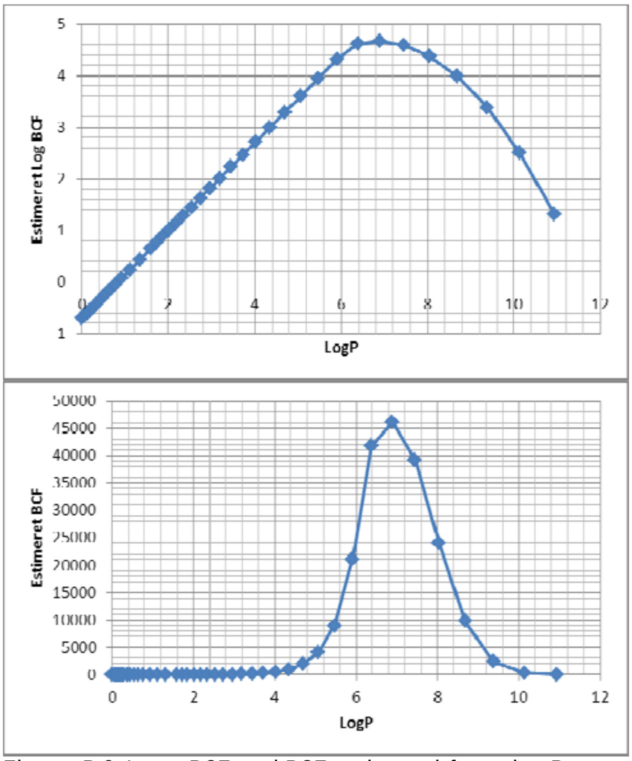

Figure B.2. Log_{10} BCF and BCF estimated from logP.

6. Estimated SCI-GROW index

The calculation of the SCI-GROW index for the active substance and it's metabolites is based on DT_{50} for soil and the Koc value (partitioning coefficient between octanol and organic carbon)) and the following equation is used.

$$U = 0.89\ 10^{-2.24 + 0.61 \log_{10}(DT50 - 5)\left(4 - \log_{10}(Koc + 5)\right)}$$

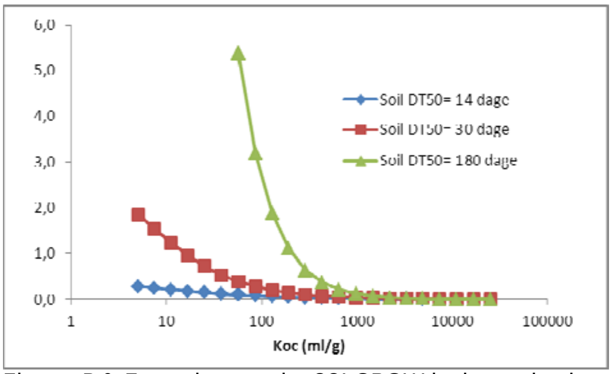

Figure B.3. Examples on the SCI-GROW index, calculated from Koc values. (Dage = days).

For metabolites, the U value is multiplied by the relative occurrence of the metabolite. In case DT_{50} or Koc is not available, U is set to 0, equivalent to no load.

Miljøministeriet
Miljøstyrelsen

Strandgade 29
DK - 1401 København K
Tlf.: (+45) 72 54 40 00

www. mst.dk