Unclassified **ENV/JM/MONO(2006)4**

Organisation de Coopération et de Développement Economiques
Organisation for Economic Co-operation and Development

25-Jan-2006

English - Or. English

ENVIRONMENT DIRECTORATE
JOINT MEETING OF THE CHEMICALS COMMITTEE AND
THE WORKING PARTY ON CHEMICALS, PESTICIDES AND BIOTECHNOLOGY

ENV/JM/MONO(2006)4
Unclassified

OECD SERIES ON EMISSION SCENARIO DOCUMENTS
Number 14

Emission Scenario Document for Insecticides for Stables and Manure Storage Systems

English - Or. English

JT00197426

OECD Environmental Health and safety Publications

Series on Emission Scenario Documents No. 14

Emission Scenario Document for Insecticides for Stables and Manure Storage Systems

Environment Directorate

Organisation for Economic Co-operation and Development

2006

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Explanatory Notes

Purpose and background

This ESD should be seen as a ‘living’ document, which provides the most updated information available. As such, an ESD can be updated to take account of changes and new information that becomes available. Users of the document are encouraged to submit comments, corrections, updates and new information to the OECD Environment, Health and Safety Division. The comments received will be forwarded to the OECD Task Force on Biocides, which will review the comments and update the document. The submitted information will also be made available to users on the OECD web-site (www.oecd.org/env/biocides).

How to use this document

The user of this ESD needs to consider how the information contained in the document covers the situation for which they wish to estimate releases of chemicals. The document could be used as a framework to identify the information needed, or the approaches in the document could be used together with the suggested default values to provide estimates. Where specific information is available it should be used in preference to the defaults. At all times, the values inputted and the results should be critically reviewed to assure their validity and appropriateness.

The primary aim of this ESD is for use in risk assessments in notification and authorisation procedures in regulatory frameworks used in OECD countries.

How this document was developed

This Emission Scenario Document was prepared by P. van der Poel and J. Bakker of RIVM, the Netherlands, and overseen by the OECD Task Force on Biocides and Task Force on Environmental Exposure Assessment. The work was funded by the Austrian Federal Minisry of Aguiculture, Forestry, Environment and Water. The Expert Group on ESDs for Insecticides, a sub-group under the Task Force on Biocides, provided guidance in drafting of this document. Chapter 7 on model refinement options was prepared by Paul Mason (Cambridge Environmental Assessments, UK), a member of the Expert Group on ESDs for Insecticides.

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1. Introduction

This Emission Scenario Document (ESD) addresses active substances for insecticides, acaricides and products to control other arthropods (in the EU, "product type 18"[1]), used in animal housing and manure storage systems. Biocidal products marketed as insecticides are used in many different applications. They may be used in buildings, outdoors, in sewer systems and for veterinary purposes in animal housings (Van Dokkum *et al.*, 1998). The emission scenarios of insecticides for manure storage systems and for stables are connected closely to those of veterinary hygiene biocidal products (the EU "product type 3"). For this product type and for veterinary medicinal products, several reports have been published already (Montfoort *et al.*, 1996; Montforts, 1999; Van der Linden, 2000). In specific cases, there may be borderline cases[2] with food and feeding area disinfectants (the EU "product type 4"), veterinary medicinal products (the EU "product type 3") or wood preservatives (the EU "product type 8"). This can occur if a biocide is used for more than one purpose. This is, for example, the case when a biocide is often used as an insecticide in animal housings, as a preservative in feed (disinfectant) and as a medicinal product against external parasites for chickens.

The scope of this ESD for insecticides used in animal housing and manure storage systems will be limited to their use as biocidal insecticide products, and will not cover similar products used as plant protection products or veterinary medicines. The distinction of biocidal products from proprietary medicinal products and veterinary medicinal products is defined as: "Products used in areas in which animals are housed, kept or transported in order to kill external (check) parasites by treating the structures but not the animal, including situations where the products are intended to be active while animals are in the structures, are classified as biocidal products[3]". Basically, biocidal products are used for non-animal (structure) treatment, while veterinary products are used on animals with therapeutic indications. Thus, manure treatment (larvicides) also falls under the scope of this ESD.

On the other hand, the following will not be included the scope of this study as they are considered as medicinal/veterinary products with precise therapeutic indications (but in the absence of such a claim and in specific cases could be considered as biocidal products):

- Products (insecticides) used for sheep dipping for the control of external parasites;
- Products for the control of external parasites of fish, used by adding the products to the water where fish swim; and
- Products/articles which contain an insecticide or another active substance with a lethal activity or with an effect on growth or reproduction of the harmful arthropods, for example collars, neckties, ears marks etc".

[1] For EU countries, "Product Type 18" – insecticides – is one of the 23 biocidal product types covered by the EU Directive 98/8/EC concerning the placing on the market of biocidal products. Commission Regulation 2032/2003 lists notified existing active substances under product type 18 which must be submitted to the competent authority of the Rapporteur Member State no earlier than 1 November 2005 and no later than 30 April 2006.

[2] In the EU, the borderlines with other EU directives and other product types are important issues and, in some cases, are still being discussed. Readers should check the original borderline guidance documents (for instance EC, 2002). The Guidance Documents set the general rules and the Manual for Decisions summarise the discussions on various issues on a case-by-case basis. All documents are available on the website: http://europa.eu.int/comm/environment/biocides/index.htm.

[3] Definition used for the EU Directive 98/8/EC.

On farms the main problem encountered is flies. There are several species of manure-breeding flies, which can become a serious problem on the farm and within the community if manure-handling systems are not managed properly. The house fly (*Musca domestica*) is one of the predominant species that breed in fresh manure, decaying silage, spilled feeds, bedding and other decaying organic matter (Penpages, 1992). The more common measures involved with the control of houseflies are sanitation, use of traps and insecticides. Depending on the stage of development of flies, specific insecticides may be applied, i.e. adulticides and larvicides. Indoors, the control of flies includes automatic misters, fly paper, electrocuting and baited traps that can be used in milk rooms and other areas of low fly numbers (Sanchez-Arroyo, 1998).

The other insects and arthropods, which may cause serious problems, are e.g. bloodsucking flies, lice, mites (acarids), louse flies and fleas. Especially poultry is susceptible to bloodsucking parasites. Active ingredients used as adulticides for flies are usually also effective against imagos of other arthropods. Baits with sugar for flies do not attract bloodsucking flies and other insects and therefore have to be treated differently.

Livestock farming in many OECD countries, often concentrated in specific regions, results in local manure surpluses and has led to a series of environmental problems, especially water pollution, ammonia emission and odour nuisance (Burton, 1996). In response to this, many governments have introduced regulations specifying minimum requirements and restrictions for the storage and spreading of wastes/manure to protect groundwater. A common theme underpinning these rules is the closer matching of manure nutrient applications to their uptake by crops and the avoidance of spreading in sensitive areas (Burton, 1996).[4]

In general, treatment of wastes, including processing to produce useful products, represents an important waste management option; in some situations, treatment may indeed represent the only effective management option in satisfactorily dealing with the manure. Such processes have received considerable interest with much research now on-going in many OECD countries. However, there is a need both to bring together many of the ideas being explored and to assess them in terms of effectiveness.

As stated above, countries may have legislation setting standards for the maximum amount of phosphate and/or nitrogen per area of agricultural soil (arable land or grassland). So, in the emission scenarios the calculation of the concentration of the insecticide in soil for the risk assessment will need to be coupled to applicable standards set for phosphate and nitrogen.

The main destination of insecticides applied in animal housings (stables, barns, etc.) is the manure. The fraction of the insecticide that is transferred with manure to the manure storage system depends on a variety of factors. In the case of application in the storage system itself, the whole amount of insecticide gets there of course. The factors of importance may be the animal species and the type of housing, the application methods and the cleaning operations, and processes such as degradation and

4 For EU member states which represent nearly 10% of the world livestock numbers, Directive 91/676/EEC (EEC, 1991) applies, which aims at: (a) the protection of surface water and groundwater with regard to the concentration of nitrates in accordance with Directive 75/440/EEC (EEC, 1975), and (b) the protection of waters from eutrophication. Member states had to establish codes of good agricultural practice to be implemented by farmers on a voluntary basis, containing provisions at least covering the items mentioned in Annex II A to Directive 91/676/EEC (see Appendix 1). In addition, member states are also required to establish action programs that consist of the mandatory measures as specified in Annex III of the Directive (see Appendix 2). A resulting proposal for an action programme for integrated groundwater protection and management includes actions addressing nitrates and other mineral emissions (action 3.2) and plant protection products and biocidal products (action 3.3) (EEC, 1996).

volatilisation. The manure containing the insecticide is stored for a certain period after which it is used for land application.

Chapter 2 is a reading guide that explains the various factors and parameters influencing the potential environmental releases. This has been done as we deal here with a very complex situation. The emission scenarios supply the Predicted Initial Environmental Concentration for soil (PIECsoil), and – for some situations – the load for (private) on-farm wastewater treatment plant (WWTP) or the standard (municipal) sewage treatment plant (STP). It should be kept in mind that this ESD provides a generic first-tier model as a tool which can be further refined. The emission scenarios presented serves to fill in gaps in our knowledge on data we do not have and which are very difficult to obtain experimentally. Validation of the models will be very useful but difficult to achieve.

The emission scenarios are for the local scale as has been common practice in the European Union for biocides so far. As soil is the main receiving compartment and leaching to groundwater may occur, it has to be considered if a more or less regional scale has to be considered in future as well. This will comprise estimation of the area receiving manure and the volume of groundwater involved in order to calculate the concentration of the insecticide in groundwater. To this purpose the predicted initial environmental concentration (PIEC) may serve as an input to more sophisticated modelling tools like for instance FOCUS (1995, 2000 and 2001) or may serve as input to more detailed calculation procedures like the FEDESA model (Spaepen, 1997), taking degradation in soil into account. This will be discussed later on in the report in chapter 7.

It should be noted that large differences may exist among countries for:

I Housing periods

For example, cattle in colder climates, e.g. Nordic European countries, will be in the stable during a long period and only a short period (or probably not at all) in warm climates, e.g. Mexico. The period that flies are present will be much longer in warmer countries than in colder countries. Furthermore, in some countries an animal species like ducks will be kept indoors exclusively while in some others they will probably be outdoors all year round.

II Land application of manure

In a number of countries land application of manure is regulated by means of immission standards for phosphate and/or nitrogen. For grassland and/or arable land a maximum amount applied per ha per year may be given, sometimes dependent on the type of soil. In various cases there are periods during which land application is not allowed.

III Composition of the livestock and manure production

The number of animals for each animal species and category kept in housing and per surface area varies a lot per country or even region. Also the average production of manure, phosphate and nitrogen per animal varies enormously due to factors such as breed and differences in the feed.

The first two aspects have a considerable impact on the storage time of the manure, the timing of the biocide application in relation to the land application of manure and thus on the concentration and degradation time of the insecticide present in the manure.

It will be clear that this emission scenario document concerns an extensive and very complicated area. This is even more complex due to the difference in daily practice, climatic and geographic variations and legislation among OECD member countries. Therefore, it is difficult to produce representative "defaults" for most parameters. The values presented refer mainly to the Dutch (average) situation and where possible values for other OECD member countries have been reported; these values can be changed when better (more representative) data become available. The aim of this report is to present realistic worst case emission scenarios that are applicable in each of the member countries It is suggested to use the scenarios for a first tier assessment. The defaults presented may be overwritten by the user with more locally relevant data, as is common practice in all biocide scenarios. Options for further model refinements and additional guidance are provided in Chapter 7.

2. Reading Guide

2.1. Coherence of factors

Insecticides may either be applied in animal housings or in manure storage systems as stated in Chapter 1. Figure 2.1 presents an overall flow scheme of the fate of insecticides for both types of application. In practice it turns out that an insecticide may be used for both the application in animal housings and in manure storage systems (larvicides). In those cases the overall concentration of both applications has to be calculated.

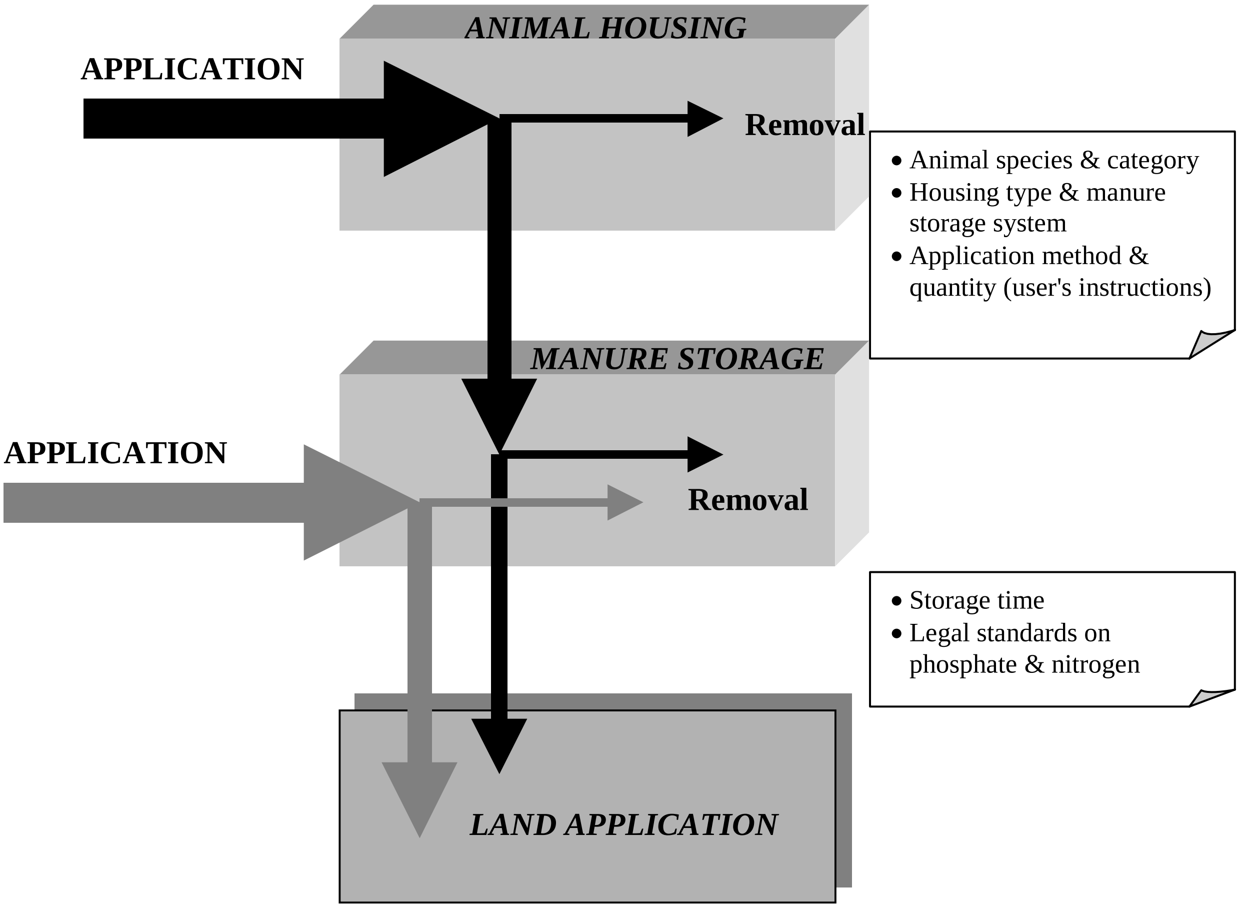

Figure 2.1 Overall flow chart of an insecticide applied in animal housings and manure storage systems; in the blocks at the right the factors influencing the transfer to manure storage systems and soil have been summarised.

Potential effects such as degradation[5], volatilisation, release to waste water have been represented as 'removal' in this figure. In order to build the emission scenarios the parameters needed for the factors influencing the releases have to be identified.

Figure 2.2 presents the connection between the various factors influencing the application and emission of insecticides. It should be noted that the type of manure storage system and housing are directly linked to each other. They are depicted separately as the emission factor of the insecticide applied in the housing to the manure storage system depends on the place where the insecticide has been applied in the housing. The grey and black block arrows represent the flow of insecticides, which for the purpose of this ESD ends with land application. Possible leaching from soil to groundwater could be considered by further refining the model. The numbered bullets in Figure 2.2 at the arrows with broken lines - representing the relations - are discussed below:

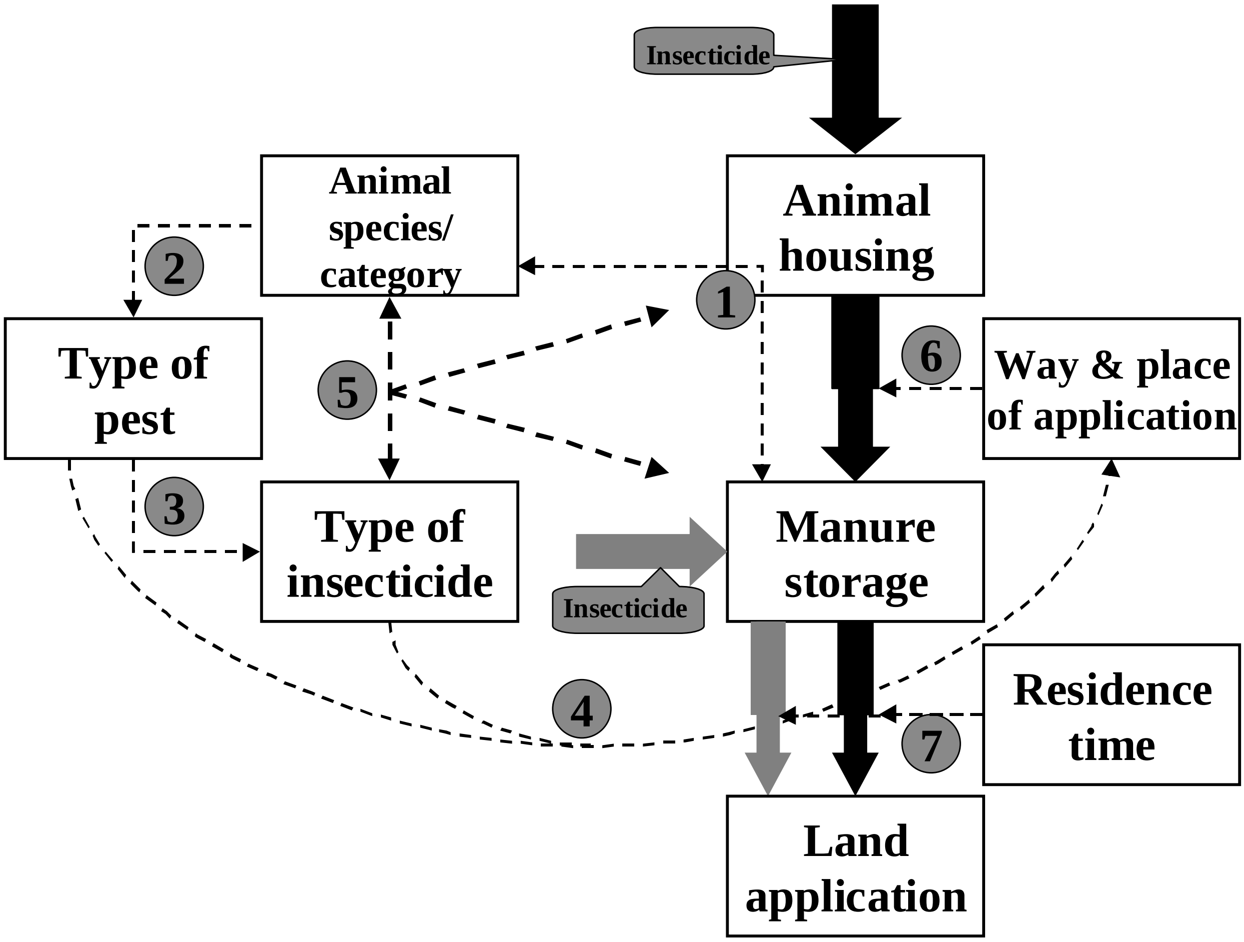

Figure 2.2 Factors influencing the application and emission of insecticides; the block arrows represent the flow of insecticides and the arrows with broken lines the relations (for explanation see text).

[5] Test Guideline for degradation in manure does not exist, while Test Guideline for degradation in soil does exist.

❶ The type/category of manure storage system (including the way the waste water is used/treated) is linked with the type of housing and the animal species/category.
Example: For the animal species pigs and category fattening pigs, the type of manure storage system is wet storage and the category slurry pits. The pigs will be placed in barns with grating floors; the type of housing is connected to the manure storage system.

❷ The animal species is linked to the various pests in the housing/manure storage system. Flies are in principle a potential pest for all animal species/categories. Especially poultry are susceptible to other insects.

❸ The type of pest dictates the type of insecticide to be used.

❹ The type of pest and type of insecticide together have an influence on the way and place of application. It should be noted that this is described in the statutory user's instructions together with the dosage.

❺ The specific animal category and type of insecticide determine the application in animal housing(s) and/or manure storage systems.

❻ The way and place of application in the animal housing have a direct influence on the fraction of the insecticide going to the manure storage system. *Example: Sprinkling of the insecticide on the floor will lead to a larger fraction than bait placed at a windowsill.*

❼ The storage time of manure together with the timing and frequency of insecticide application influences the amount of insecticide entering the storage system. The manure storage time also determines the residence time in manure, thus the degree of degradation of the insecticide in the manure at land application. As a first tier (approach) the degradation in manure is not taken into account (i.e. degradation is assumed to be zero) in this ESD, but could be replaced by users if data is available.

It is assumed that the legal standards on the phosphate and nitrogen load determine the amount of the insecticide in soil at the moment of land application, although these standards actually only apply for Nitrate Vulnerable Zones (NVZs). In practice, however, these standards are generally not exceeded in the European Union with the exception of some small regions. Thus, generally the standards also hold for non-vulnerable zones. In the context of the risk assessment of veterinary medicine, NVZ standards are used in the same way for the identification of safe use/best case situation (Montforts, 2003).

Because the nitrogen and phosphate application loads determine the amount of insecticide ending up in soil, the parameters needed for the calculation had to be determined "from the bottom up". The whole scheme with the factors and parameters needed are presented in Figure 2.3. The arrows with the broken line denote the relation between the factors/parameters opposed by the factor at the start of the arrow.

In Figure 2.3 the situation for one application has been represented. In the scenario the possibility of several applications of the insecticide is considered. In that case, the calculated concentration of the insecticide (active ingredient) depends on the time span between two treatments and the timing of the land applications for manure. The degradation in the manure is not taken into account because there are not yet standardized test guidelines available for degradation in manure, but could be added if data are available. Many of the parameters involved are dependent on items such as the animal species and category involved, the type of housing for them, the manure storage system, etc. The factors and parameters shown in the figure are presented one by one in the sections of Chapter 4. Chapter 3 presents an overview of active ingredients and the applications of formulations for the various housings and manure storage systems.

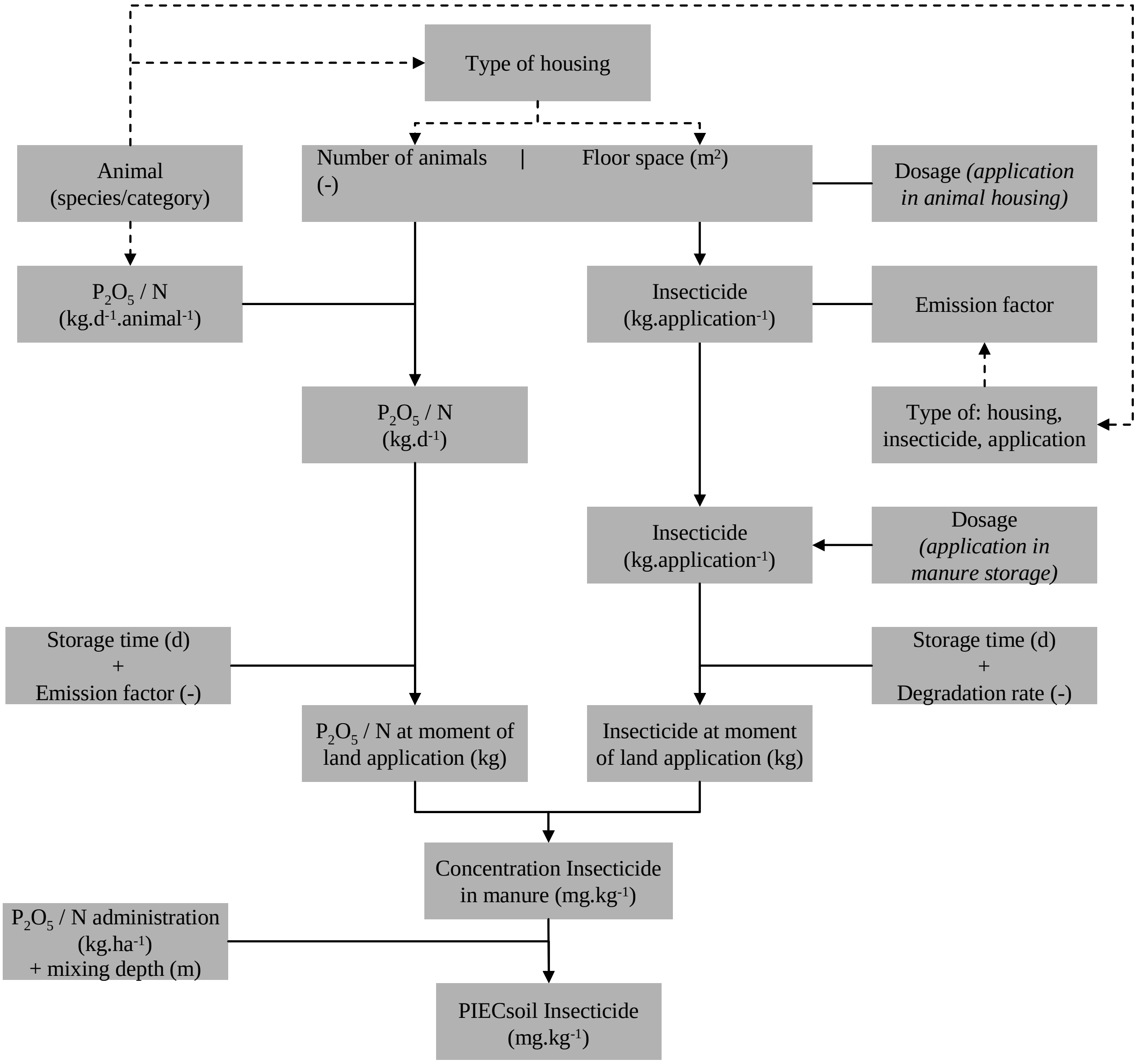

Figure 2.3 *Flow chart of an insecticide applied in animal housings and manure storage systems, where the arrows indicate the interrelationship; in the blocks on the right the factors influencing the amount and the transfer of the active ingredient to the manure storage systems are summarised. On the left the factors influencing the amount of manure produced and the transfer of manure to soil are summarised.*

Structure of the following chapters

The first section of this chapter makes clear that the situation is complicated, as there are many factors that influence the releases of insecticide; furthermore, many of these factors are linked in some way or the other. Therefore, the following chapters present:

Chapter 3 'Active substances and range of application'

In this chapter number and types of active substances have been identified.

Chapter 4 'Emission routes and fate of insecticides'

This chapter deals with the potential routes of the insecticides to the environmental compartments, i.e. soil and water. Furthermore, the chapter addresses factors that influence the fate, i.e. the effect of the place where in the housings and how the insecticides are applied.

Chapter 5 'Release estimation and the parameters involved'

All parameters needed for the emission model are discussed in separate sections in this chapter.

Chapter 6 'Emission model'

Finally the emission model is presented

Chapter 7 'Refinement options for the Emission Scenario Document'

The report includes a separate chapter on options for further refinements of the emission scenario. Alternative methods and models are described for higher tier calculations for groundwater and surface water concentrations.

The model presented in this ESD is meant to be a generic first-tier model or a tool which can be further refined by users to better reflect specific situations. It also provides guidance on available sources of locally relevant data for selected OECD countries.

3. Active substances and range of application

In the case of the EU, one hundred and four different substances are notified altogether as active substances for insecticides, acaricides and products to control other arthropods (EC, 2003a). To show the complexity in notification/authorisation of biocidal preparations, Table 3.1 presents as an example the number and range of application of notified/authorised biocide preparations for use in stables and on manure in the Netherlands (CTB, 2005). In the Netherlands, all together there are 109 biocidal products and 28 active substances authorised under the EU biocides products type 18. The complexity and variety of products authorised for stable and manure uses may be similar in other OECD countries.

Table 3.1 Number of biocide preparations authorised in the Netherlands (CTB, 2005) and the purposes for which they may be used according to the authorisation/notification.

Number of authorisations[1]	Purposes for which the biocide preparations have been authorised				
	All kinds of housings[2]	Housing for all categories	Housing for ≥1 category[3]	Manure/slurry pits	Manure heaps
35	X				
13		X			
1			X		
4		X		X	
2				X	
1				X	X

[1)] Only products for non-household indoor applications, structure, space and manure treatment are considered. Thus, excluding household insecticides against ant, lice, fleas and wasps.
[2)] Insecticides can be applied in all kinds of housing (living), accommodation and spaces, not specifically excluding livestock housing.
[3)] Sometimes one category is explicitly excluded.

The data in Table 3.1 show that it is important for the emission model to offer the possibility to assess biocides for both the application in housing and on manure heaps and in manure/slurry pits; the application in housings may occur for more than one animal species/category.

4. Emission routes and fate of insecticides

The fraction of the biocide reaching the manure storage system ($F_{manure\_storage}$) will depend on the animal species and category considered (i.e. the type of housing and manure collection system), the way of application and the way of action of the biocide.

4.1. Animal housings and manure storage systems

4.1.1. Manure storage systems

As already stated before, insecticides applied as a larvicide at manure storage systems end up completely in the manure. The degradation process in the manure storage during the time that the manure is collected and stored until it is used for land application is not taken into account. This is because no validated or standardized methods for assessing the fate in manure at either field or laboratory level are present at the moment (Montforts et al., 2003).

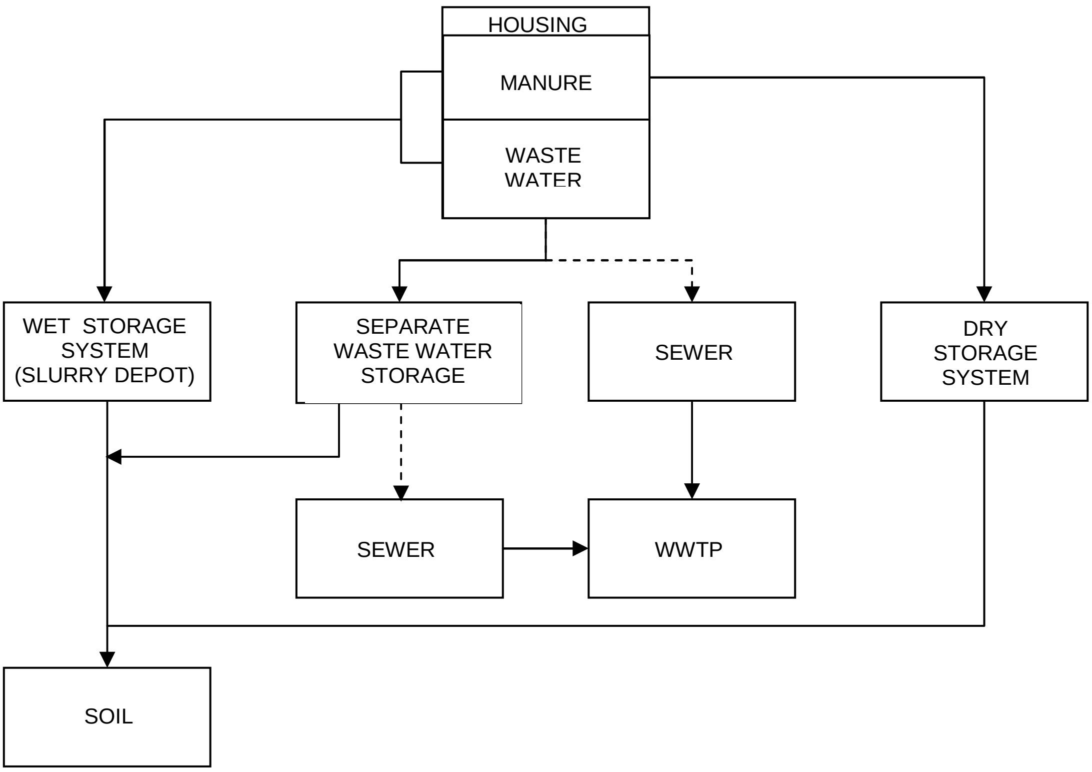

Figure 4.1 Storage systems of manure and destination of waste water and manure; dashed line indicates the possible route of stable cleaning water to the municipal or on-farm waste water treatment plant.

Liquid waste may be comprised of liquid manure (urine), effluents from dry manure storage, wet precipitation, cleaning water from milking systems or stable cleaning or juices from ensilage or household waste water. The latter is normally discharged to the public sewerage.

If a farmer has a dry storage system (manure heap or manure pit), in some cases the liquid waste or part of the liquid waste can be discharged to the sewer (third flushing of the milking system and household waste water) or will be collected in a separate slurry tank. The liquid waste from stable cleaning containing manure then may be either removed to a slurry or waste water collection tank and commonly be applied to land or treated in a communal or on-farm waste water treatment plant (EC, 2003b). In general it is believed that it is prohibited to discharge waste water containing manure to the public (municipal) sewer, although local authorities might allow livestock farms to discharge diluted waste streams to the public sewer if they are able to treat the extra pollution load. In the case of discharge to a (private) on-farm waste water treatment plant (WWTP) the same situation as for direct discharge to a municipal sewage treatment plan (STP) is considered with respect to emission routes.

In the case of field application, it may be assumed that the liquid waste is applied evenly on all fields together with the manure, as is the case with wet storage (slurry pits, where manure and waste water are collected together) (Van der Linden, 2000). This has been visualised in Figure 4.1. The option for discharge to the public sewer is left open to meet country specific legislation and for specific situations where discharge to the public sewer is allowed.

The ways of manure storage and waste water destination are independent of the biocide applied and may vary from farm to farm. Therefore, the following situations have to be considered in the risk assessment:

1. Wet storage (slurry), where the whole amount of biocide is being spread on agricultural soil;
2. Dry storage, where all of the biocide is being spread on agricultural soil. Partly with the manure and partly through irrigation of the soil with the collected waste water. With respect to the emission to soil this situation resembles the first situation;
3. In rare cases for dry storage, where a part of the biocide is being spread on agricultural soil with the manure and the other part is going to the WWTP or the public STP with the waste water. A STP model may be used for these scenarios. USES 4.0 (RIVM, 2002) and EUSES 2.0 (EC, 2004a) comprise a STP model based on the SimpleTreat model (Struijs, 1996).

Only for poultry the statutory user’s instructions may state that the insecticide is only to be used in housings with dry manure storage. For the emissions the way of application of the insecticide to manure is not important, e.g. sprinkling or spraying. The aim is to cover the whole surface of the manure.

Solid manure (Farm yard manure; FYM)

Solid or dry manures are normally transported by front loader or belt systems and stored on an impermeable concrete floor in the open or in closed barns. The store can be equipped with side walls to prevent slurry or rainwater from leaking away. These constructions are often attached to an effluent tank to store the liquid fraction separately. The liquid fraction from the solid manure storage is assumed to be spread on land and not to waste water. Within the EU, only one member state (Finland) currently requires farmers to provide a cover for solid manure heaps.

Poultry systems mostly produce solid manure. The manure may be stored in the same building as where poultry is kept until it is cleared out after the production cycle, i.e.:

- annually for laying hens in deep pit and deep litter systems (laying period 13-15 months)

- every 6 weeks for broilers (deep litter and grating floor)

Clearing out of poultry manure to external storage can also be on a more regular basis, i.e.:

- twice a week for battery systems with manure belts (belt drying and no treatment)

- daily or weekly removal from battery systems with shallow manure channel with scrapers (compact system).

Slurry

Slurry is generally stored beneath fully-slatted or partly slatted floor of livestock buildings (cattle and pigs). The in-house storage period can be quite short but may extend to several weeks, depending on design. For further storage the slurry is sluiced to collection pits and/or to slurry stores. Many pig farms produce both slurry and solid manure, but pig manure is often handled as slurry. The same holds for cattle livestock. Slurries are pumped from the slurry pit or inside slurry storage to external slurry storage. The external slurry storage may be above of below ground. Below ground storage is often rectangular as above ground storage tanks are generally circular. Slurry tanks can be open or may be covered with natural or artificial layer of floating matter or with a firm cover (canvas or concrete roof). Slurry can also be stored in earth-banked stores or lagoons. Lagoons are commonly used to store slurry for extended periods of time. Their design varies from simple ponds without any provisions to relatively well monitored storage facilities with thick plastic sheets.

4.1.2. Animal housings

The notifier/registrant of a biocide states in the statutory user's instructions how to apply the preparation. This may concern possible dilution, the way of application, for example smearing of certain places or spraying of floor, walls and ceiling, the interval for repetition and need for ventilation after application for treatment of animal housing facilities. This may influence the fraction of the biocide reaching the manure storage system and the fraction emitted directly to the air.

The type of manure and liquid waste storage system varies between the animal species and type of housing. Therefore, animal categories are distinguished in relation to their phosphate (P_2O_5) production, nitrogen (N) production and manure production; especially the farm system (manure storage system) and age of the animals are of importance.

Table 4.1 presents the animal categories and the categories for manure storage systems used in this ESD for modelling. Appendix 3 presents numerical data for livestock in OECD member countries and Appendix 4 on a more detailed level specifically for the Netherlands.

Table 4.1 Categories of animals ("housings") and storage systems used in this report.

Animal	Specific category
Cattle	Dairy cattle
	Beef cattle (fat stock)
	Veal calves
Pigs	Sows
	Fattening pigs (bacon)
Poultry	
– Chickens	Laying hens
	Broilers
	Laying hens in rearing
	Broilers in rearing
– Turkeys	
– Ducks	
– Geese	
Manure storage	**Specific category**
Dry storage	Dung heaps
Wet storage	Slurry pits

In building the scenarios for the various types of animals in livestock farming, lower ranges of stocking densities are chosen, giving a relatively large range in livestock housing systems. Furthermore when necessary, the minimum requirements for animal welfare, which have been laid down in various directives of the European Union have also been taken into account in estimating the size of livestock buildings. Much of the information on livestock farming and sizing of housing is taken from EC (2003b), the EU Directive 1999/74/EC and 2001/88/EC. Additional information has been retrieved from two publications from the Animal Science Group of the University of Wageningen (ASG, 2004a and 2004b) and Praktijkonderzoek (1999).

Cattle

Housings for pigs, fat stock and veal calves have wet manure storage exclusively. Montforts (1999) considers for dairy cows the situation that they come to the milking place in the stable twice a day during the fly season, where the manure is going to the slurry storage (wet storage) together with the water used for cleaning. The grazing period would probably to a large extent overlap with the fly season. In this particular case about 15% of the manure produced during the grazing period goes to the slurry storage (Hoek, 2002). However, the following situations for dairy cows may occur altogether. Between brackets the share of manure which goes to the manure storage during the grazing period (Hoek, 2002):

- Day and night grazing, visit to the milking parlour twice a day (15%).
- In the stable at night (40%)
- Summer stable feeding (100%)

For the local assessment, the last situation, i.e. the summer stable feeding of the cows will probably not be the worst case situation, although more insecticides may be applied (and more frequently) but on the other hand more manure is collected resulting in lower concentrations. The realistic worst case situation will probably be the situation where cattle are kept in the stable at night and in addition assuming regular use of insecticides. For example, the percentage of farms keeping their dairy cows in the stable the whole year round was estimated to be about 10% in 2003 for the Netherlands (Bont, 2004). Also for other countries this situation may not be considered as a reasonable worst case. The scenario where dairy cows are in the stable at night during the summer season is considered to be the realistic worst case situation. When more data become available, an animal (sub-)category can be added. If a scenario for a regional situation is developed in future all three situations have to be considered together with the fractions and the numbers of cows involved. A correction factor (housing period) should be applied to the manure production rates depending on the relevant situation for summer grazing (see section 5.5.).

For beef cattle the situation of summer grazing as for dairy cows might be applied. Veal calves will generally be housed through out the whole year. Dairy and beef cattle is assumed to be on the pasture during a period of about 190 days (Van Eerdt, 1998).

Cattle can be split up into dairy cows (including young cattle and dry cows) and cattle for meat production (beef cattle and veal calves). Dairy cows can be kept in free range systems with bedding and in cubicle stalls. The available area is split up in a zone for walking and feeding and a zone for resting. The flooring of the walking zone consists of slats (concrete or wood) and the resting zone consists either of concrete flooring with bedding material or cubicles on concrete with special bedding cover like rubber mats. Dairy farms usually have a separate stall for young cows up to the age of one year.

For this ESD, we consider the cubicle stall system, the available area for walking, feeding and resting for dairy cows to be 8.8 m^2 per animal. This does not include the feed alley and the milking room. The total housing floor area is about 11.7 m^2 per animal. About 2/5th of the available area consists of slatted floors. (Boederij, 2004; Oogst, 2004). Beef cattle are assumed to be kept in groups on fully slatted floors. The available area is about 2.7 m^2 per bull (PV-Wageningen, 2004a and 2004b). Veal calves are also assumed to be kept in groups on fully slatted floors. The available area is 1.8 m^2 per animal (EC, 1991).

A third (31%) of the dairy cattle in the European Union is kept in units from 50-99 animals as 20 percent of the animals are kept in herd sizes of more than 100 animals (DGA, 2004). For dairy cattle a default herd size of 100 animals is assumed. For beef cattle in the European Union the majority of the animals, 58% is kept in herds of 100 animals or more (DGA, 2004) and the default number of animals is assumed to be 125 animals. For veal calves there were no separate statistics on the EU level. The number of animals is assumed to be 80 for the default situation.

Pigs

For pig housing variations in flooring consist of fully-slatted, partly-slatted or solid floors. For the housing of sows, a distinction can be made between group and individual housing, whereas weaners and growers-finishers are always housed in a group (EC, 2003b). In the EU, the distribution pattern of the application of the two systems is about 70% individual and 30% group-housed, for both mating and gestating sows. In the UK mating and gestating sows are group-housed. Gestating sows are increasingly kept in loose-housing in countries like Germany, Ireland, and Portugal. In Spain, France, Greece and Italy sow housing is dominated by stalls (EC, 2003b). Loose-housing and stalls can be considered as a particular form of group-housing. Manure storage and removal systems vary from deep pits with a long storage period to shallow pits and manure channels through which the slurry is removed frequently by gravity or by flushing.

Pig production is generally split up in pig breeding (replication) and pig growing (finishing or fattening), although both systems can be combined in the so called total system. Different scenarios will be presented for the pig breeding systems (sows) and the pig finishing (fattening). Sows are housed in different systems according to the phase of the reproduction cycle. For each phase, fitting accommodation is needed. The pig breeding is split up to the following groups:

- Mating and gestating sows (sows)
- Lactating sows (farrowing sows)
- Weaned piglets (weaners)
- Breeders

Group-housed sows are generally on partly slatted floors. For sows which are kept individually, fully slatted, partly slatted as well as solid floor systems are applied in practice. The fully-slatted flooring systems are believed to be still the most commonly applied method in the EU (EC, 2003b) Therefore, scenarios are worked out for group-housed sows on partly-slatted floors and individually kept sows on fully-slatted floors, except for a specific type of breeding sows which are generally kept on a different flooring (e.g. mating and breeding sows, which are kept on partly-slatted floors).[6]

Fattening pigs are always housed in groups. The housing is divided into compartments (pens) for 10-15 (small groups) pigs or up to 24 pigs (large groups). The pens are arranged either with the aisle on one side or in a double row with the aisle in the centre. Pigs are kept on partly-slatted, fully-slatted or solid concrete floors. Restricted straw is applied in the partly slatted pen that is designed with a concrete floor and one slatted area (solid/slatted: 2:1). In housings systems for growers with a concrete floor, straw is applied in restricted amounts for reasons of animal welfare. Fully-slatted pens have no physical separation of the lying, eating and dunging areas. Manure is trodden through and urine mixes with the manure or runs off through manure channels.

Housing of fattening pigs on fully-slatted floor is very common for both small and large group. Therefore only fully slatted flooring is considered in the emission scenario document. Fattening pig housings usually contain about 100-200 pigs. In the EU, the majority of the animals (63%) is kept in units of 400 pigs (EC, 2003b). This number is therefore taken as the default herd size for fattening pigs.

Horses

Horses will often be in stables during the fly season, especially at riding stables. The manure is often stored in the open at manure heaps. The situation of insecticides for housing of horses is not clear and is therefore not considered in this emission scenario document. Also, for this animal category intensive livestock farming is not considered to be relevant.

Sheep

Sheep will usually only be in housing during winter. Therefore, it has been assumed that no insecticides are used in their housings. For goats the situation around the application of insecticides in housings is unclear. These two animal categories are therefore not considered.

[6] Across the EU, 67% of sows live in units of more than 100. In Austria, Finland and Portugal, smaller sow units are predominant (IPPC, 2003). For every 100 productive sows there are about 133 pigs in total, of which there are 83 mating and gestating sows, 25 lactating sows and 25 sows for raising in a one week production system. The average number of weaners in this system is about 325 (ASG, 2004). The default value for the herd size is assumed to be 133 sows (including weaners).

Poultry

For poultry, attention has been focused on chickens, as they are most numerous by far. For the emission scenario the relation between age, destination (laying hen or chickens for meat production) and manure storage (housing type) is considered. The housing type and manure storage systems for poultry are discussed in detail here to explain the key relationships between the housing type, manure storage systems and the emission route (to soil or waste water).

Broilers are generally not housed in cages, although cage systems exist. The majority of poultry meat production is based on an all-in all-out system applying littered floors. The litter (chopped straw, wood shavings or shredded paper) is spread over the entire house floor area which, in turn is built as a solid concrete slab. Manure is removed at the end of each growing period. Broiler farms with over 40,000 bird places are quite common in Europe, but generally houses can stock between 20,000 and 40,000 birds. Broilers are kept at stocking density of 18 to 24 birds per m^2. The duration of the production cycle varies between 5-8 weeks. After every cycle the housing is fully cleaned and disinfected (EC, 2003b).

For laying hens the number of birds per floor surface area varies between housing systems. For commonly used cage systems the stocking density ranges from 30 to 40 birds per square meter, depending on the tier arrangement. Alternative systems have much lower densities of 7 birds/m^2 for littered floor systems to 12 birds/m^2 for enriched cage systems (EC, 2003b).

Most laying hens are still kept in batteries using cage systems[7]. For cage battery systems four major battery designs can be distinguished: flatdeck, stair-step, compact and belt-battery. Constructions can have up to 8 levels or tiers. Typical cages are 45 cm x 45 cm x 46 cm deep and house 3 to 6 birds. No current application rates for the different cage systems are known, but it is believed that most of the laying hens in OECD countries are kept in compact or belt battery cage systems. Battery systems also differ according to the manure management systems applied. Droppings may be collected in an open manure pit (wet manure), in open aerated storage systems (deep-pit or high-rise and canal house), on shallow channels with scrapers and by manure belts under each tier to remove to closed storage. Some of the modern large enterprises have buildings with 20,000 to 30,000 birds or more (EC, 2003b).

Enriched cages must be equipped with perches, laying nest and a sand bath with litter material. Generally birds are kept in groups of 40 and more. The cages are arranged in tiers of 3 and more. Manure is removed automatically via manure-belts (with or without aeration). The practical success of this system is still limited. Enriched cage systems still suffer from difficulties, which impede the economical sound production of eggs (EC, 2003b). It is therefore expected that this system has no widespread use and will not be considered in the emission scenario document.

Non-cage housing systems for laying hens can be split up in deep litter systems (litter floor) and aviary systems (grating floor). The floor area in deep litter systems must at least for one third be covered with bedding and two thirds must be arranged as droppings pit. The pit is covered with slats. Laying nests, feed installations and the water supply are placed on the slats. Birds are kept in large groups at a stocking density of 7 birds square metre of ground surface with 2,000 to 10,000 birds per housing facility (EC, 2003b).

The housing space of aviary system is subdivided into different functional areas. The birds can use several housing levels that allow for higher stocking densities. Droppings are removed via manure

[7] From January 2003, European legislation (Directive 1999/74/EC) will not allow the commonly used battery systems in new installations and by January 2012 these housing systems will have to be phased out completely. However it will be decided (2005) whether Directive1999/74/EC will be reviewed (IPPC, 2003).

belts, which are located under the stored slats, into a manure pit. Litter is spread onto a fixed concrete area. Stocking density is maximised to 9 birds per usable square metre or to 16 birds per ground surface. Houses can accommodate between 2,000 and 20,000 birds (EC, 2003b). The scenario for this system is based on 16 birds per square metre of ground surface.

For chickens, there are four types of farms (apart from farms where poultry races are improved by selection and hybridisation):

1. Multiplication farms: hens and cockerels, coming from breeding farms, providing fertilised eggs (hatching eggs); the 'day-old' chicks from these eggs go to breeding farms or poultry farms for slaughtering (parent broilers, breeders).
2. Breeding farms: raising the chicks to become laying hens (laying hens in rearing).
3. Poultry farm for laying hens: production of eggs for consumption (laying hens).
4. Poultry farm for broilers: production of chickens for slaughtering (broilers).

For poultry, the following systems are used (Van der Linden, 1999; Hesters and Zoons, 1998; Van der Hoek, 2000):

1. Cage system (battery cage) for laying-hens, where the manure is collected on conveyor belts. The *wet manure* is collected in a pit and has a content of 20 – 25 % d.s. (dry solids). In order to make it pumpable, tap water or water from the waste water tank of the pen system (see figure 4.2) can be used. The *manure may be dried* with an air current, before it is tipped in the pit. This yields a content of 50 – 60 % d.s. At a compact battery, the wet manure is transported to a *closed central storage* system twice a day with the aid of slides and a central conveyor belt. Last, there are battery cages where the manure is *dried by force under the cages* (deep pit, high-rise).
2. Pen system with a litter or partly litter floor (deep litter or aviary) for broilers and laying-hens. After emptying the housing mandatory cleaning has to be carried out. The liquid waste is collected in tanks; possibly, this waste water may be discharged to the sewer (connected to an STP) depending on national legislation, but more commonly it will be used for spreading over agricultural soil or as dilution water for manure from the cage system with 20 – 25 % d.s. (dry solids) to make it pumpable.
3. Pen system with a grating floor for breeders, where the liquid waste might be kept with the manure (wet storage).

Each type of farm, i.e. phase of poultry farming (e.g. breeding) and type of housing, has its own characteristics for size (number of animals, size per section). This is considered in the calculations. Existing housing systems in the Netherlands for laying hens with wet manure storage (adding waste water) have nearly all been converted to systems with dry manure. For other OECD member countries the situation is not clear.

The flows of liquid waste and manure from housing systems for poultry, containing insecticide, can be depicted as shown in Figure 4.2. Discharge of stable cleaning water contaminated with manure to the municipal STP might still be possible, although this will generally not be the case and will depend on national legislation. The most probable way to deal with dirty waste water is to collect it and either mix it with manure or bring it on the land (irrigation). Either way to waste water (stable cleaning water) will go to the soil. In this ESD it is assumed that in case the route via municipal waste water treatment is not relevant, the waste water will go to land together with manure. For the risk assessment the following basic calculations for soil and for waste water (WWTP/STP) are involved

Soil

- Insecticide present in liquid waste and manure that are spread together (for battery cage systems with aeration, forced drying or compact, and free-range system with grating floor).
- Insecticide present in (1) manure + liquid waste for battery cage system without drying, plus (2) liquid waste and manure from free-range system with litter floor.
- Insecticide present in manure from free-range system with litter floor.

Waste water

- Insecticide present in liquid waste for battery cage systems with aeration or forced drying.
- Insecticide present in liquid waste for pen system with a litter floor for broilers and laying-hens and for free-range pens with grating floor.

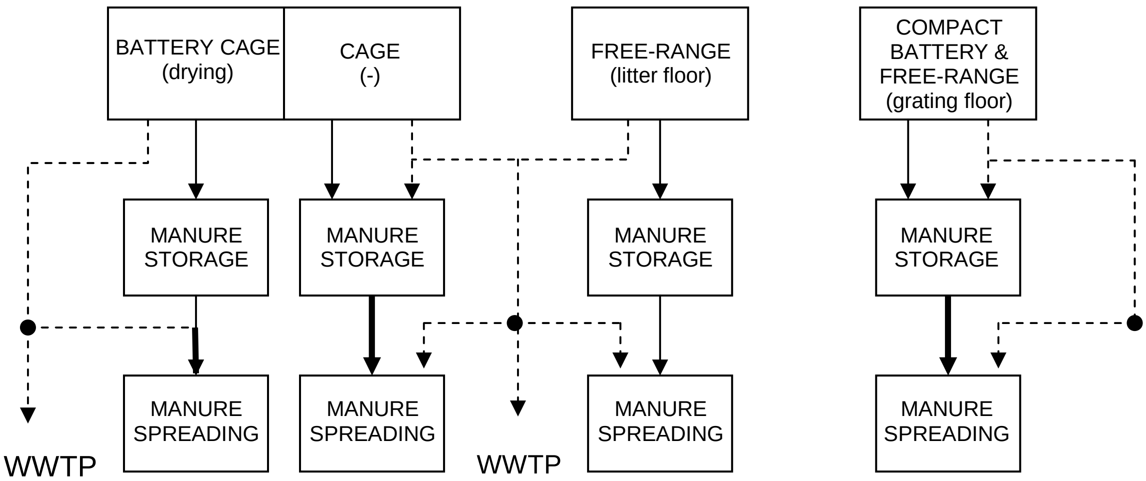

Figure 4.2 Housing systems for poultry (chickens) and manure and liquid waste flows with insecticide (----- liquid waste, ——— manure, ━━━ liquid waste + manure,● liquid waste storage tank).

Ducks are mainly kept for meat and down production (Anon, 2001). Ducks are kept in housing, although in some EU member states outdoor rearing is also allowed. There are three main housing systems for fattening of ducks: fully littered; partly slatted/partly littered and fully slatted. The commonly applied duck house is a traditional housing system and is similar to the broiler house with a concrete floor that is covered with litter. Production cycles will vary, and the finishing period generally takes about 28 days. After each cycle, manure is removed and stalls are cleaned and disinfected. Stocking density for finishing is about 5-6 animals per square metre accessible floor area (EC, 2003b). If it turns out that other farms do use insecticides this animal category should be added to the emission scenario.

Turkeys are also kept in housings with a litter floor. Different production systems apply according to the ages which relate to different feeding ratios. Finishing stags (toms) after the first breeding period of 4-6 weeks to a weight of 14.5 kg takes additionally about 15-18 weeks. Commonly applied turkey housing is a traditional housing construction, which is very similar to the housing of broilers. They are housed in closed, thermally insulated buildings or (more frequently) in open houses with open sidewall

(EC, 2003b). The scenario assumes a closed system. Typical stocking density is 3 and 4 animals per square meter for toms and hens respectively (TII, 2005).

Geese can be grown to market weight under either intensive confinement conditions, extensive range-type conditions or a mixture of the two. Broiler type geese can go to market at 8-9 weeks of age at a body weight of 4.0 kg and heavy type geese can go to market at 12-14 weeks of age at a body weight of 6.0 kg. Geese grown in confinement are generally raised on deep litter which is considered the classical system of poultry production. At six weeks of age, the density of geese raised on deep litter should not exceed four geese per square metre, and only three after 13 weeks. For those raised on a slatted floor system, the respective values are seven and five birds per square metre FAO (2002).

Other poultry are only raised and kept in comparatively low numbers in the OECD member countries. Therefore no consideration is given to poultry other than chicken, turkey, geese and ducks in the emission scenario document.

So, the fraction of the insecticide reaching the manure depends on the category (animal species, manure storage system) and the type of insecticide. These fractions have been estimated on the basis of the data available for the insecticides permitted in the Netherlands (see section 5.4).

4.2. Way and place of application

The ways of application of importance for the emission to manure are briefly discussed below.

Sprinkling

Granules will be sprinkled on those parts of the floor where organic substrate (manure, bedding material and spilled feed) will be usually present. These places are gratings, manure passages, cracks, the surroundings of feeding- and drinking troughs. Application rates are usually expressed as amount per unit of floor area or unit of manure surface area.

Spraying

Solutions and dispersions, which are sprayed, will reach larger surfaces and may not only be applied on the floor but also on the walls and ceiling. Spraying powders will be mainly applied on floors and the surface of manure heaps. The application rate is either expressed as per unit of treated area (walls and ceiling), unit of effectively treated area, unit of manure surface area or unit of floor area of the structure. The area effectively treated area is a fraction of the total treated area. This should be specified in the user instructions.

Smearing

Smearing, for example with a brush (“brushing”), can be carried out on those places where flies use to stay, e.g. on window sills, ceiling, roof beams, lamp shades, etc. In some cases the insecticide is mixed with substances attracting the insects. Concerning the application area, the same holds as for spraying.

Baiting

In this case, the insecticide is mixed with substances attracting the insects. For flies sugar is used, often in combination with sex attractants. The baits that are authorised/notified in the Netherlands may both be used in open containers and be sprinkled. Another way of application is the use of impregnated paper or cardboard. In the user instruction usually the amount of bait per floor area is given.

Aerosols or fogging

Cleared stables may be treated with authorised/notified fumigants or with insecticide through the aid of a mist blower or aerosol cans. These methods are only applicable to empty stables e.g. cleared housings and battery cage systems for laying hens after each cycle. Usually the user instructions indicate a use rate based on the volume of the housing. Aerosol cans may also be used to treat the structure. For this type of application some part of the insecticide will go to the air. From information in (CTB, 2004) this has been estimated to be only about 2%.

Figure 4.3 presents the emission routes of insecticides applied in animal housings. This scheme is discussed here for the emission routes of interest for the emission model:

1. <u>Insecticide application</u>

The direct emission to air depends on both the vapour pressure and the way of application. The vapour pressure of the products is usually low. Typically the vapour pressure ranges between 10^{-8} and 10^{-2} Pa at 20 °C. The main emission to air occurs when the diluted formulation or spraying powder is sprayed, fogging or aerosol treatment is applied. Most insecticide will settle soon within the housing with the droplets or powder. It is assumed for the model that the emission factor to air is zero, with the exception of fogging and aerosols for this application an emission the air will be relevant.

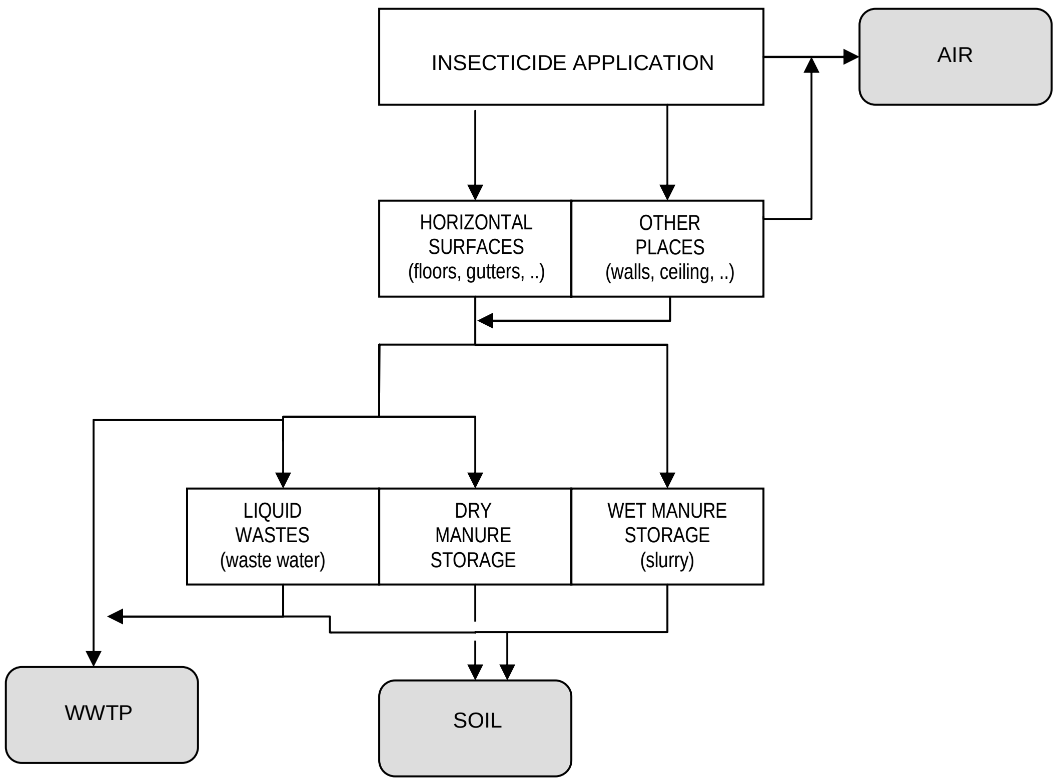

Figure 4.3 Scheme of emission routes of biocides depending on places of application and type of manure storage system

2. Horizontal surfaces

Depending on the user's instructions a certain fraction of the formulation is applied on horizontal surfaces like the floor and gutters. This fraction will almost completely be removed with manure and liquid wastes.

3. Other places

The fraction applied on walls, ceilings, windows, window sills, ledges and other places will have three possible destinations. A certain fraction will be removed during cleaning operations in the housing and end up in the liquid wastes. Another fraction will degrade in due time and a third fraction will evaporate. At this moment no data are available to estimate the fraction degraded. On account of the low vapour pressure of the active substances authorised/notified so far, the fraction evaporated is assumed to be negligible. Therefore, degradation and evaporation have not been considered in this report. Only the fraction removed at cleaning operations has been considered; an expert judgement has been made, which can be used until better data become available (see section 5.4, Table 5.4). This fraction joins the fraction removed from horizontal surfaces at simultaneous application of insecticides.

4. Stable space

The insecticide, which is applied through aerosols or either fogging with the aid of mist blower, will generally go to air. After treatment the room will have to stay closed for a certain period of time, afterwards it will be ventilated. In the mean time the mist will settle on the floor or adhere to objects or vertical surfaces. Existing model(s) for fumigation of disinfectants for greenhouses in agriculture may be used. This model is actually only suitable for fumigation (RIVM, 2002) and differs from the situation where an object is treated through aerosol spraying (spray on). It gives a default fraction emitted to air of 0.98 and fraction of 0.02, which adheres to goods (the structure). The fraction, which adheres to the structure, follows the same pathways as discussed for the horizontal surface and other places. For aerosols and fogging treatment (both for structure and space), it can be assumed that only a small fraction will go to air in contrast with fumigation for which nearly complete emission to air can be assumed.

5. Liquid wastes

A certain fraction of the insecticides used in animal housings will be removed in cleaning operations. This liquid waste can either be discharged to the sewer, which will generally not be the case, or more commonly kept in a separate waste water slurry tank as described before. Expert judgement has been used for estimation of the fraction removed with liquid waste. As a first tier approach the degradation process in this slurry tank is not considered. If any biodegradation data are available, these can be used for further refinement of the emission calculations. For the emission model, in the default case it is considered that the liquid waste is spread together with the manure from the dry storage. This means that the calculation is identical to the wet manure storage. For the case that the liquid wastes are discharged to the sewer, the calculation has to be made for the emission to waste water, e.g., the standard STP.

6. Dry manure storage

For the dry storage of manure (manure or dung heaps and such) the calculation has to be made for spreading of the manure on agricultural soil. Degradation as for liquid waste and wet manure storage is not taken into account during the storage period.

7. Wet manure storage

In wet manure storage (slurry pit), both manure and liquid wastes are stored together. The whole amount will be spread on agricultural soil.

4.3. Types of insecticides

In the introduction the various types of biocides were described. The types of biocides – i.e. insecticides - that are distinguished in modelling are:

1 Insecticides (adulticides), specifically against flies

Adult flies can be controlled through aerosol sprays or foggers and through baits, which are applied via granules, smear-on or spraying.

2 Insecticides (adulticides) against other insects and arthropods (bloodsucking pests)

Bloodsucking pests like lice, ticks and cattle crub are generally controlled by using pour-ons, sport-ons, sprays or dusts on cattle and poultry. For poultry the bedding material or the structure may be treated as well through sprays, dusts and baits. After treating the floor should be covered with new litter especially when applying baits.

3 Larvicides (larvae of flies)

Larvicides are directly applied to manure or other breeding sites like spilled feed and bedding material through sprays or granules. Direct application is discouraged because beneficial arthropods associated with the manure can be killed. However, if manure cannot be kept dry or removed on a weekly basis, it is possible to use larvicides.

4 Insecticides against other insects (not affecting livestock)

Beetles may not directly affect livestock but may be damaging to building material especially in poultry houses. Beetles are controlled by treating the bedding material, the floor or the target material (wooden post, foam insulation, panelling etc). Products to protect wooden materials are not addressed by this ESD, as they are considered to be wood preservatives (EU “product type 8”) rather than insecticides.

5. Release estimation

In the following sections, the individual parameters for the release estimation are described and default values discussed. The symbols used are in conformity with the notation in (E)USES and follow the formats according to Van der Poel (2000); they may differ from Van der Linden (1999) and Montforts (1999).

The scheme of calculations – depicted by hexagons – and the parameters discussed – depicted as rectangles – is presented in Figure 5.1. The first section – section 5.1 – deals with the basic parameters, which influence the fraction of the insecticide (i.e. the active ingredient) that reaches the manure storage system. Section 5.2 and 5.3 deal with the parameters which influence the amount of active ingredient used and section 5.5 discusses the manure production per animal category which in combination with the number of animals (section 5.3) determines the amount of manure produced. Section 5.4 discusses the determination of the fraction of active ingredients reaching manure and waste water. The amount of active ingredient left in manure after the storage period is determined by parameters discussed in Section 5.6 and 5.7, degradation and storage time respectively. Immission standards (section 5.8), degradation (section 5.6) and the number of applications (section 5.9) finally determine the concentration in soil.

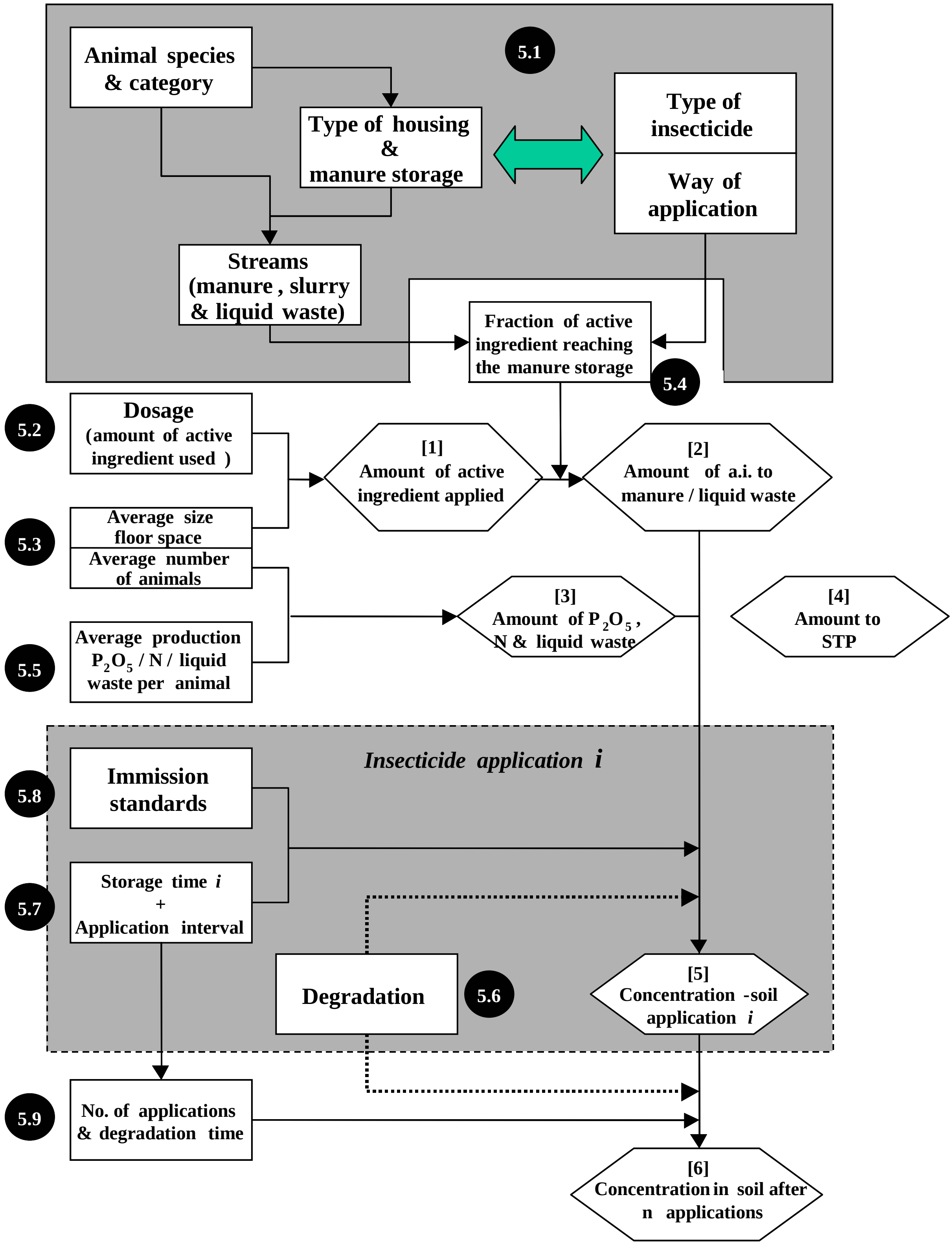

Figure 5.1 Scheme of parameters and variables (rectangles) for the calculations (hexagons); the numbers in the black bullets refer to the sections concerned.

5.1. Basic steering parameters

As has been shown in various figures some parameters are linked to each other. They are at the basis for the release estimation. For modelling they have been provided with variable names. These basic parameters with their variable names (in bold between parentheses) are:

- Animal (sub-)categories and/or manure storage system for which the insecticide has been notified or registered (**cat-subcat**).
- For poultry the housing type(s) concerned (**cat-subcat**).
- The way the insecticide is applied (**appway**).
- The type of insecticide (**bioctype**).
- The stream(s) where the biocide is emitted to (**stream**)

It should be noted that the first two parameters have been combined to one. Furthermore, it should be kept in mind that the way of application is "included" so to speak in the parameter for the way the insecticide is applied. This is of particular importance for the emission factor to the manure storage, in other words the fraction of the insecticide (active ingredient) that is transferred to the manure storage system (section 5.4)

The variable names are used as subscripts in the symbols for the parameters. In order to maintain oversight, these variable names in the subscripts of the symbols have been replaced by indices:

index	variable subscript name	parameter description
i1	cat-subcat	animal subcategories and manure storage type
i2	bioctype	biocide type
i3	appway	the way the insecticide is applied
i4	stream	the stream(s) where the biocde is emitted to

Table 5.1 presents the pick list with the values of the variable names with the description of the variable content, the variable names and indices. The values of the variable names are used in the formulas for the calculations.
It should be noted that for laying hens data for hens ≥18 weeks are used.

The cat-subcat numbers i1 = 19 (manure storage "wet") and i1 = 20 (manure storage "dry") are not the same as the respective streams i4 = 3 (slurry) and i4 = 1 (manure); the cat-subcats are used to identify the application of the biocide directly at the storage systems. The choice of *i1* (for *i1* = 1 to 18) implies the value of *i4* for the waste stream manure or slurry.

This is also the case for other animal species such as various poultry species and for animal species where probably larvicides are used at manure heaps. When data become available new cat-subcats can be added to the scenario easily.

Table 5.1 Pick list for the variables based on the user's instructions; the variable names are used as subscripts or representing indices in various parameters involved in the model.

Value	Description of variable content
Variable name: cat-subcat, Index: i1	
1	Dairy cows (milking parlour treatment)
2	Beef cattle
3	Veal calves
4	Sows, in individual pens
5	Sows in groups
6	Fattening pigs
7	Laying hens in battery cages without treatment
8	Laying hens in battery cages with aeration (belt drying)
9	Laying hens in battery cages with forced drying (deep pit, high-rise)
10	Laying hens in compact battery cages
11	Laying hens in free range with litter floor (partly litter floor, partly slatted)
12	Broilers in free range with litter floor
13	Laying hens in free range with grating floor (aviary system)
14	Parent broilers in free range with grating floor
15	Parent broilers in rearing with grating floor
16	Turkeys in free range with litter floor
17	Ducks in free range with litter floor
18	Geese in free range with litter floor
19	Manure storage "wet" (slurry pits)
20	Manure storage "dry" (manure heaps)
Variable name: bioctype, Index: i2	
1	Insecticide (adulticide), specifically against flies
2	Insecticide (adulticide) against other insects and arthropods (bloodsucking pests)
3	Larvicide (larvae of flies)
4	Insecticides against other insects (not affecting livestock)
Variable name: appway, Index: i3	
1	Spraying
2	Aerosol/fogging
3	Smearing
4	Sprinkling
5	Bait
6	Both sprinkling and bait
Variable name: stream, Index: i4	
1	Manure
2	Waste water (wwater)
3	Slurry

5.2. Dosage

Usually the notifier/registrant states the concentration of the active ingredient, i.e. the biocide assessed, in the formulation as a percentage (%, weight/weight) or as $g.l^{-1}$ (weight/volume). These data are presented in the model by the variable names *Fbioc%* and *Fbioc* respectively. Furthermore, the notifier/registrant usually states the dilution for aqueous formulations as an amount of the preparation to be diluted with a certain amount of water ($ml.l^{-1}$). In the user's instructions the notifier/registrant also states the area (m^2) which can be treated with those amounts (hexagonal [1] in Figure 5.1). This requires that the amount of active ingredient used per square meter of area to be treated ($Qai\text{-}prescr_{i1,i2,i3}$) is applied in the emission model.

In some cases, the user's instructions state that specific places should be treated (mainly smearing and brushing), and the amount needed for a certain surface is given; sometimes this surface is the floor area of the housing, sometimes it is the total area (walls, ceiling and if applicable cages) to be treated or sometimes it may be the effective area to be treated. An estimate of the area of window sills, ledges, roof beams, lampshades, wall frames etc. in the housing has been made. This area differs for spraying and smearing. For spraying a width of 30 cm has been adopted and for smearing a width of 10 cm has been assumed. This has been multiplied by the total length of the structure elements mentioned before. The area of the structure elements is about 30% of the total wall and ceiling area for spraying and about 10% for smearing. The user instruction of an insecticide indicated that the amount prescribed for spraying is sufficient to treat a surface area of 100 m^2 of which 25% needs actually be treated. Another example found in the user instructions says that the prescribed amount should be sufficient to treat a surface area of 100 m^2 of which 2% needs actually to be treated. This is less than the calculated 10%, which is thought to be overestimated because generally the structure elements are not completely treated through smearing in contrast with spraying. These fractions can be used when user instructions indicate the prescribed amount for the effectively treated area, which in general is not the case.

5.3. Average size of housings and numbers of animals

For every category, i.e. the species of the animal considered or the storage type (for example poultry), and subcategory, i.e. the specific brand of animal species (for example laying hens), the average treated surface area has to be established: for animals the floor area, space volume, total treated area or the effectively treated area and for storage systems the top surface area of the manure. For poultry, the average area may be different for each type of housing applicable. The typical size of the housing is based on descriptions of stalls for pigs and poultry from EC (2003b), for cattle (Boerderij, 2004; Oogst, 2004; PV-Wageningen, 2004a and b) and typical figures for the minimum requirements and provisions for keeping animals as laid down in various EU Directives (Laying hens: CD 2002/4/EC; pigs: CD 2001/88/EC and calves 97/2/EC). Regulatory minimum space requirements for keeping animals in Australia (Jackson, 2005) are comparable to those in the EU.

The default values for the areas and volume of the animal housing are presented in Table 5.2 Default values for the surface area of manure storage inside the animal housing and other areas treated are presented in the Table 5.3. The area of the manure storage outside the housing is presented in Appendix 5.

Table 5.2 Defaults for floor surfaces of animal housings $AREAfloor_{cat\text{-}subcat}$ (m^2), the surface area of walls and ceilings, $AREAwall_{cat\text{-}subcat}$ (m^2), and the housing volume, $VOLUMEhousing_{cat\text{-}subcat}$ (m^3), with the numbers of animals present, $N_{cat\text{-}subcat}$ (-); the subscript cat-subcat presents the animal (sub)category and for poultry the type of housing, or the type of manure storage (see Table 5.1).

index i1	Category-subcategory				Number animals*	Floor area** [m^2]	Wall and Roof area [m^2]	Housing Volume [m^3]
1	Cattle	- Dairy cattle			100	1170	1670	9630
2		- Beef cattle			125	370	1000	3063
3		- Veal calves			80	160	330	590
4	Pigs	- Sows		Individual	132	560	910	1960
5		- Sows		Group	132	710	1160	2480
6		- Fattening pigs			400	600	970	2110
7	Poultry	- Battery	- no treatment	Laying hens	21000	750	1100	2810
8			- belt drying	Laying hens	21000	750	1100	2810
9			- deep pit, high-rise	Laying hens	21000	750	1100	2810
10			- compact	Laying hens	21000	750	1100	2810
11		- Free range	- litter floor	Laying hens	10000	1430	2030	5360
12		(indoors)	- litter floor	Broilers	20000	1110	1600	4170
13			- grating floor	Laying hens	20000	1270	1822	4780
14			- grating floor	Parent broilers	7000	390	600	1458
15			- grating floor	Parent broilers in rearing	9000	500	750	1880
16			- litter floor	Turkey	10000	3330	4650	12500
17			- litter floor	Ducks	10000	2000	2820	7500
18			- litter floor	Geese	10000	2500	3500	9380
19	Manure storage	- Wet	- tanks	circular		1)		
				rectangular		2)		
			- slurry pool	rectangular		3)		
20		- Dry	- manure heaps			4)		

* Default number of animals have been derived from various sources: EC (2003b); Boarder, 2004; Oust, 2004; PV-Wageningen, 2004a and b; DGA (2004)

** the treated area for the various manure storage systems depends on the amount of manure produced for each animal category for detailed information see Appendix 5

1) $A = ½ * (20 * V)^{2/3}$

2) $A = ¼ * 3.14 * (7.5 * V)^{2/3}$

3) $A = ½ * (88.7 * V)^{2/3}$

4) Specific area = 0.4 m^2/m^3

Table 5.3 Defaults for surfaces of manure and spilled feeding, $AREA_{cat\text{-}subcat}$ (m^2), inside the housing specifically for larvicides and the surface area for insecticides in addition to walls, floor and ceiling for battery systems, $AREAother_{cat\text{-}subcat}$ (m^2); the subscript cat-subcat presents the animal (sub)category and for poultry the type of housing, or the type of manure storage (see Table 5.1).

index i1	Category-subcategory				Number animals	Slatted area[1] [m^2]	Other areas [m^2]	Manure area inside [1] [m^2]
1	Cattle	- Dairy cattle			100	360	30 [2]	
2		- Beef cattle			125	340	40 [2]	
3		- Veal calves			80	140	20 [2]	
4	Pigs	- Sows		Individual	132	390	70 [2]	
5		- Sows		Group	132	290	40 [2]	
6		- Fattening pigs			400	400	50 [2]	
7	Poultry	- Battery	- no treatment	Laying hens	21000	n.r.	1360 [3]	1200 [5]
8			- belt drying	Laying hens	21000	n.r.	1360 [3]	1200 [5]
9			- deep pit, high-rise	Laying hens	21000	n.r.	1360 [3]	600 [6]
10			- compact	Laying hens	21000	n.r.	1360 [3]	300 [7]
11		- Free range	- litter floor	Laying hens	10000	950	200 [4]	
12		(indoors)	- litter floor	Broilers	20000	n.r.	20 [2]	
13			- grating floor	Laying hens (aviary)	20000	n.r.	300 [4]	1600 [5]
14			- grating floor	Parent broilers	7000	260	40 [2]	
15			- grating floor	Parent broilers in rearing	9000	330	60 [2]	
16			- litter floor	Turkeys	10000	n.r.	60 [2]	
17			- litter floor	Ducks	10000	n.r.	60 [2]	
18			- litter floor	Geese	10000	n.r.	60 [2]	

* the treated area for the various manure storage systems depends on the amount of manure produced for each animal category for detailed information see Appendix 5

n.r.: not relevant

1) The slatted area can be considered as the treated area for the manure storage inside (under) the housing

2) This is the area under feed troughs
3) This is the front side area of all cages
4) This is the area under nesting places and feed troughs
5) This is the area of manure belts
6) Area of manure heaps in deep pit system
7) Manure collection area under cage, cleaned by scrapers

The surface area of the manure storage systems is estimated from typical storage dimensions and scaling up or down according to the storage capacity (Appendix 5). According to common practices, the storage capacity is calculated to hold the amount of manure produced during one year including waste water and precipitation for wet storage (see Appendix 5). Typical dimensions for rectangular, circular storage tanks and for a slurry lagoon are taken from LPES (2004). The surface area of the rectangular earthen impoundment depends on the amount of manure, therefore as an estimate the average surface area is taken to be half the maximum area. For the calculation of the concentration in manure, the time between following biocide and manure applications are the steering parameters, which determines the amount of manure produced before the larvicide is applied the next time, see section 5.7.

5.4. Fraction of active ingredient reaching manure and waste water

The fraction of the insecticide, i.e. the active ingredient, reaching the manure depends on the animal species, type of manure storage system and specific purpose of the biocide, as described in section 5.1. The estimates have been generated solely by expert judgement, based on the use directions available for the insecticides, particularly those authorised/notified in the Netherlands. There are to our knowledge no other data available on emission factors used in animal housing and therefore the presented emission factors are to be considered as first estimates. If any refined or better substantiated data are available, they can be used instead. Assumptions had to be made on account of the user's instructions of these preparations. It was assumed, for example, that spraying leads to a larger fraction for manure than smearing and brushing. A larger fraction was also assumed if the floor has to be treated besides walls and ceiling. The estimates are presented in Table 5.4, where:

- Spraying includes pouring in the case of larvicides;
- Smearing includes also application by means of utensils like brushes;
- Aerosols includes fogging and excludes fumigation
- Livestock comprises all mammals considered (cattle, veal calves and pigs);
- Poultry comprise chickens.

The estimates take into account that a biocidal product present on window sills or rafters, for example, will remain there at cleaning. Furthermore, degradation and evaporation might take place after a biocide has been applied to the structure or manure. As mentioned before, degradation is not accounted for because there are no data to substantiate the derivation of loss factors. Also, evaporation has not been taken into account as the vapour pressure of active ingredients is generally low.

Table 5.4 Estimates for the fraction of active ingredient released to the relevant streams ($F_{cat\text{-}subcat,bioctype,appway,stream}$): for animal (sub)category and housing (variable cat-subcat), type of insecticide (variable bioctype), way of application (variable appway) and stream where the biocide is emitted to (variable stream); • = not applicable.

Category (cat-subcat)	Type of biocide (bioctype)	Spraying (1)			Aerosol (2)			Smearing (3)		
		Manure (1)	Waste water (2)	Slurry (3)	Manure (1)	Waste water (2)	Slurry (3)	Manure (1)	Waste water (2)	Slurry (3)
Livestock										
Cattle, Veal calves, Pigs										
(1,2,3,4,5,6)	All insecticides (1,2,4)	•	•	0.5	•	•	0.35	•	•	0.35
(1,2,3,4,5,6)	Larvicides (3)	•	•	0.5	•	•	0.35	•	•	0.35
(19)	Larvicides (3)	•	•	1	•	•	1	•	•	•
Poultry										
<u>Battery cage</u>:										
- conveyor belt with aeration										
(8)	All insecticides (1,2,4)	•	0.2	0.5	•	0.1	0.35	•	0.1	0.35
(8)	Larvicides (3)	•	0.2	0.5	•	0.1	0.35	•	0.1	0.35
(20)	Larvicides (3)	•	•	1	•	•	1	•	•	•
- forced drying (deep pit, high-rise) (9)	All insecticides (2,4)	0.5	•	•	0.35	•	•	0.35	•	•
(9)	Flies (1)	0.8	•	•	0.35	•	•	0.35	•	•
(9)	Larvicides (3)	0.8	•	•	0.35	•	•	0.35	•	•
(20)	Larvicides (3)	1	•	•	1	•	•	1	•	•
- conveyor belt (no aeration)										
(7,10)	All insecticides (1,2,4)	•	•	0.5	•	•	0.35	•	•	0.35
(7,10)	Larvicides (3)	•	•	0.5	•	•	0.35	•	•	0.35
(19)	Larvicides (3)	•	•	1	•	•	1	•	•	•
<u>Free-range</u>:										
- litter floor (11,12,16,17,18)	All insecticides (1,2,4)	0.3	0.2	•	0.25	0.1	•	0.25	0.1	•
(11,12,16,17,18)	Larvicides (3)	0.3	0.2	•	0.25	0.1	•	0.25	0.1	•
(20)	Larvicides (3)	1	•	•	1	•	•	•	•	•
- grating floor (13,14,15)	All insecticides (1,2,4)	•	•	0.5	•	•	0.35	•	•	0.35
(13,14,15)	Larvicides (3)	•	•	0.5	•	•	0.35	•	•	0.35
(19)	Larvicides (3)	•	•	1	•	•	1	•	•	•

Table 5.4 (continued) Estimates for the fraction of active ingredient released to the relevant streams ($F_{cat\text{-}subcat,bioctype,appway,stream}$), for animal (sub)category and housing (variable cat-subcat), type of insecticide (variable bioctype), way of application (variable appway) and stream where the biocide is emitted to (variable stream); • = not applicable.

Category (cat-subcat)	Type of biocide (bioctype)	Sprinkling (1)			Bait (2)			Sprinkling & Bait (3)		
		Manure (1)	Waste water (2)	Slurry (3)	Manure (1)	Waste water (2)	Slurry (3)	Manure (1)	Waste water (2)	Slurry (3)
Livestock										
Cattle, Pigs, Veal calves										
(1,2,3,4,5,6)	All insecticides (1,2,4)	•	•	0.9	•	•	0.5	•	•	0.75
(1,2,3,4,5,6)	Larvicides (3)	•	•	•	•	•	•	•	•	•
(19)	Larvicides (3)	•	•	1	•	•	•	•	•	•
Poultry										
Battery cage:										
- conveyor belt with aeration										
(8)	All insecticides (1,2,4)	•	•	•	•	0.45	0.5	•	0.35	0.75
(8)	Larvicides (3)	•	0.1	0.9	•	•	•	•	•	•
(20)	Larvicides (3)	•	•	1	•	•	•	•	•	•
- forced drying (deep pit, high-rise) (9)	All insecticides (2,4)	0.8	•	•	0.4	•	•	0.75	•	•
(9)	Flies (1)	0.9	•	•	0.5	•	•	0.8	•	•
(9)	Larvicides (3)	0.9	•	•	•	•	•	•	•	•
(20)	Larvicides (3)	1	•	•	•	•	•	•	•	•
- conveyor belt (no aeration)										
(7,10)	All insecticides (1,2,4)	•	•	0.9	•	•	0.5	•	•	0.75
(7,10)	Larvicides (3)	•	•	0.9	•	•	•	•	•	•
(19)	Larvicides (3)	•	•	1	•	•	•	•	•	•
Free-range:										
- litter floor (11,12,16,17,18)	All insecticides (1,2,4)	0.8	0.1	•	0.05	0.45	•	0.4	0.35	•
(11,12,16,17,18)	Larvicides (3)	0.8	0.1	•	•	•	•	•	•	•
(20)	Larvicides (3)	1	•	•	•	•	•	•	•	•
- grating floor (13,14,15)	All insecticides (1,2,4)	•	•	0.9	•	•	0.5	•	•	0.75
(13,14,15)	Larvicides (3)	•	•	0.9	•	•	•	•	•	•
(19)	Larvicides (3)	•	•	1	•	•	•	•	•	•

5.5. Average production of liquid waste, phosphate and nitrogen

For the average amounts of manure, liquid wastes (waste water), slurry and phosphate produced per animal per day, data from Montforts (1999) and Montfoort *et al.* (1996) were used in combination with data from Van Eerdt (1998). The amount of waste water for poultry has been estimated from the difference in the values of Van Eerdt (1998) and Montfoort *et al.* (1996); it was assumed that the highest value included the water used for cleaning.

The default values for the liquid waste, nitrogen and phosphate production per animal are presented in Table 5.5. These values can also be replaced when specific data for OECD countries are available.

Table 5.5 Defaults for the average amounts of liquid waste, Qlwastecat-subcat (kg.animal^{-1}.d^{-1}) in relevant cases, phosphate, Qphosphcat-subcat (kg.animal^{-1}.d^{-1}) and nitrogen, Qnitrogcat-subcat (kg.animal^{-1}.d^{-1}) per animal (sub)category $_{i1}$.

cat-subcat	Category	Subcategory	Housing	Amounts of: liquid waste	P_2O_5	N [3]
1	Cattle	Dairy cow*			0.10466	0.33890
		Grazing season**			0.04053	0.14316
2		Beef cattle*			0.07123	0.28819
		Grazing season**			0.02863	0.12863
3		Veal calf			0.01422	0.02382
4/5	Pigs	Sow			0.05566	0.07106
6		Fattening pig			0.02033	0.03043
8	Poultry	Laying hen	Battery + aeration	0.08 [2]	0.00111	0.00181
9			Deep pit, high-rise	0.08 [2]	0.00111	0.00181
10			Compact		0.00111	0.00181
7			Battery (no treatm.)		0.00122 [1]	0.00202 [1]
11			Free-range, litter	0.08 [1] [2]	0.00111	0.00171
12		Broiler	Free-range, litter	0.08 [1] [2]	0.00066	0.00156
13		Laying hen	Free-range, grating	0.08 [1] [2]	0.00111	0.00171
15		Parent broiler in rearing	Free-range, grating		0.00077	0.00137
14		Parent broiler ≥18 weeks	Free-range, grating		0.00188	0.00298
16		Turkeys	Free-range, litter		0.00230	0.00482
17		Ducks	Free-range, litter		0.00164	0.00274
18		Geese	Free-range, litter		0.00230 [4]	0.00482 [4]

* If relevant nitrogen and phosphorous production rates have to be corrected for the time spend in the housing (40%) during the grazing season, a period of 190 days

** This figure represents the amount of manure in the manure storage during the grazing season

1) In the case of authorisation for both battery (no treatment) and free-range (litter floor) combination of slurry stream battery and liquid waste stream free-range (only for battery without treatment: 0.0011)

2) If relevant separate calculation of load to STP

3) Excluding the nitrogen which volatilised during excretion in the housing and storage

4) Mineral production from manure for Geese is assumed to be the same as for turkeys

Additional information on the nitrogen and phosphate content in manure is gathered from literature. As expected the contents in manure are not identical due to differences in feed, race and housing conditions. Differences are ranging from a factor of 1.5 to about 3. As a worst-case situation the lower range may be chosen, because the amount of manure spread on land is then relatively large. These data are presented in Annex 6. For veterinary medicinal products there is currently a proposal on the nitrogen contents in manure to be used in the environmental impact assessment (VICH, 2005). These values might as well be used for the current ESD.

5.6. Degradation during manure storage and in soil

Degradation in manure and soil is not considered in the current emission scenarios. Degradation might be included in a more detailed and realistic assessment, providing standardised methods for determining biodegradation are available. Standardised methods for biodegradation in soil are already available. The results of these tests can be used as a surrogate for degradation in manure when no other data are available. If degradation is to be taken into account, calculation methods provided by Montforts (1999) in conjunction with models like FOCUS can be used. Chapter 7 on further model refinement options gives a more detail overview of available methods and important issues with regard to degradation in manure and soil.

5.7. Time aspects

5.7.1. Application intervals and period of application

The users of an insecticide usually apply the product only if needed, to address nuisance or for prevention. For the application intervals, the four types of insecticides distinguished in this report have to be considered:

Bioctype 1 (index i2=1): Insecticides against flies (adulticides)

Formulations against flies will only be necessary during the warmest months (fly season). For the Netherlands, for example, it may be assumed that application takes place from April to the end of September. Some manufacturers give advice on periods for repetition of the treatment. The frequency may depend on the type of active ingredient, the insects to fight and the livestock category concerned. Some user instructions state that the insecticide (adulticide against flies) will be effective for 4 to 6 weeks or that treatments should be repeated every 5 or 6 weeks. The same default value for the frequency of application is used in the emission scenario.

The application interval stated in the user instructions should be used preferably in the model calculations. If the user instructions state an application interval as a range, the lowest value should be used for the reasonable worst case situation. If nothing is stated, the default value for the application interval is 28 days.

The insecticides against flies will be used from the moment when manure is present in considerable quantities or when fly populations are building up. For the fly season − i.e. the application period for biocides − a default period of half a year is used. The first biocide application is assumed to be at the end of the other half year period, after manure has been spread on land, so the first application is after one application interval period of 28 days. These defaults imply a number of insecticide applications $Napp\text{-}bioc_{max}$ of 183 / 28 = 6-7.

Bioctype 2 (index i2=2): Insecticide (adulticide) against other insects and arthropods (bloodsucking pests)

To fight bloodsucking insects, such as fleas and bloodsuckers, in housings for poultry three formulations have been authorised/notified in the Netherlands. It is assumed here that they will be applied throughout the year. One of the three manufacturers with a product authorised/notified in the Netherlands states that the insecticide is effective during “several weeks”.

It has been assumed that the application of the insecticide takes place after thorough cleaning of the housing. Such a cleaning will be carried out when the poultry is replaced or when necessary. For the model the moments of replacements are considered. So, the time between two replacements is the application interval (Tbioc-int). Therefore, the number of cycles for poultry ($Ncyclus_{i1}$) has to be taken for the number of insecticide applications ($Napp_{max}$). It should be noted that this might lead to an underestimation if insecticide application is required more often when the number of cycles is low. Therefore, the number of applications has been set at a minimum value of 4 (application interval 3 months). This may seem a low number but it may be realistic as in between other active ingredients may be used to prevent the pests from becoming resistant. Table 5.6 presents the number of applications and application intervals for poultry (the data are derived from Montforts, 1999). The defaults should be updated when more – and more representative for the OECD countries - data become available. The timing of the biocide application in relation to manure application is of no importance as degradation in manure is not considered, see also section 5.6., and the biocide is applied throughout the whole year with equal intervals.

Table 5.6 Defaults for poultry (chickens) for the number of biocide applications, Napp-bioc$_{max}$ (-) and the interval time, Tbioc-int (d) related to the number of animal cycli, Ncyclus$_{i1}$ (y^{-1}) and the defaults

			Based on cycli		Default	
Index i1	Category-subcategory	$Ncyclus_{i1}$	$Napp\text{-}bioc_{max}$	Tbioc-int	$Napp\text{-}bioc_{max}$	Tbioc-int
7-10	Laying hens, batteries	0.85	1	365	4	91
11,13	Laying hens, free range	0.84	1	365	4	91
12	Broilers	7	7	52	7	52
14	Parent broilers	1	1	365	4	91
15	Parent broilers in rearing	3	3	122	4	91

There are no indications that this type of biocide is used in housings of other livestock.

Bioctype 3 (index i2=3): Insecticides against other insects (not affecting livestock)

Insecticides against insects like tempex beetles will be applied after emptying and cleaning housings for poultry. The insecticide can be applied as bait directly to the manure. For poultry houses in which birds are grown on litter, the bait is applied uniformly to the floor. Also dusting and spraying of surfaces (walls, posts, framing) can be applied. It has been assumed that the application of the insecticide takes place after emptying and cleaning of the housing. Such a cleaning will be carried out when the poultry is replaced. So, the time between two replacements is the application interval (Tbioc-int). Therefore, the number of cycles for poultry ($Ncyclus_{i1}$) from Table 5.6 has to be taken for the number of insecticide applications ($Napp_{max}$).

Bioctype 4 (index i2=4): Larvicides for manure storage systems

Application of larvicides directly on the surface of the manure in storage only will take place in the fly season. The same defaults as for bioctype 1 have been chosen.

In Table 5.7 the defaults for all four biocide types have been summarised.

Table 5.7 Defaults for the insecticide application interval Tbioc-int (d) and maximum number of applications Napp-bioc (-) for all biocide types (index i2) and − if appropriate − animal category/subcategory (index i1)

i2	i1	Interval Tbioc-int	No. applications Napp-bioc
1		28	6
2	7-10	91	4
2	11,13	91	4
2	12	52	7
2	14	91	4
2	15	91	4
3	6-11,13,14	(365)	1
3	12	52	7
3	15	122	3
4		28	6

5.7.2. Storage time and land application of manure

The fraction of the biocide (insecticide) that reaches the manure storage will remain there until the next land application[8] of manure. The storage time of manure in the storage system depends on:

I Period of land application

The period that land application is may vary from several months for grassland/arable land for specific soil types in one country/region to the whole year for other countries.

II Number of land applications

There are no countries within the EU where it is prohibited to apply the whole amount of manure (based on the immission standards) in one time. Agricultural practise indicates though that three or four applications can be applied. This may also differ for grassland and arable land.

For the period that land application takes place, the provisional default periods used in the model are presented in Table 5.8. Actual application dates for selected OECD countries are provided in Chapter 7 on refinement options.

Table 5.8 Default values (Northern Hemisphere) for the periods of land application by target field and the manure storage time interval (Tmanure-int) in days.

Target field	Start date	End date	Period	Tar/gr-int
Arable land	1st September	1st February	153	212
Grassland	1st February	1st September	212	53

The timing of the biocide application in relation to the timing of land application of manure determines the number of biocide applications in between subsequent manure applications and the

8 Where 'land application' is mentioned in the remainder of this report the land application of manure is meant.

amount of manure produced. Data on manure spreading periods other than the default are provided by Defra (2005).

5.8. Nitrogen immission standards

For the calculation of the concentration in soil, the approach of Defra (2005) is used. This means that the amount of biocide present in the manure is related to the nitrogen content and the nitrogen load, which is allowed according to the immission standard. However, in various countries there may be an immission standard for P_2O_5 instead. It is even possible that there are standards for both P_2O_5 and nitrogen. Information for different countries on tolerated N values for use of manure are taken from Defra (2005) which are presented in Table 5.9

Table 5.9 Maximum immission standards ($kg.ha^{-1}.yr^{-1}$) on arable and grassland for nitrogen in NVZs ($Q_{N,grassland}$, $Q_{N, arable\_land}$) and phosphate ($Q_{P2O5,grassland}$ and $Q_{P2O5,arable\_land}$) [1)].

Country	Arable		Grass	
	$Q_{N,s}$	$Q_{P2O5,s}$	$Q_{N,s}$	$Q_{P2O5,s}$
Belgium	120		280	
Denmark	140		230	
Finland	130		250	
France	170		170	
Germany	170		210	
Italy	170		170	
Ireland	170		210	
The Netherlands[2)]	170	85	170[3)]	110
Portugal[4)]	250		250	
Spain	170		210	
Sweden	170		170	
UK	210		250	

[1)] VetCalc: Exposure Modelling Tool for Veterinary Medicines. Draft User's Manual, December 2004. Defra Research Project VM02133 Veterinary Medicines Directorate, Addlestone, UK.
[2)] Uniquely in the EU, NL has set a maximum on the application of manures on the basis of P content for arable land of 85 kg P_2O_5. ha^{-1}. $year^{-1}$ and for grass land of 85 kg P_2O_5. ha^{-1}. $year^{-1}$ (Van Bruggen, 2005).
[3)] in the situation where the area consists at least of 70% grass land the extended standard of 250 $kg.ha^{-1}$ can be used (Van Bruggen 2005).
[4)] Nitrogen application rates depend on type of crop and range from 80-280 kg N. ha^{-1}. $year^{-1}$. The application rate for grassland is not an official number, but assumed to be the same as for arable land

For the model calculations in this ESD, it is assumed that for arable land, the maximum application rates for manure as presented in Table 5.9 are applied in one time.

The mixing depth of the soil depends on the manure application system. Typical method is the surface application of manure through broadcast spreaders. In this case a mixing depth of 5 cm can be applied[9] and manure may be the matrix in which exposure occurs. The default values for the mixing depth and the number of land applications for arable and grassland are presented in Table 5.10.

[9] In the Netherlands manure application is regulated i.e., injection of manure is required to reduce emissions (IPPC, 2003).Manure can be injected into the soil at various depths, shallow (5-10 cm) or deep (15-20 cm). Manure can also be incorporated by working it into the soil after spreading it on the surface. In this case a plough depth of 20 cm is used.

Table 5.10 Default values for the number of land applications per year, Nlapp-grass and Nlapp-arab for grassland and arable land respectively (yr^{-1}) and the mixing depth with soil, $DEPTH_s$ (m), where the subscript "s" stands for the target soil: grassland or arable_land)

Target field	$Nlapp_s$	$DEPTH_s$
arable land	1	0.20
grassland	4	
- surface application (broad cast)		0.05

5.9. *Timing aspects*

Grassland

When the time period between two biocide applications Tbioc-int is larger than the period between two land applications Tmanure-int, the number of biocide applications between two repeated manure applications equals 1. When the period between two manure applications is longer than the period between two repeated biocide applications, the number of biocide applications between two manure applications is calculated by, dividing the manure storage period by the biocide application interval and rounding it to whole numbers. The number of repeated biocide applications calculated this way could by higher than the number of repeated treatments given in the user instructions. In that case the calculated number of biocide applications is set equal to the number of repeated treatments given in the user instructions ($Napp\text{-}bio_{max}$). In equations the above reasoning is as follows:

input		
Tmanure-int	manure storage time	[d]
Tbioc-int	period between biocide treatments	[d]
Napp-bioc	number of repeated treatments prescribed	[-]
output		
$Napp\text{-}bio_{manure}$	number of biocide applications during manure storage period	[-]

If Tbioc-int > Tmanure-int, then $Nappl\text{-}bio_{manure}$ = 1

If Tbioc-int < Tmanure-int, then $Nappl\text{-}bio_{manure}$ = ROUND(Tmanure-int/Tbioc-int) [1)]

If $Napp\text{-}bio_{manure}$ > Napp-bioc, $Napp\text{-}bio_{manure}$ = Napp-bioc

[1)] ROUND is the sign for rounding off to a whole numbers.

As a worst-case situation for grassland the time between two land applications Tmanure-int is used to estimate the amount of manure produced during that period.

Arable land

For arable land there is only one land application during the year in the period after the fly season. For this situation, for one biocide application, the amount of manure produced during the application interval, Tbioc-int, is used to calculate the concentration in manure. This implies a worst case situation as dilution with manure which may be collected in the period before the fly season is not considered.

On the other hand dilution with manure can be taken into account by taking the manure storage period (Tmanure-int = 212) for calculation of the amount of manure produced and taking the maximum number of biocide applications ($Napp\text{-}bioc_{max}$) to calculated the amount of biocide used.

For biocides applied throughout the whole year the same estimation procedure as for grassland can be applied for both application on grassland and application on arable land.

5.10. Degradation time

It may be expected that an insecticide applied just before spreading of manure/slurry will not yet have reached the storage completely according to the emission factor stated in Table 5.4. As long as the degradation rates for the biocide in manure and soil are not considered or are identical the difference in the result of the calculations is not an issue.

For soil the initial concentration is calculated and may be used for risk evaluation as it is assumed that the maximum application rate is applied at one time. Only for substances with degradation halve lives of longer than one year accumulation in soil might become relevant.

For the possible releases of liquid waste into the sewer the assumption has been made that a discontinuous process is involved with one occurrence every month. This means a peak release from one application at the time reaching the WWTP.

6. Emission model

6.1. General remarks

The model presented in the next subsection comprises the calculation of the concentration in soil of biocides (active ingredient) applied in housings and in manure storage systems, and the amount emitted to waste water, which is subsequently treated in an on-farm (private) waste water treatment plant (WWTP) or a municipal sewage treatment plant (STP) (as applicable). In the case that a larvicide is used in both housings and manure storage systems, the concentration has to be calculated as the sum of both individual concentrations (the same amount of manure is concerned). This has not been expressed in the presentation of the model by means of subscripts in order to avoid further complication.

In the case, an insecticide formulation is notified for the general category ‘animal housings’, calculations for all animal categories and subcategories have to be performed. This, because it may turn out that application may be without risk for certain (sub-)categories but not for others.

In the case of poultry, where the notification comprises application in both batteries (without treatment with an air current) and free-range housings with litter floor, the concentration has to be calculated for the slurry consisting of the manure from the battery plus the liquid waste from the free-range housing (stored in slurry tanks).

For batteries with aeration or forced drying (deep pit, high-rise stables), also the amount of active ingredient going to an STP has to be calculated. It has been assumed that only one farm releases liquid waste with the insecticide involved to the sewer at one day.

A part of the insecticide will be emitted to the air directly, depending on the application method and volatility. In the case, that a formulation is sprayed, most of the product will settle with the droplets (solutions) or particles (powders) soon after the treatment. It is unclear at this moment which fraction of an insecticide on walls, ceilings, windows, etc. will be lost due to degradation, evaporation or run-off (e.g. at cleaning). The fraction of insecticide emitted to the air is expected to have such a low rate that a zero emission is assumed.

An insecticide applied in animal housings will probably degrade to some extent before it reaches the manure storage system (such as pits) or the manure heaps. In one case, a biocide has been authorised/notified for application in both housing and at manure heaps. As the application of a biocide (adulticide) in manure storage systems is not very likely to occur, the situation that the amount present in the manure from the housing will be added to the amount present in the storage system is not considered here.

It should be noted that a notification is done for a <u>product</u>, for example a spray containing a certain concentration of an active ingredient, but not for the specific <u>active ingredient</u> present in different products. For every product the registrant/notifier states in the user's instructions:

1. The applications, i.e. the definition of the type of housing/manure storage 'cat-subcat' (index i1) (animal species, housing type, etc.).
2. The type of biocide 'bioctype' (index i2); this will usually be only one out of the four possibilities.
3. The ways the product may be applied 'appway' (index i3), for example spraying and smearing.

It should also be noted that the model presentation does **<u>not</u>** contain subscripts for *m housing type-animal species* (index i1) and *n* types of application (index i3) in order to maintain overview.

The general part of the model is presented in Table 6.3 and the specific scenarios for surface water and degradation in Table 6.1 and 6.2.

The flags that may be used in the tables of the emission model (with their meaning are):

S Parameter must be present in the input data set for the calculation to be executed.
D Parameter has a standard default value (can be overwritten by the user with alternative data).
O Parameter is output from another calculation (can be overwritten by the user with alternative data).
P Parameter value can be chosen from a 'pick-list' with values.
* Value can not be overwritten

Where a default has been specified (flag = D) the defaults for these parameters can be found in the tables of Chapter 5 specified between []. In those cases where S/P has been specified this means that the parameter is present in the input data supplied by the notifier and that the corresponding value is selected from the pick-list. The pick-list is indicated as the table number specified between [].

For those cases where dates and hence day numbers are needed D/P may be stated in order to indicate that the default date can be found in the first table number specified between [] and that conversion into the corresponding day number occurs automatically with the aid of the pick-list presented in the table specified after the "/"-sign between the [].
If a reference is made to a section the figure is in *italic*.

The model considers the following possibilities of notifying the dosage of the biocide formulation and the content of the biocide (active ingredient) in the user's instruction as (based on the products notified in the Netherlands):

[A] Amount (weight) of product, i.e. the biocide formulation as such, to be used for a certain area (number of m^2) of floor area of the housing or manure surface in storage.
[B] Volume of product, i.e. the biocide formulation as such, to be used for a certain number of m^2 of floor area of the housing or manure surface in storage (some notifiers specify the volume in ml, others in l).
[C] Number of m^2 of floor area of the housing to be treated with one container in the case of aerosol cans.

A simple scenario is described assuming:

- maximum immission standards for nitrogen and phosphorous
- application of the maximum manure application rate in one time
- simple calculations for the number of biocide applications during the relevant manure storage period
- no degradation during storage and in soil (initial concentration in soil)
- incorporation into soil for arable land, 20 cm and for grassland either 5 cm (no tillage) or 10 cm (injection)

As a first tier (approach) the surface water concentration is calculated from the pore water concentration according to the method of Montforts (1999) and assuming a dilution on entry of run-off water into the receiving water of a factor of 10. For further refinements in the surface water exposure assessment it is suggested to use FOCUS or comparable modelling tools instead. For further suggestions the reader is referred to chapter 7.

Table 6.1 Default values for parameters used in the calculation of the concentration in fresh surface water.

Variable/parameter	Symbol	S/D/O/P	Value
Input			
Fresh surface water (-)	DILUTION	D	10
Soil water partition coefficient ($l.kg^{-1}$)	Kp_{soil}	S	-
Organic carbon-water partition coefficient (-)	Koc	S	-
Fraction organic carbon in soil (-)	Foc	D	0.02
Fraction air in soil (-)	Fair	D	0.2
Fraction water in soil (-)	Fwater	D	0.2
Fraction solid in soil (-)	Fsolid	D	0.6
Bulk density of solids ($kg.m^{-3}$)	RHOsolid	D	2500
Air-water equilibrium distribution coefficient ($m^3.m^{-3}$)	$K_{air\text{-}water}$	S	-

Output

Soil water partition coefficient ($l.kg^{-1}$)

$$Kp_{soil} = Koc * Foc \tag{1}$$

Soil-water equilibrium distribution coefficient ($m^3.m^{-3}$)

$$K_{soil-water} = Fair * K_{air-water} + Fwater + Fsolid * \frac{Kp_{soil}}{1000} RHOsolid \tag{2}$$

6.2. Emission model

Table 6.3 presents the general part of the emission scenarios for all situations of insecticide application in animal housings and at manure storage systems. Degradation in manure is not yet considered in the scenarios. But might be considered when good degradation test methods will become available.

The specific model for taking degradation into account is presented in Table 6.2.

Table 6.2 Specific part of the emission scenarios taking degradation into account

Variable/parameter (unit)	Symbol	S/D/O/P	[table/*section*]
Input:			
Half-life time for biodegradation in slurry (d)	$DT50bio_{slurry}$	S	-
Half-life time for biodegradation in soil (d)	$DT50bio_{soil}$	S	-
Output:			
Rate constant for biodegradation in slurry (d^{-1})	$kdeg_{slurry}$	S	-
Rate constant for biodegradation in soil (d^{-1})	$kdeg_{soil}$	S	-

Model calculations:

Rate constant for biodegradation in slurry (d^{-1})

$$\mathrm{kdeg}_{\mathrm{slurry}} = \frac{\ln 2}{\mathrm{DT50bio}_{\mathrm{slurry}}} \qquad (3)$$

The fraction of biocide in the manure storage at the end of the storage period for a number of repeated treatments within the storage period (soil is either arable land or grassland):

$$\mathrm{F}_{\mathrm{slurry}} = \frac{1 - \left(e^{-k\deg_{slurry} * Tbioc-\mathrm{int}}\right)^{Napp-manure_{soil}}}{1 - e^{-k\deg_{slurry} * Tbioc-\mathrm{int}}} \qquad (4)$$

Amount (maximum) of biocide in manure at the end of the storage period

$$\mathrm{Qai\text{-}manure}_{\mathrm{p/q}} = Qai_{p/q,i1,i2,i3,i4} * F_{slurry} \qquad (5)$$

Rate constant for biodegradation in soil (d^{-1})

$$\mathrm{kdeg}_{\mathrm{soil}} = \frac{\ln 2}{\mathrm{DT50bio}_{\mathrm{soil}}} \qquad (6)$$

The fraction of biocide in soil after the last land application of manure for repeated manure applications (soil is either grassland or arable land):

Grassland

$$\mathrm{F}_{\mathrm{soil}} = \frac{1 - \left(e^{-k\deg_{soil} * Tsoil-\mathrm{int}}\right)^{Nlapp-soil}}{1 - e^{-k\deg_{soil} * Tsoil-\mathrm{int}}} \qquad (7)$$

Arable land

$$\mathrm{F}_{\mathrm{soil}} = \frac{1 - \left(e^{-k\deg_{soil} * Tsoil-\mathrm{int}}\right)^{Nlapp-soil}}{1 - e^{-k\deg_{soil} * Tsoil-\mathrm{int}}} \qquad (8)$$

Amount (maximum) of biocide in soil at the last land application:

$$\mathrm{Qai\text{-}soil} = Qai - manure * F_{soil} \qquad (9)$$

Table 6.3 Emission scenarios for insecticide application in animal housings and at manure storage systems

Variable/parameter (unit)	Symbol	S/D/O/P	[table/*section*]
Input:			
Type of housing/manure storage (for application *m* of the notification) (-)	cat-subcat (i1)	S/P	[5.1]
Type of insecticide (-)	bioctype (i2)	S/P	[5.1]
Type of application *n* (-)	appway (i3)	S/P	[5.1]
Type of manure storage	manstore (i4)	S/P	[5.1]
Area of the housing for application *m*	$AREA_{i1,i2,i3}$		[5.2]/[5.3]
Surface area of the manure storage	$AREAmanure_{i1,i2,i3}$		[5.3]/[A5]
Volume of the housing	$VOLUME_{i1,i2,i3}$		[5.2]
[A]			
Content of active ingredient in formulation (%)	Fbioc%	S	
Area to be treated with amount prescribed (m^2) for application *m*	$AREAui_{i1,i2,i3}$	S	
Amount of product prescribed to be used for area specified (g) for application *m*	$Qprod\text{-}uins_{i1,i2,i3}$	S	
[B]			
Content of active ingredient in formulation ($g.l^{-1}$)	Fbioc	S	
Area to be treated with amount prescribed (m^2) for application *m*	$AREAui_{i1,i2,i3}$	S	
Amount of product prescribed to be used for area specified (l) for application *m*	$Vprod\text{-}uins_{i1,i2,i3}$	S	
[C]			
Capacity of one aerosol can (g)	Qaerosol	S	
Volume to be treated with one aerosol can (m^3)	$VOLUMEui_{i1,i2,i3}$	S	
Area to be treated with one aerosol can (m^3)	$AREAui_{i1,i2,i3}$	S	
[A, B and C]			
For every relevant application *i1* specified in the notification and every relevant stream *i4*:			
Fraction of active ingredient released (-)	$F_{i1,i2,i3,i4}$	D	[5.4]

. . . .

Table 6.3(continued) Emission scenarios for insecticide application in animal housings and at manure storage systems

Variable/parameter (unit)	Symbol	S/D/O/P	[table/*section*]
Number of repeated treatments prescribed (-)	Napp-prescr	S	-
Maximum number of insecticide applications (-)	$Napp\text{-}manure_{soil}$	O/D	[5.7]
Insecticide application interval (d)	Tbioc-int	D	[5.7]
Number of land applications for grassland (-)	Nlapp-grass	D	[5.10]
Number of land application for arable land (-)	Nlapp-arab	D	[5.10]
Land application interval for grassland (d)	Tgr-int	D	[5.8]
Land application interval for arable land (d)	Tar-int	D	[5.8]
. . . .	. . . .		
Number of animals in housing for every relevant category/subcategory *i1* (-)	N_{i1}	D	[5.2]
Amount of phosphate per animal for every relevant category/subcategory *i1* ($kg.d^{-1}$)	$Qphosph_{i1}$	D	[5.5]
Amount of nitrogen per animal for every relevant category/subcategory *i1* ($kg.d^{-1}$)	$Qnitrog_{i1}$	D	[5.5]
If phosphate immission standards are applied: *NB)*			
Phosphate immission standard for one year on grassland ($kg.ha^{-1}$)	$Q_{P2O5,grassland}$	D	[5.9]
Phosphate immission standard for one year on arable land ($kg.ha^{-1}$)	$Q_{P2O5,arable\_land}$	D	[5.9]
. . . .	. . . .		
If nitrogen immission standards are applied: *NB)*			
Nitrogen immission standard for one year on grassland ($kg.ha^{-1}$)	$Q_{N,grassland}$	D	[5.9]
Nitrogen immission standard for one year on arable land ($kg.ha^{-1}$)	$Q_{N,arable\_land}$	D	[5.9]
. . . .	. . . .		
Mixing depth with soil (m)	$DEPTH_{grassland}$	D	[5.10]
Mixing depth with soil (m)	$DEPTH_{arable\_land}$	D	[5.10]
Density of wet bulk soil ($kg.m^{-3}$)	$RHOsoil_{wet}$	D	1700

NB) At least one of the immission standards should be applied; if none is specified the phosphate immission standard is used with the default values in Table 5.9.

Table 6.3(continued) Emission scenarios for insecticide application in animal housings and at manure storage systems

Output:

Soil

For every relevant application *i1* and stream *i4* and

$PIECgrs\text{-}P2O5_{i1,i2,i3,i4}$	Concentration of the biocide (active ingredient) in soil ($mg.kg^{-1}$) in the case of an immission standard for phosphate and land application on grassland
$PIECgrs\text{-}N_{i1,i2,i3,i4}$	Concentration of the biocide (active ingredient) in soil ($mg.kg^{-1}$) in the case of an immission standard for nitrogen and land application on grassland
$PIECars\text{-}P2O5_{i1,i2,i3,i4}$	Concentration of the biocide (active ingredient) in soil ($mg.kg^{-1}$ in the case of an immission standard for phosphate and land application on arable land
$PIECars\text{-}N_{i1,i2,i3,i4}$	Concentration of the biocide (active ingredient) in soil ($mg.kg^{-1}$) in the case of an immission standard for nitrogen and land application on arable land

STP

$Qai\text{-}stp_{i1,i2,i3,i4}$	Amount of biocide (active ingredient) ($kg.d^{-1}$) reaching the standard STP of EUSES/USES for the relevant cases of *i1* = 6, 7, 10 and 11

Intermediate calculations

$Napp\text{-}manure_{gr}$ number of biocide applications during storage period forapplication on grassland (-)
$Napp\text{-}manure_{ar}$ number of biocide applications during storage period for application on arable land (_)

Tgr-int periode used for calculation of the amount of manure produced for grassland (d)
Tar-int periode use for calculation of the amount of manure produced for arable land (d)

For grassland:

If Tbioc-int > Tgr-int, then

$\mathrm{Napp - manure} = 1$ ***If Tbioc-int < Tgr-int, then***

$\mathrm{Napp - manure} = \mathrm{ROUND}(\mathrm{Tgr - int} / \mathrm{Tbioc - int})$ ***If Napp-manure > Napp-prescr, then***

$\mathrm{Napp - manure} = \mathrm{Napp - prescr}$

Table 6.3(continued) Emission scenarios for insecticide application in animal housings and at manure storage systems

For arable land:

$Napp - manure = 1 \quad Tar - int = Tbioc - int$

Amount of active ingredient to be used in housing or manure storage for one application (kg)

[A] $Qai - prescr_{i1,i2,i3} = 10^{-5} * Qprod - uins_{i1,i2,i3} * Fbioc\% * AREA_{i1} / AREAui_{i1}$ (10)

[B] $Qai - prescr_{i1,i2,i3} = 10^{-3} * Vprod - uins_{i1,i2,i3} * Fbioc * AREA_{i1} / AREAui_{i1}$ (11)

[C.1] $Qai - prescri_{1,i2,i3} = 10^{-3} * Qaerosol * VOLUME_{i1} / VOLUMEui_{i1}$ (12)

[C.2] $Qai - prescri_{1,i2,i3} = 10^{-3} * Qaerosol * AREA_{i1} / AREAui_{i1}$ (13)

[A + B + C]
Amount of active ingredient in relevant stream *i4* after one application (kg)

$$Qai_{i1,i2,i3,i4} = F_{i1,i2,i3,i4} * Qai\text{-}prescr_{i1,i2,i3} \quad (14)$$

If the insecticide has been notified for both housings – for every relevant cat-subcat *p* (*p* = *i1, where i1* = 1 to 18) – and manure storage systems *q* (*q* = *i1*, where *i1* = 19 or 20):
Amount of active ingredient in relevant stream *i4* after one application (kg) in both a housing and manure storage system

$$Qai_{tot,i2,i3,i4} = Qai_{p,i2,i3,i4} + Qai_{q,i2,i3,i4} \quad (15)$$

Soil

[I] For all relevant applications *i1* and relevant waste streams *i4*

Amount of active ingredient in soil (kg) after land application of manure/slurry on grassland after for the maximum number of relevant biocide applications

$$Qai - grass_{i1,i2,i3,i4} = Qai_{i1,i2,i3,i4} * Napp - manure_{gr} \quad (16)$$

$$Qai - arab_{i1,i2,i3,i4} = Qai_{i1,i2,i3,i4} * Napp\text{-}manure_{ar} \quad (17)$$

Amount of phosphate produced during the relevant period for every relevant (sub)category of animal/housing *i1* ($kg.yr^{-1}$)

$$Qphosph\text{-}arab_{i1,i4} = N_{i1} * Qphosph_{i1} * Tar - int_{i2} \quad (18)$$

$$Qphosph\text{-}grass_{i1,i4} = N_{i1} * Qphosph_{i1} * Tgr - int_{i2} \quad (19)$$

Table 6.3(continued) Emission scenarios for insecticide application in animal housings and at manure storage systems

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Amount of nitrogen produced during the relevant period for every relevant (sub)category of animal/housing *i1* ($kg.yr^{-1}$)

$$Qnitrog\text{-}arab_{i1,i4} = N_{i1} * Qnitrog_{i1} * Tar\text{-}int_{i2} \tag{20}$$

$$Qnitrog\text{-}grass_{i1,i4} = N_{i1} * Qnitrog_{i1} * Tgr\text{-}int_{i2} \tag{21}$$

End calculations

Soil

For all relevant applications i1 and the waste stream i4:

If the phosphate immission standard is applicable:

Concentration of the active ingredient in soil is applied ($mg.kg^{-1}$) based on the nitrogen immission standard for grassland

$PIECgrs\text{-}P2O5_{i1,i2,i3,i4} =$

$$PIECgrs\text{-}P2O5_{i1,i2,i3,i4} = \frac{100 * Qai - grass_{i1,i2,i3,i4} * Q_{P2O5,grassland}}{Qphosph\text{-}grass_{i1,i4} * Nlapp - grass * DEPTH_{grassland} * RHOsoil_{wet}} \tag{22}$$

Concentration of the active ingredient in soil ($mg.kg^{-1}$) based on the phosphate immission standard for arable land

$$PIECars\text{-}P2O5_{i1,i2,i3,i4} = \frac{100 * Qai - arab_{i1,i2,i3,i4} * Q_{P2O5,arable\_land}}{Qphosph\text{-}arab_{i1,i4} * DEPTH_{arable\_land} * RHOsoil_{wet}} \tag{23}$$

If the nitrogen immission standard is applicable:

Concentration of the active ingredient in soil ($mg.kg^{-1}$) based on the nitrogen immission standard for grassland

$$PIECgrs\text{-}N_{i1,i2,i3,i4} = \frac{100 * Qai - grass_{i1,i2,i3,i4} * Q_{N,grassland}}{Qnitrog\text{-}grass_{i1,i4} * Nlapp - grass * DEPTH_{grassland} * RHOsoil_{wet}} \tag{24}$$

Concentration of the active ingredient in soil ($mg.kg^{-1}$) based on the phosphate immission standard for arable land

$$PIECars\text{-}N_{i1,i2,i3,i4} = \frac{100 * Qai - arab_{i1,i2,i3,i4} * Q_{N,arable\_land}}{Qnitrog\text{-}arab_{i1,i4} * DEPTH_{arable\_land} * RHOsoil} \tag{25}$$

Table 6.3(continued) Emission scenarios for insecticide application in animal housings and at manure storage systems

Ground water and Surface water

For the concentration in surface water the porewater/groundwater concentration is used:

Based on nitrogen immission standards

$$\text{PIECgrs - gw - N}_{\text{i1,i2,i3,i4}} = \frac{\text{PIECgrs - N}_{\text{i1,i2,i3,i4}} * \text{RHOsoil}_{\text{wet}}}{K_{soil-water} * 1000} \tag{26}$$

$$\text{PIECgrs - water - N}_{\text{i1,i2,i3,i4}} = \frac{\text{PIECgrs - gw - N}_{\text{i1,i2,i3,i4}}}{DILUTION_{run-off}} \tag{27}$$

$$\text{PIECars - gw - N}_{\text{i1,i2,i3,i4}} = \frac{\text{PIECars - N}_{\text{i1,i2,i3,i4}} * \text{RHOsoil}_{\text{wet}}}{K_{soil-water} * 1000} \tag{28}$$

$$\text{PIECars - water - N}_{\text{i1,i2,i3,i4}} = \frac{\text{PIECars - gw - N}_{\text{i1,i2,i3,i4}}}{DILUTION_{run-off}} \tag{29}$$

Based on phosphate immission standards

$$\text{PIECgrs - gw - N}_{\text{i1,i2,i3,i4}} = \frac{\text{PIECgrs - P2O5}_{\text{i1,i2,i3,i4}} * \text{RHOsoil}_{\text{wet}}}{K_{soil-water} * 1000} \tag{30}$$

$$\text{PIECgrs - water - N}_{\text{i1,i2,i3,i4}} = \frac{\text{PIECgrs - gw - P2O5}_{\text{i1,i2,i3,i4}}}{DILUTION_{run-off}} \tag{31}$$

$$\text{PIECars - gw - N}_{\text{i1,i2,i3,i4}} = \frac{\text{PIECars - P2O5}_{\text{i1,i2,i3,i4}} * \text{RHOsoil}_{\text{wet}}}{K_{soil-water} * 1000} \tag{32}$$

$$\text{PIECars - water - N}_{\text{i1,i2,i3,i4}} = \frac{\text{PIECars - gw - P2O5}_{\text{i1,i2,i3,i4}}}{DILUTION_{run-off}} \tag{33}$$

STP

Amount of active ingredient reaching the standard STP (kg.d^{-1}) (for the relevant cases of *i1* = 8, 9, 11 and 12)

$$\text{Qai}_{\text{i1,i2,i3,i4}} = \text{F}_{\text{i1,i2,i3,i4}} * \text{Qai - prescr}_{\text{i1,i2,i3}} \tag{34}$$

7. Refinement options for the Emission Scenario Document

7.1. Introduction

The ESD provides guidance for calculating an initial PECsoil. However, it must be recognised that after it has been applied to land in manure, an insecticide may be subject to further transport to groundwater. For EU member states, this is in accordance with guidance provided in the Technical Guidance Document (EC, 2003c). In addition, it is also appropriate to consider the potential for transport of insecticides to surface waters via runoff or field drainage systems. A number of potential approaches are available for estimating exposure to these environments, ranging in complexity from simple screening calculations to higher-tier modelling investigations. Some of the potential approaches for estimating exposure are briefly described below, for both surface water and groundwater. It is envisaged that, for estimating exposure to these compartments, applicants would follow a stepwise approach, using simple lower-tier approaches to provide an initial standard assessment and moving on to more complex approaches when a more refined estimate of exposure is required.

Additionally a number of potential refinement options are considered in order to make a more realistic estimate of exposure. The approach presented in this ESD is intended to provide an initial, first-tier estimate of environmental exposure. As a result, the exposure calculation methodology has necessarily been simplified and does not always extensively consider the potential for certain aspects of environmental fate (e.g. potential for degradation in manure or agricultural soil).

7.2. Predicted Environmental Concentrations in Groundwater

Potential methods for estimating exposure to groundwater by insecticide residues following application of organic manures to agricultural land may include, but are not limited to, the following:

7.2.1. Porewater Calculation Method

It is suggested that for an initial indication of potential groundwater levels, the concentration in porewater of agricultural soil may be used. It should be noted that this represents an extreme worst-case neglecting transformation and dilution in deeper soil layers.

The calculation for deriving the concentration in porewater is:

$$\mathrm{PIECwater} = \frac{\mathrm{PIEClocal_{soil}} * \mathrm{RHOsoil_{wet}}}{K_{soil-water} * 1000} \qquad (19)$$

Table 7.1 Parameters used in the calculation of the concentration in pore water.

Symbol	Variable/parameter	Unit
$PIEC_{soil}$	Local concentration in soil (initial)	$g.kg^{-1}$
$K_{soil\text{-}water}$	Soil water equilibrium partition coefficient	$l.kg^{-1}$
$RHOsoil_{wet}$	Bulk density of wet soil	$kg.m^{-3}$
PIECpore water	Local concentration in porewater (initial)	$mg.l^{-1}$

7.2.2. Groundwater Ubiquity Score (GUS) method

Another simple screening calculation can be carried out using the Groundwater Ubiquity Score (GUS) method (Gustafson, 1989). It is suggested that if such an approach is adopted the parameterisation (i.e. selection of appropriate soil DT50 and Koc values) is based upon the guidance presented in the FOCUS groundwater report (FOCUS, 2000).

$$GUS = \log(DT_{50}) * (4 - \log K_{oc})$$

If GUS > 2.8 Leacher
If GUS 1.8-2.8 Transitional or intermediate leacher
If GUS <1.8 Non-leacher

7.2.3. FOCUS Models

A series of more complex, mechanistic environmental models and accompanying scenarios have been created by work groups in Europe known as FOCUS (Forum for the Coordination of Pesticide Fate Models and Their Use) to simulate the fate and transport of agrochemicals in the environment. Groundwater calculations developed by FOCUS involve the simulation of the leaching behaviour of agrochemicals using a set of four models (FOCUS version of PEARL, PELMO, PRZM and MACRO) in a series of up to nine geographical scenarios with various combinations of crops, soils and climate representing a wide range of arable agriculture in the EU. Groundwater concentrations are estimated by determining the 80th percentile annual average concentrations in shallow groundwater (1 m soil depth) for a period of 20 consecutive years. Detailed explanations of the FOCUS models as well as the modelling scenarios, key assumptions, required modelling inputs and model outputs are provided in the respective FOCUS modelling reports (FOCUS 2000, FOCUS 2001). The FOCUS surface water and groundwater models have been placed on a website (viso.ei.jrc.it/focus/index.htm) where they can be freely downloaded.

In addition, the FOCUS Groundwater framework is a scenario-based tool that has been developed for assessing risks associated with specific arable uses of pesticides. A wide range of crops are considered but the framework does not extend into wet grassland situations where livestock grazing is the predominate form of agricultural activity. With respect to biocidal uses of insecticides this may be a significant omission of dairy production in certain areas of Europe (e.g. south-west England and Ireland). As a consequence, in some situations it may be appropriate to develop more suitable scenarios that more realistically reflect environmental conditions in typical use areas. As with all modelling approaches, full and transparent justification of all parameterisation, including scenario selection, should be provided.

7.2.4. Other Models

Another model that may be of particular interest is the VetCalc tool (Defra, 2005). The development of the VetCalc modelling framework was commissioned by the UK Veterinary Medicines Directorate and was designed to consider exposure and risk potential associated with usage of veterinary medicines, taking into account agricultural practices and environmental situations throughout Europe. The VetCalc tool addresses a wide variety of agricultural and environmental situations including:

- Animal characteristics for major food-producing animals;
- Associated manure characteristics;
- Local agricultural practices;
- Characteristics of the destination environment;
- Fate and behaviour within three critical compartments (soil, groundwater and surface water)

VetCalc may be freely downloaded from the website of the UK Veterinary Medicines Directorate (www.vmd.gov.uk\downloads\vetcalc\vetcalc.htm). The installation package includes a number of databases in Microsoft Excel format, as well as a comprehensive user's manual giving a full background to the model development and scenario characteristics.

In addition, there is also the option to consider using a broader range of modelling tools to predict the fate of insecticides applied to agricultural land in organic manures. These may include, but are not limited to, non-FOCUS versions of PEARL (Leistra, 2000), PELMO (Klein, 1995), PRZM (Mullins (1993) and MACRO (Jarvis, 1994) and other models such as LeachP (which is used in the VetCalc tool, but is also available as a standalone model) GLEAMS (Knisel, 1993) and EXPOSIT (Winkler, 2001). It is suggested that, provided full and transparent justification of model selection and parameterisation is given, these models may also provide a valid approach for predicting environmental concentrations in groundwater.

7.2.5. Experimental Data

More refined determinations of environmental fate can be generated through experimental studies. However, it must be stressed that such approaches are higher-tier options and need only be considered if simple, lower-tier calculations identify an unacceptable exposure level. Potential experimental approaches might include lysimeter studies, field mobility studies and groundwater monitoring.

In many cases (e.g. in the EU where compounds have already been submitted as the active ingredient in a plant protection product under 91/414/EEC), experimental data may already be available. It is suggested that, where applicable, these data may be used to provide an indication of leaching potential. In these cases, care must be taken to ensure that application rates and environmental conditions are representative of those expected to result from the application of residues within manure.

7.3. Predicted Environmental Concentrations in Surface Water

Depending upon site-specific characteristics (e.g. climate, soil hydrology, topography etc.), exposure to surface waters may occur as a result of transport of insecticide residues from treated agricultural land via runoff and/or via agricultural drainage systems. Potential methods for estimating exposure to surface waters via these pathways may include, but are not limited to, the following:

7.3.1. Porewater Calculation Method

It is suggested that for an initial indication of potential groundwater levels, the concentration in porewater of agricultural soil, adjusted to account for dilution in the receiving water body, may be used to indicate potential for runoff and drainage (Montforts, 1999). Using this method, it is assumed that on entry of run-off water into the receiving water body dilution by a factor of 10 will occur.

7.3.2. Drainage Classification Schemes

For assessing pesticide submissions, the UK Pesticide Safety Directorate employs a simple mobility classification scheme to assess whether a compound displays potential to reach surface waters via drainage. It is suggested that such an approach could be used to provide a simple assessment of mobility for insecticide residues applied to agricultural land via organic manures. The approach presently adopted by PSD can be described as follows (PSD, 2000): Based on a classification of adsorption coefficient (Koc), a proportion of the chemical is assumed to leach to drains. This is transported in 100,000 L of drainage water (i.e. 10 mm of leachate over 1 ha) and diluted into a further 30,000 L of receiving waters in a destination ditch, giving a total dilution volume of 130,000 L. The classification scheme is outlined in Table 7.2.

Table 7.2 Percentage of pesticide loss in drain flow to be used according to the pesticide Koc value (PSD, 2000).

Mobility Classification	K_{oc} ($l.kg^{-1}$)	% pesticide transported per 10 mm drain water
Very mobile	< 15	1.9
Mobile	15-74	1.9
Moderately mobile	75 – 499	0.7
Slightly mobile	500 - 1000	0.5
	1000 - 4000	0.02
Non-mobile	> 4000	0.008

7.3.3. Run-off Classification Schemes

There exist a number of simple classification schemes that may be used to predict losses of pesticides applied to agricultural fields via runoff to surface waters based on simple environmental fate and physico-chemical data. Provided that suitable justification is provided, such schemes could be used to predict losses of insecticide residues applied in organic manures via this pathway. A scheme proposed by Goss (1992) is reproduced below:

Soil run-off potential for sediment transport
DT_{50} (days); Koc ($l.kg^{-1}$); Solubility ($mg.l^{-1}$)

Large:
If $DT_{50} \geq 40$ and $K_{oc} \geq 1000$
or
If $DT_{50} \geq 40$ and $K_{oc} \geq 500$ and Solubility ≤ 0.5

Small:
If $DT_{50} \leq 1$
or
If $DT_{50} \leq 2$ and $K_{oc} \leq 500$
or
If $DT_{50} \leq 4$ and $K_{oc} \leq 900$ and Solubility ≥ 0.5
or
If $DT_{50} \leq 40$ and $K_{oc} \leq 500$ and Solubility ≥ 0.5
or
If $DT_{50} \leq 40$ and $K_{oc} \leq 900$ and Solubility ≥ 2.0

Medium:
All other circumstances

Soil run-off potential for solution-phase transport
DT_{50} (days); Koc ($l.kg^{-1}$); Solubility ($mg.l^{-1}$)

Large:
If Solubility ≥ 1 and $DT_{50} \geq 35$ and $K_{oc} < 100{,}000$
or
If Solubility ≥ 10 Solubility < 100 and and $K_{oc} \leq 700$

Small:
If $K_{oc} \geq 100{,}000$
or
$K_{oc} \geq 1000$ and $DT_{50} \leq 2$
or
If $DT_{50} < 35$ and Solubility < 0.5

Medium:
All other circumstances

7.3.4. FOCUS Surface Water Framework

Another potential approach for estimating potential exposure to surface waters could be to employ aspects of the framework that has been developed for pesticides by the FOCUS Surface Water Working Group (FOCUS, 2001). The assessment framework consists of three steps, which are progressively more sophisticated.

At step1, a joint drainage/runoff event is simulated corresponding to the movement of 10% of the application, at the time of application This drainage/runoff input is simulated to instantaneously partition between the water and sediment phases depending on the KOC value for the compound. The fraction of the pesticide added to the water phase is given by:

$$\text{Fpest - water} = \frac{\mathrm{Q}_{\mathrm{water}}}{Q_{water} + \left(Q_{se\,\mathrm{dim}\,ent} * F_{oc} * K_{oc}\right)} \qquad (20)$$

Table 7.3 Parameters used in the calculation of the fraction of pesticide in water.

Symbol	Variable/parameter	Unit
Q_{water}	Mass of water	kg
$Q_{sediment}$	Mass of sediment available for partitioning	kg
F_{oc}	Fraction organic carbon in sediment	-
K_{oc}	Organic carbon partition coefficient	$l.kg^{-1}$

At step 2, a single drainage/runoff event is simulated four days after the application event. The percentage of the remaining substance in the soil moved to the surface water is a function of the region of Europe (North or South) and the season of the applications:

Table 7.4 Step 2: run-off/drainage input into surface water.

Region/Season	% of soil residue
North Europe, October- February	5
North Europe, March – May	2
North Europe, June - September	2
South Europe, October- February	4
South Europe, March – May	4
South Europe, June - September	3
No run-off/drainage	0

At step3, the simple assumptions used in the previous steps are replaced with a more complicated arrangement and more sophisticated calculation tools. Input into standard water bodies via drainage are calculated using the MACRO model, whilst runoff loadings are estimated using the PRZM model (FOCUS, 2001). The TOXSWA model (Beltman, 1999 and Horst, 2003) is used to simulate fate in the sediment/water phases of the different water bodies associated with each scenario. One of the advantages of the FOCUS modelling framework is that it incorporates a more realistic approach to the issue of dilution than is available in the lower-tier approaches that have already been described.

The FOCUS Surface Water framework is a scenario-based tool that has been developed for assessing risks associated with specific arable uses of pesticides. As a result, the same caveats apply when considering applicability to wet grassland/grazing situations as discussed earlier.As a consequence, in some situations it may be appropriate to develop more suitable scenarios that more realistically reflect environmental conditions in typical use areas. As with all modelling approaches, full and transparent justification of all parameterisation, including scenario selection, should be provided.

7.3.5. Other Models

The VetCalc tool (see earlier Section on Groundwater modelling) has been developed to include the option to assess the potential exposure to surface waters resulting from the transport of chemicals applied to land in organic manures. The framework simulates losses to surface waters via runoff and/or drainage for a number of European scenarios (using a modified LeachP model, (Hutson , 1992)). Dominance of the different transport pathways is determined by topographical, hydrological and climatic characteristics built into the scenarios, which can be selected based upon their relevance to particular production systems. The fate of the chemical within the surface waterbodies is simulated using a fugacity model that is incorporated into the software shell.

VetCalc may be freely downloaded from the website of the UK Veterinary Medicines Directorate (www.vmd.gov.uk\downloads\vetcalc\vetcalc.htm). The installation package includes a number of databases in Microsoft Excel format, as well as a comprehensive user's manual giving a full background to the model development and scenario characteristics.

The modelling approaches that have been outlined here have only been selected for the purpose of demonstration. Many other models may be used to simulate movement of chemicals from fields and into surface waters. For example, GLEAMS (Knisel (1993) to simulate run-off and EXAMS (US-EPA, 2005) to simulate exposure and fate in surface water. Again, these models may be suitable for estimating exposure to surface waters resulting from the application of manures containing insecticide residues to land. However, full and transparent justification of model selection and all parameterisation would be required.

7.3.6. Other higher-tier options

More refined determinations of environmental fate can be generated through experimental studies. However, it must be stressed that such approaches are represent higher-tier options and need only be considered if simple, lower-tier calculations identify an unacceptable exposure level. Potential experimental approaches might include drainage studies, runoff studies and monitoring programmes.

7.4. Refining estimates of environmental exposure

The approach presented in this ESD is intended to provide an initial, first-tier estimate of environmental exposure. As a result, the exposure calculation methodology has necessarily been simplified and does not consider the potential for certain aspects of environmental fate (e.g. potential for degradation in manure or agricultural soil). It is envisaged that should the initial, first-tier assessment identify a potential environmental risk resulting from the use of a product, then a number of potential refinement options may be considered by the applicant in order to make a more realistic estimate of exposure.

7.4.1. Potential Refinement Options

Depending upon the scenario and the characteristics of the compound being studied, a number of potential options may be available to refine the exposure assessment. Broadly speaking, these refinements may fall into one of two main categories:

- Refinements of Agricultural Practice
- Refinements of Chemical Fate

When considering the suitability of refinement options it should be noted that, as a general principle, any departure from the default values provided within the ESD must be fully justified and, if possible, supported by suitable evidence.

7.4.2. Refinements of Agricultural Practice

Potential refinements in agricultural practice may include, but are not limited to, the following:

- Assumptions regarding the size of the animal housings that are treated and the number of animals that kept in the housings
- Manure Application Rates
- Number of Manure Application Events
- Timing of Manure Application Events
- Riparian Buffer Zones

The potential refinement options are explored in more detail below:

Assumptions regarding the size of the animal housings that are treated and the number of animals kept in the housings

Default values have been suggested based upon a review of relevant literature. However, where more representative data are available, it may be suitable to replace these values.

Manure Application Rates

The scenarios provided in this ESD are intended to represent a realistic worst case: It has been assumed that applications are limited on the basis of nitrogen content, with the maximum individual field application limits 250 $kg_N.ha^{-1}.yr^{-1}$ for both arable and grassland systems. At the whole-farm scale, the relevant application limits are 210 $kg_N.ha^{-1}.yr^{-1}$ for grassland and 170 $kg_N.ha^{-1}.yr^{-1}$ on arable land. These values are based upon typical Nitrate restrictions stipulated for Nitrate Vulnerable Zones

(NVZ's) that were established under the EC Nitrates Directive (91/676/EC). However, it is recognised that significant variation may exist in manure management practice between different OECD Member Countries. Indeed, in a number of OECD Member Countries there are no comparable manure restrictions based upon nutrient content (N or P). It is recognised that there is the potential to exceed these limits (both inside the European Union under circumstances where NVZ's do not apply and in other OECD member countries). As such, the NVZ limits have been adopted here purely as a pragmatic attempt to represent a typical upper limits to manure applications. However, in certain cases it may be more realistic to replace default values, provided full justification is given. A table of relevant nitrogen (and phosphorous) restrictions for EU member states has been included in section 0 of this document.

Number of Manure Application Events

For the purposes of simplicity it has been assumed that, in the case of arable land, manure/slurry is applied to the permissible limit during a single, annual application event. This partly reflects the fact that the presence of a crop will prevent applications of manure/slurry throughout much of the year. In the case of grassland, it is more typical to make a number of applications of manure/slurry throughout the year, with the total amount of nitrogen applied adding up to equal the annual permissible limit. The ESD suggests a default of four manure application events for grassland systems.

In the first-tier screening approach presented in this ESD, the calculation of (initial) PECsoil is based upon the maximum permissible nutrient immission limit ($kg_N.ha^{-1}.yr^{-1}$), resulting an annual total (initial) PECsoil. In the case of a multiple application situation (such as on grassland, where four applications are typically carried out) this represents an unrealistic worst-case situation, since it effectively assumes that no degradation of the active substance occurs between successive applications, so that after one year (four applications) the concentration in soil is equal to four times that of any individual application. This situation assumes an exposure profile displaying a stepped pattern, with the maximum PECsoil being equivalent to that which would result from a single application made at a rate equivalent to the maximum permissible nutrient immission limit ($kg_N.ha^{-1}.yr^{-1}$) (see Figure 7.1).

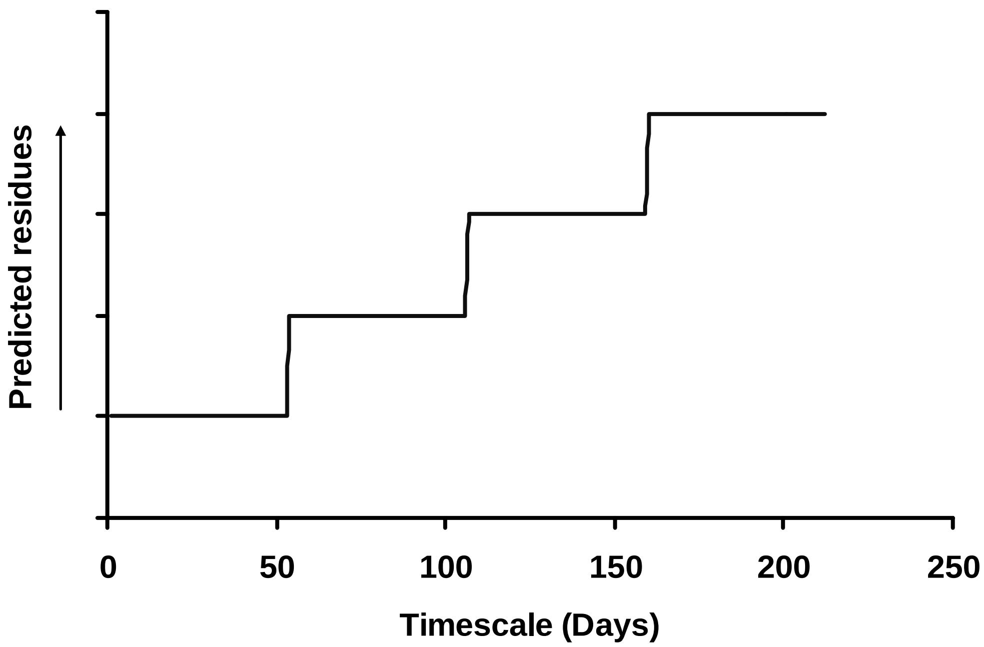

Figure 7.1 Soil exposure profile associated with grassland systems under the worst-case assumption that no degradation of active substance occurs between successive applications. In this example, manure applications are made on days 0, 53, 106 and 159.

In order to produce a more realistic estimate of soil exposure for multiple application agricultural systems (e.g. grassland), it may be more appropriate to calculate a PECsoil for each individual manure/slurry application event. This can be achieved by dividing the annual nutrient immission limit ($kg_N.ha^{-1}.yr^{-1}$) used in the PECsoil calculation (Equation 22 and 24) by the number of applications events carried out in one year. However, if such an approach is employed, the influence of degradation of the active substance within the soil should be considered carefully since, due to the possibility of carry-over between applications, the maximum annual PECsoil will not necessarily occur following an individual application. More information concerning the degradation of insecticides within soil is given in the section about refinements of chemical fate. A typical soil exposure profile is presented in Figure 7.2. In this situation it is clear that, due to the effect of carry-over of residues between successive application events, the maximum PECsoil is associated with the final (fourth) application.

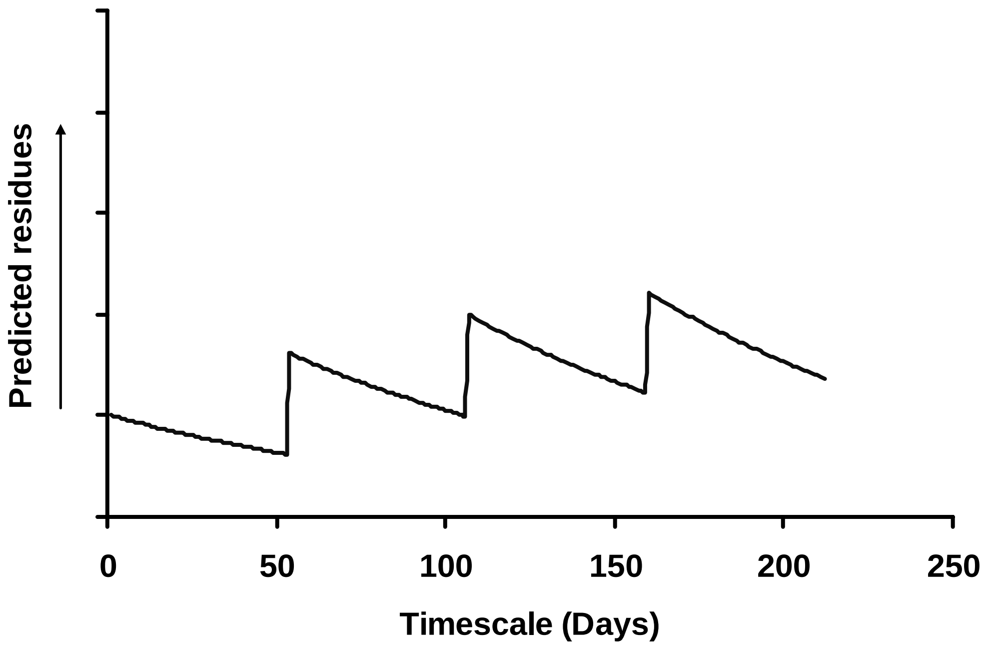

Figure 7.2 Soil exposure profile associated with grassland systems showing the effect of degradation of active substance occurring between successive applications. In this example, manure applications are made on days 0, 53, 106 and 159. Due to carryover of soil residues, the maximum PECsoil occurs on day 159.

Timing of Manure Application Events

In the first-tier screening approach presented in this ESD it is not necessary to consider the specific timings of manure applications. However, this is an aspect that may need to be considered if higher-tier modelling approaches are to be used to predict potential exposure to surface waters and/or groundwater, since many environmental fate models require an application date in order to be run.

It is suggested that, if required, selection of suitable application dates should be based upon typical agricultural practice for representative countries or regions. It should be noted that in many OECD Member Countries there exists legislation to restrict manure application timings to safe time windows in order to avoid periods of high rainfall when soils are excessively wet or periods when the soil surface is frozen. It may be suitable to consider these restrictions when selecting application dates. Information concerning typical manure application timings and relevant restrictions in a number of

European member states has been summarised within the databases provided in the VetCalc software (Defra, 2005).

Riparian Buffer Zones

In many OECD Member Countries, there exists legislation to prevent applications of manure and slurries in areas immediately adjacent to surface waters. For example, in the UK there is a requirement to observe a 10 meter buffer zone around surface waters for all organic manure applications (Defra, 2002). Situations may vary in other countries. Clearly the observation of a buffer zone will have a significant influence upon the potential for transport of insecticide residues in runoff from treated areas. Therefore, if relevant, it may be suitable to consider the impact of buffer zones in order to make a more refined estimate of exposure in surface waters resulting from transport via runoff. If such a refinement option is used full justification should be given, including a consideration of the relevance of any regional/country specific legislation within the context of the product usage.

7.4.3. Refinements of Chemical Fate

Potential refinements in the way that the fate of the active substance is considered may include, but are not limited to, the following:

- Retention of the insecticide on treated area during cleaning procedure / degradation of insecticide during product service life
- Relevance of wastewater exposure pathway
- Degradation of insecticide in manure during storage
- Degradation of insecticide in soil

The potential refinement options are explored in more detail below:

Retention of the insecticide on treated area during cleaning procedure/ degradation of insecticide during product service life

The assumptions regarding the fraction of the chemical that is lost to manure/slurry during the cleaning procedure in the animal housing presented in Table 5.4 of the ESD are worst-case estimates that have been established by expert judgement. In order to elaborate upon potential refinement options, the conditions defining the loss fractions are the following.

- sorption characteristics (i.e. can less losses can be expected for more strongly sorbed compounds)
- compound persistence (i.e. if a compound is rapidly degraded during it's service life lower losses would be expected)
- applied cleaning method (e.g. high-pressure or low pressure hose etc.) (i.e. the cleaning method may possibly affect losses accordingly).

A further, higher-tier, option for refining these assumptions would be the generation of experimental data concerning the fate of the insecticide under service life conditions. Such data could be obtained by carrying out a simple wash-off study on surfaces representative of those to which applications take place.

Relevance of wastewater exposure pathway

As a worst-case, it is assumed that liquid waste (from cleaning activities) produced by laying hens in batteries with drying and pens with a grating floor is lost to the waste water compartment and, hence fate in the waste water treatment plant (sewerage) should be considered. However, it should be noted that, due to the high nutrient loading of these manures, there may be significant restrictions concerning the release of such wastes to waste water (sewerage) in many OECD member countries. For example, in the UK, Water Service Companies only allow livestock farms in suitable locations to discharge diluted waste into a public sewer if they are able to treat the extra pollution load (MAFF, 1998). In the Netherlands it is not allowed to discharge waste water (containing manure) from farms to the sewerage without consent permit. However there are some exceptions and therefore the waste water is still a potential route for the water compartment. In Germany and New Zealand there is no permit for waste water effluent discharge to domestic sewage system at all (Drury, 2005). As a consequence, it may be appropriate not to consider releases to the wastewater compartment for applications made to laying hen production systems for certain member countries.

Degradation in Manure

The framework presented in the ESD is intended to provide an initial first-tier assessment and has, necessarily, not considered the potential for degradation of insecticide to occur during manure/slurry storage. Consideration of potential degradation in manure during storage presents a number of complexities into the PECsoil estimation framework.

The previous document prepared by RIVM (van der Poel and Bakker, 2002) explores these issues and suggests one possible PECsoil estimation method. In order to carry out such calculations, a number of pieces of information will be required: Degradation rate of the active substance in slurry and/or manure (depending on which is the most relevant system); information regarding the length of time that Manures are stored for; knowledge of how the timing of manure applications interact with the application regime for the insecticide being considered.

Degradation rate of the active substance in slurry and/or manure

Essentially, there are two main types of manure storage systems; slurry and farmyard manure (FYM). The different characteristics of the two systems will have implications upon the fate of insecticides. For example, the temperature of manure in the two storage systems will be different. Often FYM heaps act as composting systems, resulting in greater-than-ambient temperatures. Conversely, slurry temperatures will generally more closely reflect ambient conditions. Similarly, moisture content, organic carbon content, pH, and redox conditions will vary considerably between storage systems. Due to the diversity of these conditions, to date it has not been possible to develop a standard test to reflect degradation potential in all systems. In the past Veterinary Medicine registrants have employed the results of lab-based soil degradation studies as a surrogate. However, this makes the assumption that there is no influence of temperature and moisture content on degradation in manure/slurry (i.e. conditions are the same as, or more favourable than, those at which the DT_{50} for soil are derived). While this has, in the past, been successful under certain circumstances, this approach is increasingly not considered acceptable in reflecting manure/slurry storage conditions and matrix characteristics.

With respect to the EU Biocidal Products assessment procedure, there is currently no definitive regulatory guidance on selection of appropriate degradation values for the fate of active substances within organic manures. Therefore, there is scope for the applicant to select the most appropriate endpoint, provided that a suitably robust scientific justification is provided. It is important that if degradation is to be considered, an appropriate DT_{50} value should be used considering conditions (organic carbon content, water content, pH, temperature and redox conditions) in the most relevant type of storage system. Standardised guideline studies in soil may provide an opportunity to very crudely represent general persistence and degradability. While these studies are not directly relevant to farmyard manure and slurry matrices and storage conditions, they can provide persistence benchmarks that could be used to provide a general indication of biodegradability.

- It might be appropriate to account for degradation potential within Farmyard Manure (FYM) systems to select a suitably justified worst-case aerobic soil DT_{50} based upon the results of Simulation tests such as the OECD 307 “Aerobic and anaerobic transformation in soil” (OECD, 2002 and EC, 2004b)

- To account for degradation potential within slurry systems it might be appropriate to select a suitably justified worst-case anaerobic soil DT50 based upon the results of Simulation tests such as the OECD 307 “Aerobic and anaerobic transformation in soil” (OECD, 2002 and EC, 2004b)

Information regarding the relative importance of the different storage systems for a wide range of production types is provided within the VetCalc software (Defra, 2005).

Manure Storage Periods

Clearly the length of time that manures are stored for has a significant influence upon the amount of degradation that an active substance may undergo before it is applied to agricultural land. The storage time of manures is closely related to agricultural practice, which vary considerably between OECD Member Countries. In order to derive a storage period for insecticides within manure, consideration must be given to the fact that insecticide application timings may be driven by the ‘fly season’, therefore insecticide use will not be spread evenly throughout the year. The previous document prepared by RIVM (van der Poel and Bakker, 2002) provides a framework for estimating the storage times for insecticide residues in manures that considers the ‘overlap’ between these timescales. Figure 7.3 provides a representation of the calculation scheme used in this framework, based on the assumption that 6 insecticide applications are made over a period of 6 months and that manure applications are made to a grassland system. From the diagram, it is clear that for some storage periods the amount of insecticide residue contributed to the manure in storage will be significantly different to that contributed during others (i.e. manure in some storage periods will receive residues from two biocide application events, whilst others will receive residues from only one event). In addition, the length of time available for residues to be degraded will also vary considerably. In figure 7.3, potential degradation periods for storage in manure for residues resulting from individual biocide applications range from 0.5 days (for the second biocide application) to 50 days (for the fifth biocide application). These issues highlight the complexities that should be considered when degradation in manure is to be taken into account.

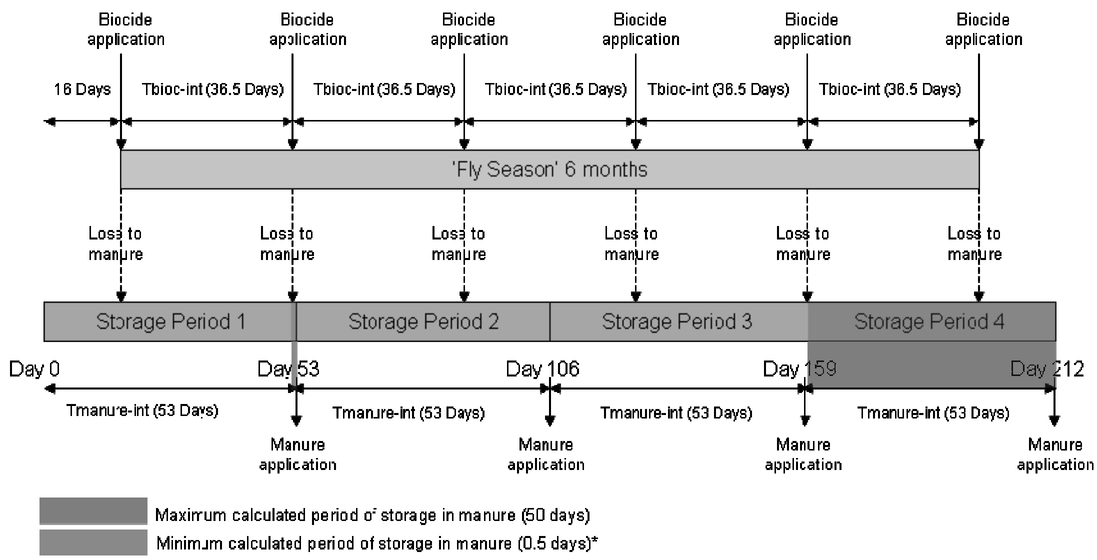

Figure 7.3 A representation of the calculation scheme presented by van der Poel and Bakker (2002) that may be used to estimate periods of storage in manure for insecticide residues.

It should be noted that the approach to calculating storage times in manure for insecticides presented by van der Poel and Bakker (2002) is only a suggested methodology and, provided justification is given, alternative frameworks or further refinements may also be appropriate. One assumption that is made by van der Poel and Bakker (2002) is that insecticide residues are lost to manure during the biocide application event. Whilst this may be suitable for applications made directly to manure, such an assumption may not be suitable for all products. For example, for products that are applied to walls and ceilings of animal housings, losses of insecticide residues to manure are most likely to occur when the housing is cleaned. In these situations, it may be appropriate to also consider the length of the animal production cycle, since this is typically linked to the timing of cleaning events (e.g. housings are often cleaned at the end of production cycles).

Further information regarding typical manure and slurry storage periods for a range of EU member states, as well as information relating to the length of production cycles for the major livestock categories, may be obtained from the databases provided in the VetCalc software (Defra, 2005).

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APPENDIX 1
ANNEX II TO DIRECTIVE 91/676/EEC

CODE(S) OF GOOD AGRICULTURAL PRACTICE

A. A code or codes of good agricultural practice with the objective of reducing pollution by nitrates and taking account of conditions in the different regions of the Community should certain provisions covering the following items, in so far as they are relevant:

1. periods when the land application of fertilizer is inappropriate;
2. the land application of fertilizer to steeply sloping ground;
3. the land application of fertilizer to water-saturated, flooded, frozen or snow-covered ground;
4. the conditions for land application of fertilizer near water courses;
5. the capacity and construction of storage vessels for livestock manures, including measures to prevent water pollution by run-off and seepage into the groundwater and surface water of liquids containing livestock manures and effluents from stored plant materials such as silage;
6. procedures for the land application, including rate and uniformity of spreading, of both chemical fertilizer and livestock manure, that will maintain nutrient losses to water at an acceptable level.

B. Member States may also include in their code(s) of good agricultural practices the following items:

7. land use management, including the use of crop rotation systems and the proportion of the land area devoted to permanent crops relative to annual tillage crops;
8. the maintenance of a minimum quantity of vegetation cover during (rainy) periods that will take up the nitrogen from the soil that could otherwise cause nitrate pollution of water;
9. the establishment of fertilizer plans on a farm-by-farm basis and the keeping of records on fertilizer use;
10. the prevention of water pollution from run-off and the downward water movement beyond the reach of crop roots in irrigation systems.

APPENDIX 2
ANNEX III TO DIRECTIVE 91/676/EEC

MEASURES TO BE INCLUDED IN ACTION PROGRAMMES AS REFERRED TO IN ARTICLE 5 (4) (a)

1. The measures shall include rules relating to:
   1. periods when the land application of certain types of fertilizer is prohibited;
   2. the capacity of storage vessels for livestock manure; this capacity must exceed that required for storage throughout the longest period during which land application in the vulnerable zone is prohibited, except where it can be demonstrated to the competent authority that any quantity of manure in excess of the actual storage capacity will be disposed of in a manner which will not cause harm to the environment;
   3. limitation of the land application of fertilizers, consistent with good agricultural practice and taking into account the characteristics of the vulnerable zone concerned, in particular:
      (a) soil conditions, soil type and slope;
      (b) climatic conditions, rainfall and irrigation;
      (c) land use and agricultural practices, including crop rotation systems;
      and to be based on a balance between:
      (i) the foreseeable nitrogen requirements of the crops, and (ii) the nitrogen supply to the crops from the soil and from fertilization corresponding to:
         - the amount of nitrogen present in the soil at the moment when the crop starts to use it to a significant degree (outstanding amounts at the end of winter),
         - the supply of nitrogen through the net mineralization of the reserves of organic nitrogen in the soil,
         - additions of nitrogen compounds from livestock manure,
         - additions of nitrogen compounds from chemical and other fertilizers.
2. These measures will ensure that, for each farm or livestock unit, the amount of livestock manure applied to the land each year, including by the animals themselves, shall not exceed a specified amount per hectare.
   The specified amount per hectare be the amount of manure containing 170 kg N. However:
   (a) for the first four year action programme Member States may allow an amount of manure containing up to 210 kg N;
   (b) during and after the first four-year action programme, Member States may fix different amounts from those referred to above. These amounts must be fixed so as not to prejudice the achievement of the objectives specified in Article 1 and must be justified on the basis of objectives criteria, for example:
      - long growing seasons,- crops with high nitrogen uptake,
      - high net precipitation in the vulnerable zone,
      - soils with exceptionally high denitrification capacity.

If a Member State allows a different amount under subparagraph (b), it shall inform the Commission which will examine the justification in accordance with the procedure laid down in Article 9.

3. Member States may calculate the amounts referred to in paragraph 2 on the basis of animal numbers.
4. Member States shall inform the Commission of the manner in which they are applying the provisions of paragraph 2. In the light of the information received, the Commission may, if it considers necessary, make appropriate proposals to the Council in accordance with Article 11.

APPENDIX 3 LIVESTOCK SIZES IN THE OECD

Livestock in OECD member countries in 2003 (figures X 1,000)

Area\Species	Turkeys	Sheep	Pigs	Horses	Goats	Geese	Ducks	Chickens(laying)	Chickens	Cattle(milked)	Cattle
Australia	1 400	98 200	2 960	220	420	-	540	11 000	94 000	2 052	27 215
Austria	700	304	3 305	85	58	22	95	5 770	11 000	630	2 067
Belgium	200	146	6 539	33	26	-	-	10 766	32 032	600	2 778
Canada	6 000	976	14 667	385	30	300	1 150	26 000	160 000	1 075	13 454
Czech Republic	670	103	3 363	20	13	132	446	11 716	12 442	460	1 474
Denmark	376	144	12 949	43	-	8	291	2 967	19 700	596	1 724
Finland	-	67	1 375	59	5	-	-	3 016	6 000	334	1 000
France	42 000	9 204	15 058	345	1 214	820	25 000	61 000	220 000	4 072	19 517
Germany	9 000	2 658	26 251	520	165	400	1 900	50 700	110 000	4 356	13 732
Greece	90	9 100	903	29	5 000	33	70	15 500	28 000	245	585
Hungary	3 251	1 103	5 082	67	140	2 009	3 443	16 849	32 206	332	770
Iceland	-	470	44	-	0	-	-	160	220	26	67
Ireland	1 622	4 829	1 782	73	8	55	190	3 600	11 342	1 129	6 924
Italy	25 000	10 950	9 111	290	1 330	-	-	45 899	100 000	1 911	6 430
Japan	3	11	9 725	20	34	-	-	137 272	283 955	1 210	4 523
Luxembourg	-	9	84	3	2	-	-	-	79 288	41	190
Mexico	5 850	6 560	18 100	6 260	9 500	-	8 100	158 000	540 000	7 100	30 800
Netherlands	1 450	1 300	11 154	122	265	-	1 020	29 800	98 000	1 486	3 780
New Zealand	75	39 250	380	77	155	68	180	3 250	18 049	3 842	9 656
Norway	-	1 081	460	28	65	-	-	3 107	3 328	278	923
Poland	762	338	18 605	550	-	698	3 593	42 178	48 393	2 750	5 489
Portugal	7 000	5 500	2 344	17	550	-	-	5 293	35 000	340	1 395
Republic of Korea	17	1	8 912	14	435	13	6 000	50 000	98 000	239	1 935
Spain	800	23 813	23 517	238	3 047	22	80	47 130	128 000	1 168	6 478
Sweden	200	451	1 904	85	-	-	-	4 535	5 749	403	1 612
Switzerland	-	449	1 529	45	68	-	-	2 301	7 440	716	1 565
Turkey	3 300	27 000	3	271	7 000	1 400	900	57 139	217 000	4 200	10 400
United Kingdom	8 000	35 729	5 050	184	-	110	3 000	35 800	167 100	2 200	10 459
USA	86 500	6 300	59 513	5 300	1 200	-	6 700	337 900	1 950 000	9 084	96 100

Source: FAO (2005) Global livestock production and health Atlas, Animal production and health devision.

APPENDIX 4
LIVESTOCK SIZES IN THE NETHERLANDS

Number of animals per animal category considered in the manure legislation in the Netherlands (Numbers X 1,000)

Animal category	1990	1995	2002
Cattle			
Beef cattle	120	146	151
Dairy cows	1 878	1 708	1 486
Veal calves	602	669	713
Cattle (total)	4 926	4 654	3858
Pigs			
Fattening pigs 20 – 50 kg	3 142	3 114	2 215
Fattening pigs ≥50 kg	3 883	4 010	3 376
Sows for breeding, not served > 50 kg	225	215	171
Served sows	958	983	762
Sows with piglets	252	246	198
Pigs (total)	13 915	14 397	11 648
Sheep (total)	1 702	1 674	1 186
Goats (total)	61	76	255
Horses and ponies (total)	70	100	121
Poultry			
Chickens:			
- Laying hens <18 weeks	11 121	8 890	10 186
- Laying hens ≥18 weeks – 10 months	33 199	29 272	28 703
-			
- Broilers	41 172	43 827	54 660
- Parent broilers <18 weeks	2 882	3 065	2 554
- Parent broilers ≥18 weeks	4 390	4 507	4 949
Ducks:			
- Ducks for meat production	1 086	869	852
Turkeys	1 003	1 176	1 451

Source: LEI (2004)

APPENDIX 5
DIMENSIONS OF MANURE STORAGE SYSTEMS

Manure storage capacity

The manure storage capacity is calculated from the number of animals, the daily manure production, the desired storage length in days and the dilution volume for storage of collected waste water and wet precipitation. The desired storage length is assumed to be 365 days.

$$Qmanure\_storage = Nanimal_i * Qprod\_manure_i * Tstorage * DILUTION_i$$

Where:
$Qmanure\_storage_{i1}$ manure storage capacity for one year and specific animal category i
$Nanimal_{i1}$ number of animal in livestock housing
$Qprod\_manure_{i1}$ daily manure production for animal category i
Tstorage desired storage length
$DILUTION_{i1,i4}$ dilution faction for wet storage of waste water and wet precipitation for animal category i and wet storage

For dry manure storage the dilution factor is 1. For dairy farming 60 percent dilution volume should be added. For pig farming 25 percent should be added for waste water and wet precipitation storage. In case of wet manure storage for poultry 10 percent dilution volume is added (OSU, 1992).

Above ground manure slurry storage

Where:
V volume of the storage facility
A surface area of the manure storage facility
l length of the storage facility
w width of the storage facility
d depth of the storage facility
D diametre of the storage facility

<u>Square or rectangular manure tank</u>:

$$V = l * w * d$$

$$w = 0.5 * l$$
$$d = 0.1 * l$$

$$V = l * 0.5 * l * 0.1l$$
$$V = 0.05 * l^3$$
$$l = \sqrt[3]{20 * V}$$

$$A = l * w = 0.5 * l^2 \quad => \quad A = 0.5 * (20 * V)^{2/3}$$

<u>Circular manure tank:</u>

$$V = D^2 * d \; ; \; d = 0.13 * D$$

$$V = D^2 * 0.13 * D$$
$$V = 0.13 * D^3$$
$$D = \sqrt[3]{7.5 * V}$$

$$A = \tfrac{1}{4} * \pi * D^2 \quad => \quad A = \tfrac{1}{4} * \pi * (7.5 * V)^{2/3}$$

<u>Square or rectangular earthen impoundment:</u>

$$V = l * w * d - s * d^2 * (l + w) + \tfrac{4}{3} * s^2 * d^3$$

$$d = 0.03 * l$$
$$w = 0.5 * l$$
$$s = 3$$

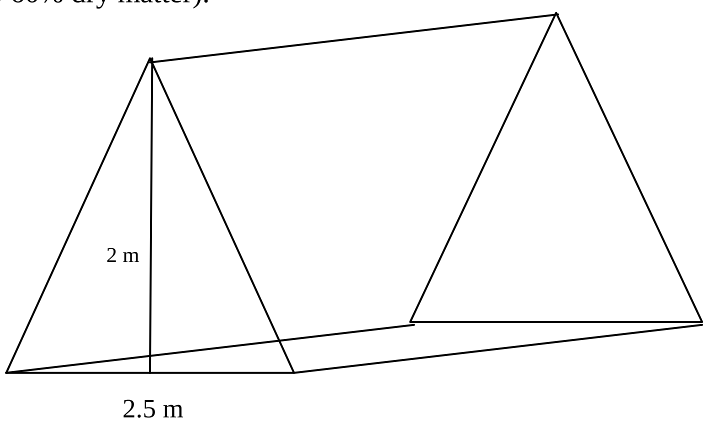
$$V = l * 0.5l * 0.03l - 3 * (0.03l)^2 * 1.5l + \tfrac{4}{3} * 9 * (0.03l)^3$$
$$V = 0.015l^3 - 0.00405l^3 + 0.000324l^3$$
$$V = 0.01127l^3$$
$$l = \sqrt[3]{88.7 * V}$$

$$A = 0.5 * l^2 \quad => \quad A = 0.5 * (88.7 * V)^{2/3}$$

Above ground dry manure storage

<u>Manure heaps</u>

Height and width of the manure heap are assumed to be about 2 and 2.5 meters respectively. The length of the heap is variable and depends on the total amount of dry manure produced (number of animals) and the storage time. Manure heaps with these dimensions have a surface area of about 1 m^2 (0.4) per cubic meter of dry manure, assuming a triangular prism as an approximation to shape of a real manure heap. When for poultry fresh droppings are dried, this reduces its volume to about one third (from 20% dry matter to 60% dry matter).



Defaults for the surface areas of manure storage systems, AREAmanure$_{cat\text{-}subcat}$ (m^2), with the minimum storage time and the storage time inside the building, $T_{storage\text{-}subcat}$ (-); the subscript cat-subcat presents the animal (sub)category and for poultry the type of housing, or the type of manure storage (see Table 5.1).

index i1	Category-subcategory	Amount of manure ($l.animal^{-1}.day_{-1}$)	Common storage time (days) average/internal	Storage capacity for one year (m^3)	Dry storage Manure heaps	Wet storage Slurry tanks rectangular	Slurry tanks circular	Slurry lagoon
	Cattle							
1	- Dairy cattle	66	183[1)]	8440	n.r	1515	1238	4086
2	- Beef cattle	34	183[1)]	1570	n.r	495	404	1335
3	- Veal calves	7	183[1)]	815	n.r	319	261	861
	Pigs							
4/5	- Sows	21	183[1)]	1010	n.r	369	301	994
6	- Fattening pigs	9	183[1)]	1270	n.r	369	301	994
	Poultry							
7	-Battery, no treatment,laying hens	0.11	56/4	910	n.r.	350	280	930
8	-Battery, belt drying, laying hens	0.11	56/4	910	610	n.r.	n.r.	n.r.
9	-Battery, deep pit,laying hens	0.11	56/365[2)]	910	610	n.r.	n.r.	n.r.
10	-Battery, compact, laying hens	0.11	56/4	910	n.r.	350	….280	930
11	-Free range, litter, laying hens	0.11	56/365[2)]	440	290	n.r.	n.r.	n.r.
13	-Free range, aviary, laying hens	0.11	56/365[2)]	610	n.r.	330	270	900
12	-Free range, litter, broilers	0.08	56/42	870	410	n.r.	n.r.	n.r.
14	-Free range, grating floor, broilers	0.08	56/42	210	n.r	131	107	16
15	-Free range, grating floor, broilers in rearing	0.08	56/42	280	n.r	155	127	33
16	-Free range, turkey	0.36	28/56[2)]	1420	950	n.r.	n.r.	n.r.
17	-Free range, ducks	0.14	183/28[2)]	570	380	n.r.	n.r.	n.r.
18	-Free range, geese	0.36	183/56[2)]	1420	950	n.r.	n.r.	n.r.

1) may be both internal (slurry pit under the stables) or external

2) maximum internal storage time, depending on the duration of the production cycle of the animals

APPENDIX 6 PHOSPHOROUS AND NITROGEN CONTENT IN MANURE

P_2O_5 production rates per animal subcategory (kg P_2O_5.animal^{-1}.d^{-1})

cat-subcat	Category	Subcategory	Housing	Report	Defra (2005)	OSU (1992)	EFSA (2005)	min/max	Diff
1	Cattle	Dairy cow		0.10466	0.10730	0.07620	0.0878	0.1073/0.07620	1.4
2		Beef cattle		0.07123	0.07590	0.11430	0.0385	0.07590/0.0385	2.0
3		Veal calf		0.01422	0.01130	0.00590	0.0080	0.01422/0.00590	2.4
4/5	Pigs	Sow		0.05566	0.03850	0.08010	0.0368	0.05566/0.03680	1.5
6		Fattening pig		0.02033	0.02070	0.03992	0.0216	0.03992/0.02033	2.0
8	Poultry	Laying hen	Battery + aeration	0.00111	0.00150	0.00113	0.0008	0.00150/0.0008	1.9
9			Deep pit, high-rise	0.00111	0.00150	0.00113			
10			Compact	0.00111	0.00150	0.00113			
7			Battery (no treatm.)	0.00122	0.00150	0.00113			
11			Free-range, litter	0.00111	0.00150	0.00113			
12		Broiler	Free-range, litter	0.00066	0.00110	0.00054	0.0007	0.00110/0.00054	2.0
13		Laying hen	Free-range, grating						
14		Parent broiler in rearing	Free-range, grating	0.00077	0.00030	0.00054	0.0007	0.00077/0.00030	2.6
15		Parent broiler ≥18 weeks	Free-range, grating	0.00188	0.00220			0.00220/0.0018	1.2
16		Turkey	Free-range, grating	0.0023	0.0032		0.0038	0.0038/0.0023	1.7
17		Ducks	Free-range, grating	0.0016	0.0021			0.0021/0.0016	1.3
18		Geese	Free-range, grating						

N production rates per animal subcategory (kgN.animal^{-1}.d^{-1}).

cat-jsubcat	Category	Subcategory	Housing	Report[1)]	Defra (2005)	OSU (1992)	EFSA (2005)	VICH (2005)
1	Cattle	Dairy cow		0.33890	0.20822	0.13018	0.23562-0.30959	0.21096
2		Beef cattle		0.28819	0.12877	0.10764	0.11781	0.14521
3		Veal calf		0.02382	0.01918	0.01715	0.03288	0.03014
4/5	Pigs	Sow		0.07106	0.05342	0.07493	0.05370	0.06849
6		Fattening pig		0.03043	0.02877	0.03572	0.03562	0.02740
8	Poultry	Laying hen	Battery + aeration	0.00181	0.00181	0.00092	0.00204	0.00153
9			Deep pit, high-rise	0.00181	0.00181	0.00099	0.00204	
10			Compact	0.00181	0.00181	0.00099	0.00204	
7			Battery (no treatm.)	0.00202	0.00181	0.00099	0.00204	
11			Free-range, litter	0.00171	0.00181	0.00079	0.00079	
12		Broiler	Free-range, litter	0.00156	0.00136	0.00052	0.00145	0.00137
13		Laying hen	Free-range, grating					
14		Parent broiler in rearing	Free-range, grating	0.00137	0.00034	0.00063	0.00098	0.00268
15		Parent broiler ≥18 weeks	Free-range, grating	0.00298	0.00267	0.00063	0.00145	0.00090
16		Turkey	Free-range, grating	0.00482	0.00381	-	0.00653	0.00384
17		Duck	Free-range, grating	0.00274	0.00247	-		0.00247
18		Geese	Free-range, grating			-		

1) Excluding the nitrogen which volatilised during excretion in the housing and storage

GLOSSARY

Acarid : any of an order (Acarina) of arachnids including the mites and ticks; *especially* **:** a typical mite (family Acaridae)

Adulticide : an agent for killing adult pests

Anticholinesterase : a substance (as neostigmine) that inhibits a cholinesterase by combination with it

Arthropod : any of a phylum *[one of the usually primary divisions of the animal kingdom]* (Arthropoda) of invertebrate *[lacking a spinal column]* animals (as insects, arachnids, and crustaceans) that have a segmented body and jointed appendages, a usually chitinous *[a horny polysaccharide that forms part of the hard outer integument]* exoskeleton *[an external supportive covering of an animal]* molted at intervals, and a dorsal *[relating to or situated near or on the back]* anterior brain connected to a ventral *[being or located near or on the anterior or lower surface of an animal opposite the back]* chain of ganglia *[a mass of nerve tissue containing nerve cells external to the brain or spinal cord]*

Cholinesterase : an enzyme that hydrolyzes choline esters and that is found especially in blood plasma

Ecdyses : the act of molting or shedding an outer cuticular *[the outermost layer of animal integument (as in humans) when composed of epidermis]* layer

Eutrophication : the process by which a body of water becomes enriched in dissolved nutrients (as phosphates) that stimulate the growth of aquatic plant life usually resulting in the depletion of dissolved oxygen

Imago : an insect in its final, adult, sexually mature, and typically winged state

Immission : transfer or release of pollutants into the free environment or a receptor. (www.iupac.org, http://www.eionet.eu.int/)

Insecticide : agent that destroys insects

Land application : the addition of materials to land whether by spreading on the surface of the land, injection to the land, placing below the surface of the land or mixing with the surface layers of the land (Article 1 of EEC, 1991)

Larvicide : Agent for killing larval pests

Manure : material that fertilizes land; *especially* **:** refuse of stables and barnyards consisting of livestock excreta with or without litter (livestock manure: waste products excreted by livestock or a mixture of litter and waste products excreted by livestock, even in the processed form according to Article 1 of EEC, 1991)

Slurry : semi-liquid manure

Note: For this glossary Merriam-Webster On-Line (http://www.m-w.com/) has been used unless stated otherwise