NATIONAL INSTITUTE OF PUBLIC HEALTH AND ENVIRONMENTAL PROTECTION
BILTHOVEN, THE NETHERLANDS

Report nr. 679102021

EVALUATION SYSTEM FOR PESTICIDES (ESPE)

2. Non-agricultural pesticides.

To be incorporated into the
Uniform System for the Evaluation of Substances (USES)

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mber, 1993 116

This study was performed on behalf of and commissioned by the Directorate-General for Environmental Protection, Directorate for Chemicals, Safety and Radiation Protection and Directorate for Drinking Water, Water and Agriculture, project no. 679102

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SUMMARY

After the presentation of the Evaluation System for Pesticides (ESPE) 1. Agricultural pesticides (Emans *et al.* 1992) this present report is describing the logical successor ESPE 2: non-agricultural pesticides. Starting with an extensive emission analysis of the different types of non-agricultural pesticides the introduction into the environment is estimated. The distribution and risk-analysis follow thereafter the lines outlined in ESPE 1. The non-agricultural pesticides are distinguished in some classes:

1. disinfectants,
2. industrial biocides,
3. preservatives,
4. household products,
5. wood preservatives and -protectors
6. antifouling paints.

Taking into consideration the way of emission into the environment proposals are presented for the data that will be desirable for the registration evaluation. Thereafter, the data will be used, together with standardized assumptions on the environment, in calculation schemes, leading to the calculation of so-called Predicted Environmental Concentrations (PECs). The ratio between the PEC and the NEC (No Effect Concentration) or sometimes the LC50 or EC50 leads then to a risk phrase, where a policy decision can be based upon.

Besides the decision trees introduced in ESPE 1 two extra trees are developed additionally for beneficial micro-organisms in municipal sewage treatment plants (because an interference with these micro-organisms can lead to an unacceptable contamination of the surface water) and for bats (because remedial treatment of timbers in buildings has been considered a significant cause of mortality to bats). These trees take an analogous format as those in ESPE 1.

With the presentation of part 2 of the evaluation system ESPE the first step to a methodology for the evaluation of pesticides within the scope of registration has been made. In the report several open ends are still present, because sufficiently accepted methods for all routes are not yet available in the literature.

The largest part of ESPE 2, the evaluation system for non-agricultural pesticides is incorporated in the Uniform System for the Evaluation of Substances (USES). All further developments which can lead to adaption, changes, and completion of the Evaluation System for Pesticides will be carried out in the framework of USES.

SAMENVATTING

Na de presentatie van het Evaluation System for Pesticides (ESPE) 1: landbouwbestrijdingsmiddelen (Emans *et al.* 1992) wordt in het onderhavige rapport het logische vervolg ESPE 2: niet-landbouwbestrijdingsmiddelen beschreven. Aan de hand van een uitgebreide emissie analyse van de diverse soorten niet-landbouwbestrijdingsmiddelen wordt de introductie in het milieu geschat. De verspreiding en risico-analyse volgen daarna de lijnen die in ESPE 1 zijn uitgezet. De niet-landbouwbestrijdingsmiddelen worden ingedeeld in enkele klassen:

1. desinfectantia,
2. industriële biociden,
3. conserveermiddelen,
4. huishoudmiddelen (inclusief voorraadbescherming),
5. houtverduurzamingsmiddelen,
6. aangroeiwerende verven.

Rekening houdend met de wijze van emissie in het milieu worden voorstellen gepresenteerd voor de gegevens, die wenselijk zijn voor de toelatingsbeoordeling. Deze gegevens zullen standaard aan de aanvragers van dit type bestrijdingsmiddelen gevraagd moeten worden bij de aanlevering van het dossier voor de toelating. De gegevens worden vervolgens, samen met standaardiserende veronderstellingen over het milieu, gebruikt in rekenschema's, die leiden tot de berekening van zgn. Predicted Environmental Concentrations (PEC's). De ratio tussen de PEC en NEC (No Effect Concentration) of in sommige gevallen de LC50 of EC50 leidt dan tot een risico-uitspraak, waarop een beleidsbeslissing kan worden gebaseerd.

Naast de in ESPE 1 geïntroduceerde beslisbomen is nog een tweetal beslisbomen ontwikkeld en wel voor nuttige micro-organismen in de rioolwater zuiveringsinstallaties, omdat een storing in de zuiveringsinstallatie kan leiden tot niet acceptabele verontreiniging van het oppervlakte water en voor vleermuizen, omdat met name houtverduurzamingsmiddelen die in gebouwen gebruikt worden sterfte onder vleermuizen (o.a. in kraamkolonies) hebben veroorzaakt. Deze beslisbomen zijn op analoge wijze vorm gegeven als die in ESPE 1.

Met het gereed komen van deel 2 van het beoordelingssysteem ESPE is de eerste stap tot een methodiek van de toelatingsbeoordeling van bestrijdingsmiddelen afgerond. In het rapport zijn nog verschillende open plekken, omdat in de literatuur nog niet voor alle routes een voldoende geaccepteerde methode beschikbaar is.

Het grootste deel van ESPE 2, het beoordelingssysteem voor niet-landbouw-

bestrijdingsmiddelen, zal worden ingebouwd in het Uniform Beoordelingssysteem (UBS). Verdere ontwikkelingen die kunnen leiden tot aanpassing, bijstelling en verdere completering van het Evaluation System for Pesticides (ESPE) zullen worden uitgevoerd in het kader van UBS.

1. INTRODUCTION

1.1 General context

The annual total amount of pesticides used in 1988 in the Netherlands was about 45 million kg active ingredients (industrial biocides not included), of which c. 18 million kg for agricultural purposes (see Table 1). Hence, the amount of non-agricultural pesticides is higher than the amount of agricultural pesticides. Therefore the use of non-agricultural pesticides is a potential source of risk not to be neglected. The minister of Housing, Physical Planning and Environment has promised the 2nd Chamber to fill in the policy concerning of the non-agricultural pesticides more fully. An important condition for an adequate registration policy is the availability of an evaluation system for the assessment of possible risks of non-agricultural pesticides in the environment. This report is the first step for the further development of such a system. This system will be part of the Uniform System for the Evaluation of Substances (USES) which is developed on behalf of the Ministry of Housing, Physical Planning and Environment.

Part I of the Evaluation System for Pesticides (ESPE) dealt with the agricultural pesticides (Emans *et al.*, 1992). This report, part II of ESPE, gives an overview of the risk assessment of non-agricultural pesticides.

Table 1. Use of pesticides (tonnes per year) in the Netherlands (ROM, 1993 and Overleggroep Deskundigen Wasmiddelen-Milieu, 1989).

Category	1988	1989	1990	1991
Agriculture (total amount)	18,163	19,177	18,835	17,207
Non-agriculture:				
- Wood preservatives, antifoulings and fungicides in paint	7,657	8,566	12,074	7,362
- Pesticides used in accommodations for for work and man (including domestic use)	65	65	72	133
- Industrial biocides	5,700	No data available		
- Disinfectants:				
Sodium hypochlorite (non-household)	4,650	No data available		
Sodium hypochlorite (household)	3,900	No data available		
Other compounds	2,641	2.076	2,275	2,442

1.2 Classification of non-agricultural pesticides

In the Netherlands the following groups of non-agricultural pesticides are distinguished by the government: disinfectants, industrial biocides, preservatives, household products, wood preservatives and protectors, and antifoulings. A short elucidation of each group is presented below. In the following paragraphs the terms non-agricultural pesticides and biocides are interchangeable.

Disinfectants:
Disinfectants are utilized for the disinfection of accommodations for man (e.g. schools, hospitals, office buildings) and animals (stables and transportation means), and for disinfection of accommodations for preparing, handling or storing food and drinks. Further, it is used in chemical toilets and for disinfection of drinking and swimming water.
The majority of the disinfectants is based on active chlorine, but active ingredients like aldehydes, ethyleneoxide, phenols, cresols, potassium and sodium hydroxide, quats, and peroxides are also customary. Since 1964, disinfectants are considered as pesticides, based on Article 1 paragraph 2 of the Dutch Pesticide Act.

Industrial biocides:
Applications for industrial biocides can be found in the wool and textile industry, the paper and cardboard industry, the sugar industry and in process and cooling-water installations. In the latter three cases they are applied to prevent the growth of harmful micro-organisms in water, necessary in the production process. In the textile industry, biocides are added to prevent textile or wool materials for damage by micro-organisms or insects during use by the consumers.

Preservatives:
Preservatives are utilized in the metal and leather industry, but also in air conditioners and drill installations, and they are added to paints. Preservatives are applied to protect products against (micro-)organisms.

Household products:
Household product are applied in houses and other accommodations for man to kill rats, mice and insects. For the same reason they are used as gasses in empty storage accommodations, shipyards, factories and silos, but also as fumigants for quarantine treatments and commodities. Household products are also utilized as rodenticides (in houses and on dump-sites), baits, flea-belts and moth-balls. Finally, agricultural pesticides used in private gardens (estimated annual use

circa 200,000 kilos, personal communication with RIZA) are also considered as household products.

Wood preservatives and wood protectors:
These biocides are used to protect wood against damaging fungi and insects. A distinction can be made in wood preservatives and wood protectors, depending on the duration of the effect.

Antifoulings:
Antifoulings are added to paints for application on ship hulls to prevent the growth of algae and shells.

1.3 Framework of the report

Chapter 2 of this report describes the risk assessment model for non-agricultural pesticides in general and the assumptions, starting points and data requirements. In chapter 3 a detailed description is given of the possible routes of emission of the substances, the distribution through the environment and the hazard assessment for the organisms at risk. Chapter 4 provides guidelines for the necessary information for the different types of non-agricultural pesticides, while in chapter 5 a discussion is given and some conclusions are stated.

2. THE RISK ASSESSMENT MODEL FOR NON-AGRICULTURAL PESTICIDES

2.1 Starting points

The evaluation system for non-agricultural pesticides is based on several prerequisites and assumptions:

* The system is to be used in the Netherlands. Therefore, the environmental and meteorological conditions are defined in accordance with average Dutch circumstances.

* Emissions to the environment are regarded as emanating from point sources with local impact on the environment. In case of diffuse emission to the environment regional scale models will be used.

* The local scale is defined as the near surroundings of the main source of a substance after emission.

* Instead of actual sites, hypothetical sites are defined with average environmental characteristics for the Netherlands.

* The evaluation system for biocides is as complete as possible. This means that all quantitative descriptable routes of emission, distribution and exposure are taken into consideration. It has to be noticed that these routes are not equally important for all biocides. The relevance of a certain route depends eventually on the degree of contribution to the total risk for the environment (i.e. a significant contribution).

* It has to be noticed that in case of big accidents with industrial installations separate legislation (with its own risk assessment models) is available (besluit Risico's Zware Ongevallen), therefore calamities etc. are not taken into account.

* The risk assessment model for biocides is incorporated in the Uniform System for the Evaluation of Substances. Therefore, it is harmonized with methods for assessment of other types of substances, and especially with the methods applied to agricultural pesticides. Routes through the environment and organisms exposed are considered in the same way as has been described in

Emans *et al.* (1992). However differences in application methods and emission patterns make it necessary to alter some of the modules or to add new modules.

* The risk assessment model only confines to the exposure of the environment (for the human exposure only the indirect pathways are taken into account).

2.2 Data requirement and availability

Up to now, the base set, with regard to the environmental risk assessment, that should be submitted by the company which intends to market a pesticide (agricultural and non-agricultural) consists of the following data (Anonymous, 1993):

* Identity:
  - primary name
  - chemical names
  - trade names
  - CAS-number

* Properties:
  - structure and molecular weight
  - purity, additives and formulations
  - appearance
  - melting point
  - boiling point
  - density
  - Henry coefficient
  - surface tension
  - solubility in water, fat and other solvents
  - stability
  - spectra
  - vapour pressure (active ingredient and other substances)
  - octanol/water partitioning coefficient
  - sediment/water partitioning coefficient
  - particle size
  - spraying patterns
  - degree of fixation to fibres
  - stability of baits

- <u>Analysis and detection</u>:
  - analytical methods for soil and water

- <u>Function and uses</u>:
  - application
  - frequency
  - dosage
  - description of processes in which the compound/formulation is used
  - estimation of concentration of the compound in the effluent (waste water of industry/plant)

- <u>Chemobiokinetics and metabolisms</u>:
  - in animals and plants

- <u>Ecotoxicology</u>:

- fate and degradation products of active ingredient (a.i.) in soil
- degradation rate in soil (a.i. and metabolites)
- mobility in soil (a.i. and metabolites)
- fate and degradation products of a.i. in water
- degradation rate in water (a.i. and metabolites)
- adsorption of a.i. and metabolites to particles
- photochemical degradation
- hydrolysis
- data on flux of a.i. from paint or treated wood to the water phase
- emission to air

- acute oral toxicity study (LD50) with mammals
- chronic oral toxicity study (NOEC or NOAEL) with mammals
- acute oral toxicity study (LD50) with birds
- semi chronic oral toxicity study (LC50) with birds
- chronic oral toxicity study (NOEC) with birds
- short term toxicity study (EC50) with algae
- short term toxicity study (EC50) with daphnids
- short term toxicity study (LC50) with fish
- short term toxicity study (LD50 oral and contact) with bees
- short term toxicity study (LC50) with earthworms
- sub-acute toxicity study (NOEC) with earthworms
- study on the influence of a.i. (nitrification, respiration) on the Municipal Sewage Treatment Plant (MSTP)
- study on the influence of a.i. on the nitrification in soil

- study on the influence of a.i. on the respiration in soil
- bioaccumulation
- secondary poisoning

However, some experience with biocides shows that a more specific base set for an adequate risk assessment for these substances is desirable. This will be discussed in more detail in Chapter 4.

2.3 Modules of the evaluation system

The evaluation system for the non-agricultural pesticides consists of three parts: an emission module, a distribution module and a hazard assessment module. The distribution and hazard assessment modules are nearly the same as those described in the report of Emans *et al.* (1992) concerning the agricultural pesticides. The emission module is almost completely different and much more extensive due to the wide range of application methods of non-agricultural pesticides. The emission, distribution and hazard assessment modules will be discussed in chapter 3.2, 3.3 and 3.4, respectively.

3. MODEL DESCRIPTIONS

3.1 Introduction

The basic model patterns for the biocides are presented in Figure 1 and for each class of biocides in figures 2, 3, 5, 7, 8, and 12. These figures consists of 3 parts:

1) emission (indicated by bold arrows),
2) distribution (indicated by thin arrows), and
3) risk assessment (indicated by broken arrows).

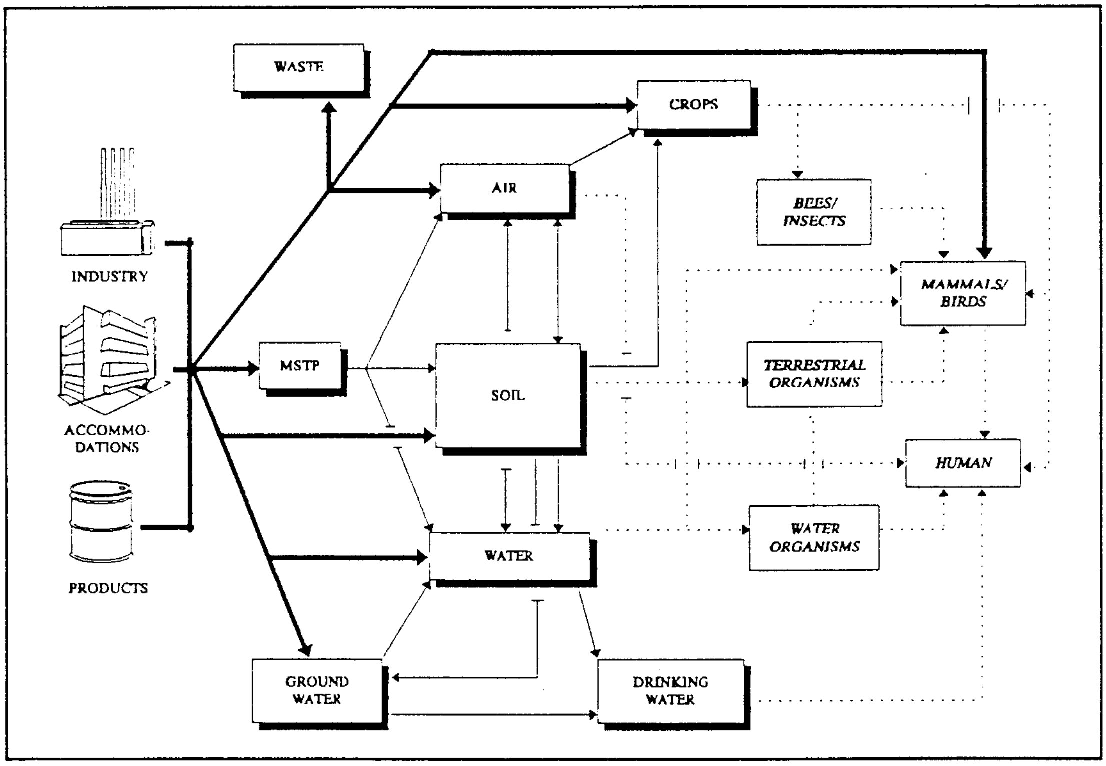

Figure 1 Exposure routes for non-agricultural pesticides

Each rectangle in these figures represents a sub module in the evaluation system. The rectangles of the emission part are different for each group of compounds and the others are the same for every group. They will be briefly discussed and described in terms of model descriptions. For each sub module, input and output data are presented, as well as the model calculations. The input and output data can be divided into four groups:

C Constants (if possible the constants are presented);
R (Required) values from the test results in the notification of a biocide;

E Expert estimations (if possible the expert estimations (defaults) are presented);
O Output from previous modules/calculations.

Emission modules will be discussed per group of biocides; distribution modules and hazard assessment modules are discussed for all biocides together.

3.2 Emission modules

3.2.1 Disinfectants

In 1988 about 11,000 tonnes of active ingredient were used in the Netherlands (see Table 1). In Figure 2, the various application possibilities of disinfectants and the ways they are introduced into the environment are presented.

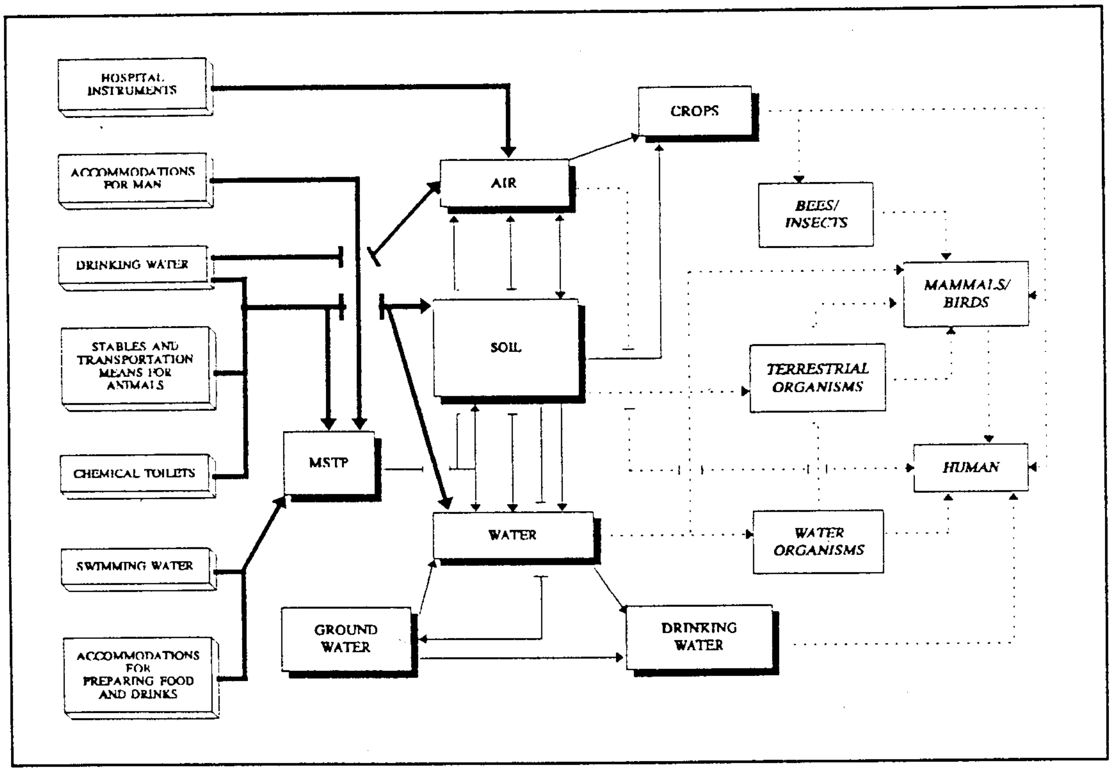

Figure 2 Detailed exposure pathways for disinfectants. MSTP = Municipal Sewage Treatment Plant

A) *Disinfectants in swimming water*

According to (Loos, 1993) there were 285 indoor swimming pools (average water surface 377 m^2) 365 outdoor swimming pools (average water surface 1380 m^2)

and 135 combined swimming pools (average water surface 2210 m^2) in the Netherlands in 1988. The disinfectants used are based on chlorine or ozone. There are about 4 swimming pools where ozone is used. The others mainly use hypochlorite as a disinfectant. Another possibility is the use of chlorine prepared on the spot by electrolysis of a sodium chloride solution; this situation is not considered in this report however.

On account of regulations a standard amount of disinfectant has to be added for every visitor entering the swimming pool. In some installations this is performed automatically, in others this is done once a day on account of the number of tickets sold. Occasionally the total volume is blown off and replaced by new water (comment B. Loos).

Nearly all swimming pools discharge their water into the sewer and the others will do so in near future. The water blown off contains small amounts of sodium hypochlorite which will be transformed rapidly in the sewage system. So, no relevant emission of the active ingredient into the environment is expected. Ozone is readily transformed into oxygen and will not reach the sewer system.

Transformation products of the disinfectants can cause health effects to swimmers and employees of swimming accommodations. However, these effects are not yet taken into consideration in the evaluation system.

B) *Disinfectants in drinking water*

Chemicals used for the disinfection of drinking water (also mainly based on chlorine) are applied inside waterworks-systems. After disinfection of the drinking water system there will be a blow off of the water containing the disinfectant. If the piping system leading to the users has been disinfected, e.g. after an incidental contamination, the users are advised to open the tap for some time to avoid possible intake of the disinfectant.

Besides, disinfectants are applied outside the waterworks-system, for example, in watertanks of ships and planes. The disinfectants are introduced into the environment via the soil, the MSTP or directly discharged into the surface water.

C) *Disinfectants in accommodations*

After use, disinfectants applied in accommodations for man and accommodations for preparing food and drinks are discharged into the sewerage and will subsequently reach the MSTP, where they can cause damage to beneficial micro-organisms. Chlorine based disinfectants (hypochlorites) rapidly will be transformed into other products and will therefore not reach the sewage treatment plant as such. For other substances the scenario for diffuse emissions into waste water as described by Van der Poel (1991) is used, i.e. the tonnage (amount of active ingredient used per years) is divided by the number of inhabitants and days per year, assuming an average daily amount of water per inhabitant of 150 litres. The tonnage must be known (submitted by the company or estimated value) in this case. The parameters used in the scenario are presented in Table 2.

Table 2. Parameters/variables for disinfectants in accommodations

Parameter/variable (unit)	Symbol	Default	C/R/E/O
Input:			
Quantity of a.i. used in the Netherlands (tonnes/year)	X		R
Quantity of water used per inhabitant per day (l/day)	Q_{water}	150	C
Number of inhabitants in the Netherlands (-)	i_{NL}	1.5E7	C
Number of days disinfectant is used (days/year)	d	365	C
Fraction released to waste water (-)	f_{wwat}	0.9	R/E
Removal in an MSTP (calculated by standard module of USES)	R_{STP}		O
Dilution factor of receiving surface water (-)	F_{dilut}	32	C
Output:			
Concentration of a.i. in receiving surface water (mg/l)	C_{surf}		

Model calculations:

$$C_{surf} = X * 10^9 * f_{wwat} * R_{STP} / d * Q_{water} * i_{NL} * F_{dilut}$$

The health effects of disinfectants as a result of residues in food and drinks after use are not taken into consideration in the evaluation system.

D) *Disinfection of hospital instruments*

For disinfecting hospital instruments mainly etheneoxide is used. The disinfectants are emitted into the air. Besides, as a result of this application method, CFCs are emitted. No scenario for this application has been developed, because in future closed systems with recycling possibilities will be used for the disinfection of hospital instruments by which no disinfectants are emitted into the air.

E) *Disinfectants for stables and transportation means for animals*

Various products, like sodium hydroxide and chlorine products, are used for disinfecting stables and transportation means for animals. After use, the disinfectants are discharged onto the soil or into the sewerage or directly into the surface water.

F) *Disinfectants in chemical toilets*

The content of chemical toilets which contain disinfectants are deposited at special collection sites at recreation centres (campings, water sports areas, etc.) or are discharged into the sewerage, after which it reaches the MSTP. Here the disinfectants may cause damage to beneficial micro-organisms. The contents can also be discharged directly into the surface water or onto the soil.

G) *Disinfectants used at MSTPs*

In cases where effluent of an MSTP is discharged into surface water used for recreation or containing shell-fish, disinfection takes place according to legal provisions.

3.2.2 Industrial biocides

For the biocides in several industrial sections, admission is provided according to the Pesticides Act. In Figure 3 the various application possibilities of industrial biocides and the ways they are introduced into the environment are presented.

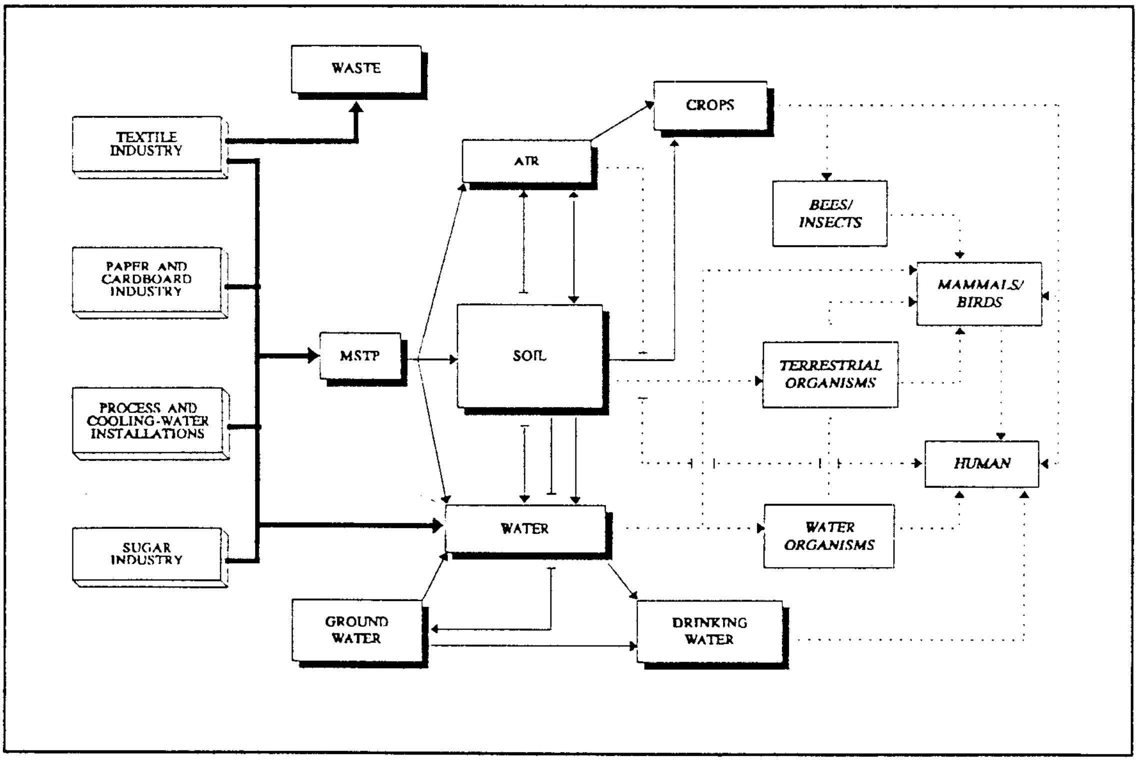

Figure 3. Detailed exposure pathways for industrial biocides.

A) *Biocides in textile industry*

Biocides, like carbendazim, sulcopherone and permethrine, are regularly used in

the textile industry to prevent damaging of wool and other textiles by insects and micro-organisms.
Emission to the environment can take place by discharge of waste water and by evaporation during the drying procedure and in a diffuse way, namely during and after use by consumers. The emission to the air is considered to be a negligible pathway, due to the high attachment characteristics of the compounds. For the time being the scenario assumes that the waste water from textile processing industries goes to the "standard" MSTP of the model (1,800 m^3/day); the possibility of a pre-purification at the factory and/or the use of an industrial STP is not considered.

The impregnation process depicted in Figure 4 is based on instructions and data sheets received from the producers of biocides. Releases to the waste water can take place at two stages of the impregnation process, namely at the discharge of the spent bath liquid and at the discharge of the water used for the wash out.
Calculation of the concentration in the influent and effluent is done with the standard modules of USES. In case the user does not specify values for the parameters, the defaults stated in Table 3 (page 14) are used.

B) *Biocides in paper and cardboard industry*
In the paper and cardboard industry biocides are applied to protect the process water against micro-organisms, which can cause great damage. Mainly oxidizing biocides, like hypochlorite and chlorodioxide, and organic biocides, like methylenebisthiocyanate, are used.
Because recycling of process water is applied in many cases nowadays, the use of biocides is necessary to fight slime formation. The use of water per tonne of paper/cardboard produced has dropped from 50 - 600 m^3 to 15 - 20 m^3 and to 0-15 m^3 for massive cardboard, because of the recycling (Huizinga *et al.*, 1992 and Regoort, 1992).
According to Ros and Berns (1988) biocides used in the paper and cardboard industry are discharged into the sewer completely. Due to recycling the residence time in the process can be 3 to 5 hours. The degradation of the biocide in this period depends on the half-life time.

In many cases paper and cardboard producers have their own STP. In some cases they have an anaerobic STP; after treatment in the anaerobic STP the water is treated in an industrial STP (active sludge) or treated in a municipal STP. In the case of industrial STPs the effluent is discharged to large surface waters usually (e.g. rivers Rhine and Meuse). As only a model for aerobic STPs is available at the moment, the removal calculated for this situation is used.

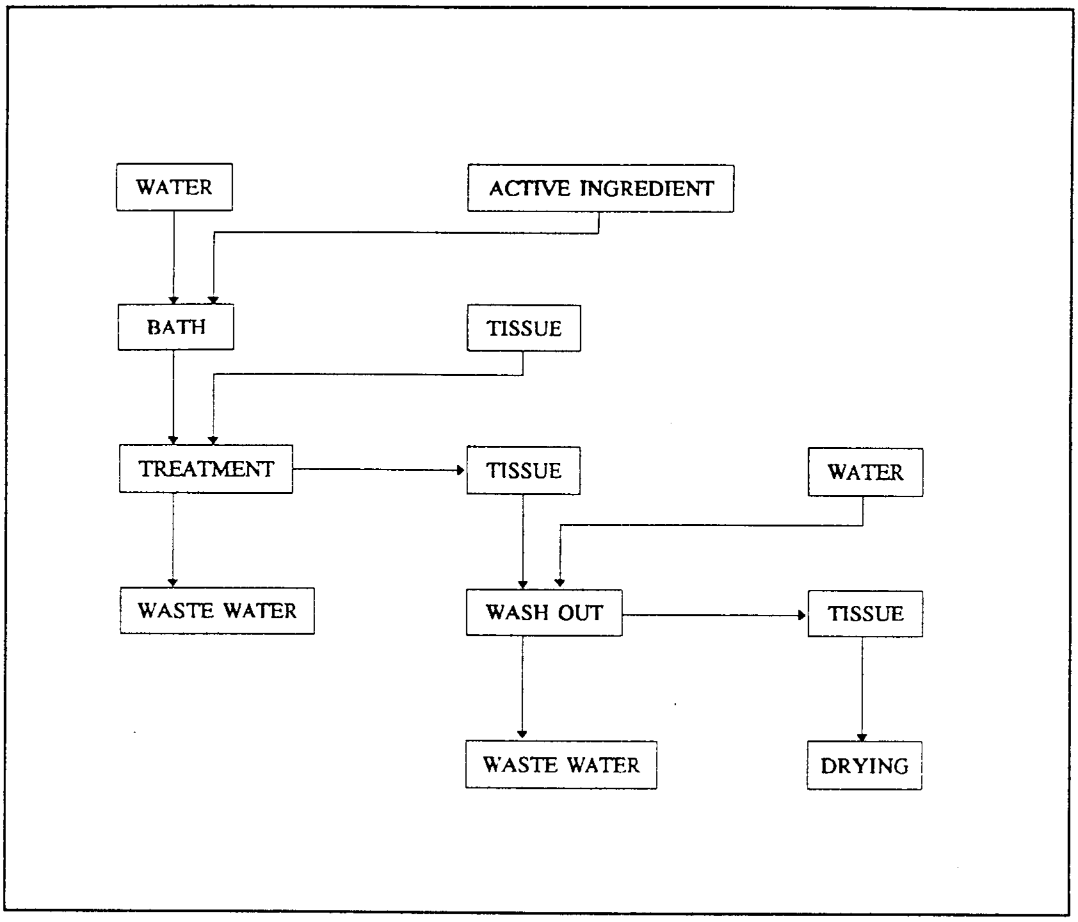

Figure 4 Schematic design of the impregnating process in the textile industry.

Table 3. Model for textile industry

Parameter/variable (unit)	Symbol	Default	C/R/E/O
Input:			
Quantity of material treated per day (kg/day)	Q_{mater}	1000	R/E
Quantity of active ingredient per kg material (mg/kg)	$Q_{a.i.}$	5000	R/E
Fraction fixed to material (-)	f_{fixat}	0.8	R/E
Fraction of a.i. transferred to wash water (-)	f_{washw}	0.001	R/E
Quantity of waste water in STP (m^3/day)	Q_{STP}	1800	C
Fraction removed in STP (-) (calculated by standard module of USES)	R_{STP}		O
Dilution factor of receiving surface water (-)	F_{dilut}	32	C
Output:			
Concentration of a.i. in receiving surface water (mg/l)	C_{surf}		

Model calculations:

L_{wwb} = Quantity of a.i. released from bath (kg/day)

$= Q_{mater} * Q_{a.i.} * (1 - f_{fixat}) * 10^{-6}$

L_{www} = Quantity of a.i. released from wash out (kg/day)

$= Q_{mater} * Q_{a.i.} * f_{fixat} * f_{washw} * 10^{-6}$

L_{wwt} = Quantity of a.i. totally released with waste water (kg/day)

$= L_{wwb} + L_{www}$

R_{STP} Calculation by standard module of USES

$C_{surf} = L_{wwt} / Q_{STP} * R_{STP} / F_{dilut} * 10^3$

In the Netherlands the production of paper/cardboard, excluding two extreme large producers, lies between 20,000 - 200,000 tonnes per year (background information at Ros and Berns, 1992). Assuming that they all apply water recirculation leading to a usage of 15 - 20 m^3 per tonne paper/cardboard this leads to a water consumption of 800 - 11,000 m^3 for paper/cardboard per day. The default estimate for the water consumption is 3,000 m^3 per day. This estimate exceeds the estimate for a standard MSTP in USES of 1,800 m^3. Therefore in the scenario the use of an industrial STP is assumed (default), where a default value of the flow equal to the waste water quantity of 3,000. For the receiving surface water Regoort (1992) uses dilution factors of 3 for stagnant waters (e.g. lakes), 10 for semi-stagnant waters (e.g. canals) and 100 for large rivers. As effluent from several factories is discharged to semi-stagnant water a dilution factor of 10 is used as a default value.

Calculations of the PEC are carried out with the standard modules of USES and the specific values for size of the STP and dilution factor.

In Table 4 the parameters used in the scenarios are given together with the default values.

Table 4. Model for paper and cardboard industry and default values for parameters

Parameter/variable(unit)	Symbol	Default	C/R/E/O
Input:			
Quantity of water discharged per day (m^3/day)	Q_{water}	3000	R/E
Concentration of a.i. in process water discharged (mg/l)	$C_{a.i.}$		R
Quantity of water in STP (m^3/day)	Q_{STP}	3000	R/E
Dilution factor of receiving surface water (-)	F_{dilut}	10	E(D)
Output:			
Concentration of a.i. in receiving surface water (mg/l)	C_{surf}		

Model calculations:

L_{ww1} Quantity of a.i. totally released with waste water (kg/day)

$$= Q_{water} * C_{a.i.} * 10^{-3}$$

R_{STP} Calculation by standard module of USES

$$C_{surf} = L_{ww1} / Q_{STP} * R_{STP} / F_{dilut} * 10^3$$

C) *Biocides in process and cooling-water installations*

In process and cooling water installations biocides, like sodium hypochlorite, are applied to prevent the growth of damaging micro-organisms. As a result of this function, the biocides are introduced into the environment via the effluent of a STP or by direct discharge into the surface water. There are two types of cooling water systems where biocides are applied (IMET/RIZA, 1992):

1°. continuous flow systems;

2°. open circulation systems using cooling towers.

In the scenario it is assumed that the blow off water of circulation systems and the water of cooling systems with continuous streams are discharged directly into the surface water. As a default it is assumed that the dilution factor is 3 (stagnant water like lakes), relating to the scheme proposed by IMET/RIZA (1992). For open circulation systems with a cooling tower IMET/RIZA (1992) gives a daily loss due to spray and wind drift of 2% of the water circulated (h^{-1}) for old types of cooling towers and <<0.1% for modern ones. The default for these losses is 0.025%. This emission takes place throughout the year. The default for the quantity of water in circulation is 10,000 m^3/day.

In Table 5 the parameters used in the scenario are given together with the default values.

Table 5. Model for process and cooling water installations

Parameter/variable(unit)	Symbol	Default	C/R/E/O
Input:			
Dilution factor in receiving surface water (-)	F_{dilut}	3	E
or:			
Quantity of water discharged per day (m^3/day)	Q_{water}		R
Surface water flow (m^3/day)	Q_{surf}		R
and:			
Concentration of a.i. in cooling water (mg/l)	$C_{a.i.}$	0.5	R/E
only circulation systems:			
Quantity of water in circulation (m^3/day)	Q_{circ}	10000	R/E
Fraction of water lost due to spray and wind drift (-)	W_{depos}	0.00025	R/E
Soil surface where deposition occurs (m^2)	A_{soil}	100	R/E
Output:			
If flows of water discharged and receiving water are input	F_{dilut}		
Concentration of a.i. in receiving surface water (mg/l)	C_{surf}		
Daily dosage of 1 m^2 soil surface with a.i. ($mg/m^2.day$)	D_{soil}		

Model calculations:

$F_{dilut} = (Q_{water} + Q_{surf}) / Q_{water}$ (if flows of water discharged and receiving water are input)

$C_{surf} = C_{a.i.} / F_{dilut}$

$D_{soil} = Q_{circ} * C_{a.i.} * W_{depos} / A_{soil} * 10^3$

(The Predicted Initial Environmental Concentration (PIEC) in the soil can be calculated according to route 4 of Emans *et al.* (1992)).

D) *Biocides in sugar industry*

In the sugar industry 2 substances are allowed in the process. Hypochlorite is used in cooling water treatment and the other is a formaldehyde solution (40% formalin) for disinfection of the extraction unit. Cooling water treatment is covered in "*Process and cooling water installations*" in this chapter. The process and cooling water in the sugar industry is recycled largely and the waste water finally discharged into the sewer for treatment in a STP amounts 400 - 650 litres

per tonne of beets. The waste water stream first goes to a thickener (removal of floating and settling particles) and from there to sludge fields (settling of fine particles). At some factories the overflow from the sludge fields is treated in anaerobic reactors before the waste water goes to an aeration pond. After aeration the major quantity is used again. The remainder is discharged into the sewerage for treatment in a STP.
The concentration of formaldehyde in the water reaching the sludge fields is assumed to be low enough to expect a rapid depletion. As the literature available (Hulskotte & Matthijsen, 1992) states that there is an overflow, it is assumed that the bottom of the sludge fields consist of the natural soil, so infiltration will occur. It is to be expected however that deterioration of formaldehyde will be complete before it will infiltrate into the ground and it is unlikely that it will reach the shallow ground water. According to Pijnenburg (1992) 50 - 75 grams of formaldehyde per tonne of sugar beets is applied. The average capacity of a sugar factory in the Netherlands is 250 - 550 tonnes of sugar beets per hour. The process is carried out continuously over 3 months (with an extension up to 4½ months).

3.2.3 Preservatives

The term "preservatives" is not mentioned as such in the Pesticides Act; with preservatives a group of chemicals is meant, that is used to preserve aqueous industrial processes or products to micro-organisms. Preservatives are made in formulations, which are applied to the product to be preserved. These products have another function than protection against micro-organisms. Until now, only a few preservatives are registrated, this contrary to the industrial biocides, which have almost the same function, but are not used in a formulation.
As mentioned before, preservatives are applied in various industrial sections or products. Hence, there are various ways in which the preservatives are emitted into the environment. This can also be seen in Figure 5.

A) *Preservatives in painting products*
The amount of biocides in painting products reached about 220 tonnes in 1991. The biocides are used for preservation of the product as well as the painting-layer against biological degradation after application. The preservatives added are highly toxic and slightly biodegradable (e.g. isothiazolone-derivates, carbamates and chloro-acetamides).
Preservatives in painting products are diffusely introduced into the environment as waste-products. Besides, they are introduced into the soil and surface water in a diffuse way after use.

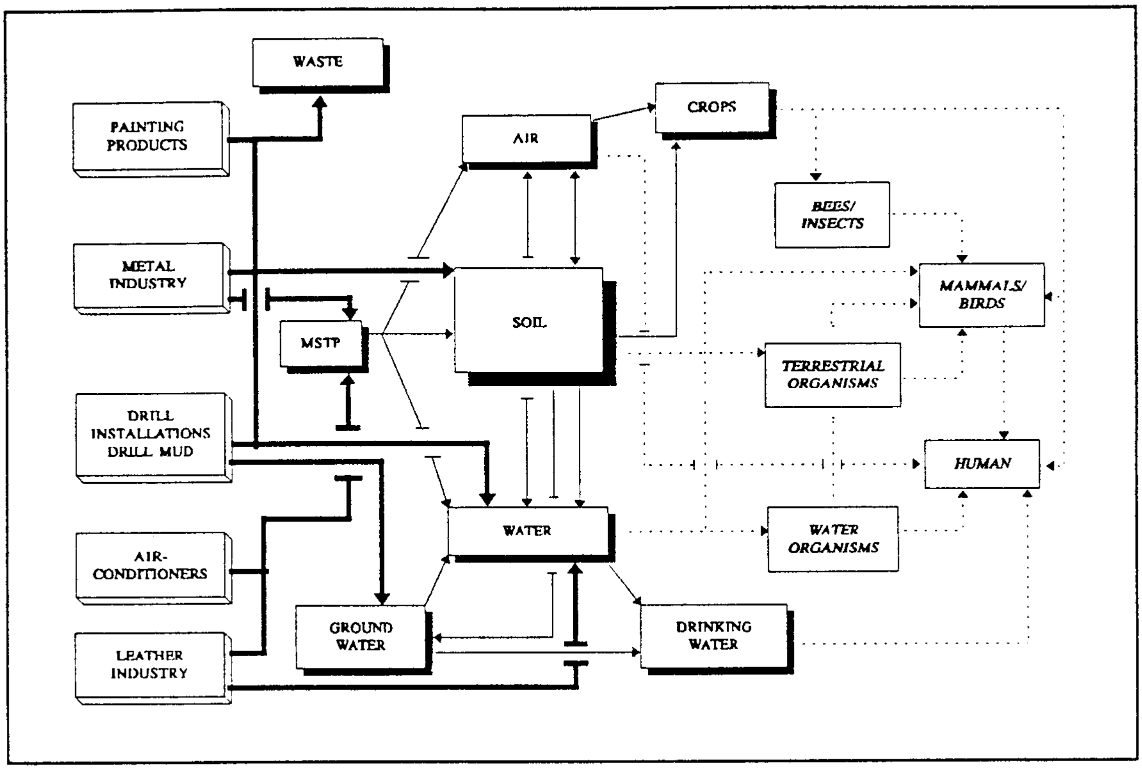

Figure 5. Detailed exposure pathways for preservatives.

B) *Preservatives in metal industry*

In metal industry large amounts of metalworking fluids are used for their cooling and lubricating abilities. In many cases water based metalworking fluids are used, often in circulation systems. According to Pijnenburg (1992) some 10 tonnes/year of biocides are in use for preservation of these fluids (assuming 0.5% of biocide in metalworking fluids). Water based metalworking fluids are delivered as concentrates which are diluted with water before use. The dilution is depending on the type of water based fluid (i.e. emulsion, dispersion, synthetic or semi-synthetic) and the type of machining. Though spent fluid has to be treated as hazardous waste a part of the fluid will be discharged into the waste water (sewerage). These emissions are not taken into account here. In Figure 6 the scheme for metalworking processes is depicted.

Emissions leading to discharges to waste water are:

1. evaporation and misting, followed by deposition and cleaning operations;
2. leakage, splashing and spills;
3. degreasing of processed materials by means of alkaline aqueous systems;
4. leak out of chips and spin drying of chips before they are going to recycling processes.

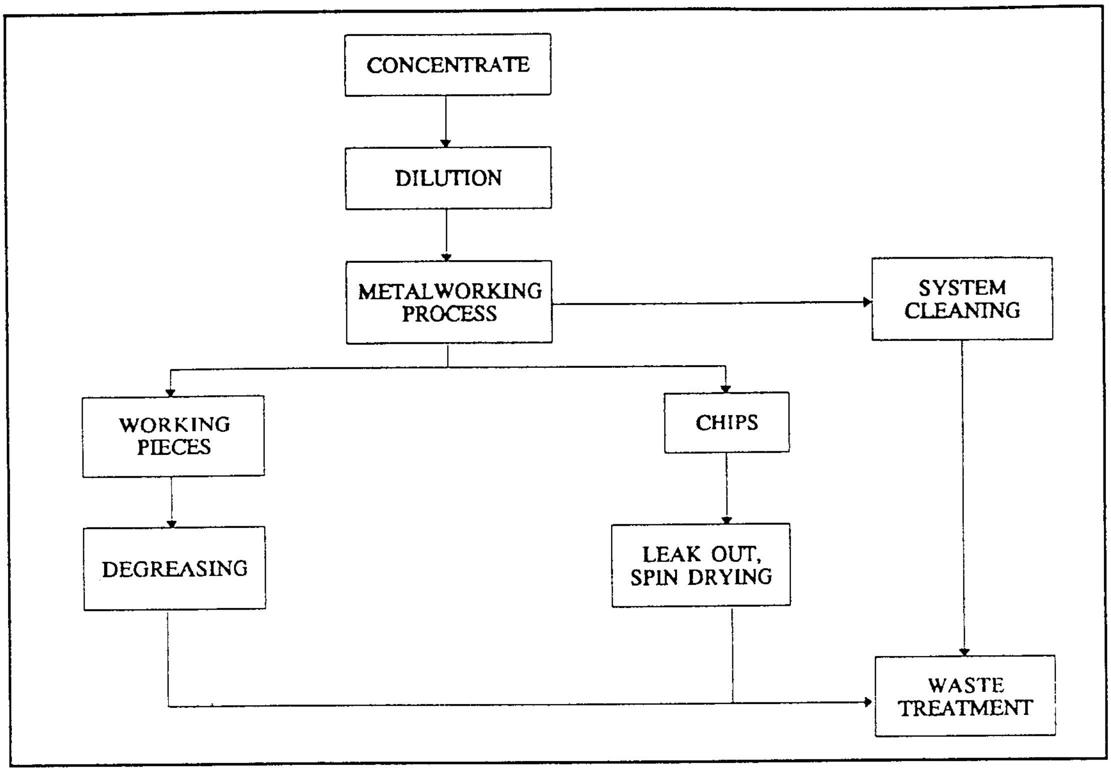

Figure 6. Scheme of metalworking processes with water based fluids

The first two are the main sources of discharges to the waste water. The other two are minor ones; degreasing of the processed materials occurs in many cases not at the same place.

In Table 7 the parameters used in the scenarios are presented. The scenarios are based on Van der Poel and Ros (1987). It is assumed that the waste water is treated in a STP (1,800 m^3/day); the removal of the a.i. is calculated with the standard module of USES.

Table 7. Parameters/variables and default values for water based metalworking fluids

Parameter/variable (unit)	Symbol	Default	C/R/E/O
Input:			
System capacity (kg)$^{1)}$	Q_{syst}	100	R/E
Fraction of fluid supplemented per day (1/day)	f_{suppl}	0.035	R/E
Fraction of active ingredient in (diluted) fluid (-)	$f_{a.i.}$		R/E
- emulsions and unknown		0.0005	E
- dispersions		0.00025	E
- synthetics		0.0002	E

- semi-synthetics		0.00035	E
- unknown		0.0005	E
Quantity of water in STP (m^3/day) (standard value)	Q_{STP}	1800	C
Fraction removed in STP (calculated by standard module of USES)	R_{STP}		O
Dilution factor of receiving surface water (-) (standard value)	F_{dilut}		C

Output:

C_{surf} = Concentration of a.i. nearby point of discharge in receiving surface water (mg/l)

Model calculations:

L_{wwt} = Quantity of a.i. released with waste water (kg/day)

$= Q_{syst} * f_{suppl} * f_{a.i.}$

$C_{surf} = L_{wwt} / Q_{STP} * R_{STP} / F_{dilut} * 10^3$

---

[1] Amount of metalworking fluid in system of machinery used

C) *Preservatives in drilling installations and drill mud*

Preservatives can be used to prevent drill installations (at sea) and drill mud (at land) from adverse effects by bacteria. Examples are biguanides, glutaraldehydes and halogenated phenols. Inherent to this function the preservatives can enter the environment in many ways: via the soil, the ground water, the surface (sea) water and as waste product.

D) *Preservatives in leather industry*

Preservatives in the leather industry (tannery), like phenols, heterocyclic fungicides and metal-compounds, are used to keep the leather supple and to prevent it from deterioration. As this preservation is not carried out in the actual leather industry and a large portion of the hides is imported, this aspect is not taken into account. It should be kept in mind however that, once the hides are treated in the Dutch leather industry, these bactericides will end up in the process water.

In the Netherlands most leather processing firms have their own flocculation unit; the efficiency of such a unit is dependent on the water solubility of the substances involved (comment by RIZA). After this pre-treatment the water is discharged via the sewerage into an MSTP. Besides, preservatives in leather can enter the environment as a waste product.

E) *Preservatives in air-conditioners*

Preservatives in air-conditioners systems are applied to prevent the growth of bacteria in the water which is used in these systems for air-moisturing. Preservatives are introduced into the environment via the MSTP. However, in the Netherlands these kind of preservatives are hardly applied.

3.2.4 Household products

Household products are defined as chemicals which are used for destroying pests (insects and rodents) inside and outside houses or accommodations for man,in storage places, silos and shipyards, in private gardens or on dump sites. According to the Pesticides Act admission of household products is provided. A classification can be made in rodenticides and insecticides. Both groups can be applied in various ways. As a result of this the way in which household products enter the environment is variable, which can also be seen in Figure 7.

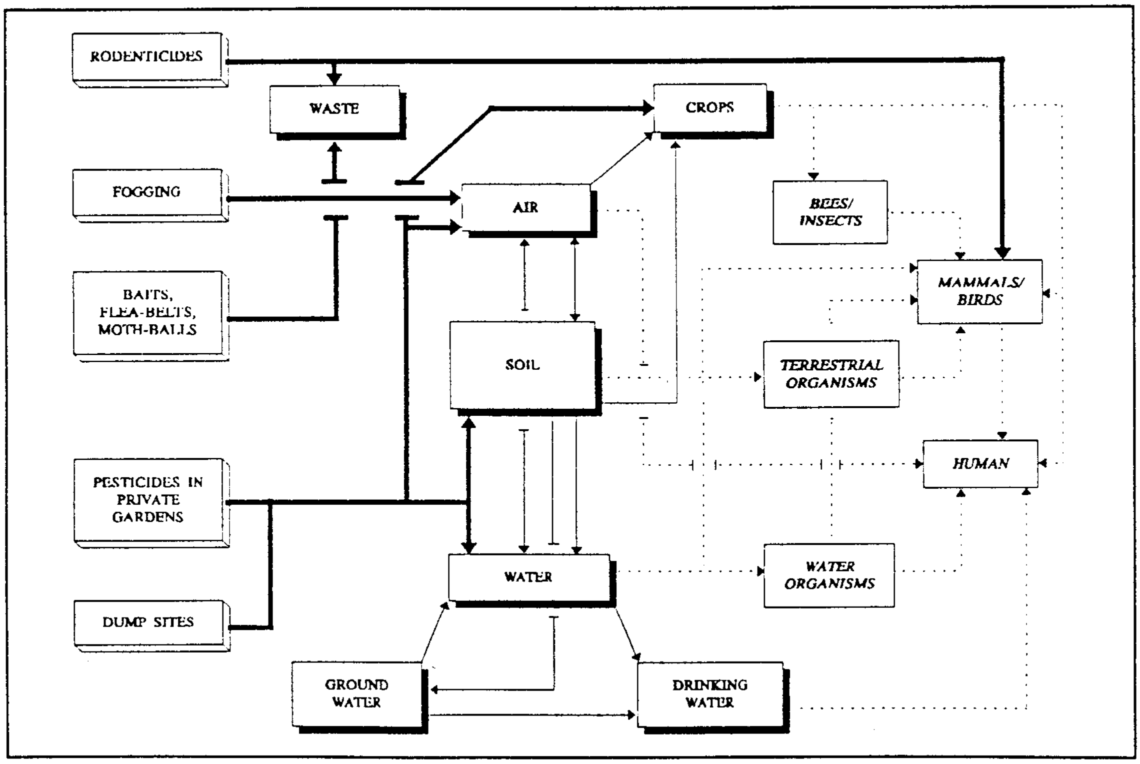

Figure 7. Detailed exposure pathways for household products.

A) *Rodenticides*
Rodenticides are meant for killing rodents inside and outside accommodations for man, like houses, office buildings and schools. A classification can be made in multi-dose rodenticides and acute-working rodenticides. Rodenticides can be consumed by non-target organisms, like birds. Besides they can enter the environment as waste product.

B) *Household products used for fogging*

One of the application methods of both rodenticides and insecticides is fogging, in which the product is applied gaseously. Fogging is used against insects, in storage places, silos and shipyards, against pests in rooms where baits or sprays cannot be applied (like planes), and against pests in various materials, like wooden packing material. Especially methylbromide is regularly used. As a result of leakages high amounts of the fogging gasses can be emitted into the air.

C) *Insecticides in baits, flea-belts and moth-balls*

Insecticides are used for killing insects, mainly inside the house. Insecticides are worked up in baits, flea belts and moth-balls. The insecticides can enter the environment as waste products.

D) *Pesticides in private gardens*

Pesticides used in private gardens (e.g. allotment gardens) and not for agricultural purposes, can be considered as household products as well. The emission routes are almost similar to those of the agricultural pesticides: they can enter the environment via the air, the soil and the surface water or they can be intercepted by plants. The scenarios for this group of pesticides can be found in the report of Emans *et al.* (1992).

E) *Rodenticides on dump sites*

The use of rodenticides nowadays is limited to occasions of population outbreaks of rats. The bait is placed at regular places in special feeding tubes preventing other animals from eating the bait. At one large site where the freshly dumped garbage is not covered the same day systematic use of rodenticides is applied with several types of feeding places (personal communication with Van Blaaderen, Stichting Vakopleiding Ongediertebestrijding).

3.2.5 Wood preservatives and wood protectors

Wood preservatives and wood protectors are used to protect wood against damaging effects by bacteria, fungi and insects. Wood preservatives should protect the wood for a period lasting more than 10 years. Wood protectors should protect the wood for a shorter period. The preservatives/protectors can be distinguished for several application areas:

- agriculture and horticulture
- ground engineering, water engineering, road building
- railway building
- house building

- private markets

The most regular used preservation products are creosote oil, mixtures of soluble metal salts and organic-tin-compounds. Wood preservatives and wood protectors can enter the environment during three stadia of preserved wood: the process-phase, the users-phase and the waste-phase (see Figure 8). During the process-phase, in which the wood is treated, the chemicals can enter the environment via the soil or via the surface water as a result of leaching/lixivation. Besides, the chemicals can reach the environment from waste materials such as chips, saw dust and bore-meal produced by processing the treated wood. During the waste-phase, the chemicals can enter the environment via waste products consisting of treated wood. Then, processes like lixivation can take place.

Biocides for wood preservation can be incorporated into the wood by impregnation or can be applied by brush, roller or fogging. Impregnation is carried out at a large scale by specialized firms. Drenching, dipping and coating is done at a small scale by trades such as carpenter's workshops. In cases where existing constructions with wood have to be treated, i.e. buildings, pesticides are sprayed to fight pests.

The processes considered here are impregnation, drenching/dipping, spraying and pest fighting in buildings. For treated wood, e.g. poles and timber, scenarios for environmental releases during article life have been made.

Emission of wood preservatives into the environment during treatment phase

a. Impregnation

The two main impregnation processes carried out are *creosote impregnation* and *salt impregnation* (Quarles van Ufford, draft). A schematic presentation of the process of *creosote impregnation* can be found in Figure 9 and of *salt impregnation* in Figure 10. Emissions to the air take place at several stages during the process:

- at the vacuum after impregnation (removal of surplus and sticking amounts of creosote);
- at boiling out the creosote;
- evaporation at cease of the vacuum, with the vacuum air and replacement air;
- at the pull out of the wood from the impregnation tank (main release); and
- at storage.

Releases to water take place at storage because of leaching by rainwater. Usually the water is collected, if the surface of the storage area is metalled, and carried

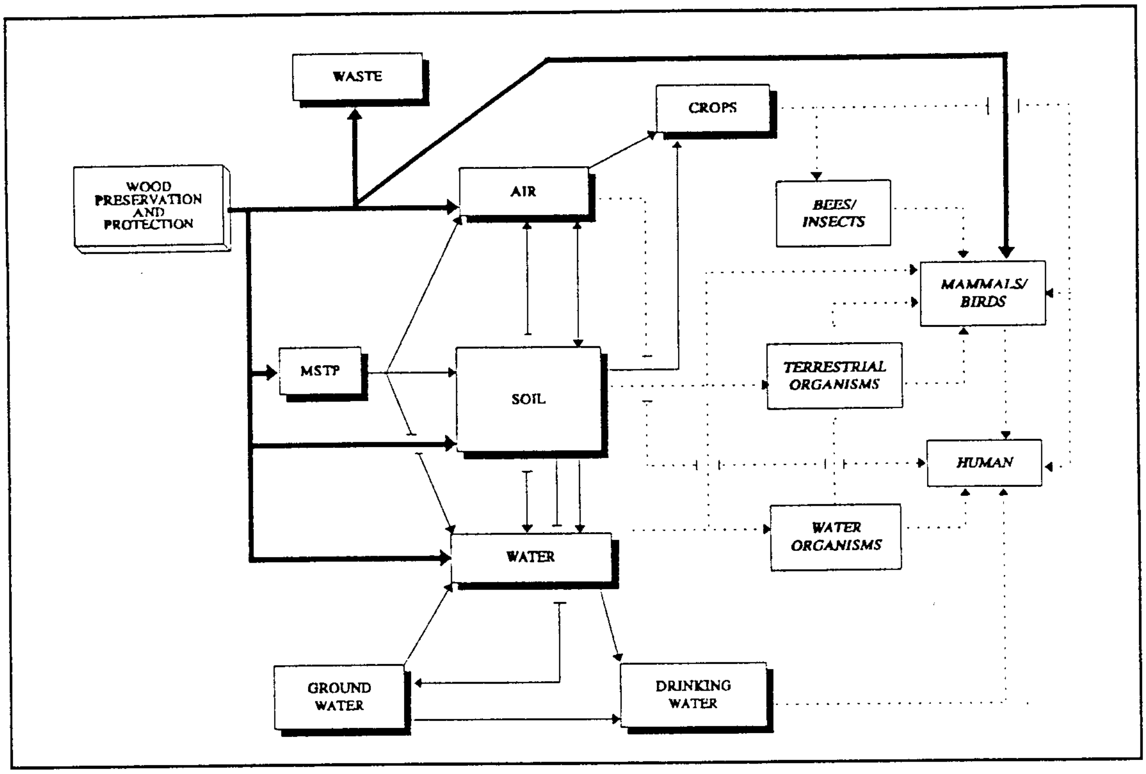

Figure 8. Detailed exposure pathways for wood preservatives and wood protectors.

off to the sewer connected with an MSTP. Other releases to water can take place at the vacuum pump, where vapours are transferred to water (especially water ring pumps). Furthermore water from condensers released to the sewer is a source; these condensers can be placed between the tank and blow-off pipe (release of the pressure after impregnation) and between the tank and the vacuum pump. Finally in practice some firms release the water used for cleaning operations of the apparatus to the sewer.

Dependent on the pavement of the storage area little or much of the leached creosote will enter the soil.

Also other substances are used for impregnation, where these substances are dissolved in organic solvents, such as organo-metal compounds. For these types of impregnation agents no pressure is used.

b. *Drenching, dipping and coating*

At *drenching* and *dipping* the wood is immersed completely in the preserving agent for a certain time (drenching: a few hours - 8 days; dipping: a few minutes - 1 hour). The scheme for drenching and dipping can be found in Figure 11.

Releases with water can be completely prevented in a simple way (prevention of

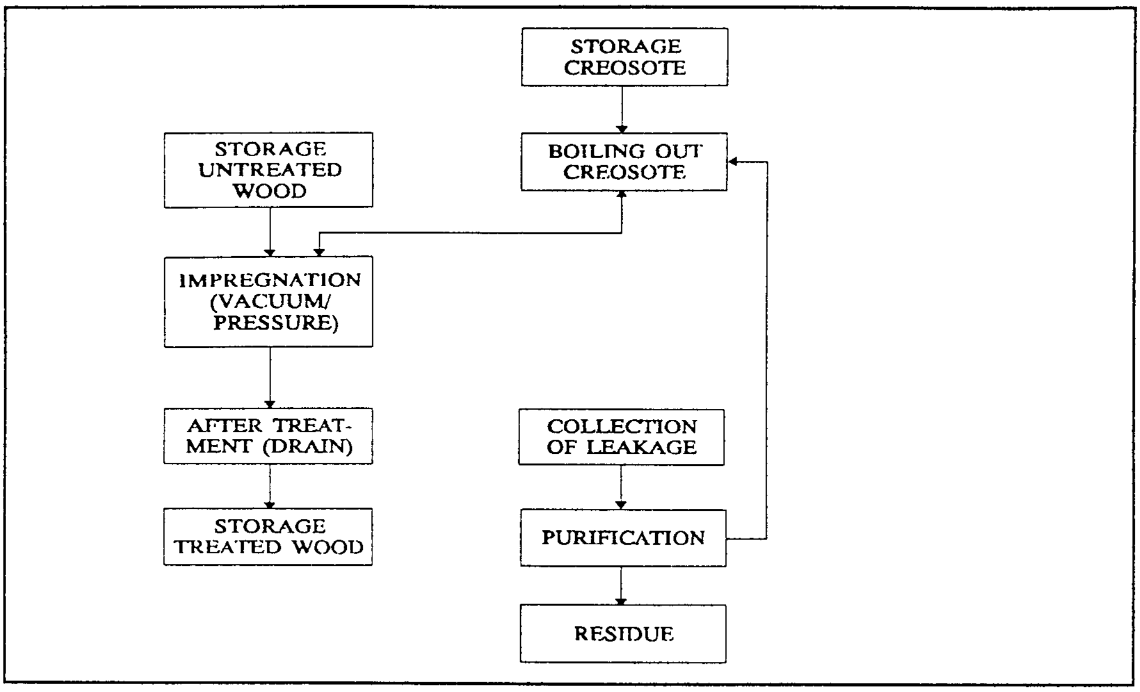

Figure 9. Schematic design of the creosote impregnation process.

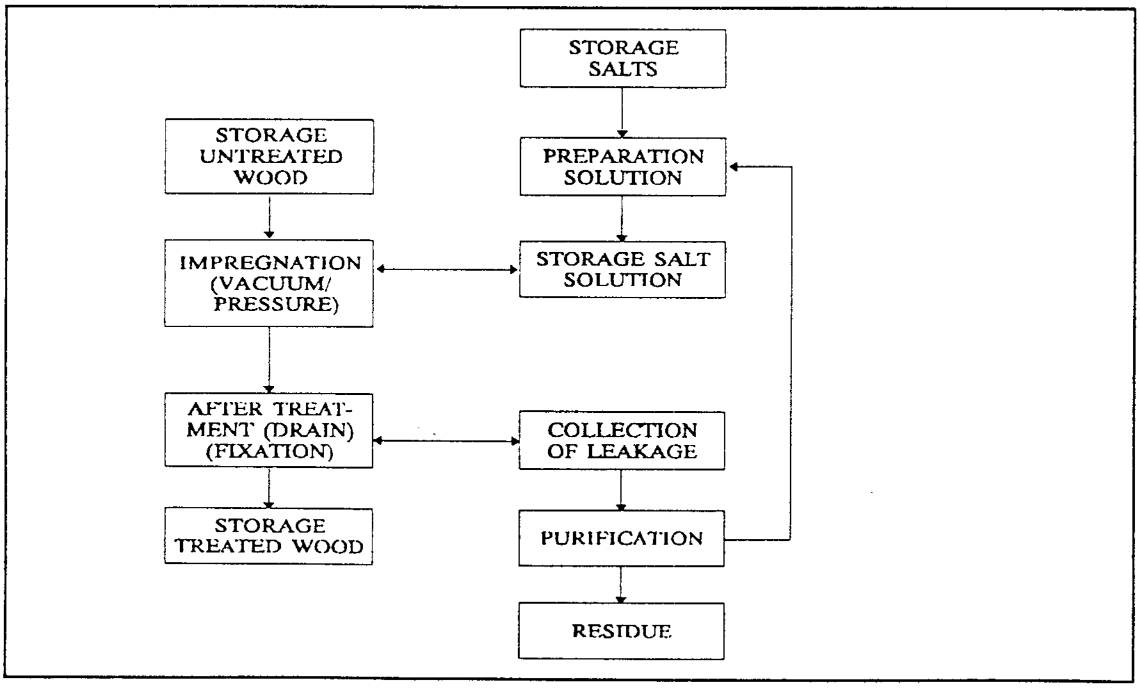

Figure 10. Schematic design of the salt impregnation process.

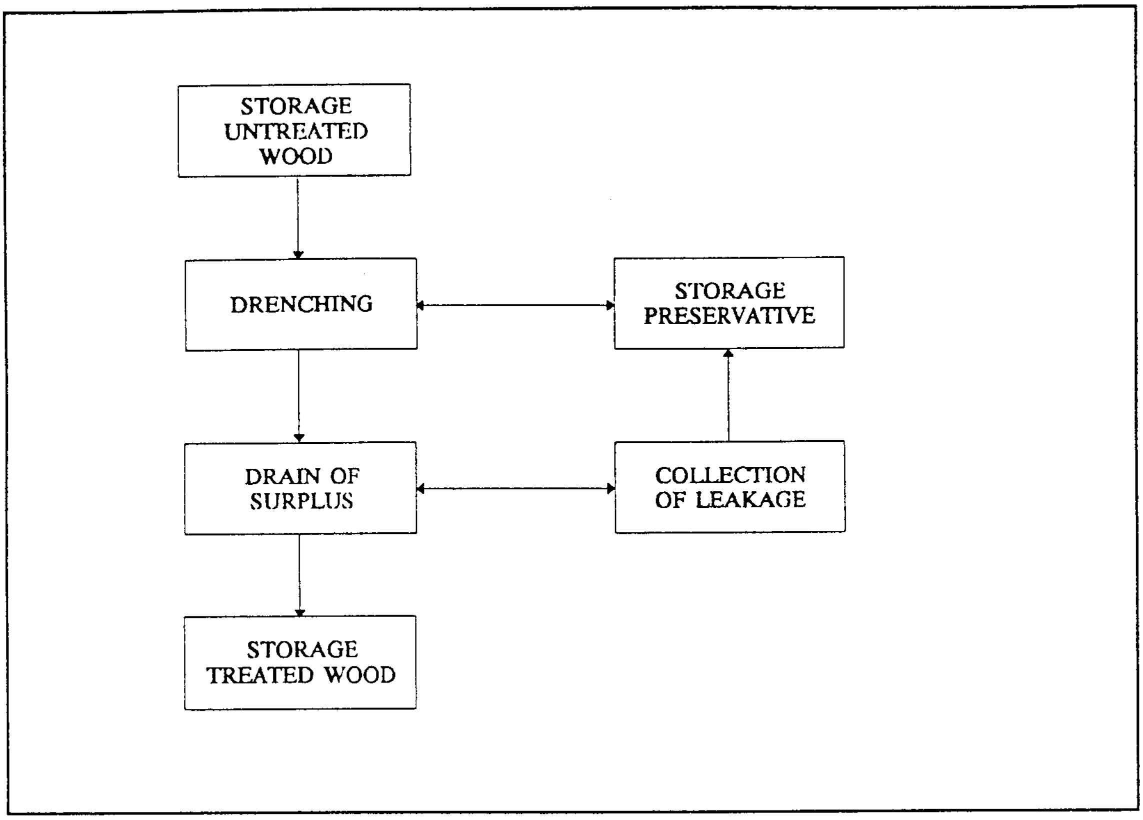

Figure 11. Scheme for drenching and dipping process

overflow of the drenching vessel by rain or overfilling and at the collection of the surplus at drainage). Emission to the air takes place because of volatilization during drenching. Normally only substantial amounts of the most volatile substances (components of creosote and solvents) will be released, especially in those cases where the contents of the tank are heated initially to ≥60°C or when the wood is heated before treatment (shortening of treatment period). Releases to the soil take place at the treatment site and at storage, depending on the pavement. At *spraying* a film of preservative (solution) is applied, by techniques varying from using a simple hand spray-gun up to a fully automated spray street with recirculation of the preservative flowing from the wood. Releases to water and soil are easy to prevent; emissions to air are dependent on the volatility of the substance regarded, while a large amount is emitted as an aerosol. At hand spraying this can be ±30% and in case cabins are used condensers at the vents can limit the releases considerably.

Coating with a brush is usually done at a small scale. Releases to water and soil can be prevented, while emissions to the air are once more dependent on the volatility of the substance regarded. As releases are very limited, especially taking into account the scale compared to impregnation and drenching/dipping, no further consideration is given to this technique.

c. *Wood preservation in buildings*

At last remedial timber treatment (fogging or spraying) in buildings is of importance, especially if the building is inhabited by animals such as bats.

scenarios

The scenario used is dependent on the type of preservative. The scenarios dealt with in this paragraph are impregnation (vacuum/pressure and vacuum), drenching, dipping and spraying. The scenarios have to be split in 3 parts, i.e. one for process releases at application, one for releases at storage and one for releases during the user phase. The preservatives for treatment of wood in buildings is treated separately. The scenarios for application of the preservatives and types of preservatives are given in Table 8. For the calculation of the concentration in the surface water the removal is calculated with the standard MSTP of USES (with 1800 m^3 water per day).

Table 8. Preservatives and suited methods of application

preservative		application methods					
group	type	1	2	3	4	5	6
agents (salts) dissolved in water	fluorine & chromium compounds (≤6% soluble)	x		x			
	fluorine, chromium & arsenic compounds (≤6% soluble)	x		x			
	fluorine & chromium compounds (>10% soluble)			x	x	x	x
	bifluorides			x	x	x	x
	boron compounds			x	x	x	x
	copper and chromium compounds	x					
	copper, chromium and arsenic compounds	x					
agents dissolved in organic solvents	pentachlorophenol *)		x	x	x	x	x
	copper/zinc naphthenate		x	x	x	x	x
	tributyl tin compounds		x	x	x	x	x
tar oil	creosote	x					
	carbolineum				x		x

1 = vacuum and pressure impregnation
2 = vacuum impregnation
3 = drenching
4 = dipping
5 = spraying
6 = coating (by brush)
*) not admitted any more

A) *Scenario for creosote impregnation*

Creosote oil is a multi-component agent, whereas risk assessments are carried out for single substances. For specific components some data were available in literature on emissions to air, water and soil (Slooff *et al.*, 1989a). From these data estimates have been generated using physico-chemical properties. For the releases to water and soil it is assumed that 1% of the releases goes to soil and 99% to (waste) water, i.e. to an MSTP (no data available). The mean storage time of creosote impregnated wood is 10 weeks (5 storage events per year per m^2) and storage density of the treated wood is 0.76 m^3 wood per m^2 (CUWVO 1992). In Table 9 the parameters used in the scenarios are given together with the default values.

Table 9. Parameters/variables and default values for creosote impregnation

Parameter/variable (unit)	Symbol	Default	C/R/E/O
Input:			
Quantity of wood impregnated (m^3/day)	Q_{mater}	50	R/E
Quantity of creosote per m^3 wood (kg/m^3)	Q_{creos}	80	R/E
Fraction of substance in creosote (-)	f_{creos}	0.05	R/E
Fraction released to water/soil (-)	$f_{w/s}$		R/E
solubility in water (mg/m^3)			
<0.25		0.0001	E
0.25 - 1		0.0015	E
1 - 50		0.003	E
50 - 100		0.015	E
>100		0.03	E
Fraction to waste water	f_w	0.99	R/E
Quantity of water in STP (m^3/day)	Q_{STP}	1800	C
Fraction removed in STP (-)			
(calculated by standard module of USES)	R_{STP}		O
Dilution factor of receiving surface water (-)	F_{dilut}		C
Fraction released to air (-)	f_a		R/E
vapour pressure at 20°C (Pa)			
<0.005		0.0005	E
0.005 - 0.05		0.005	E
0.05 - 0.5		0.01	E
0.5 - 1.25		0.05	E
1.25 - 2.5		0.1	E

2.5 - 15		0.2	E
≥15		0.25	E
Storage density of treated wood per m^2 (m^3/m^2)	D_{wood}	0.76	R/E
Output:			
Concentration in receiving surface water (mg/l)	C_{surf}		
Quantity of the substance released to air (kg/day)	L_{air}		
Dosage of a.i. per 1 m^2 soil surface for 1 storage period (mg/m^2)	D_{soil}		

Model calculations:

L_{wwt} = Quantity of the substance released with waste water (kg/day)

$= Q_{mater} * Q_{creos} * f_{creos} * f_{w/s} * f_w$

$C_{surf} = L_{wwt} / Q_{STP} * R_{STP} / F_{dilut} * 10^3$

$L_{air} = Q_{mater} * Q_{creos} * f_{creos} * f_a$

$f_s = 1 - f_w$

$D_{soil} = D_{wood} * Q_{creos} * f_{creos} * f_{w/s} * f_s * 10^6$

B) *Scenario for salt impregnation*

The releases to air can be assumed to be of no importance at all, as the vapour pressure of the salts used are very low. The releases to water (and soil) can be assumed to be very small (Slooff *et al.*, 1989b and Quarles van Ufford, concept). For existing substances and new substances estimates have been generated (see Table 10). In case of a mixture of salts the quantity of the salt (substance) regarded per m^3 wood must be entered (Q_{salt}). For the MSTP and for the dilution the same assumptions as for the creosote impregnation have been made. The mean storage time of salt impregnated wood is 1-5 weeks (default for calculation 5 weeks (10 storage events per m^2 per year)) and storage density of the treated wood is 0.76 m^3 wood per m^2 (CUWVO 1992).

Table 10. Parameters/variables and default values for salt impregnation

Parameter/variable (unit)	Symbol	Default	C/R/E/O
Input:			
Quantity of wood impregnated (m^3/day)	Q_{mater}	50	R/E
Quantity of salt per m^3 wood (kg/m^3)	Q_{salt}	2	R/E

Fraction released to water/soil (-)	$f_{w/s}$	0.0001	R/E
Fraction to waste water (-)	f_w	0.99	R/E
Quantity of water in MSTP (m^3/day)	Q_{STP}	1800	C
Fraction removed in s.t.p (-) (calculated by standard module of USES)	R_{STP}		O
Dilution factor of receiving surface water (-)	F_{dilut}		C
Storage density of treated wood per m^2 (m^3/m^2)	d_{wood}	0.76	R/E
Output:			
Concentration in receiving surface water (mg/l)	C_{surf}		
Dosage of a.i. per 1 m^2 soil surface for 1 storage period (mg/m^2)	D_{soil}		

Model calculations:

L_{wwt} = Quantity of the substance released with waste water (kg/day)

$= Q_{mater} * Q_{salt} * f_{w/s} * f_w$

$C_{surf} = L_{wwt} / Q_{STP} * R_{STP} / F_{dilut} * 10^3$

$f_s = 1 - f_w$

$D_{soil} = D_{wood} * Q_{salt} * f_{w/s} * f_s * 10^6$

C) *Scenario for drenching and dipping*

A distinction has been made between agents dissolved in water and agents dissolved in organic solvents. The substances dissolved in water usually have a very low vapour pressure and a low Henry coefficient; for this reason releases to the air are assumed to be negligible. In organic solvent systems also releases to the air of solvents have been taken into account. Table 11 gives the estimates generated. Estimated storage time 5 weeks, 10 episodes per year and a storage density of 0.5 m^3/m^2.

Table 11. Parameters/variables and default values for drenching and dipping

Parameters/variable (unit)	Symbol	Default	C/R/E/O
Input:			
Quantity of wood impregnated (m^3/day)	Q_{mater}	2	R/E
Quantity a.i. per m^3 wood (kg/m^3)	$Q_{a.i.}$	1	R/E
Fraction released to water/soil (-)	$f_{w/s}$	0.0005	R/E
Fraction to waste water (-)	f_w	0.9	R/E
Quantity of water in MSTP (m^3/day)	Q_{STP}	1800	C

Fraction removed in s.t.p (-) (calculated by standard module of USES)	R_{STP}		O
Dilution factor of receiving surface water (-)	F_{dilut}		C
Storage density of treated wood per m^2 (m^3/m^2)	D_{wood}	0.76	R/E
Fraction released to air (-)	f_{air}		R/E
vapour pressure at 20°C (Pa)			
<0.005		0.001	E
0.005 - 0.05		0.01	E
0.05 - 0.5		0.02	E
0.5 - 1.25		0.075	E
1.25 - 2.5		0.15	E
>2.5		0.25	E
Output:			
Concentration of a.i. in receiving surface water (mg/l)	C_{wastew}		
Concentration of a.i. in air (mg/m^3)	C_{air}		
Dosage of a.i. per 1 m^2 soil surface for 1 storage period (mg/m^2)	D_{soil}		

Model calculations:

L_{wwt} = Quantity of the substance released with waste water (kg/day)

$= Q_{mater} * Q_{a.i.} * f_{w/s} * f_w$

$C_{surf} = L_{wwt} / Q_{STP} * R_{STP} / F_{dilut} * 10^3$

L_{air} = Quantity of a.i. released to air (kg/day)

$= Q_{mater} * Q_{a.i.} * f_{air}$

$C_{air} = L_{air} / V_{air} * 10^6$

$f_s = 1 - f_w$

$D_{soil} = D_{wood} * Q_{a.i.} * f_{w/s} * f_s * 10^6$

D) *Scenario for remedial timber treatments in buildings*

To fight damage to the timbers used in the constructions of the buildings (especially wood at attics of large buildings such as churches) by insects and fungi remedial timber treatment products are applied by spraying or fogging. In

Table 12 the parameters necessary for a hazard/risk assessment of the use of remedial timber treatment products (organic compounds) to bats are given.

Table 12. Parameters/variables and default values for remedial timber treatments in buildings

Parameter/variable (unit)	Symbol	C/R/E/O
Input:		
Fraction of a.i. in formulation (-)	$f_{a.i}$	R
Application rate of formulation (mg/m^2)	A_{solid}	R
or:		
Application rate of formulation (ml/m^2)	A_{fluid}	R
Density (kg/m^3)	R_{den}	R
Output:		
Dosage of a.i. per m^2 wood (mg/m^2)	Q_{wood}	

Model calculations:

$$Q_{wood} = A_{solid} * f_{a.i.} \quad \text{or}$$

$$Q_{wood} = A_{fluid} * R_{den} * f_{a.i.} * 10^3$$

Emissions of wood preservatives to the environment during the consumer phase.

A) *Leaching from impregnated wood to surface water*

The yearly emission in the Netherlands of 4 components of PAHs (Berbee, 1989) to the surface water of creosoted wood is estimated to be approximately 5000 kg/y (fluoranthene 1300 kg/y, phenanthrene 2200 kg/y, pyrene 1000 kg/y, and anthracene 500 kg/y). The yearly emission in the Netherlands of copper, chromium and arsenic to the surface water is estimated to amount approximately 170, 40 and 950 kg/y, respectively (Berbee, 1989).

For calculating the impact of leaching to the surface water of compounds used for impregnating wood a small model waterway with the following characteristics will be used (Berbee, 1989):

- the model waterway is a rectangular box;
- the residence time of the water in the waterway is put on 20 days;
- complete mixing perpendicular to the direction of the water flow and no back-mixing is assumed;
- length 1000 meter;
- depth 1.5 meter;
- width 5 meter;
- at both sides along the complete length of the waterway impregnated wooden poles are placed (5 poles per meter waterway (both sides). It is assumed that all poles have 100% contact with the surface water;
- diameter of the poles 0.1 meter.

The use of the total surface of the poles leads to an overestimation. However, in practice, besides impregnated wooden poles often impregnated planks are present which will also release compounds to the surface water. The overestimation of the surface will be very limited. In such a model waterway the highest concentrations of compounds used for impregnating will be noticed at the end of the model waterway. Calculations have reference to this point in the system.

For calculating the concentration of the compound used for impregnating wood in surface water it is necessary to have results from a lixivation experiment (mean flux (mg/m^2) over a certain period). Test designs are given in Berbee (1989).

Table 13. Model for calculating concentrations in surface water for compounds used for impregnating wood

Variable/parameter (unit)	Symbol	Default	C/R/E/O
Input:			
Waterway depth (m)	W_{depth}	1.5	C
Waterway width (m)	W_{width}	5	C
Residence time of waterway water (d)	R_{wway}	20	C
Diameter of poles (m)	P_{diam}	0.1	C
Number of poles per meter (both sides) (m^{-1})	P_{numb}	5	C
Mean flux of compound (mg/m^2 per day) over a certain period	F_{comp}		R
Regression constant a (curve fitting) (-)	a		R
Regression constant e^b (curve fitting) (-)	e^b		R

Output:

Concentration in water at end of waterway after 1 residence time (μg/l)	C_{wway}

Model calculations:

Leaching surface of impregnated wood per meter model waterway:

$$L_{surf} = 2 * P_{numb} * P_{diam} * \pi * W_{depth} = 4.71 \text{ m}^2/\text{m}$$

In general the experimentally determined compound-flux will decrease in time. The function of the lixivation time and the flux can be described as follows:

$F(t) = e^b * t^a$ (a and e^b can be estimated by curve fitting)

$$C_{wway} = \frac{L_{surf} * e^b}{W_{depth} * W_{width} * (a+1)} * [t^{a+1} - (t - R_{wway})^{a+1}]$$

$$= \frac{4.71 * e^b}{7.5 * (a+1)} * [t^{a+1} - (t - 20)^{a+1}]$$

In case curve fitting is not possible C_{wway} can be estimated as follows:

$$C_{wway} = L_{surf} * F_{comp} / (W_{depth} * W_{width} / R_{wway})$$

$$= 4710 * F_{comp} / 375$$

$$= 12.56 * F_{comp}$$

B) *Leaching from impregnated wood to soil* and

C) *Waste phase of impregnated wood*

p.m.

3.2.6 Antifoulings

Antifoulings prevent the growth of bacteria, algae, diatoms, seaweeds, acorn-sells or mussels on ships hulls both in seawater (for the time being outside the scope of this evaluation system) and in freshwater. Organic-tin-compounds like copper(I)oxide and tributyltinoxide are used as active ingredients in these paintings. In The Netherlands antifoulings are included in the Pesticides Act. Since January 1st 1990 organic-tin-compounds are forbidden by the European Commission for ship smaller than 25 m.

The schematic design of the evaluation system for antifoulings is presented in Figure 12. Antifoulings can enter the soil during application of the paintings, which takes place on the dock. After application, the active ingredients in the paintings are continuously released from the ship hulls and, in this way, prevent fouling. However, also non-target organisms can be affected. In addition, the sediment-layer can be seriously polluted.

Emissions of antifoulings to the environment during the consumer phase

For calculating the risk of antifoulings in the aquatic environment a middle size yacht-basin is modelled (see Table 14). For this calculation it is necessary to have results of a lixivation study (mean flux (mg/m^2) over a certain period).

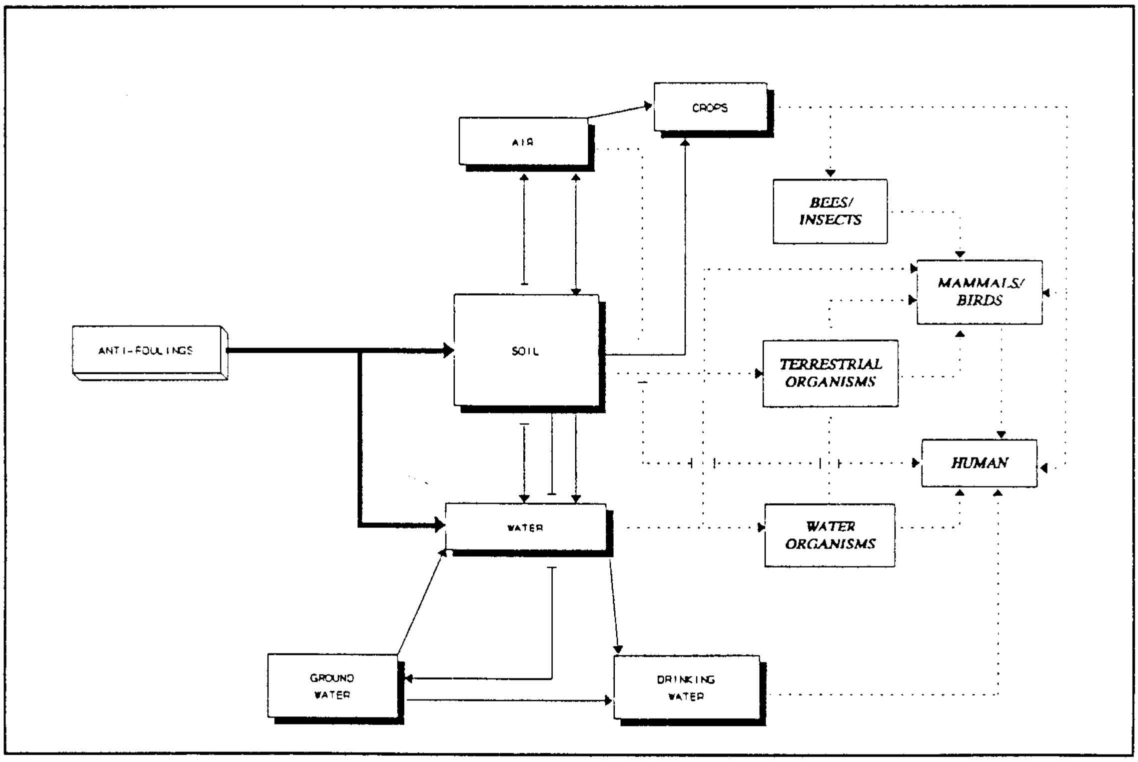

Figure 12. Detailed exposure pathways for anti-foulings.

Table 14. Model for calculating concentrations in surface water for compounds used as antifoulings

Parameter/variables (unit)	Symbol	Default	C/R/E/O
Input:			
Number of yachts in yacht-basin (-)	N_{ship}	250	C/E
Mean ship deck area (m^2)	D_{ship}	10	C/E
water/ship ratio in yacht-basin (-)	$R_{w/s}$	3	C/E
Fraction ships in water	F_{ship}		
- Whole year		0.5	C/E
- Summer		1.0	C/E
- Winter		0.25	C/E
Litres paint per yacht (l)	L_{anti}	2	E/R
Cover of antifouling paint (m^2/l)	C_{anti}	2.5	E/R
Depth of yacht-basin (m)	$D_{y\text{-}b}$	2.5	C/E
Fraction ships in yacht-basin	$F_{s/ns}$	0.71	C/E
Mean flux of compound ($\mu g/cm^2$ per day)	F_{anti}	4	E/R
Octanol/water partitioning coefficient	K_{ow}		R
Concentration suspended matter (mg/l)	C_{susp}	15	C
Degradation rate (first order) (d^{-1})	k_1	0	E/R
Advection time in basin (d^{-1})	$DT50_a$	50	E
Output:			
Concentration in yacht-basin water (mg/l)	C_{anti}		

Model calculations:

K_{sed} (adsorption coeff. sediment), (dm^3/kg) $= 0.025 * K_{ow}$

A_{ship} (necessary harbour area per yacht), (m^2) $= (1 + R_{w/s}) * D_{ship}$

W_{quan} (water in yacht-basin), (l) $= N_{ship} * A_{ship} * D_{y\text{-}b} * 1000$

A_{surf} (antifouling surface per yacht-basin), (m^2) $= C_{anti} * L_{anti} * N_{ship} * F_{ship} * F_{s/ns}$

$k_a = \ln 2 / DT50_a$

$$k = k_1 / (1 + K_{sed} * C_{susp} * 10^{-6}) + k_a$$

C_{water} (concentration a.i. in yacht-basin), (mg/l)

$$= \frac{A_{surf} * F_{anti} * 10}{W_{quan} * k}$$

3.3 Distribution

After emission of a biocide into a certain compartment the biocide will be transported through the environment, due to several physical and chemical processes. The distribution part of the model is described in Figure 13. The final

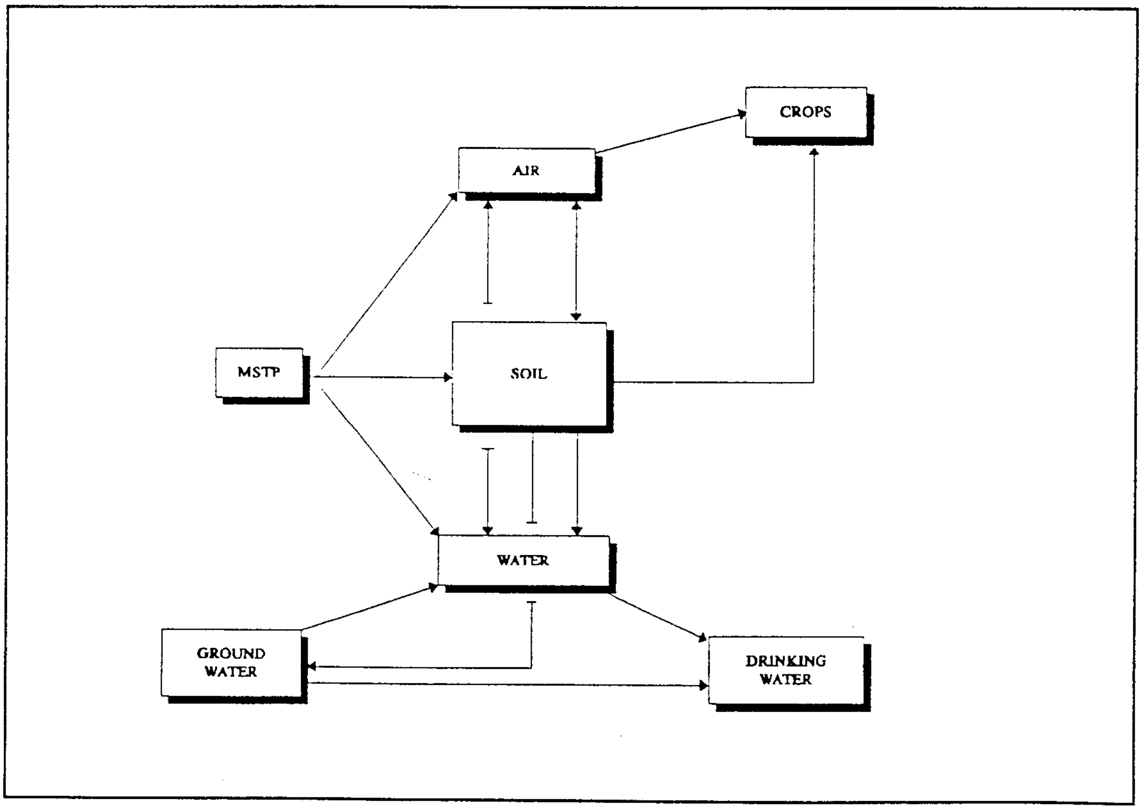

Figure 13. Schematic design of the distribution module of the evaluation model.

goal of this part of the model is to calculate PECs for air, water, drinking water, ground water, soil, sludge and crop.
In case a biocide (or other compound) has reached the MSTP it is assumed to be distributed instantaneously between water (dissolved), air and sludge (in USES one has the option to use the MSTP or to use direct emission to the surface water). Biodegradation may also occur if a substance is classified as 'readily biodegradable'. However, biocides can have a great effect on the bacteria, necessary for biodegradation. Therefore, a risk assessment for beneficial bacteria will be made as well (see paragraph 3.4.1).
The effluent of the MSTP can be diluted into the surface water, intended for the production of drinking water. Organisms living in this water can be exposed to the biocides and bioaccumulation can take place.
The sludge of the MSTP, containing sorbed biocides, is assumed to be applied as "fertilizer" on agricultural soil (grass land and arable land) for the production of crops for human nutrition. The sludge is mixed with the soil, after which the biocides can be taken up by crops. A part of it will be degraded or leach to the shallow ground water. Another part will evaporate into the air. Besides, run-off and erosion to the surface water can take place.
Biocides which have entered the air, either after direct emittance or after volatilization, will deposit on crops and surface water and on soil. Having entered the soil the biocides can volatilize to the air, can reach the surface water by run-off, erosion or drainage, and can reach the ground water by leaching. After entering the surface water biocides can volatilize to the air and can reach the ground water by leaching. Both ground water and surface water can be used for drinking water.

All the modules for the distribution part of the risk assessment model for biocides are already described in Emans *et al.* (1992):

1) Discharge from MSTP into surface water and dilution.

The effluent of the MSTP is discharged into recipient water. This process has been modelled by Toet *et al.* (1991). Two processes take place in the recipient water:
- dilution, modelled by means of a median dilution factor;
- adsorption on or desorption from suspended solids, dependent on the (calculated) partition coefficient.

Eventually, also precipitation may take place, in case the dissolved concentration exceeds the solubility by more than a factor 10.

2) Application of sludge from MSTP on soil.

Distribution of biocides to soil may take place by means of the use of the sludge of the MSTP as fertilizer on arable land or grassland. Concentrations in the soil are the result of mixing the top layer of the soil with an amount of sludge.

3) Volatilization from the soil.

A part of the dosage that has reached the soil volatilizes. This process has been modelled according to Van de Meent *et al.* (1992).

4) Atmospheric deposition on the soil, surface water and crops.

Deposition on soil, surface water and crops can be calculated with the OPS model, developed by Van Jaarsveld (1990). As with advection, the final calculation of this model, the deposition flux averaged over a circle with a radius of 1 km (in $g/m^2.s$), is split up in two parts:

1. calculations for gaseous substances;
2. aerosol-bound substances.

5) Run-off and erosion to surface water.

Besides volatilization and percolation into the root zone and connected soil layers, horizontal transport can take place, i.e. run-off and erosion. The mathematical models for run-off and erosion fluxes are described by De Greef and Linders (in prep.). The models assume that run-off and erosion are calculated under circumstances that represent a soil with an average uniform vegetation cover and directly following application of a pesticide. The soil is in an average moisture condition prior to the application. Interception and water losses as result of evapotranspiration and evaporation are assumed not to contribute significantly to the amount of water that is available for transport over land. The pesticide is distributed instantaneously between the soil matrix and moisture; the precipitation starts shortly after the moment of application. Finally, conservation management practices, such as tillage, aimed at reduction of run-off and erosion are not taken into account.

6) Leaching to ground water.

An estimation of leaching to ground water is made on the basis of the rate of conversion of a pesticide and its mobility (Support Group M model: PESTLA;

Van der Linden & Boesten, 1989). The model is based on the following assumptions:

- Soil type: relatively vulnerable sandy soil. The organic matter content is determined to be 4.7% in the A_p horizon (0-30 cm) and 0.8% and 0.2% in the lower B_3 and C_{11} horizons (30-50 cm and 50-59 cm, respectively); the C_{12} horizon (110-120 cm) contains 0.1%.
- Soil treatment: none (untilled soil). After applying a pesticide, the soil is not ploughed or otherwise tilled so that displacement of the substance through mixing of soil layers is excluded.
- Culture: maize (important for evaporation, evapotranspiration).
- Dosage: a single spring or autumn application of 1 kg a.i./ha, that reaches the soil.
- Precipitation: data from a 75% wet year (gross precipitation in 74% of the years is lower).

7) Drainage.

After the pesticide has reached the shallow ground water via leaching, there are two possibilities:

- Drains are not present;
- Drains are present.

In case there are no drains, it is assumed that all the pesticide disappears to the ground water or drinking water. A worst case assumption would be: conservative behaviour in the saturated zone. This would give the same concentration as calculated according to PESTLA. In the Multi year Crop Protection Plan (Anonymous 1991), a method is included on the calculation of the concentration in the saturated zone. If data are available about the rate of hydrolysis of a substance, the concentration of the substance shall be calculated according the known hydrolysis rate using a depth of 10 m or a period of 4 years, where a concentration of 0.1 μg/l should be reached.

The model calculation is:

$$C_{10\,m} = C_{0\,m} * e^{-(1460*\ln 2)/DT50(h)} \text{ or}$$

$$C_{4\,y} = C_{0\,y} * e^{-(1460*\ln 2)/DT50(h)}$$

It is assumed that the net water flow is 10 m in 4 years, a rather worst case assumption.

In case there are drains, it is assumed that 40% of the pesticide disappears to the ground water and that 60% is drained to the surface water. The concentration of the pesticide in the drains is similar to the concentration in the shallow ground water, but will decrease after the dilution by surface water.

8) Volatilization from surface water.

Volatilization from surface water can be described with the model of Liss & Slater (1974). In this model the main water body is assumed to be well mixed, with a thin layer on the surface in which there is a concentration gradient. The air above is assumed to be well mixed (i.e. the background level is assumed to be low), and a thin layer, in contact with the surface, contains another concentration gradient. At the interface between these two layers there is a concentration discontinuity, and the ratio of concentrations across it (air to water) is assumed to equal the Henry's law constant.
Transfer through these films is by straightforward molecular diffusion. The molecules are assumed to diffuse through the layers at a rate dependent on the phase exchange coefficients found in the equations rather than vaporize directly from solution along with the water vapour. This method is used in the SLOOT.BOX-model (Linders *et al.* 1990).

9) Surface water used for drinking water.

The drinking water module has originally been described by Hrubec & Toet (1992). In this route it is assumed that water entering the surface water via the MSTP is used for drinking water. Therefore, the concentration of the pesticide is dependent on the concentration in the effluent water of the MSTP after dilution. The model assumes a complete removal of suspended particles from the surface water. Removal of the dissolved fraction of a pesticide is modelled by means of a purification factor. This factor is based on simple physico-chemical substance properties, namely:

- K_{ow};
- Henry-coefficient;
- Aerobic biodegradation.

The various treatment processes are distinguished in:

- Dune recharge;
- Open storage;
- Coagulation, flocculation, or rapid sand filtration;
- Ozonization;

- Slow sand filtration.

10) Leaching to ground water used for drinking water.

As already described in the drainage route there are two possibilities after the pesticide has reached the shallow ground water:
- Drains are present;
- Drains are not present.

If there are drains it is assumed that only 40% of the net precipitation will leach to the ground water. If there are no drains 100% of the net precipitation will leach to the ground water. However, the concentration in the ground water will always be the same as in the shallow ground water.

11) Volatilization from crops.

The National Institute of Applied Scientific Research, TNO, has developed a method for calculating pesticide volatilization from crops (Huygen *et al.*, 1986a and 1986b). The model is designed to calculate the evaporative flux in the period immediately following treatment. It is therefore suitable for computing peak concentrations and deposition rates. An assumption is that only compounds left on the crop evaporate.
It has to be noticed that volatilization from crops will play a minor role in the evaluation system, this contrary to the evaluation system for agricultural pesticides. Volatilization from crops will only take place after the use of pesticides, i.e. spraying liquids, in private gardens, like allotment gardens.

12) Uptake by crops.

A part of the biocides discharged onto the soil can be taken up by crops. This uptake is modelled according to findings of Briggs *et al.* (1982 and 1983). As reported by De Nijs & Vermeire (1990), a Stem Concentration Factor (SCF), a bioconcentration factor from transportation stream solution in a plant to a concentration in stem tissue (barley), can be calculated. Concentration in the transportation stream can be calculated by means of a Transport Stream Concentration Factor (TSCF) which links the concentration in the soil solution to concentrations in the transportation stream. The TSCF can be estimated, according to Briggs *et al.* (1982 and 1983), by means of the octanol/water partition coefficient.

3.4 Hazard assessment

Organisms can be exposed to pesticides in various ways. For making a hazard assessment for these organisms decision trees have been developed:

- by the CTB (1992):
  - bees and insects,
  - earthworms,
  - effects on nitrification,
  - aquatic organisms, and
  - leaching to the ground water
- by Luttik (1992):
  - birds and mammals,
  - secondary poisoning of birds and mammals by fish,
  - secondary poisoning of birds and mammals by earthworms.

In these decision trees, exposure data (e.g. dosage, PIEC, PEC, PED), which are calculated in the previous routes, are compared with acute and chronic toxicity data. The lowest LD50, LC50 or NOEC value per group of organisms is used. In case of chronic exposure, extrapolation methods, which calculate a NOEC for a whole group of organisms (i.e. birds, mammals and aquatic organisms) taking into consideration the number of available toxicity data, are used. A description of the various routes in which organism are exposed and the input data of the corresponding decision trees for hazard assessment are discussed in Emans *et al.* (1992): the decision trees themselves are presented in Appendices 5 - 13 and discussed on page 42 to 49.

In these decision trees four different risk[1] classifications for pesticides are distinguished:

* No risk;
* Low risk;
* Intermediate risk;
* High risk;

These for categories of risk are only used for the risk management and are not a part of the Uniform System for the Evaluation of substances (USES).

For the hazard assessment of human beings after indirect exposure, no decision trees have been developed. Hazard assessment is performed in agreement with Toet *et al.* (1991) and is discussed by Emans *et al.* (1992) on page 49 to 54.

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[1] Although "hazard" is meant, the term "risk" is used in the decision trees.

Although it is not the intention to develop decision trees for each single animal species two new decision schemes have been developed for this evaluation system:

- exposure of micro-organisms in an MSTP to biocides, and
- exposure of bats to remedial timber treatment chemicals.

The reasoning behind the choice to incorporate 2 new scheme is:

- an interference of a compound with the micro-organisms in an MSTP can lead to an unacceptable contamination of the surface water,
- remedial timber treatment chemicals have been considered a significant cause of mortality to bats which use treated buildings for roosting and as nurseries (Mitchel-Jones *et al.*, 1989 and Leeuwangh and Voûte, 1985).

These decision schemes will be discussed in the next two chapters.

3.4.1 Exposure of micro-organisms in the MSTP

As already stated before it is possible that a biocide reaches the aeration tank of a municipal sewage treatment plant (MSTP), either directly or via a settling tank, and will interfere with the biological processes in the aeration tank. Adverse effects in MSTPs by emission of toxic compounds can be investigated with the Dutch guidelines: NEN 6511 or NEN 6512.

In NEN 6511 the acute toxicity in nitrifying active sludge is determined by measurement of ammonia conversion and in NEN 6512 the acute toxicity in aerobic active sludge is determined by measurement of the respiration rate.

A steady state, non-equilibrium, multimedia box model "Mackay Level III" (Mackay & Paterson, 1982), which has originally been developed by Struijs *et al.* (1991, 1987), describes the fate of a chemical in an MSTP. It has been completed by Toet *et al.* (1991). In this nine-box model, irreversible and reversible intercompartment transport is accounted for, as well as removal due to biodegradation (see Figure 2.5 of USES 1992). The compartments that are relevant for the risk calculation for possible interference of pesticides with the biological processes are compartments 5 and 6 (the two compartments of which the aeration tank consists). The $PEC_{\text{active sludge}}$ can be calculated as follows:

$$PEC_{\text{active sludge}} = \frac{C(5) * V(5) + C(6) * V(6)}{V(5) + V(6)}$$

Where: C is the concentration of a compound in a certain compartment, and V is the volume of that compartment.

Model calculations:

The concentrations of a pesticide in compartment 5 and 6 can be calculated with the following mass balance (USES 1992):

$$\mathrm{Volume}_i * \frac{d(\mathrm{conc}_i)}{dt} = \sum_j \mathrm{Flow}_{j,i} * \mathrm{Conc}_j - \sum_j \mathrm{Flow}_{i,j} * \mathrm{Conc}_i + \sum_j N_{j,i} * \mathrm{Conc}_j$$

$$- \sum_j N_{i,j} * \mathrm{Conc}_i - \mathrm{Removal}_i = 0 \text{ (steady state) for } i = 1..9$$

Where:	Volume_i	: volume of compartment i
	Conc_i	: concentration in compartment i
	$\mathrm{Flow}_{j,i}$	: advective flow from compartment j to compartment i
	$N_{j,i}$	: dispersive (exchange) flow from compartment j to compartment i
	$\mathrm{Removal}_i$	: removal by biodegradation in compartment i

The volumes of compartment 5 and 6 can be calculated as follows:

$$\mathrm{Volume}_5 = 0.0197 * \mathrm{InhabitEquiv}$$

$$\mathrm{Volume}_6 = \mathrm{Volume}_5 * \frac{\mathrm{AT\_SuspSolConc}}{\mathrm{AT\_RhoSol}}$$

Where:	InhabitEquiv	: number of inhabitant equivalents
	AT_SuspSolConc	: suspended solid concentration in aeration tank
	AT_RhoSol	: Specific density of activated sludge

The decision scheme for the risk/hazard of the use of pesticides for the MSTP is given in Appendix 1a (see also Table 15). The lowest available test outcome is used for the IC50 in the PEC/IC50 quotient. Instead of results from NEN 6511 and/or NEN 6512 other comparable tests can be used.

Table 15. Municipal Sewage Treatment Plant module

Variable/parameter (unit)	Symbol	Default	C/R/E/O
Input:			
NOEC for inhibition of nitrification in active sludge (a.s.) (mg/l)	$NOEC_{nit}$		R
NOEC for inhibition of respiration in a.s. (mg/l)	$NOEC_{resp}$		R
IC50 for inhibition of nitrification in a.s. (mg/l)	$IC50_{nit}$		R
IC50 for inhibition of respiration in a.s. (mg/l)	$IC50_{resp}$		R
Extrapolation factor (-)	ExtraPolfact	0.1	C
Concentration of compound in active sludge (mg/l)	PEC_{sludge}		O
Output:			
PEC/NEC ratio for active sludge in MSTP (-)	$R_{pec/nec}$		

Model calculations:

NEC_{nit} = No-effect concentration for inhibition of nitrification
= $NOEC_{nit}$ if this value is given, or
= $0.1 * IC50_{nit}$

NEC_{resp} = No-effect concentration for inhibition of respiration
= $NOEC_{resp}$ if this value is given, or
= $0.1 * IC50_{resp}$

$R_{pec/nec}$ = PEC_{sludge} / NEC_{nit} if $NEC_{nit} \leq NEC_{resp}$, or
= $PEC_{sludge} / NEC_{resp}$ if $NEC_{resp} < NEC_{nit}$

3.4.2 Exposure of bats by remedial timber treatment products used in buildings

Bats prefer clean and fairly draught-free buildings. Typical locations for bat roosts are in the roof apex, under flashing, between rafters, behind large boards, etc. The timbers used in the constructions of the buildings are susceptible to insect and fungal damage. This damage is controlled through the use of remedial timber treatment products which contain pesticides such as pentachlorophenol, lindane and permethrin (Chadwick and Reston, 1993).

The Nature Conservancy Council of Great Britain has developed a Relative Toxicity Index (RTI, see Table 16) which can be used to predict the risk to bats from active ingredients in remedial timber treatments (Mitchell-Jones *et al.*, 1989 and Chadwick and Reston, 1993).

Table 16. Model for calculating the Relative Toxicity index (RTI) for bats exposed to remedial timber treatment products which contain organic compounds.

Parameter/variables (unit)	Symbol	C/R/E/O
Input:		
Dosage of a.i. per m^2 wood (mg/m^2)	Q_{wood}	O
Acute oral toxicity for mammal (mg/kg BW)	$T_{mam.}$	R
Output:		
Relative Toxicity Index (RTI)	RTI	

Model calculations:

$$RTI = Q_{wood} / T_{mam.}$$

The RTI is the number of LD50s per square meter for treated wood. In case of a formulation with 0.5% active ingredient, application rate 330 ml/m^2, a density of 1000 kg/m^3 and a toxicity of 88 mg/kg BW for the rat, this index would be $((0.5/100) * 1000 * 330)/88 = 19$.

The validity of the index is, to some extent, confirmed by the experiments of Racey and Swift (1986), Boyd and Myhill (1988) and Shore *et al.* (1991). Mitchell-Jones *et al.* calculated RTIs of 36, 19, <0.5, 80 and 17, for dieldrin, lindane, permethrin, PCP and TBTO, respectively. The experiments of Racey and Swift (1986) showed that bats exposed to treated wood with lindane, PCP and TBTO, according to manufacturers' recommendations, were killed by those fluids and that permethrin did not kill the bats. Mixtures of PCP and lindane were fatal to bats even if the wood had been treated 14 months previously. Experiments of Boyd and Myhill (1988) showed that bats survived significantly less well in the groups exposed to treated wood with lindane than in the control groups. The research of Shore *et al.* (1991) showed that wood treated with PCP according to commercial application rates were fatal for all tested bats and that the results with wood treated with permethrin did not differ from the control group. In bat experiments of Kulzer (1985) with summer-roosts treated with permethrin (RTIs 0.7-2.0, no differences were noticed between adult bats and their young who lived for 100 days in treated roosts and control roosts.

In the Netherlands it is proposed to use the RTI as follows (see also decision scheme in Appendix 1b):

1) High risk is assumed in case the RTI is equal or greater than 10,
2) Low risk is assumed in case the RTI is equal or less than 0.1, and
3) Intermediate risk is assumed for $0.1 < RTI < 10$.

In contrast with the original proposed Relative Toxicity Index it is proposed to use the lowest available acute oral toxicity test for mammals instead of the rat oral LD50 and not to require a bat toxicity test in case of RTIs greater than 10 (as was proposed in the U.K.). In case the applicant submits such a test, the results will be evaluated and can change the outcome of the hazard/risk assessment.

4. INFORMATION NECESSARY FOR THE ECOTOXICOLOGICAL RISK/ HAZARD ASSESSMENT OF NON-AGRICULTURAL PESTICIDES

The base set of requirements, with regard to to the environmentel hazard/risk assessment, is given in Chapter 2.2. Most of the additional requirements are related to a specific use of the biocide and are necessary to run the models as described in Chapter 3. For these specific requirements the reader is referred to this chapter.

An overview of the more general required data/information for the ecotoxicological hazard/risk assessment of the use of certain non-agricultural pesticides according to the different uses is presented in Table 17 (x = information necessary, - = information not necessary).

Codes used in Table 17 for information required for the ecotoxicological risk/hazard assessment of non-agricultural pesticides.

ANTIFOULINGS

Aa	Antifoulings

DISINFECTANTS:

Da	Stables and transportation means for animals
Dc	Chemical toilets
Dd	Drinking water
Df	Accommodations for preparing food and drinks
Dh	Hospital instruments
Dm	Accommodations for man
Ds	Swimming water

HOUSEHOLD PRODUCTS:

Hb	Baits, flea-belts, moth-balls, etc.
Hd	Dump sites
Hf	Fogging
Hp	Pesticides in private gardens
Hr	Rodenticides

INDUSTRIAL BIOCIDES:

Ic	Process and cooling-water installations
Ip	Paper and cardboard industry
Is	Sugar industry
It	Textile industry

PRESERVATIVES:

Pa	Air-conditioners
Pd	Drill installations / drill mud
Pl	Leather industry
Pm	Metal industry
Pp	Painting products

WOOD PRESERVATIVES/PROTECTORS

Wp	Wood preservatives/protectors

Table 17. Data/information necessary for the ecotoxicological hazard/risk assessment of non-agricultural pesticides.

Code	Aa	Da	Dc	Dd	Df	Dh	Dm	Ds	Hb	Hd	Hf	Hp	Hr	Ic	Ip	Is	It	Pa	Pd	Pl	Pm	Pp	Wp
Identity:																							
Primary name	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Chemical names	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Trade names	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
CAS-number	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Structure and molecular weight	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Purity	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Additives and formulations	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Appearance	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Analytical methods	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Physico-chemical properties:																							
Melting point	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Boiling point	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Density	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Sediment/water partitioning coefficient	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Stability	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Solubility in water, fat and other solvents	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Vapour pressure	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Henry coefficient	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Log K_{ow}	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Surface tension	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Compartment MSTP:																							
NEN 6511 (nitrification) (H.5[1])	-	x	x	x	x	-	x	x	-	-	-	-	-	x	x	x	x	x	-	x	x	-	x
NEN 6512 (Respiration) (H.5)	-	x	x	x	x	-	x	x	-	-	-	-	-	x	x	x	x	x	-	x	x	-	x

Code	Aa	Da	Dc	Dd	Df	Dh	Dm	Ds	Hb	Hd	Hf	Hp	Hr	Ic	Ip	Is	It	Pa	Pd	Pl	Pm	Pp	Wp
Compartment water:																							
DT50 and information about degradation products (G.2.1)	x	x	x	x	x	-	x	x	-	x	-	x	x	x	x	x	x	x	x	x	x	-	x
Adsorption at sediment particles (G.2.2)	x	x	x	x	x	-	x	x	-	x	-	x	x	x	x	x	x	x	x	x	x	-	x
Algae test short term (H.2.1)	x	x	x	x	x	-	x	x	-	x	-	x	x	x	x	x	x	x	x	x	x	-	x
Daphnid test short term (H.2.1)	x	x	x	x	x	-	x	x	-	x	-	x	x	x	x	x	x	x	x	x	x	-	x
Fish test short term (H.2.1)	x	x	x	x	x	-	x	x	-	x	-	x	x	x	x	x	x	x	x	x	x	-	x
Long term test aq. org. (H.2.2)	x	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-
Bioaccumulation (H.6)	x^2	x^2	x^2	x^2	x^2	x^2	x^2	x^2	x^2	x^2	x^2	x^2	x^2	x^2	x^2	x^2	x^2	x^2	x^2	x^2	x^2	-	x^2
Water/sediment study	x	x	x	x	x	-	x	x	-	x	-	x	x	x	x	x	x	x	x	x	x	-	x
Flux study	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x
Compartment air:	P.M.																						
Compartment soil:																							
DT50 and information about degradation products (G.1.1)	-	x	-	-	-	-	-	-	-	x	-	x	x	x	-	-	-	-	-	-	-	-	x
Adsorption coefficient (G.1.2)	-	x	-	-	-	-	-	-	-	x	-	x	x	x	-	-	-	-	-	-	-	-	x
Earthworm study (H.4.2)	-	x	-	-	-	-	-	-	-	x	-	x	x	x	-	-	-	-	-	-	-	-	x
Special requirements:																							
Acute oral (LD50) mammal	-	-	-	-	-	-	-	-	-	x	-	x	x	-	-	-	-	-	-	-	-	-	x
Acute oral (LD50) bird (H.1.1)	-	-	-	-	-	-	-	-	-	x	-	x	x	-	-	-	-	-	-	-	-	-	-
Sub acute (LC50) bird (H.1.2)	-	-	-	-	-	-	-	-	-	x	-	x	x	-	-	-	-	-	-	-	-	-	-

[1] = The number between brackets refers to the explanation of the registration form.

[2] = Bioaccumulation study according to H.6 is only asked in case log $K_{ow} \geq 3$.

5. DISCUSSION AND CONCLUSIONS

1. The evaluation system for non-agricultural pesticides as presented in this report has to be considered as the starting point for the methodology to identify the risks for man (indirect exposure according to USES) and environment if non-agricultural pesticides (biocides) are applied in practice. Together with the evaluation system for agricultural pesticides it offers the possibility to screen the risks of a wide variety of pesticides. The evaluation system for pesticides (ESPE) is therefore completed and consists of:
   1. agricultural pesticides and
   2. non-agricultural pesticides.

Both systems are part of the uniform system for the evaluation of substances (USES).

2. The following subjects of this report are incorporated in USES:
   - biocides in the textile industry,
   - biocides in paper and cardboard industry,
   - biocides in process and cooling-water installations,
   - biocides in sugar industry,
   - preservatives in metal industry,
   - pesticides in private gardens,
   - rodenticides on dump sites,
   - wood preservatives and wood protectors, and
   - antifoulings.

3. It has been dealt with several times in this report, but it should be stressed once more that only the risks are estimated as they can occur after application of the biocides according to proper use following manual instructions. Accidents or malpractice are not taken into account. A risk evaluation for incidents has to be carried out separately, when such an occasion has happened.

4. Several open ends in the evaluation process have been identified. In the near future it has to be seen if these gaps can be filled with appropriate model equations that take into account best state-of-the-art situations. The filling in of some gaps will show to be easier than others; for some gaps there are currently no methods available to describe the risks; these will have to be postponed until scientific knowledge has made additional progress. Of course, regular literature surveys are carried out to follow the latest developments.

5. An important missing item in the evaluation methods for non-agricultural pesticides as presented here as well as for the methods for agricultural pesticides is the uncertainty analysis. Currently available capacity will be invested in the elaboration of this uncertainty analysis within the framework of the uniform system for the evaluation of substances (USES).

6. In ESPE 1 and 2 no attention has been given to the sediment compartment of the environment. First of all, the information available on sediment is very limited and secondly no toxicity data are available for sediment organisms, like filter feeders, etc. In the near future more attention has to be payed to the sediment. If possible, USES will be adjusted for additional data on the sediment compartment.

7. The following items could be topics for future research:
   - contamination of soil by wood preservatives and -protecters during the consumer phase,
   - the use of disinfectants in swimming pools, and
   - the use of compounds for fogging against insects in storage places, silos and shipyards.

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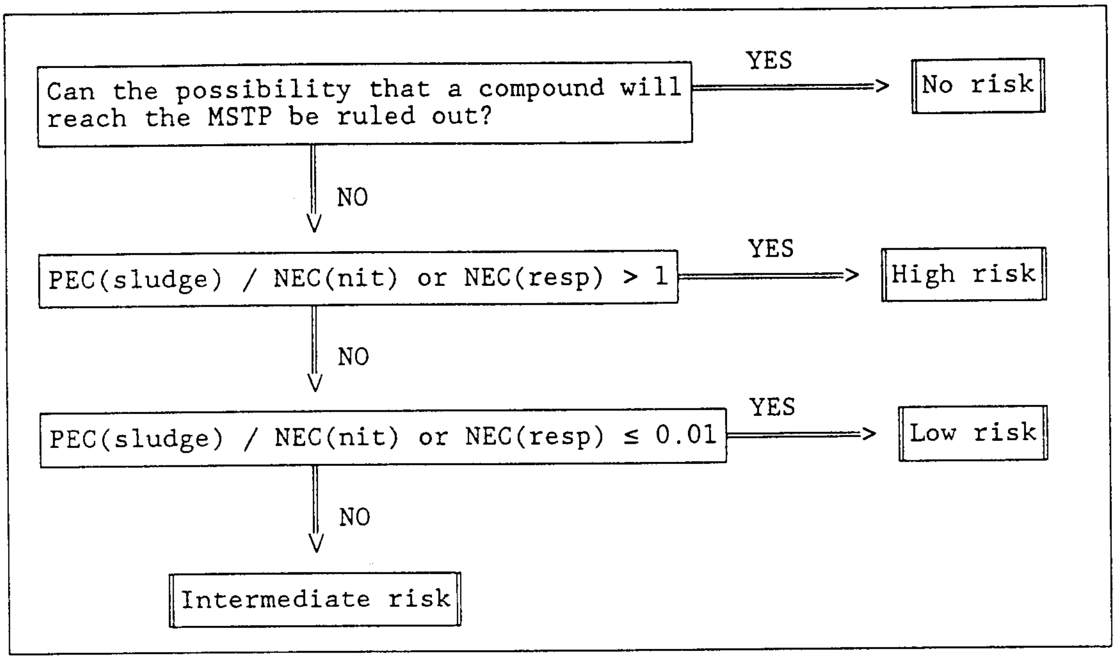
Appendix 1a

Decision scheme for assessing the risk/hazard of the use of pesticides for the Municipal Sewage Treatment Plant.



Appendix 1b

Decision scheme for assessing the risk/hazard of the use of organic wood preservatives (remedial timber treatment products) for bats.