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Disinfectant Products Fact Sheet

To assess the risks for the consumer

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Abstract

Exposure to compounds in disinfectants

Exposure to compounds in consumer products can be assessed using the computer program ConsExpo (Consumer Exposure). Given the huge number of consumer products, it is not possible to calculate the exposure for each separate product, so a limited number of groups containing similar products are defined. The information for each group of products is described in a fact sheet. Paint, cosmetics, children's toys and pest control products are examples of fact sheets which have been published already.
This fact sheet covers the use of disinfectant products by consumers. In the fact sheet nine product categories are described, including algae, green deposit removers, black mould removers, swimming pool disinfectants, veterinary hygiene biocidal products and disinfectants for drinking water, waterbeds, chemical toilets and for rubbish bins. To assess exposure of compounds in the disinfectant products default values for all product categories have been determined.

Key words: disinfectant products, biocides, exposure, consumer, risk, compounds

Rapport in het kort

Blootstelling aan stoffen uit desinfectantia

Een snelle, transparante en gestandaardiseerde blootstellingsschatting van desinfectantia is dankzij een nieuwe factsheet voor het computerprogramma ConsExpo nu mogelijk. ConsExpo 4.0 is een computerprogramma, dat gebruikt kan worden om de blootstelling van mensen aan stoffen in consumentenproducten uit te rekenen. Hierbij wordt rekening gehouden met verschillende blootstellingsroutes (dus via de huid, via inhalatie en via orale opname).
Bij het ConsExpo programma hoort ook een database, waarin standaardwaarden voor vele producttypen en voor een groot aantal blootstellingsscenario's worden aangeboden. De beschrijving van deze achtergrondinformatie bij deze standaardwaarden wordt gerapporteerd in zogenoemde 'factsheets'.
In dit rapport, factsheet desinfectiemiddelen, is de meest recente informatie bijeengebracht om de blootstelling aan stoffen uit desinfectantia te berekenen. De verschillende typen desinfectantia zijn verdeeld in 9 categorieën, bijvoorbeeld algenreinigers, desinfectiemiddelen voor zwembaden, desinfectantia om dierverblijven te behandelen en desinfectiemiddelen voor drinkwater. Voor iedere categorie wordt de samenstelling en gebruik van producten uit die categorie beschreven. Daarnaast wordt aangegeven welk model of modellen van ConsExpo het meest geschikt zijn om de blootstelling uit te rekenen en worden voor alle gegevens die nodig zijn voor de berekening standaardwaarden ingevuld. Naast deze factsheet desinfectiemiddelen zijn er ook factsheets voor ongediertebestrijdingsmiddelen, verf, cosmetica en reinigingsmiddelen.

Trefwoorden: desinfectantia, biociden, blootstelling, consument, risico, stoffen

Contents

Summary

Exposure to and intake of compounds in consumer products are assessed using available mathematical models. Calculations are carried out with the computer program ConsExpo (Consumer Exposure). Given the huge number of consumer products, it is not possible to define exposure models and parameter values for each separate product, so a limited number of main categories containing similar products are defined. The information for each main category is described in a fact sheet. Paint, cosmetics, children's toys and pest control products are examples of fact sheets which have been published already.
This fact sheet covers the use of disinfectants by consumers for nine product categories including algae, green deposit removers, black mould removers, swimming pool disinfectants, veterinary hygiene biocidal products and disinfectants for drinking water, waterbeds, chemical toilets and for rubbish bins. Information is given on the composition and the use of products within a product category. Default models and values for all nine product categories have been determined to assess exposure and intake of compounds in the disinfectant products.

Samenvatting

Om de blootstelling aan stoffen uit consumentenproducten en de opname daarvan door de mens te kunnen schatten en beoordelen zijn wiskundige modellen beschikbaar. Voor de berekening wordt gebruik gemaakt van het computerprogramma ConsExpo. Het grote aantal consumentenproducten verhindert dat voor elk afzonderlijk product blootstellingsmodellen en parameterwaarden vastgesteld kunnen worden. Daarom is een beperkt aantal hoofdcategorieën met gelijksoortige producten gedefinieerd. Voor elke hoofdcategorie wordt de informatie in een factsheet weergegeven. Verf, kinderspeelgoed, cosmetica en ongediertebestrijdingsmiddelen zijn voorbeelden van factsheets die al gereed zijn. In deze factsheet wordt informatie gegeven over het gebruik van desinfectantia.
Het gebruik van desinfectantia die verkrijgbaar zijn voor de consument ten behoeve van particuliere toepassing wordt beschreven met negen productcategorieën, zoals groene-aanslag-verwijderaars, zwarte-schimmelverwijderaars, zwemwaterdesinfectantia, veterinaire desinfectantia, desinfectantia voor drinkwater, waterbedden, chemische toiletten en voor vuilnisbakken. Het gehele gebied van het gebruik van desinfectantia door consumenten wordt met deze productcategorieën bestreken. Voor elke productcategorie wordt ingegaan op samenstelling en gebruik van het type producten binnen de categorie. Om de blootstelling en opname van stoffen uit desinfectantia te kunnen schatten en beoordelen zijn voor elke productcategorie defaultmodellen met defaultwaarden voor de parameters vastgesteld.

1 Introduction

1.1 General

Descriptive models have been developed within the National Institute for Public Health and the Environment (RIVM) to be able to estimate and assess the exposure to substances from consumer products and the uptake of these by humans. These models are brought together in a computer program called ConsExpo 4.0. When a model is chosen in ConsExpo, and the required parameters are filled in, the program calculates the exposure to, and the uptake of, the substance involved.

Because of the large number of consumer products currently on the market, it is not possible to assign exposure models and parameter values to each individual product. Therefore, a limited number of main categories of similar products have been defined. Examples of the main categories are: paint, cosmetics, children's toys, cleaning products and pest control products. The relevant information with respect to the estimate of exposure to and the uptake of substances from consumer products is given in a fact sheet for each of the main categories. These fact sheets can be used to characterize and standardize the exposure.

For the risk assessment of the private user to biocides (i.e. non-agricultural pesticides), there also appears to be a significant need for characterization/ standardization of the exposure. However, as a group of products, biocides vary enormously with regard to exposure and uptake. Therefore the decision was taken to define the different main categories within the biocides, and to put together a fact sheet per main category. The first fact sheet dealt with private (= non-professional) use of pest control products[1)]. The present fact sheet deals with disinfectant products.

Disinfectant products are used to control or to prevent growth of micro-organisms i.e. bacteria, viruses, and fungi. There is a great diversity in use and application types for the products. There are liquids, granulates, powders, tablets, gasses. Some of these products can be used without any preparation, while others have to be processed (mixed and loaded) before use, for example by diluting or cutting up. All of these product forms imply a different type of exposure, whereby differences can occur in the exposure phase (mixing and loading, during or after exposure) and the route of exposure (inhalation, oral, and dermal).

The number of product categories defined within the disinfectant products main category has been kept to a minimum. The 'disinfectant products' main category includes the following product categories: algae, green deposit removers, swimming pool disinfectants, disinfectants for animal accommodations or animal transport vehicles. The composition and the use of the type of products within the category are examined for every product category. To estimate the exposure and uptake of substances from disinfectant products, default models with default parameter values are determined for every product category in this fact sheet. The default models and default parameter values are available via a database. Using these data, standardized exposure calculations for consumers resulting from the use of disinfectants can be performed.

1.2 ConsExpo

ConsExpo is a software tool for Consumer Exposure assessment. ConsExpo is a set of coherent, general models that can be used to calculate the exposure to substances from consumer products and their uptake by humans. It is used for the consumer exposure assessment for New and Existing Substances in scope of Directive 67/548/EC and the Council Regulation 793/93/EC, respectively. Furthermore, ConsExpo is also one of the models that is used to assess the consumer exposure to biocides. (Technical Notes for Guidance (TNsG): Human Exposure to Biocidal Products – Guidance on Exposure Estimation[5)] (http://ecb.jrc.it))

ConsExpo is built up using data about the use of products, and from mathematical concentration models. The program is based on relatively simple exposure and uptake models. The starting point for these models is the route of exposure, i.e. the inhalation, dermal or oral route. The most appropriate exposure scenario and uptake model is chosen for each route. The parameters needed for the exposure scenario and the uptake models are then filled in. It is possible that exposure and uptake occur simultaneously by different routes. In addition to data about the exposure and uptake, contact data is also needed, such as the frequency of use and the duration of use. Using the data mentioned above, ConsExpo calculates the exposure and uptake. ConsExpo 4.0, the most recent ConsExpo version, is described in detail in Delmaar et al.[2)].

ConsExpo 4.0 can be used for a screening assessment or for an advanced (higher tier) assessment. Per exposure route i.e. inhalation, dermal and oral route, different models are offered for calculating external exposure. ConsExpo also integrates the exposure via the different routes resulting in a systemic dose. Different dose measures can be calculated (acute, daily, chronic exposure). ConsExpo can also run calculations using distributed input parameters and sensitivity analysis can be performed.

The computer model is publicly available. Default data are available via the database which is an integral part of ConsExpo. The software, the user manual and the various fact sheets (see section 1.3) can be downloaded via the website of the National Institute for Public Health and the Environment in the Netherlands (RIVM; www.rivm.nl/consexpo)

1.3 Fact sheets

This report is one of a series of fact sheets that describes a main category of consumer products, such as paint, cosmetics, children's toys, and pest control products. The fact sheets give information that is important for the consistent assessment of the exposure to, and the uptake of, substances from consumer products.

A separate fact sheet called the 'General Fact Sheet'[3)] gives general information about the fact sheets, and deals with subjects that are important for several main categories. The 'General Fact Sheet' gives details of:

- the boundary conditions under which the defaults are estimated
- the way in which the reliability of the data is shown
- parameters such as the ventilation rate and room size
- parameters such as body weight and the surface of the human body, or parts thereof

In the facts sheets, information about exposure to chemical substances is collected into certain product categories. These categories are chosen so that products with similar exposures are grouped. On the one hand, the fact sheet gives general background information; while on the other hand, it quantifies exposure parameters which, together with one or more of the ConsExpo exposure models, produce a quantitative estimate of the exposure.

The fact sheets are dynamic documents. As new research becomes available or as perceptions change, the parameter default values may need to be changed. Additional models can also be developed within ConsExpo; this too will require adaptations. The fact sheets are linked with ConsExpo since the fact sheets define the default values for the parameters used in the different ConsExpo models. Alterations in either the default values or the parameters influence both the fact sheets and (data base of) ConsExpo. We intend to produce updates of the published fact sheets on a regular basis.

This fact sheet is principally aimed at exposure to the formulation (i.e., the whole product) and is, as such, independent of the active substance. This means that the information about the active substance must be added separately. This mainly concerns information about the concentration and the physical-chemical properties of the active substance.

1.3.1 Definition of the consumer

Non-professional use only
The default values in the fact sheets have been collected for consumers (private or non-professional users). They are not aimed at describing exposure for people who professionally work with disinfectants, such as in the institutional or industrial sector, for example. This fact sheet therefore only describes disinfectant products which are available to the consumer for private use.

Using the models in ConsExpo and the default values for consumers presented here as background data, it is nonetheless possible to calculate the exposure and uptake of disinfectant products by professional users. Of course, the differences in products and product use between the consumer and those using disinfectant products professionally must be taken into account.

Groups to consider
Two groups can be distinguished in the exposure assessment for consumers: the group experiencing the highest exposure during use (in most cases the user) and the group exposed after application (e.g. children). The person applying the product (the user) is the one actually using the formulation and, if necessary, diluting it to the required concentration (‘mixing and loading’). It is expected that the user will be exposed to high levels during mixing and loading and during application.

In the post-application phase, for relevant scenarios, young children can be relatively high exposed, due to their specific time-activity pattern (crawling on treated surfaces, hand-to-mouth contact, relatively low body weight).
In the present fact sheet, if relevant, the exposure calculations are based on children. More information on specific exposure scenarios for children is provided in Van Engelen and Prud’homme de Lodder [4)].

1.3.2 'Reasonable worst case' estimate

The basis for the calculation and/or estimation of the default parameter values is a realistic worst-case scenario, and considers consumers who frequently use a certain disinfectant product under relatively less favourable circumstances. For example, when using a disinfectant product, basic assumptions are relatively frequent use, application of a relatively large amount in a small room with a low ventilation rate, and a relatively long stay in that room.

The parameter values in the fact sheets are aimed at (Dutch) consumers. They are chosen such that a relatively high exposure and uptake are calculated, in the order of magnitude of a 99^{th} percentile of the distribution. To achieve this goal, the 75^{th} or the 25^{th} percentile is calculated (or estimated) for each parameter. The 75^{th} percentile is used for parameters which give a higher exposure for higher values, and the 25^{th} percentile is used in the reverse case. For a significant number of parameters, there is actually too little data to calculate the 75^{th} or 25^{th} percentile. In such cases, an estimate is made which corresponds to the 75^{th} or 25^{th} percentile.

Multiplication of two 75^{th} percentile parameter values will result in a 93.75^{th} percentile, whereas multiplication of three 75^{th} percentile parameter values will result in a 98.5^{th} percentile. Since for all parameter values a 75^{th} /25^{th}-percentile is calculated or estimated, the resulting outcome in the calculation is a higher exposure and/or uptake. Given the number of parameters and the relationship between the parameters, it is expected that in general the calculated values for exposure and uptake will result in a 99^{th}-percentile. The result is a 'reasonable worst-case' estimate for consumers who use relatively large amounts of disinfectant products under less favourable circumstances.

1.3.3 Reliability of the data

A number of parameters is difficult to estimate based on the literature sources and unpublished research. A value must still be chosen for these parameters; otherwise it is not possible to carry out any quantitative exposure assessments. This is why a quality factor (Q-factor) is introduced[3)], which is in fact a grading system for the value of the estimate of the exposure parameter. Low Q-factors indicate that the default value is based on insufficient (or no) data. If such a default is used in an exposure analysis, it should be carefully considered and, if possible, adapted. If representative data is supplied by applicants or producers, it can replace the default values. High Q-factors indicate that the defaults are based on sufficient (or more) data. These defaults generally require less attention. It is possible that they will need to be adapted according to the exposure scenarios. For example, an exposure estimate might be carried out for a room of a particular size; the well-established default room size should then be replaced by the actual value. A Q-factor is given to all parameter values in the fact sheets, indicating the reliability of the estimate of the default value. The quality factor range has been adapted and it can have a value of between 1 and 4. In previous fact sheets, the quality factor ranged from 1 to 9. Table 1 shows the meaning of the values of the quality factor.

Table 1: Value of quality factor Q

Q	Value
4	Good quality relevant data, parameter value reliable
3	Number and quality of the data satisfactory, parameter value usable as default value
2	Parameter value based on single data source supplemented with personal judgement
1	Educated guess, no relevant data available, parameter value only based on personal judgement

1.4 Definition and classification of disinfectant products

Disinfectants, belonging to the 'biocides' category, form a diverse group of products, which are used both to control and prevent growth of micro-organisms such as bacteria, viruses, fungi and algae. Biocides form an extremely diverse group of products, which are used both by professionals and non-professionals (consumers) to control or prevent damage by undesired organisms, such as microbial organisms, fungi, flying and crawling insects, small mammals such as mice and rats, but also mosses, algae and weeds. Wood preservatives also fall into the biocides category. Some of the biocides are available to consumers for private use; other products are only available for professional use.

For the professional use of disinfectants, like sterilization of medical equipment and disinfection of theatres, the products are used by specially qualified companies and personnel. The products and equipment used, and therefore exposure circumstances, are often not the same as those available to the consumer. On the one hand, professionals use more active substances than private users. Subsequently, a professional user of the product can be exposed to much higher amounts before, during and after the application than a private user. On the other hand, professionals may use special personal protection measures and, immediately after the application, special regimes with regard to entering the treated areas.

The pattern of use by consumers is very diverse: the users are not specifically trained in their task and protective measures are usually not taken. The products are often used in and around the house, whereby exposure can still take place long after application. This fact sheet describes the exposure and uptake for products that are available to the consumer for private use.

1.4.1 Classification of biocides

In this section the classification of biocides in the European Union and the United States is described.

The biocides directive (98/8/EC) came into force in the European Union in 1998. This deals with the authorization of active substances required for biocides which can occur within 23 categories, summarized as disinfectants, preservatives, pest control products and other biocidal products (see Table 2). The disinfectant products (EU category 1-5) are important for this disinfectant products fact sheet.
More information on the biocides directive is available on the website of the European Chemicals Bureau (ECB) (http://ecb.ei.jrc.it/biocides/). Guidelines for exposure aspects can be found in the Technical Notes for Guidance[5)].

Table 2: EU classification of biocide substances

1.	Disinfectants and general biocidal products
	01: Human hygiene biocidal products
	02: Private area and public health area disinfectant and other biocidal products
	03: Veterinary hygiene biocidal products
	04: Food and feed area disinfectants
	05: Drinking water disinfectants
2.	Preservatives
	06: In-can preservatives
	07: Film preservatives
	08: Wood preservatives
	09: Fibre, leather, rubber and polymerized materials preservatives
	10: Masonry preservatives
	11: Preservatives for liquid-cooling and processing systems
	12: Slimicides
	13: Metal working fluids
3.	Pest control
	14: Rodenticides
	15: Avicides
	16: Molluscicides
	17: Piscicides
	18: Insecticides, acaricides and products to control other arthropods
	19: Repellents and attractants
4.	Other biocidal products
	20: Preservatives for food or feedstock
	21: Antifouling products
	22: Embalming and taxidermist fluids
	23: Control of other vertebrates

The United States does not make any principal differentiation between agricultural pesticides and biocides. They use the term biocides almost exclusively for anti-microbials. In the US, biocides are therefore not divided into a number of categories of use. The Food Quality Protection Act is the chosen route in the US (FQPA; see http://www.epa.gov/oppfead1/fqpa/index.html for the official US-EPA site, also refer to http://www.epa.gov/pesticides/ for the site of the US-EPA Office of Pesticide Programs). In the US, it is mainly the risk due to the intake of pest control products via foodstuffs that is regulated, and the FQPA requires that the combined intake (including the uptake not via the diet) does not exceed a certain limit. The US-EPA also groups together active substances with a similar working mechanism, and the effects of these compounds are cumulated in the risk analysis. The private use of biocides is therefore included in the total risk estimate of the active substance.

1.5 Use of disinfectants by consumers

It is difficult to reveal whether biocidal products as notified at ECB will be used by non-professional users. Therefore, the products registered at the Dutch Board for the Authorisation of Pesticides (CTB) were used as a starting point.

1.5.1 General

In the Netherlands, many disinfectant products are authorized. The majority of these products are applied by professionals. Private consumers generally use few disinfectants.

Based on the authorized products in the Netherlands and using data of the CTB[6,7)], an inventory was made of products that are possibly used by consumers. Subsequently, information was gathered on whether consumers indeed use these products In addition, it was investigated to what extent shops and online stores sell disinfectants. The results of this inventory were submitted to the CTB and the branch organization of producers and distributors of disinfectants in the Netherlands (NVZ-Nefeda, subdivision of NVZ, the Dutch union of soap producers). Based on these inventories, a list was created of types of disinfectants that are possibly used by (Dutch) consumers. The disinfectants are classified in product categories, which will be described in detail in chapters 3 to 9.

1.5.2 Inventory

Product type 01: Biocides for human hygiene

In the Netherlands, no biocides for human hygiene are authorized (CTB[5]). Therefore, this fact sheet does not include a description of this product type.

Product type 02: Private use and health care

Disinfectants of private swimming pools

A large number of products are permitted for disinfection of private swimming pools in order to keep the water free of bacteria, algae and other micro-organisms that may have a negative impact on the hygiene of the water. The products include tablets or granules, whose disinfectant function is based on the release of bleach.

In addition, three products are available to control algae in swimming water. These products are permitted to prevent algae growth in swimming pools when the water is not chlorinated for a longer period of time.

Algae, green deposit removers

A large number of products are authorized that prevent and remove algae and green deposit, also for use by consumers[6,7)]. Products are applied to for example walls, roofs, pathways, flagstones, gravestones, sleepers, windows and greenhouses. Application may take place by means of spraying, pouring, brushing and scrubbing.

Black mould remover

Two disinfectants were found that are authorized to control black mould indoors[6)]. Its application includes the cleaning of tiled walls, bathroom, shower, toilet, garage and shed.

Waterbed conditioners
A few waterbed conditioner products are authorized. Mostly it concerns two products of the same producer, containing different active ingredients.

Disinfectants for chemical lavatories
One product was found for disinfection of chemical toilets, containing formaldehyde as its active substance.

Use of disinfectants indoors
Up until 2001, a disinfecting spray cleaner and a disinfectant spray were permitted for disinfection indoors. In 2001, the producer requested withdrawal of the authorization of these products. This is in line with the Hygiene code which states that disinfection in private households is undesirable[8)].
Many products do not specify that they should be used by professionals only. No products were found that were permitted specifically for disinfection indoors. The chance that new products will be submitted soon is small. However, it is possible that products are submitted, hence its uptake in this fact sheet.

Disinfection of dustbins
One product, containing the active ingredient cresol, was found to be authorized for the disinfecting of dustbins next to other applications.

Product type 03 Sector food and animal feed
As far as is known, no consumer applications of disinfectants are available in the food section[8,9)]. Many products have been described in the sector animal feed that fall under product type 03 but have also been described under product type 04 (veterinary hygiene purposes). These products are dealt with in product type 04.

Product type 04 Veterinary hygiene purposes
Products for disinfection of animal residences
This product type includes products for disinfection of residences for horses, sheep, goats, chickens and birds. However, data on disinfectants for residences for sheep and goats were not found, apart from disinfectants to be used after the breakout of serious animal diseases (e.g. foot-and-mouth disease, fowl plague). In these cases, disinfection will usually be carried out by professionals. It is assumed that little disinfection takes place in residences of horses.

Disinfection by consumers is carried out in residences for aviary birds, pigeons and chickens, but also for dogs and cats. Residences, feeding and drink troughs are disinfected when the animals have contracted a fungal, viral or bacterial disease. Disinfectant for fumigation with active ingredient paraformaldehyde is permitted as a disinfectant for bird residences. However, not only dry disinfection takes place. Both disinfectant for fumigation and Halamid with active ingredient sodium-p-toluenesulphonchloramide are regularly mentioned on the internet for consumer application.
Examples of chicken diseases are aspergillose (fungal), coryza (bacterial), fowl cholera (bacterial) and fowl tuberculosis. Birds may also have viral diseases. The disinfection of the residences is mentioned as part of the treatment of these diseases. Possibly, veterinary drugs are also used for the disinfection of residences, such as products for external application on the animal. One drugstore stated that a veterinary drug based on chlorine xylenol is used to disinfect dog residences.

Transport vehicles for animals
At transport of sheep, goats and others, disinfection is compulsory, often after each transport, and is inspected by authorities. Presumably, transport vehicles of horses do not need to be disinfected except in case of a contagious disease outbreak.

Disinfecting trays and mats
It is assumed that disinfecting trays and mats are used by amateur animal keepers only in case of an outbreak of a serious contagious disease such as hoof and mouth disease or fowl plague.

Disinfectants for milking units
Amateur animal keepers do not frequently milk sheep, goats and cows mechanically. However, some milking units specifically for amateur animal keepers are available. It is assumed that these units are cleaned with disinfectants. Generally these disinfectants contain sodium or potassium hydroxide and sodium hypochlorite.

Product type 05 drinking water
Disinfection of drinking water
Products are available to the consumer to control bacteria in drinking water for use in areas where there is doubt about the bacteriological quality of drinking water. These products, containing sodium hypochlorite, will be used mostly on vacation.

Disinfection of water coolers for drinking water
A product containing hydrogen peroxide is available to the consumer to control bacteria in water coolers for drinking water.

1.5.3 Classification into product categories

All disinfectant types that according to the inventory (section 1.5.2) appear to be used by consumers have been organized in this report in product categories (Table 3). A product category containing disinfectants for indoor use has also been included, as products in this category were available to consumers until 2001.
Default models and default parameter values are described for each product category in chapter 3 to 9.

Table 3: Product categories disinfectants used by consumers

Product categories
Algae, green deposit removers
Black mould removers
Disinfectants for use indoors
Swimming pool disinfectants
Control of bacteria, algae and other micro-organisms
Control of algae
Waterbed conditioners
Disinfectants for chemical toilets
Disinfectants for rubbish bins
Veterinary hygiene biocidal products
Disinfection of animal accommodations
Disinfection of means of transport for animals
Disinfection of milking equipment
Drinking water disinfectant products
Disinfectants for drinking water
Disinfectants for water coolers

1.6 Principles behind the exposure estimate

For the exposure assessment for private users and/or bystanders, an estimate of the potential exposure is based on the (concept) statutory operating instructions / directions for use. A preference is given to the use of existing product data and measured exposure values. If these data are not available (and this is usually the case), a consumer exposure model like ConsExpo can be used. For the product under study, the most relevant models are chosen from ConsExpo for each relevant route (inhalation, dermal and/or oral) and the parameters needed for the models are then collected.

In this fact sheet, default models and default parameter values are proposed for every product category. If additional data are available for a particular application, this should be taken into consideration. For example, if the amount of product to be applied per surface is given in the directions for use, or if the producer of an aerosol can supplies the droplet size distribution, these values are used.

The directions for use are not always complied with exactly in the assessment when it can be assumed that some of the users will not follow the instructions. For example, if the use of gloves is advised, the exposure estimate will nevertheless assume that application without gloves will occur.

This fact sheet is principally aimed at exposure to the formulation (i.e. the whole product) and, as such, independent of the active substance.

1.7 Uncertainties and limitations

This fact sheet presents a number of default parameters which can be used in the exposure assessment of the non-professional user of disinfectant products, when using ConsExpo.

There are few quantitative data about consumer exposure to disinfectant products. The model approach makes it possible to extrapolate the relatively sparse data for certain products to other products and other scenarios, for which there are no specific data. The determination of default values for the various model parameters also ensures that a high degree of consistency can be achieved in the assessments.

One should realize that the exposure estimates from a model depend on the quality and the reliability of the input-data. It is therefore recommended that one is alert in the choice of parameter values and the determination and improvement of default values. Scenarios and the related parameters can have a major influence on the final exposure estimate. It should also be noted that the models used in ConsExpo are developed for particular purposes. In the absence of specific models, one is forced to use a model developed for another purpose.

In the next versions of ConsExpo and/or in the update of this report (if more data are available) these aspects will be further elaborated on. Depending on what is needed, further adapting exposure models for certain scenarios can be considered, or developing new models, for example.

2 Models and general parameter values

In this chapter, the different models used for the exposure to disinfectant products are mentioned in section 2.1. Several default parameter values for mixing and loading (section 2.2) and for the spraying process (section 2.3) will be discussed. The parameter values are mostly independent of the final type of application; consequently, they are generally applicable. Some default parameter values for the exposure during mixing and loading or during spraying are specific for certain disinfectant products and are therefore described in the respective chapters.

2.1 Models

Table 4 shows all of the models used in this fact sheet to describe mixing and loading and the different types of disinfectant applications. The models themselves and the meaning of the parameters are not considered here; these are described in the help file and user manual of ConsExpo 4.0[2)].

Table 4: Overview of the models used for disinfectant applications

Situation		**Route of exposure**		
Before application[a)]	**Model**	**Inhalation**	**Dermal**	**Oral**
Dilution of liquid	Exposure model Uptake model	Evaporation Fraction	Instant application Diffusion through skin	
Dissolving powder/ granules	Exposure model Uptake model		Constant rate Fraction	
Dissolving tablets	Exposure model Uptake model		Constant rate Fraction	
During application				
Treating surfaces, equipment, rooms, water etc.	Exposure model Uptake model	Evaporation Fraction	Instant application/ Constant rate Diffusion through skin/ Fraction	
Spraying surfaces	Exposure model Uptake model	Spray Fraction	Constant rate Fraction	Spray Fraction
Post-application				
Disinfectants for swimming pool, drinking water	Exposure model Uptake model	Evaporation Fraction	Instant application Diffusion through skin	Direct intake Constant rate Fraction

[a)] i.e. during mixing and loading

2.2 General parameters for mixing and loading

The user is exposed to the active substance during mixing and loading the formulation with or in water. When determining the defaults for mixing and loading, a distinction is made

between ‘diluting a liquid’ (section 2.2.1), ‘dissolving a powder, granules’ (section 2.2.2) and ‘dissolving tablets’ (section 2.2.3). The product types influence the inhalation and dermal exposure of the user during mixing and loading.

2.2.1 Mixing and loading: dilution of a liquid

Inhalation exposure during mixing and loading occurs due to evaporation from a bottle. During mixing and loading a liquid, dermal exposure could occur. On one hand, this is due to liquid spills around the opening of the bottle, which depends on the size of the opening and the way a product is used. The consumer can use the cap for dosing the liquid; when replacing the cap, the remnants of the product may drip down[10)]. On the other hand, when mixing and loading a disinfecting product into water, there could be spatters of the liquid concentrate on the skin.

Scenario

A private user mixes and loads liquid into a bucket filled with water to produce 5 litres of ready-for-use product. The active substance evaporates from a one-litre bottle with a not-too-small circular opening with a 5-cm diameter, resulting in a surface area of 20 cm^2. During mixing and loading the user stays in the vicinity of the evaporating compound and it is therefore assumed that the user is present in a ‘personal volume’ instead of a room volume. Further, there could be dermal exposure due to spillage.

To calculate the exposure of the user during mixing and loading liquid, the ‘evaporation model’ is used for inhalation exposure and the ‘instant application’ model is used for dermal exposure.

Inhalation exposure: evaporation from a constant surface

- *Exposure duration and application duration*

After mixing and loading the user closes the bottle; consequently, the exposure duration equals the application duration. ‘Pest Control Products Fact Sheet’[1)] gives a default value of 1.33 minutes for both application duration and exposure duration when mixing and loading liquid in a plant sprayer. Data for mixing and loading a liquid in a bucket filled with water is not available; therefore, the above-mentioned duration of 1.33 minutes is set as default value for both exposure duration and application duration.

- *Product amount*

This parameter is for limiting the evaporated amount of active substance from the product. It is not the *used* product amount but half of the bottle content. For a one-litre bottle the averaged amount liquid in the bottle is estimated at 500 g (density 1 g/cm^3), which is set as default value.

- *Room volume*

‘Room volume’ is interpreted here as ‘personal volume’: a small area of 1 m^3 around the user. A small area around the user is relevant for the inhalation exposure of the user, for the short use duration in which the treatment takes place, as it enables the evaporation of the active substance from the concentrate to be described. Since no data with regard to the personal volume were found, a quality factor Q = 1 is assigned.

- *Ventilation*

The ventilation rate that Bremmer and Van Veen[3)] give for a non-specified room is taken as a default value; namely 0.6 hr^{-1}. To what extent this value is applicable to the 'personal volume' of 1 m^3 around the user is unknown, therefore the quality factor is set at 1.

- *Release area*

No data were found for this parameter. It is assumed that evaporation takes place from a bottle with a not-too-small circular opening with a 5-cm. diameter which gives a release area of 20 cm^2.

- *Molecular weight matrix*

The parameter 'molecular weight matrix' is the molecular weight of the 'other' components in the product. In Paint Fact Sheet[11)] this parameter is extensively discussed. The 'molecular weight matrix' is roughly given by M_w / fraction solvents. If the value for molecular weight matrix lacks, the molecular weight matrix is set at 3000 g/mol, which is a worst-case assumption. In this case, it is assumed that the fraction solvent is small; therefore, the partial vapour pressure will not be lowered by the solvent matrix.

Dermal exposure: instant application

Dermal exposure during mixing and loading of biocides for indoor use will almost always be restricted to the hands[12)].

- *Product amount*

For dermal exposure of professionals, the inventory performed by Van Hemmen[12)] results in an indicative value during mixing and loading of liquid pesticides. The indicative 90th percentile value of dermal exposure is 0.3 ml formulation/hr[12)], which is considered applicable for about 25 kg active substance applied per day. It is assumed that for consumers the quantity of active substance applied per day is 1000 times lower than for professionals; thus, the amount applied per day is circa 25 grams of active substance.
The above-mentioned *indicative value for professional application* is extrapolated to consumer application. The dermal exposure for consumers is estimated at 0.3 µl/hr, this is 0.3 mg/hr or 5 µg/min (density 1 g/cm^3). With an application duration of 1.33 minutes, the dermal exposure is 6.5 µg per operation.

Dermal exposure of consumers is described in the TNsG[5)] for dispersing a concentrate from a one-litre can and diluting with water in a small vessel (200 ml concentrate plus 2.3 L water). The dermal exposure of hands results in a range from 0 to 3.2 mg (n=10). The non-zero values varied from 0.33 to 3.2 mg (n=8).

For dermal exposure of amateurs, the UK POEM model[13)] describes the pouring of fluid from a container into a receiving vessel. The 75th percentiles for dermal exposure during mixing and loading are given for 1 litre and 2 litre containers i.e. 0.01 ml per operation. Containers of 5 litres with narrow closures or with 45/63 mm closures give a dermal exposure of 0.2 ml and 0.01 ml per operation, respectively (see Table 5).

Table 5: Hand contamination per operation of mixing and loading[13)]

Container [litre]	Type of closure	Contamination [ml/ operation]
1	Any closure	0.01
2	Any closure	0.01
5	Narrow closure	0.20
5	45 or 63 mm closure	0.01

For dermal exposure, the extrapolated value from professionals is not considered; only the reported dermal exposures for consumers are taken into account. Using these data for mixing and loading, the default value for dermal exposure is set at 0.01 ml or 10 mg (density 1 g/cm^3) per operation. For comparison, one small drop liquid is about 0.02 ml i.e. 20 mg.

Dermal uptake: diffusion through skin

- *Exposure time*

It is assumed that the exposure time (i.e. the contact time of the formulation with the skin) is longer than the application duration (1.33 min, see inhalation exposure) and it is set at 3 minutes.

Defaults

Default values for mixing and loading: dilution of a liquid

	Default value	Q	References, comments
Inhalation			
Evaporation from a constant surface			
Exposure duration	1.33 min	3	See above
Product amount	500 g	3	See above
Room volume	1 m^3	1	See above
Ventilation rate	0.6 hr^{-1}	1	Unspecified room[3)]
Release area	0.002 m^2	2	See above
Application duration	1.33 min	3	See above
Mass transfer rate	Langmuir's method		See help-file ConsExpo
Mol. weight matrix	3000 g/ mol	2	Worst-case; see above
Dermal			
Exposure, instant application			
Exposed area	215 cm^2	3	One palm: ¼ area hands[3)]
Product amount	0.01 g	3	See above
Uptake, diffusion through skin			
Exposure time	3 min	2	See above

2.2.2 Mixing and loading: dissolving powder and granules

The main difference with regard to the exposure to powder and granules during mixing and loading compared to the dilution of a liquid concentrate is that powders, and granules, to a lesser extent, can disperse.

This section describes the exposure of the user during mixing and loading of powders and granules.

Scenario
A private user loads powder/ granules into a bucket and then adds water into the bucket to produce 5 litres of ready-for-use product. The dust of the formulation disperses, resulting in inhalation and dermal exposure.

Models
For calculating the inhalation exposure to powder with ConsExpo, the spray model is applicable. However, product parameters such as mass generation rate, airborne fraction, and particle size distribution should be known. If these data are available, the inhalation exposure could be estimated with ConsExpo's spray model. If these parameter values are lacking, the below-mentioned data, derived from van Hemmen, can be used to calculate the inhalation exposure. To calculate the dermal exposure of the user during mixing and loading the 'constant rate' model can be used.

Inhalation exposure: spray model
- *'Spray' duration and exposure duration*

No data were found for the duration of mixing and loading a powder. It is assumed that the 'spray' duration and exposure duration have the same value as for mixing and loading liquids i.e. 1.33 minutes.

- *Room volume, room height and ventilation rate*

'Room volume' is interpreted here as 'personal volume': a small area of 1 m^3 around the user with a height of one meter. A small area around the user is relevant for the inhalation exposure of the user, for the short use duration in which the treatment takes place.
The ventilation rate of an unspecified room is used i.e. 0.6 hr^{-1} (3).

- *Density*

In various models that describe the spraying process, the density of the product is an important parameter. Many active ingredients in disinfectants are made of large organic compounds with densities usually between 1.0 and 1.5 g/ cm^3; for a complex mixture of (especially organic) compounds, the density is set at 1.8 g/ cm^3. The density of salts generally varies between 1.5 and 3.0 g/ cm^3 (see Table 6). If data concerning the density is lacking, the default value for density non-volatile is set at 1.8 g/cm^3 (Q = 3).

Table 6: Default values for density non-volatile compounds

Type	**Main ingredient**	**Density** [g/ cm^3]	**Q**
Non-volatile compounds	Large organic compounds	1.5	3
	Salts	3.0	3
	Complex mixture of compounds, especially organic compounds	1.8	3

Inhalation exposure: other models
For inhalation exposure of professionals, the inventory performed by Van Hemmen[12)] results in an indicative value during mixing and loading of solid pesticides (wettable powder). The indicative 90th percentile value of the inhalation exposure is 15 mg formulation/hr, which is considered applicable for about 25 kg active substance applied per day. It is assumed that for

consumers the quantity of active substance applied per day is 1000 times lower than for professionals; thus, the amount applied per day is circa 25 grams of active substance.
The above-mentioned *indicative value for professional application* is extrapolated to the consumer application. The inhalation exposure for consumers is estimated at 15 µg/hr or 0.25 µg/min. With an exposure duration of 1.33 minutes (see above), the inhalation exposure is 0.3 µg.
Dust of washing powder is given by Van Plassche et al.[14]: a cup containing 200 gram of washing powder can generate 0.27 µg dust. The term dust was not defined and the used method for determining the amount of dust was not described. Nevertheless, this value has the same order of magnitude as the extrapolated value for consumers.

The quality of granules, particularly the degree of powder forming, determines how much lower the exposure will be for granules compared to powders. Van Golstein Brouwers et al.[15] estimated that for granules a maximum of 10% is present in the form of powder. The inhalation exposure is therefore expected to be 10-fold lower than with powders, and is set at 0.025 µg/min. With an application duration of 1.33 minutes (see above), the inhalation exposure is 0.03 µg.

Dermal exposure: constant rate

- *Contact rate*

For dermal exposure of professionals, the inventory performed by Van Hemmen[12] gives an *indicative* value during mixing and loading of solid pesticides (wettable powder). The indicative 90th percentile value of dermal exposure is 2000 mg formulation/hr, which is considered applicable for about 25 kg active substance applied per day. It is assumed that for consumers, the quantity of active substance applied per day is 1000 times lower than for professionals; thus, the amount applied per day is circa 25 grams of active substance.
The above-mentioned *indicative value for professional application* is extrapolated to the consumer application. The dermal exposure for consumers is estimated at 2 mg/hr, i.e. 0.033 mg/ min. A quality factor Q = 2 is assigned.

- *Release duration*

The release duration is the time during which the compound is applied. It is assumed that the release duration has the same value as for application duration during mixing and loading liquids i.e. 1.33 minutes.

Defaults

Default values for mixing and loading: dissolving a powder / granules

	Default value	**Q**	**References, comments**
Dermal			
Exposure, constant rate			
Contact rate	0.033 mg/ min	2	See above
Release duration	1.33 min	3	See above

2.2.3 Mixing and loading: dissolving tablets

Scenario

A private user loads tablet(s) into a bucket and then adds water into the bucket to produce 5 litres of ready-for-use product. During mixing and loading the user contacts the tablet(s) which results in dermal exposure.

To calculate the dermal exposure of the user during mixing and loading tablet(s) the 'constant rate' model is used.

Dermal exposure: constant rate

- *Contact rate*

Thoroughly wiping the surface of one of the tablets with a dry gauze sponge yielded 19 mg of product [16], which is not comparable with loading tablet(s). As no further data was found, it is assumed that the contact rate has the same value as for contact rate during mixing and loading powder or granules i.e. 0.033 mg/min (section 2.2.2).

- *Release duration*

The release duration is the time during which the compound is applied. For loading tablets, the release duration is estimated at 6 seconds per tablet, i.e. 0.1 minute per tablet.

Defaults

Default values for mixing and loading: dissolving tablets

	Default value	Q	References, comments
Dermal			
Exposure, constant rate			
Contact rate	0.033 mg/ min	2	See above
Release duration	0.1 min/ tablet	1	See above

2.3 Parameters for the spray model

During spraying the user can inhale droplets of the product. Sprays produce an aerosol cloud of very small to small droplets. The speed with which the droplets fall depends on the size of the droplet; smaller droplets stay in the air longer. Further, dermal exposure can occur when droplets fall on bare skin.

2.3.1 Inhalation exposure during spraying

To calculate the inhalation exposure, the 'spray model' from ConsExpo 4.0 is used for different disinfectant spray applications for indoor use. In this section some parameters from the 'spray model' are discussed.

The spray model is developed on the basis of the results of experimental work and describes the indoor inhalation exposure to slightly evaporating or non-volatile compounds in droplets that are released from a spray can or trigger spray[2, 60]. For volatile substances the evaporation model is more appropriate. If the spray model is used for volatile substances the inhalation exposure will be underestimated, because exposure to vapour is not considered in the spray model.

Volatile is defined as compounds with vapour pressure > 0.1 Pa, non-volatile < 0.01 Pa and slightly volatile between 0.01and 0.1 Pa[61].

Inhalation: spray model

- *Mass generation rate*

TNO-PML[42] has investigated the mass generation rate of 23 aerosols spray cans and trigger sprays; no sprays with disinfectants were measured. The mass generation rate of full and of nearly empty cans was measured. The median of all full and nearly empty trigger sprays was 1.2 g/sec (SD 0.16; n= 12), the 75th percentile was 1.5 g/sec. No distinction could be made between full or nearly empty sprays, the 75th percentile of the full trigger sprays was 1.5 g/sec and of nearly empty sprays 1.4 g/sec. The mass generation of the nearly empty spray was 80-100% of the full can trigger spray.
Based on the TNO-PML investigation for all trigger sprays the mass generation rate is set at 1.5 g formulation/sec.

- *Initial particle distribution*

The droplet size is an important parameter when estimating the exposure. Smaller drops fall at a lower speed and stay in the air for longer. The large droplets will quickly disappear from the air after being formed. As an indication: the falling time of droplets with a diameter of 100 µm from a height of 3 meters is calculated at 11 sec, and for droplets of 10 µm it is calculated at 17 min[17]. If a larger droplet is sprayed, part of the aerosol cloud will consist of finer droplets which stay in the air for longer, as a result of edge effects around the nozzle and the 'bounce back' effect due to spraying onto a surface
'Assessment of human exposure to biocides' from the Biocides Steering Group[17] gives a WHO classification concerning the droplet size of sprays (see Table 7).

Table 7: Classification of aerosol droplets[17]

Droplet diameter [µm] [1]	**Classification**
< 15	Fog
< 25	Aerosol, fine
25-50	Aerosol, coarse
51-100	Mist
101-200	Spray, fine
210-400	Spray, medium
>400	Spray, coarse

[1]: the median diameter; half of the particles are larger, half are smaller

In the same study, a classification is also given for the droplet size for various types of agricultural use (see Table 8).

Table 8: Droplet size for different types of agricultural use[17]

Aim of use	**Droplet diameter [µm]**
flying insects	10-50
insects on plants	30-50
precipitation on surface	40-100
application on the ground	250-500

The Dutch Aerosol Association[18] distinguishes between aerosol sprays in aerosol cans with very fine atomized dry sprays (such as asthma sprays and insecticides) and fine atomized wet sprays (such as hair sprays and paint sprays).

Matoba et al.[19] measured the droplet size of an aerosol can with a spray for air space applications. The average droplet size was 30 µm with a range of 1-120 µm. Based on the measurements, Matoba et al. classified the droplets into three groups: 10 % of the particles have a droplet size of 60 µm, 80 % have a droplet size of 20 µm and 10 % of the particles have a droplet size of 5 µm. A spray for air space applications generally has a smaller droplet diameter than a spray for surface applications.

TNO-PML[20] has investigated the initial particle size distributions from aerosols spray cans and trigger sprays. No disinfectant trigger sprays were considered. The investigated spraying devices were aerosol spray cans, ready-to-use trigger sprays and plant sprayers with an adjustable nozzle to produce a spray with droplets as small as possible or a spray with coarse droplets. As only trigger sprays are relevant for disinfectants, the percentiles of different trigger sprays are given in Table 9. The 10, 50, and 90 percentiles for the volume distributions of the spray cans are given as d_p (V, 0.10), d_p (V, 0.50) and d_p (V, 0.90), which means that 10%, 50% or 90% of the product mass is below the mentioned size (in µm).

Table 9: Percentiles of the initial volume distribution of trigger sprays [20]

Trigger sprays	**Content**	**Percentiles of the initial particle distribution [µm]**		
		D_p (0.10)	D_p (0.50)	D_p (0.90)
Plant spray fine [a]	Full	33	88	191
affecting insects	Nearly empty	27	69	171
Plant spray coarse [a]	Full	39	127	512
affecting insects	Nearly empty	36	123	420
Spray against	Full	29	63	200
crawling insects	Nearly empty	31	65	157
All purpose cleaner	Full	46	133	391
	Nearly empty	64	183	478
Bathroom cleaner	Full	59	185	502
	Nearly empty	69	190	490
Anti-grease cleaner	Full	63	160	363
	Nearly empty	72	198	494

[a] the nozzle can be adjusted so that the plant sprayer generates a fine spray with droplets as small as possible or a spray with coarse droplets

Because of the lacking data for disinfectant trigger sprays, worst-case the default initial particle distribution used for pest control trigger sprays is applied which is defined as a lognormal distribution with a median of 50 µm and with a coefficient of variation (C.V.) of 0.6. (see Figure 1).

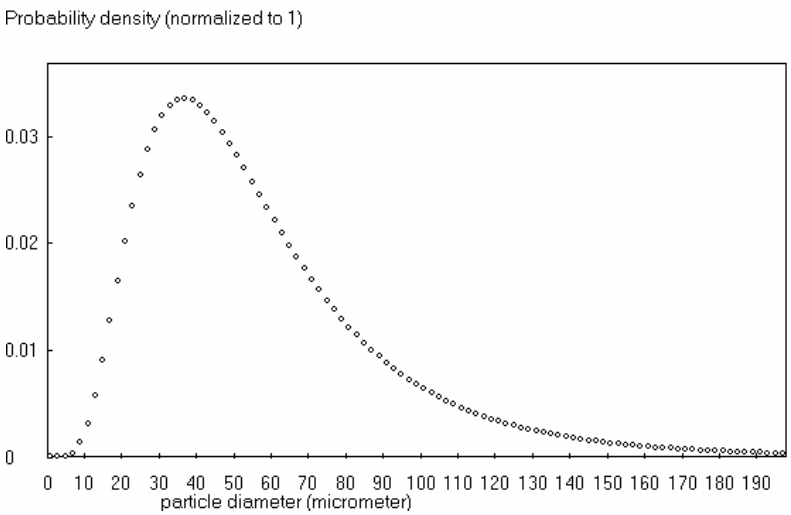

Figure 1: Default initial particle distribution for disinfectant trigger sprays i.e. a lognormal distribution with median 50 µm (C.V. 0.6)

Table 10: Default initial particle distribution for trigger sprays

Disinfectant	**Distribution**	**Median**	**C.V.**	**Q**
Surface trigger spray	Lognormal	50 µm	0.6	2

- *Airborne fraction*

The airborne fraction is the fraction of non-volatile material that becomes airborne in the form of droplets. The 'airborne fraction' combines the fraction non-volatile material that ends up in the smaller droplets and the fraction of droplets that becomes airborne. The latter is closely connected to the type of spray and the way it is used, i.e. spraying on a surface (paint, wood preservative) or spraying in the air (spraying against flies), and on the droplet size distribution that has been specified.
Airborne fractions have been determined experimentally for different sprays. The airborne fraction is derived from the TNO-PML[20] survey on the exposure from spray cans and trigger sprays (Delmaar et al., in prep.)[60]. In Table 11 the airborne fractions for the investigated trigger sprays are presented. Based on these values, the default value for trigger sprays with disinfectants is set (see Table 12).

Table 11: Airborne fractions of investigated trigger sprays

Trigger sprays (solvent water)	**Percentiles of the initial particle distribution [µm]**			**Airborne fraction [%]**
	D_p (0.10)	D_p (0.50)	D_p (0.90)	
Plant spray fine [a] affecting insects	33	88	191	20
Plant spray coarse [a] affecting insects	39	127	512	20
Spray against crawling insects	29	63	200	10
All purpose cleaner	46	133	391	10

[a] the nozzle can be adjusted so that the plant sprayer generates a fine spray with droplets as small as possible or a spray with coarse droplets

Table 12: Default value for the airborne fraction

Disinfectant spray	Airborne fraction	Q
Surface spray; median of the initial particle distribution ≥ 50 μm	0.2	2

- *Weight fraction non-volatile*

In trigger sprays, the weight fraction of the non-volatile compounds is anyhow the weight fraction of the active substance.

- *Density*

In various models that describe the spraying process, the density of the product is an important parameter. Many active ingredients in disinfectants are made of large organic compounds with densities usually between 1.0 and 1.5 g/ cm^3; for a complex mixture of (especially organic) compounds, the density is set at 1.8 g/ cm^3. The density of salts generally varies between 1.5 and 3.0 g/ cm^3 (see Table 6). If data concerning the density is lacking, the default value for density non-volatile is set at 1.8 g/cm^3 (Q = 3). See Table 6 in section 2.2.2.

- *Inhalation cut-off diameter*

The inhalation cut-off diameter is the measure for the diameter of the spray droplets that can be inhaled and reach the lower areas of the lungs (alveoli, bronchioles, bronchia). Particles that are above this diameter deposit in the higher parts of the respiratory tract and will be cleared via the gastro-intestinal tract, leading to oral exposure. The inhalation cut-off diameter is only an approximation of the complicated process of deposition of particles in the lung. In general, its value will be around 10-15 micrometer. The default value is set at 15 μm.

2.3.2 Dermal exposure during spraying

To calculate dermal exposure of the user during application the 'constant rate' model from ConsExpo is used for all spray applications. The TNsG[5)] provides data for consumer spraying, for surface spraying with pre-pressurized aerosol spray cans and hand-held trigger sprays. The measured data for dermal exposure have a wide range. For surface spraying with hand-held trigger sprays these data is used as default value for contact rate.

Dermal exposure: constant rate

- *Contact rate*

In the TNsG's[5)] 'Consumer product spraying and dusting' a surface spraying model is stated in which the consumer uses a hand-held trigger spray for spraying surfaces i.e. skirting, shelves and horizontal and vertical laminate. The dermal exposure on hands and forearms ranges from 3 to 68.2 mg/min with a 75th percentile of 36.1 mg/min. The dermal contact rate for legs, feet and face ranges from 1.9 to 12.4 mg/min with a 75th percentile of 9.7 mg/min. Using these data, the default value for contact rate is set at 46 mg/minute.

3 Algae, green deposit removers

Use
Algae, green deposit removers are used to prevent, control or to remove algae deposits from various surfaces; non-professionals undertake algae removal on paths, walls, roofs, flagstones, gravestones, sleepers, windows or greenhouses. Active substances are alkyldimethylbenzyl ammonium chloride or didecyldimethyl ammonium chloride (quaternary ammonium ions: quats). Consumer products are available as water-based concentrates and are generally applied outdoors.
Before application, if possible, dirt should be removed; not all instructions for use mention the removal of dirt. Algae, green deposit removers are applied by means of spraying, pouring, brushing or scrubbing. The formulation needs to be more diluted for porous materials (e.g. bricks, paving stones) than for smooth and hard materials (e.g. glass, marble). To illustrate the large range of application volumes, one use instruction states that 4 litres diluted formulation is sufficient for a surface area of 1 to 15 m^2. Another use instruction states that 200 ml formulation is sufficient for approximately 200 m^2 (spraying) and for approximately 100 m^2 (pouring). To calculate the application volume the mentioned 200 ml of formulation is multiplied with the dilution factor, which is in this case 200. Thus, the application volume for spraying is 2 L per 10 m^2 and for pouring 4 L per 10 m^2. As there is no other data available, these application volumes are used as default in the treatment of surfaces and pathways with algae removers.

If required, a few days after application dead algae can be removed by hosing off or scrubbing followed by sweeping up and disposal. Not all instructions for use state the removal of dead algae. During the removal of dead algae some dermal exposure to residuals of the formulation could occur. It is assumed that the exposure during post-application is negligible compared with the exposure during the application of algae removers. The post-application will therefore not be described in this chapter.

Algae, green deposit removers are generally used outdoors. Quats (active substance) used in algae removers are non-volatile due to their salt character. It is therefore assumed that the inhalation exposure to quats (vapour) is negligible and is not described in this section. Only the inhalation exposure to aerosols due to spraying is taken into account.
When another active substance is under consideration and it is applied indoors, e.g. in a greenhouse, possibility of inhalation exposure should be carefully checked.

The scenario and exposure during mixing and loading is described in section 3.1. In two scenarios the treatment of surfaces and pathways are described: the algae removers are either sprayed or poured and brushed. The exposure during spraying and during pouring and brushing are described in section 3.2 and section 3.3, respectively.

3.1 Exposure during mixing and loading

In this section, two scenarios for mixing and loading are described i.e. for spraying and for pouring and brushing. As the exposure is similar, these two scenarios are put together in one default.

Scenario
The scenarios describe the treatment of the surface area of a pavement (25 m^2). Spraying requires 5 litres of diluted formulation, pouring and brushing requires 10 litres of diluted formulation (see use) which are described in the following scenarios:
- before spraying, a private user mixes and loads liquid into a 5-litre sprayer filled with water to produce 5 litres of ready-for-use product
- before brushing, a private user mixes and loads liquid into a bucket filled with water to produce 10 litres of ready-for-use product

Disinfectant products for consumers are available as water-based concentrates in bottles of 250 ml, 500 ml or 1000 ml. As the concentration of active substance varies among the different disinfectant products, the amount of formulation used per 10 litres ranges from 50 ml to 500 ml.

Dermal exposure due to mixing and loading is described with the 'instant application' model.

General
- *Frequency*

It is assumed that the user treats the pavement in the spring, in the summer and before the winter. The default value for frequency is set at 3 $year^{-1}$.

Defaults
Default values algae removers: mixing and loading liquid

	Default value	**Q**	**References, comments**
General			
Frequency	3 $year^{-1}$	2	See above
Dermal			
Exposure, instant application			
Exposed area	215 cm^2	3	One palm: ¼ area hands[3)]
Product amount	0.01 g	3	See section 2.2.1
Uptake, diffusion through skin			
Exposure time	3 min	2	See section 2.2.1

3.2 Exposure during spraying

Scenario
The scenario describes a private user who sprays disinfectant on to the pavement, which has a surface area of 25 m^2. Three times per year, the user sprays the pavement with a home garden sprayer with an amount of 5 litres diluted formulation.

Models
ConsExpo is developed for products applied indoors. As the spraying scenario describes application outdoors, the 'spray' model will overestimate the inhalation exposure. For the scenario, a 'room' volume is defined as 62.5 m^3, i.e. 25-m^2 surface area multiplied with 2.5 m (standard room) height. For ventilation, the ventilation of an unspecified room is taken i.e. 0.6 hr^{-1} [(3)]. The scenario describes a worst-case situation. Consequently, the actual inhalation

exposure during spraying outdoors is probably smaller than the calculated exposure by ConsExpo.

Another option to assess inhalation is to apply UK POEM model[13] which describes an amateur using a 'home garden sprayer' (5 litre tank) for low-level spraying of pesticides outdoors. The target area of UK POEM differs from the surface area of the pavement i.e. crops versus surfaces; in the case of the latter the bounce back effect is large which might result in smaller droplets and thus, a higher inhalation exposure.

To calculate the exposure of the user during spraying, the 'spray' model is used for inhalation exposure and the 'constant rate' model is used for dermal exposure.

Inhalation and dermal exposure

- *Weight fraction*

The weight fraction is the calculated weight fraction of the diluted formulation.

Inhalation exposure: spray model

- *Mass generation rate*

Product information of a knapsack sprayer (16 L; 1-4 bar), which is used for spraying disinfectants by professionals, stated a flow rate of 615 ml/min[22].
The spraying by consumers is done with a 5 litre home garden sprayer. It is assumed that the mass generation rate of consumer sprayers varies between 200 to 400 ml/min. The default value for mass generation rate is set at 300 g/min, i.e. 5 g/sec.

- *Spray duration and exposure duration*

The spray duration can be calculated by dividing the volume of diluted formulation by the mass generation rate i.e. 5000 ml divided by 300 ml/min resulting in 16.7 minutes, which is set as default value for both spray and exposure duration.

Dermal exposure: constant rate

For dermal exposure, data from UK POEM[13] is used.

- *Exposed area*

It is assumed that during the application, the user wears a T-shirt and a short. The exposed area is the non-covered skin area of hands, arms and legs, which are 860 cm^2 [3], 2450 cm^2 [3] and 5600 cm^2 [3], respectively. As a result, the total exposed area is 8900 cm^2. These data can be used to calculate the dermal load of the active substance (in mg active substance/ cm^2).

- *Contact rate*

According to UK POEM[13], the dermal exposure of an amateur during spraying is 32.35 ml/hr i.e. for hands 10 ml/hr, for trunk 3.5 ml/ hr, and for legs 18.85 ml/hr. The default value for contact rate is 32.35 g/hr (density 1 g/cm^3) i.e. 540 mg/min.

- *Release duration*

The release duration is the time during which the compound is applied. In the case of spraying the release duration equals the spray duration.

Defaults
Default values algae removers: spraying

	Default value	Q	References, comments
General			
Frequency	3 $year^{-1}$	2	See section 3.1
Inhalation			
Exposure, spray model			
Spray duration	16.7 min	2	See above
Exposure duration	16.7 min	2	I.e. spray duration
Room volume	62.5 m^3	1	See above
Room height	2.5 m	1	See above
Ventilation rate	0.6 hr^{-1}	1	See above
Mass generation rate	5.0 g/s	2	See above
Airborne fraction	0.2	2	See section 2.3.1
Weight fraction non-volatile			See section 2.3.1
Density non-volatile	1.8 g/cm^3	3	See section 2.3.1
Initial particle distribution			
Median (C.V.)	50 µm (0.6)	2	See section 2.3.1
Inhalation cut-off diameter	15 µm		
Uptake			
Uptake fraction	1	2	Potential dose
Inhalation rate	24.1 L/min	3	Light exercise[62)]
Non-respirable (oral) uptake			
Oral uptake fraction	1	2	Potential dose
Dermal			
Exposure, constant rate			
Contact rate	540 mg/ min	2	See above
Release duration	16.7 min	2	I.e. spray duration
Uptake, fixed fraction			
Uptake fraction	1	2	Potential dose

3.3 Exposure during pouring and brushing

Scenario
The scenario describes a private user who spreads disinfectant three times per year on to the pavement, which has a surface area of 25 m^2. An amount of 10 litres diluted formulation is available in a bucket and it is spread over the stones by gradual pouring. The user applies a stiff broom to brush the stones of the pavement.

To calculate the dermal exposure of the user during pouring and brushing, the ‘instant application’ model is used.

Dermal exposure: instant application

- *Exposed area*

For the exposed area, the skin surface area of hands and arms is taken i.e. the non-covered skin area. Hands and arms have a surface area of 860 cm^2 (3) and 2450 cm^2 (3), respectively. The default value for exposed area is set at 3300 cm^2.

- *Product amount*

During brushing the pavement, droplets of the solution might settle on the skin. Exposure data regarding this is not available. For estimating dermal exposure due to droplets, 0.05% of the diluted formulation is taken as default value for amount of spillage. An amount of 10 litres dilution is required for brushing a pavement surface area of 25 m^2; therefore, the dermal exposure is 0.05% of 10 000 ml i.e. 5 g diluted formulation (density 1 g/ cm^3).

- *Weight fraction*

The weight fraction is the calculated weight fraction of the *diluted* formulation.

Dermal uptake: diffusion through skin

- *Concentration*

The concentration (g/cm^3) is the calculated weight fraction of the diluted formulation (density water 1 g/cm^3).

- *Exposure time*

The exposure time equals the application duration, which is estimated at 25 minutes i.e. one minute for pouring and brushing per square metre.

Defaults

Default values algae removers: pouring and brushing

	Default value	**Q**	**References, comments**
General			
Frequency	3 $year^{-1}$	2	See section 3.1
Dermal			
Exposure, instant application			
Exposed area	3300 cm^2	3	Area hands[3)] and arms[3)]
Product amount $_{dilution}$	5 g	1	See above
Uptake, diffusion through skin			
Exposure time	25 min	1	See above

4 Black mould removers

4.1 Introduction

To control and remove black mould indoors, there are two disinfectant products registered for use by consumers[7]. These two products are available as a ready-to-use trigger sprays containing sodium hypochlorite as an active substance for the removal of mould on (tiled) walls, and joints in bathroom, shower, toilet, garage and shed.

Box 1: Background information about sodium hypochlorite

When diluted in water, depending on pH value, sodium hypochlorite is partly transformed into hypochlorous acid (HOCl). Hypochlorous acid is a very weak acid in aqueous solution and its salts hydrolyse easily to free hypochlorous acid as shown in reaction (1). Under neutral conditions, equilibrium (1) shifts to the right; under alkaline conditions, equilibrium (1) shifts to the left.
Hypochlorous acid is predominant between pH 3 and 6. At pH 7.5, the ratio OCl^-/ HOCl is in the proportion of one to one. For a pH > 11, 100% is available as hypochlorite (OCl^-). Under acid conditions and in the presence of chloride, equilibrium (2) shifts to the right and chlorine gas is formed.
Dilute aqueous solutions of hypochlorous acid decompose slowly by two routes (equilibrium 3 and 4).

$Na^+ + OCl^- + H_2O \leftrightarrow HOCL + Na^+ + OH^-$ (1) neutral conditions
$HOCl + H^+ + Cl^- \leftrightarrow Cl_2 + H_2O$ (2) acid conditions

$3\ HOCL \leftrightarrow HClO_3 + H^+ + Cl^-$ (3) disproportionation
$2\ HOCL \leftrightarrow 2\ H^+ + Cl^- + O_2$ (4) metal impurities

Chlorine is available in three different forms: OCl^-, HOCl and Cl_2. The reaction capacity of the different forms of chlorine in water increases from ClO^- to Cl_2; though, the solubility of Cl_2 in water is very low. Though hypochlorous acid (active substance) is a strong oxidising agent, its salts are less strongly oxidising; the activity of sodium hypochlorite solution decreases with an increase in pH. However, the stability of these solutions is greater at an alkaline pH. Upon dilution and during use the pH of the hypochlorite solution lowers. The pH during use ranges from 8 to 13; the initial pH is approximately 12 and the pH of the effluent is approximately 8. At a pH of 7.5 there is a balance of hypochlorite ion and hypochlorous acid. This allows the hypochlorite ions to act as a reserve which convert to hypochlorous acid, as it is tied up by the organic matter [23].
Chlorine can be measured as mg/L of Cl_2. The term 'active chlorine' is sometimes used as a synonym for 'available chlorine' which covers all forms of chlorine particularly hypochlorous acid and hypochlorite. The hypochlorite concentration is expressed as % NaOCl.
The above text is largely derived from A.I.S.E.[24].

Depending on the pH of the solution, exposure during use will be exposure to HOCl, OCl^-, or Cl_2. At the alkaline pH's of the products (8 – 13), no chlorine gas is formed and equilibrium (1) has shifted to OCl^-. A small amount of released hypochlorous acid will be combined with organic matter and the amount which evaporates into the room is considered negligible.
As mentioned before the black mould removers containing sodium hypochlorite are mainly alkaline. It is assumed that at a pH of 11 maximally 5% of the sodium hypochlorite present in disinfectant products is present as hypochlorous acid.

The mentioned information (see Box 1) and data is only applicable for black mould removers with as active substance sodium hypochlorite salt. At the alkaline pH of the product, the equilibrium has shifted to hypochlorite (see Box 1). The amount of chlorine gas is considered negligible and it is not described in this section; only the inhalation exposure to aerosols due

to spraying is taken into account. When another active substance is under consideration possibility of inhalation exposure to vapour should be carefully checked.

Use
During the use of the trigger sprays, three phases can be distinguished. First, the product is sprayed onto the surface; in the case of strong contamination, the surface should be sprayed once again after 10 minutes. After spraying, it is left on the surface to soak in for 10 minutes and finally, the surface should be rinsed with water and sponge. After the application, the spray nozzle must be taken off and washed out with water (instructions for use).

Scenario
The scenario describes a private user who removes mould on the edges of the ceiling in the bathroom once a year. The user sprays the formulation on a surface of 3 m^2. After spraying, the user leaves the bathroom for 10 minutes. Then the surface is rinsed off with water after which the user leaves the room. During the application, the user wears a T-shirt, trousers and shoes, but no gloves. Although the label on the product points out the use of gloves, it is assumed that some of the users (consumers, non-professionals) will not follow the instructions. Therefore, the exposure assessment describes the application without gloves (see section 1.6).

To calculate the exposure of the user during spraying, the 'spray model' is used for inhalation exposure and the 'constant rate' model for dermal exposure (section 4.2).

To calculate the exposure during rinsing the model 'instant application' 'is used for dermal exposure (section 4.3).

4.2 Exposure during spraying

General
- *Frequency*

Insufficient ventilation, warm humid air and rough surfaces are conditions that cause mouldy surfaces in the bathroom. It is assumed that after the winter the user treats the contaminated surface area i.e. once a year.

Inhalation exposure: spray model
- *Mass generation rate*

The default value for the mass generation rate is given as 1.5 g formulation/sec (see section 2.3.1). It is assumed that the total duration of the application is twice as long as the *actual* spraying duration; therefore, the default value for the average mass generation rate is set at 0.75 g/s.

- *Spray duration and exposure duration*

Both registered black mould removers have a content of 500 ml[25)]. Both directions for use state that the content is enough for a surface area of 2 to 3 m^2. It is assumed that for 3 m^2 an amount of 500 ml (density 1 g/cm^3) is used. With a generation rate of 0.75 g/sec, a spray duration of 11.1 minutes is calculated. After spraying, the user leaves the bathroom. The default value for exposure duration is set at 13 minutes.

Defaults
Default values mould removers: spraying

	Default value	Q	References, comments
General			
Frequency	1 year^{-1}	2	See above
Inhalation			
Exposure, spray model			
Spray duration	11.1 min	2	See above
Exposure duration	13 min	2	See above
Room volume	10 m^3	3	Bathroom[3)]
Room height	2.5 m	4	Standard
Ventilation rate	2 hr^{-1}	3	Bathroom[3)]
Mass generation rate	0.75 g/s	3	See above
Airborne fraction	0.2	2	See section 2.3.1
Weight fraction non-volatile			See section 2.3.1
Density non-volatile	1.8 g/cm^3	3	See section 2.3.1
Initial particle distribution			
Median (C.V.)	50 µm (0.6)	2	See section 2.3.1
Inhalation cut-off diameter	15 µm		
Uptake			
Uptake fraction	1	2	Potential dose
Inhalation rate	24.1 L/min	3	Light exercise [62)]
Non-respirable (oral) uptake			
Oral uptake fraction	1	2	Potential dose
Dermal			
Exposure, constant rate			
Contact rate	46 mg/ min	3	See section 2.3.2
Release duration	11.1 min	2	I.e. spray duration
Uptake, fixed fraction			
Uptake fraction	1	2	Potential dose

4.3 Exposure during rinsing

Dermal exposure: instant application

- *Exposed area*

The exposed area is the skin surface area of forearms and hands. The latter has a surface area of 860 cm^2 [(3)]. The General Fact Sheet[3)] gives no default value for the skin area of forearms; the Exposure Factors Handbook[26)] gives for the surface area of the forearms a percentage of 5.9% of the total body surface area. With a total body surface area of 17500 cm^2 [(3)] the skin area for forearms is 1030 cm^2; thus, the total exposed area is 1900 cm^2.

- *Product amount*

During rinsing the treated surface area, the user has dermal contact with the diluted formulation. The Technical Guidance Document[27)] gives a default of 0.01 cm for the

thickness of film layer on skin. For cleaning products, this default value is used in the 'Cleaning Products Fact Sheet'[28]. With an exposed area of 1900 cm^2 the default value for (diluted) amount is 19 grams.

- *Weight fraction*

The amount of black mould remover on the surface is estimated at 85% of 500 g i.e. 425 g disinfectant product which is rinsed off. It is assumed that about 4.2 litres water is used to rinse the treated area; thus, the dilution is 10 times. The weight fraction of the diluted disinfectant should be divided by 10.

Dermal uptake: diffusion through skin

- *Exposure time*

According to the A.I.S.E.[29, 27], the cleaning duration of surfaces ranges from 10 to 20 minutes irrespective of surface area. Weerdesteijn et al.[30] studied the use of cleaning a kitchen working top with sprays. In this pilot study the area was 60 cm x 60 cm. The duration of rinsing and cleaning varied from 7 to 94 seconds (mean 22 sec; SD 25.87; N=10). The duration of rinsing and cleaning is directly related to the size of the cleaned area; the use duration is therefore extrapolated linearly from the pilot. The cleaning duration ranged from 0.32 to 4.35 minutes per m^2.
It is assumed that the rinsing of a rough surface contaminated with black mould takes more time than cleaning a kitchen working top. For rinsing the treated area, the default value for the cleaning duration is set at 4.35 min/m^2 (maximum value[30]); this means that the exposure time for 3 m^2 is 13 minutes.

Defaults

Default values mould removers: rinsing

	Default value	**Q**	**References, comments**
General			
Frequency	1 $year^{-1}$	2	See section 4.2
Dermal			
Exposure, instant application			
Exposed area	1900 cm^2	3	See above
Product amount $_{dilution}$	19 g	1	See above
Weight fraction $_{dilution}$	W_f / 10	1	See above
Uptake, diffusion through skin			
Concentration	W_f / 10 g/cm^3	1	Density 1 g/cm^3
Exposure time	13 min	2	See above

5 Disinfectants for use indoors

Presently (January 2005[6]) no disinfectant products are registered for consumer's use indoors. Until 2001, a disinfectant spray and a disinfectant spray cleaner were registered for disinfection indoors by consumers. These products contained didecyldimethyl ammonium chloride to disinfect surface areas and materials.
In 2001, the manufacturer had requested to withdraw the products concerned. Authorization of new disinfectant cleaning products could be requested; therefore, the use of a ready-for-use trigger spray for disinfecting surfaces indoors is described.

Use
During the use of surface sprays, three phases can be distinguished. First, the product is sprayed onto the surface; then, it is left on the surface to soak in for at least 5 minutes (surface area must remain wet); finally, the surface should be rinsed or taken off with a wet cloth. The phase of leaving the product to soak is independent of the size of the area to be cleaned; it is more dependent on the cleaning person, on the extent of filthiness and on the product type.

Scenario
The scenario describes a private user who sprays disinfectant on to the kitchen working top which has a surface area of 1.71 m^2 [30]. Every day, the working top is sprayed with a trigger spray. The disinfectant is left on the working top for 5 minutes; during this 'leaving on' time, the user stays in the kitchen. Hereafter, the user wipes the working top with a wet cloth. The user is assumed to stay in the kitchen for 1 hour after application.

To calculate the exposure of the user during the spraying application, the 'spray model' is used for inhalation exposure and the 'constant rate' model for dermal exposure (section 5.1).

To calculate the dermal exposure during wiping the 'instant application' model is used (section 5.2).

5.1 Exposure during spraying

Inhalation exposure: spray model
- *Exposure duration*

The exposure duration is the sum of spraying time, time of leaving on, the cleaning time and the time staying in the specified room after application of the disinfectant products. The exposure duration is set at 1 hour.

- *Mass generation rate*

The default value for the mass generation rate is given as 1.5 g formulation/sec (see section 2.3.1). It is assumed that the total duration of the application is twice as long as the *actual* spraying duration; therefore, the default value for the average mass generation rate is set at 0.75 g/s.

- *Spray duration*

Weerdesteijn et al.[30] found for an area of 60 x 60 cm a mean amount used of 3.35 g (SD 0.98; N=10) with a maximum of 4.815 g. In the instructions for use of the disinfectant was stated that the surface must keep wet during the 'leaving on' time. Therefore, the maximum amount is taken and to spray a kitchen working top of 1.71 m^2 [30] requires an amount of 22.87 grams. Consequently, with a mass generation rate of 0.75 g/sec, the spray duration can be calculated as 0.51 minutes.

Defaults

Default values disinfectants for use indoors: spraying

	Default value	Q	References, comments
General			
Frequency	365 $year^{-1}$	2	Estimate: 1 day^{-1}
Inhalation			
Exposure, spray model			
Spray duration	0.51 min	2	See above
Exposure duration	60 min	3	See above
Room volume	15 m^3	4	Kitchen[3]
Room height	2.5 m	4	Standard
Ventilation rate	2.5 hr^{-1}	3	Kitchen[3]
Mass generation rate	0.75 g/s	3	See above
Airborne fraction	0.2	2	See section 2.3.1
Weight fraction non-volatile			See section 2.3.1
Density non-volatile	1.8 g/cm^3	3	See section 2.3.1
Initial particle distribution			
Median (C.V.)	50 µm (0.6)	2	See section 2.3.1
Inhalation cut-off diameter	15 µm		
Uptake			
Uptake fraction	1	2	Potential dose
Inhalation rate	24.1 L/min	3	Light exercise [62]
Non-respirable (oral) uptake			
Oral uptake fraction	1	2	Potential dose
Dermal			
Exposure, constant rate			
Contact rate	46 mg/ min	3	See section 2.3.2
Release duration	0.51 min	2	I.e. spray duration
Uptake, fixed fraction			
Uptake fraction	1	2	Potential dose

5.2 Exposure during wiping

Dermal exposure: instant application

- *Product amount*

The worst-case estimate is that 0.1% of the amount on the surface area (i.e. 19.4 g) contacts the skin. This amount of 0.02 g is used as default value for product amount.

Dermal uptake: diffusion through skin

- *Exposure time*

According to Weerdesteijn et al.[30)], the averaged cleaning duration for an area of 60 x 60 cm is 22.3 sec. (SD 25.9; N=10) with a 75th percentile of 16.5 sec. The averaged cleaning duration is extrapolated for the surface area of 1.71 m^2 i.e. 1.8 min. Assuming that hands aren't washed directly, the exposure time is larger than the cleaning/wiping duration; thus, the default value is set at 3 minutes.

Defaults

Default values surface disinfectants: wiping

	Default value	**Q**	**References, comments**
General			
Frequency	365 year^{-1}	2	Estimate: 1 day^{-1}
Dermal			
Exposure, instant application			
Exposed area	215 cm^2	3	One palm; ¼ area hands[3)]
Product amount	0.02 g	1	See above
Uptake: diffusion through skin			
Exposure time	3 min	2	See above

6 Swimming pool disinfectants

6.1 Introduction

To control quality of swimming pool water, a filtering system is usually not adequate. To control or prevent growth of organisms in swimming pool water non-professional users may treat private pools. For disinfection, appropriate balanced water chemistry is required to maintain an adequate active chlorine level. The active chlorine (free chlorine) disinfectant is used to sanitize, i.e. to kill disease-causing organisms, and to oxidize, i.e. to destroy ammonia, nitrogen-containing contaminants and swimmer waste. A stabilizer in outdoor pools influences the active chlorine level by reducing the chlorine dissipation and in this way, the chlorine level is stabilized i.e. consistent. Furthermore, the pH of the pool water should measure between 7.2 and 7.8 to maintain an ample active chlorine level. Additionally, total alkalinity (amount of alkaline substances) in the pool buffers the water against sudden changes in the pH.

Note: if 'chlorine' is stated, this refers to 'active (free) chlorine'

A considerable number of disinfectant products is authorized[7)] to control micro-organisms and/ or algae. Most of these products are chlorine products in the form of tablets and granules.
Calcium hypochlorite is available as granules or tablets and besides the control of micro-organisms it is also used to clear the pool of algae (see Table 13). When used in an outdoor pool sunlight degrades some of the free (active) chlorine and it is difficult to maintain an adequate chlorine level. When only calcium hypochlorite is used, the pool water is unstabilized. In order to reduce chlorine dissipation, calcium hypochlorite is combined with a stabilizer i.e. cyanuric acid which can be added separately.
Cyanuric acid is also supplied as ingredient in stabilized chlorine granules or tablets such as trichloride isocyanuric acid (TCCA) and sodium dichloride isocyanuric acid (DCCNa). These products maintain consistent levels of chlorine in outdoor pool water, but they also make the chlorine less effective i.e. a higher cyanuric acid level requires a higher minimum free chlorine level. It is therefore necessary not to get too much cyanuric acid in the water. When the cyanuric level is too high, the pool water should be refreshed. Both stabilized chlorine products DCCNa and TCCA add chlorine (sanitizer) as well as cyanuric acid (stabilizer) to the water. TCCA is a slowly dissolving disinfectant and DCCNa is a more quickly dissolving disinfectant.

To maintain the water quality and to prevent algae growth (and bloom), outdoor pools may also require a dose of algaecide (liquid). In case of visible algae (greenish water), one has to treat the pool water with a calcium hypochlorite shock i.e. a high dose to clear the algae; subsequently, an amount algeacide can be added. Algae spores are introduced into the pool through the air, from rainwater and from grass. An algae control product can be applied to swimming pool water that will not be used and chlorinated for a long while (winter period).

In summary, to disinfect an outdoor pool during the swimming season the following products may be required:
- DCCNa or TCCA (stabilized chlorine disinfectants) plus algaecides

- Calcium hypochlorite (unstabilized chlorine disinfectant) in combination with cyanuric acid (stabilizer) plus algaecides

It is recommended to add chlorine during the evening so that it can act onto micro-organisms, algae and other contaminations; during the day most of the chlorine in an outdoor pool is degraded by UV in sunlight[39].

CTB register[7] for disinfectants of water includes swimming water, private baths, therapeutic baths, circulation baths, outdoor swimming water and indoor circulation swimming water. In 2004, the registered disinfectant agents for swimming water are restricted to active substances (a.s.) as mentioned in Table 13.

Table 13: Application of active substances in swimming pool disinfectants

Control	Active substance (a.s.)	Type	Form
Micro-organism, algae	Sodium dichloride isocyanuric acid [DCCNa]	Tablet, granules	Stabilized
Micro-organism, algae	Trichloride isocyanuric acid [TCCA]	Tablet	Stabilized
Micro-organism, algae	Calcium hypochlorite [$Ca(OCl)_2$]	Tablet, granules	Non-stabilized
--	Cyanuric acid	Granulate	Stabilizer
Algae	Didecyl dimethyl ammonium chloride [DDAC]	Liquid	Not applicable
Algae	Poly[oxyethylene(dimethyliminio) ethylene(dimethyliminio)ethylene dichloride	Liquid	Not applicable

--: cyanuric acid is a stabilizer and it is not applied to control micro-organism or algae

Swimming pool size

Product information over private swimming pools gives a volume ranging from 14 to 52 m^3. It is assumed that a private swimming pool measures 8 m x 4 m x 1.5 m, which gives a water surface area of 32 m^2 and a volume of 48 m^3.

By applying various disinfectant agents, the user maintains the pool. Mixing and loading and subsequently the application of liquids, granules and of tablets are described in section 6.2, section 6.3 and section 6.4, respectively. Post-application exposure describes dermal exposure during swimming in a private pool (section 6.5).

Note

This fact sheet considers disinfectant products applied by consumers (non-professionals). The description of the exposure during swimming in *public* pools does strictly speaking not belong to this fact sheet. Therefore, the exposure in a public pool is described in the appendix, which is done for three different groups of the population, i.e. baby swimmers, child swimmers and competitive swimmers.

6.2 Liquids

Use
All liquid swimming pool disinfectants in the CTB register[7)] for the Dutch situation are products to control algae. This type of disinfectant can only be applied to inhibit algae growth and it is not appropriate to control micro-organisms (see Table 13).

The dosing rate is given in ml per m^3 of swimming pool water. The used amount of algae control depends on the water condition in the swimming pool, active chlorine level and the concentration of the active substance in the algaecide.
In the following example, the instructions for use stated that an initial treatment of 30 ml/ m^3 is required i.e. to prevent algae growth at the start of the swimming season. After that, a maintenance dose of 8 ml/ m^3 during the swimming season is needed every 5-7 days. After rainfall, the same dose is additionally applied.
In case of visible algae (greenish water), after shock treatment, an amount of 53 ml algeacide/m^3 can be added (see introduction).
To condition the pool water during winter (off-season), the same dose algaecides can be used which is the case when maintenance stops for maximal 3 weeks and the concentration of chlorine compound is below 0.1 mg/L.

Direction for use stated that the required amount of algaecide should be diluted with water in a bucket; subsequently it should be added slowly into a skimmer or distributed evenly around the pool[39)]. A skimmer is an outlet bin situated at the surface of the swimming pool where floating particles on the water will easily be removed; via the skimmer pool water circulates to the pump. During dosing the diluted liquid, the pump should be at work to disperse the formulation in the pool water. Preferably dosing algaecides should be done in the evening, so that it can act onto algae and there is no one swimming in the pool.

Scenario
The scenario describes a private user who is sanitizing an outdoor pool of 48 m^3 every 5 days for a period of 4 months. To prevent algae growth the private user pours the required amount of liquid formulation in a bucket and dilutes it 10 times with water; subsequently, the user distributes the dilution evenly around the pool surface (32 m^2) during 5 minutes. The dosage is set at 8 ml formulation/ m^3; the liquid disinfectant amount required to control algae in a swimming pool can be calculated as dosage (ml/ m^3) x 48 m^3 (volume swimming pool).

The active substances used to control algae are assumed to be non-volatile due to their salt character. Therefore, it is assumed that the inhalation exposure to algaecides is negligible and it is not described in this section. When another active substance is under consideration, possibility of inhalation exposure should be carefully checked.
To calculate the dermal exposure of the private user the ‘instant application’ model is used during mixing and loading as well as during application.

General
- *Frequency*

For the maintenance ration, the dosage is every 5 days for a period of 4 months. It is assumed that before, during and after the winter period i.e. during the off-season, a higher dose is applied (see use). As a result, the frequency is 28 times a year.

Mixing and loading
For the defaults for mixing and loading a liquid, see section 2.2.1.

Application

Dermal exposure: instant application
- *Product amount*

There is no data available. The distribution of the diluted liquid with a bucket can be more or less compared to emptying a volume container (10 L) of unspecified design during 'mixing and loading', which is described in the model UK POEM[13)]. The contamination of emptying a 10 L container is 0.50 ml formulation per operation. In this case, the contamination is set at 0.5 g of diluted formulation (density 1 g/cm^3) during emptying the bucket.

- *Weight fraction*

The dilution is set at 10 times and so, the weight fraction should be divided by 10.

Defaults
Default values algae control liquids: mixing and loading liquid

	Default value	**Q**	**References, comments**
General			
Frequency	28 year^{-1}	2	See above
Dermal			
Exposure, instant application			
Exposed area	215 cm^2	3	One palm: ¼ area hands[3)]
Product amount	0.01 g	3	See section 2.2.1
Uptake, diffusion through skin			
Exposure time	3 min	2	See section 2.2.1

Default values for application algae control liquid, swimming pool

	Default value	**Q**	**References, comments**
General			
Frequency	28 year^{-1}	2	See above
Dermal			
Exposure, instant application			
Exposed area	1900 cm^2	3	Area hands[3)] and forearms; see section 4.3
Product amount $_{dilution}$	0.5 g	2	See above
Weight fraction $_{dilution}$	W_f / 10	2	See above
Uptake: diffusion through skin			
Concentration	W_f / 10 g/cm^3	2	Density water 1 g/cm^3
Exposure time	5 min	2	See above

6.3 Granules

Use
In the Netherlands the following authorized disinfectant products (CTB register[7)]) are available in granules:
- calcium hypochlorite
- sodium dichlorisocyanuric acid (DCCNa)
- cyanuric acid (stabilizer)

The disinfectant calcium hypochlorite is a quickly dissolving *non*-stabilized disinfectant in granular form (and in tablet form, see Table 13) for continuous disinfection in soft and medium hard water and for shock treatment. For shock treatment a large amount of chlorine (super dose) is added all at once into the pool water to break down accumulated organic wastes and/or kill existing algae and bacteria. The dosage of calcium hypochlorite depends on the presence of a stabilizer such as cyanuric acid or of chlorine products containing cyanuric acid such as TCCA or DCCNa. Cyanuric acid is a stabilizer in order to reduce chlorine dissipation due to UV radiation of the sun. This product should not be used in combination with stabilized disinfectants such as DCCNa and TCCA[31)]. Concentrations over 100 mg/l should be avoided.
DCCNa is a stabilized sanitizer and is a quickly dissolving sanitizer in granular form for shock treatment and continuous disinfection in hard and soft water. In stabilized water the chlorine level should be maintained between 1 and 2 mg/l which depends on the cyanuric acid level (see section 6.1). An example of dosing is given in Table 14.
The required amount of sanitizer should be diluted with water in a bucket; subsequently it should be added slowly into a skimmer or distributed evenly around the pool. During dosing the diluted liquid, the pump should be at work to disperse the formulation in the pool water. Preferably dosing disinfectants should be done in the evening, so that it can act onto contaminants and there is no one swimming in the pool.

Table 14: Example of dosage granules[31)]

Granules	Stabilized water	Non-stabilized water	Shock treatment/ Presence of algae
Ca hypochlorite (non-stabilized)	2 – 3 g/ m^3 every 1 or 2 days	3 – 5 g/ m^3 per day	8 – 10 g/ m^3
DCCNa (stabilized)	2 – 3 g/ m^3 every 1 or 2 days		5 – 8 g/ m^3
Cyanuric acid (stabilizer)			20 – 50 g/ m^3

Scenario
The scenario describes a private user who applies disinfectant granules to sanitize an outdoor pool of 48 m^3 with stabilized water. Once a day for a period of 4 months, the private user dissolves the required amount of granules in a bucket and dilutes it 20 times with water; subsequently, the user distributes the dilution evenly around the pool surface (32 m^2) during 5 minutes. The dosage is set at 3 g of granules per m^3 of water. The granules amount required to disinfect the water can be calculated as dosage (g/m^3) x 48 m^3 (volume swimming pool).

To calculate the dermal exposure of the private user the 'constant rate' model is used during 'mixing and loading' and the 'instant application' model during application.

General

- *Frequency*

The dosage is once a day for a period of 4 months i.e. 122 times per year.

Mixing and loading

For the defaults for mixing and loading granules, see section 2.2.2.

Application

Dermal exposure: instant application

- *Weight fraction*

The dilution is set at 20 times and so, the weight fraction should be divided by 20.

Defaults

Default values for mixing and loading, dissolving granules

	Default value	**Q**	**References, comments**
General			
Frequency	122 $year^{-1}$	2	See above
Dermal			
Exposure, constant rate			
Contact rate	0.033 mg/ min	2	See section 2.2.2
Release duration	1.33 min	3	See section 2.2.2
Uptake, fixed fraction			
Uptake fraction	1	2	Potential dose

Default values for application granules, swimming pool

	Default value	**Q**	**References, comments**
General			
Frequency	122 $year^{-1}$	2	See above
Dermal			
Exposure, instant application			
Exposed area	1900 cm^2	3	Area hands[3)] and forearms; see section 4.3
Product amount $_{dilution}$	0.5 g	2	See section 6.2
Weight fraction $_{dilution}$	W_f / 20	2	See above
Uptake: diffusion through skin			
Concentration	W_f / 20	2	Density water 1 g/cm^3
Exposure time	5 min	2	See above

6.4 Tablets

Use
In the Netherlands the following authorized disinfectant products (CTB register[7)]) are available in tablets:
- calcium hypochlorite
- trichloride isocyanuric acid (TCCA)

The disinfectant calcium hypochlorite is available as non-stabilized sanitizer tablets (20 g) for continuous disinfection in soft and medium hard water and for shock treatment.
As stabilized sanitizer TCCA is used. It is a slowly dissolving sanitizer in tablet form (20 g or 200 g) and the dosage may vary widely (sunlight, bathing-load etc.). These tablets are used to maintain a constant chlorine level in the pool water. An example of dosing is given in Table 12. The chlorine level should be between 1 and 2 ppm (stabilized water) which depends on the cyanuric acid level (see section 6.1).

Slowly dissolving tablets are put into a floating dispenser and the release rate can be adjusted by opening or closing the bottom collar. During releasing the active substance via the floating dispenser into the pool water, the pump should be at work to disperse the formulation in the pool water. During swimming the pump should not be working and the floating dispenser should be removed. TTCA tablets can also be placed into the skimmer (outlet bin) to dissolve over several days[39)].

Table 15: Example of dosage tablets[31)]

Tablets	Stabilized water	Non-stabilized water	Shock treatment/ Presence of algae
Ca hypochlorite 20 grams (non-stabilized)	1 – 2 tablets/ 10 m^3 every 1 or 2 days	2 – 3 tablets/ 10 m^3 every day divided into 2 equal doses in the morning and evening	4 – 5 tablets/ 10 m^3
TCCA 20 grams (stabilized)	10 tablets/ 30-35 m^3 every 3-5 days		
TCCA 200 grams (stabilized)	1 tablet/ 30-35 m^3 every 3-5 days		

Scenario
The scenario describes a private user who applies disinfectant tablets to sanitize an outdoor pool of 48 m^3 with stabilized water. Every day for a period of 4 months, the private user dissolves ten tablets of 20 grams (Ca hypochlorite) in a bucket and dilutes it 20 times with water; subsequently, the user distributes the dilution evenly around the pool surface (32 m^2) during 5 minutes.

To calculate the dermal exposure of the private user the ‘constant rate’ model is used during mixing and loading.

General

- *Frequency*

Ten tablets of 20 g is used every days during 4 months, which gives a frequency of 122 times a year.

Mixing and loading

For the defaults for mixing and loading tablets, see section 2.2.3.

Defaults

Default values for mixing and loading, dissolving tablets

	Default value	Q	References, comments
General			
Frequency	122 $year^{-1}$	2	See above
Dermal			
Exposure, constant rate			
Contact rate	0.033 mg/ min	2	See section 2.2.3
Release duration	1 min	1	10 tablets; see section 2.2.3
Uptake, fixed fraction			
Uptake fraction	1	2	Potential dose

Default values for application tablets, swimming pool

	Default value	Q	References, comments
General			
Frequency	122 $year^{-1}$	2	See above
Dermal			
Exposure, instant application			
Exposed area	1900 cm^2	3	Area hands[3)] and forearms; see section 4.3
Product amount $_{dilution}$	0.5 g	2	See section 6.2
Weight fraction $_{dilution}$	W_f / 20	2	See above
Uptake: diffusion through skin			
Concentration	W_f / 20	2	Density water 1 g/cm^3
Exposure time	5 min	2	See above

6.5 Post application

Scenario

The scenario describes a private user who swims in a private outdoor pool of 48 m^3. Three times a week during a period of 4 months, the user swims for 60 minutes per event.

Generally, active substances used to sanitize swimming pools are assumed to be non-volatile due to their salt character. Further, the inhalation exposure in outdoor pools will be

negligible, as atmospheric concentrations of volatile by-products such as trihalomethanes (e.g. chloroform) above the pool water surface are very low, even when their concentrations in water are high. Modelling and measurements in outdoor pools demonstrate low concentrations of volatile organic chemicals in proximity to outdoor pools.[32)]

To calculate the exposure of the user during swimming the 'constant rate' model is used for both dermal exposure and oral exposure.

Dermal and oral exposure

- *Frequency*

During a period of 4 months the user swims 3 times a week i.e. 52 times a year.

- *Exposure time*

For exposure time a default value of 60 min is used for both dermal uptake (diffusion through skin) and oral exposure.

- *Weight fraction*

The weight fraction is the calculated weight fraction of the active substance in the swimming pool water.

- *Concentration*

The concentration (g/cm^3) is the calculated weight fraction of the active substance in the swimming pool water (density water 1 g/cm^3).

Dermal exposure: instant application

- *Exposed area*

The exposed area of the body[3)] is 17 500 cm^2.

- *Product amount*

It is assumed that not the total amount of swim water is in contact with the skin but only a layer of 1 cm around the exposed skin; thus, the amount of swim water is 17500 cm^3. The default value for amount (diluted) product is set at 17500 grams.

Oral exposure: constant rate

- *Ingestion rate*

According to the Standard Operating Procedures for swimming pools[34)], the assumed mean ingestion rate for adults is 50 ml/hr. Different WHO reports stated different ingestion rates. WHO[35)] gives an assumed volume of water ingestion of 20 to 50 ml water per hour of swimming. WHO[32)] gives for an adult swimmer and for a competitive swimmer an ingestion rate of 50 and 225 ml/hr, respectively. Moreover, WHO[36)] indicates an amount of 100 ml consuming per event. Using these data, the default value for ingestion rate is set at 50 ml/hr or 830 mg/min (density 1 g/cm^3).

Default post-application swimming pool disinfectants; outdoor private swimming pool

	Default value	**Q**	**References, comments**
General			
Frequency	52 $year^{-1}$	2	See above
Dermal			
Exposure, instant application/			
Exposed area	17500 cm^2	4	3)
Product amount $_{dilution}$	17500 g	1	See above
Uptake: diffusion through skin			
Exposure time	60 min	2	See above
Oral			
Exposure, constant rate			
Ingestion rate	830 mg/ min	1	See above
Exposure time	60 min	2	See above
Uptake, fixed fraction			
Uptake fraction	1	2	Potential dose

7 Waterbed conditioners, disinfectants for chemical toilets and rubbish bins

In this chapter, disinfectant products are described for waterbeds (section 7.1), chemical toilets (section 7.2) and for rubbish bins (section 7.3).

7.1 Waterbed conditioners

Waterbeds
There are two kinds of waterbeds[37)]:
- hardside waterbed with hard, non-insulated surrounds; water volume circa 725 litres
- softside waterbed with soft insulated surrounds; water volume circa 550 litres

For the scenario below, a waterbed with a volume of 600 L is defined. The inlet of the waterbed consists of an inside plug and a sealing cap which is fastened on a valve stem threading.

Use
Waterbed conditioner is dosed to prevent and to control bacteria and algae in waterbeds. These products have as active substance didecyldimethyl ammonium chloride (DDAC: 45 g/L) or alkyldimethylbenzyl ammonium chloride (ADBAC: 490 g/L); both are quaternary ammonium compounds (quats).
According to the instructions for use of the product based on ADBAC, an amount of 4 ml is needed for every 100 litres of fresh water; thus, for a waterbed of 600 litres an amount of 24 ml is required. Two of the three instructions for use stated that the user should add the (whole) content of the bottle to the water in the waterbed every 6 months.
The instructions for use of DDAC stated a dose of 100 ml disinfectant product per 300 litres of fresh water; thus, for a waterbed of 600 litres an amount of 200 ml is required. When filling up or refilling the waterbed with fresh water, a same proportion of product should be added. The use frequency for waterbed conditioners was not stated.

Scenario
Half yearly, the private user pours one bottle (content about 120 ml) with disinfectant via the inlet into the water of the bed. The exposure due to pouring liquid waterbed conditioners is comparable with the exposure during mixing and loading liquid (see section 2.2.1).

Quats (active substance) used in waterbed conditioners are non-volatile due to their salt character. Therefore, the inhalation exposure to quats is considered to be negligible and it is not described in this section. When another active substance is under consideration, possibility of inhalation exposure should be carefully checked.
Dermal exposure due to mixing and loading is described with the ‘instant application’ model (see section 2.2.1).

Defaults

Default values for waterbed conditioners: mixing and loading liquid

	Default value	Q	References, comments
General			
Frequency	2 $year^{-1}$	3	See above
Dermal			
Exposure, instant application			
Exposed area	215 cm^2	3	One palm: ¼ area hands[3)]
Product amount	0.01 g	3	See section 2.2.1
Uptake: diffusion through skin			
Exposure time	3 min	2	See section 2.2.1

7.2 Disinfectants for chemical toilets

Use

Chemical (cassette) toilets are toilet systems that are built into the bathroom of caravans, motor homes, narrow boats or any type of recreational vehicle. The content of the cassette toilets are 17 and 21 litres. There are also portable toilets with a capacity ranging from 10 to 21 litres[38)].

To control and prevent pathogenic organisms, non-professionals use disinfectants in chemical toilets. At the moment, one disinfectant product containing formaldehyde is registered at the CTB[7)], available in containers of one litre and two litres. The private user can add the disinfectant by placing the waste tank upright and turning the emptying spout upwards. After unscrewing the emptying spout cap, the disinfectant can be added via the emptying spout to the waste tank. Next, about two litres of water should be added, enough to ensure that the bottom of the waste tank is covered with liquid[38)].

Scenario

The scenario describes a private user who pours the stated quantity of disinfectant fluid via the emptying spout into the waste tank (17 litres) i.e. 6 ml per litre toilet content (instructions for use). The chemical toilet is used for a period of 4 weeks a year. Every 4 days after emptying the waste tank, the user adds the stated amount of disinfectant to the content of the waste tank. The exposure due to pouring liquid disinfectant is similar to the exposure of mixing and loading liquid (see section 2.2.1). It is assumed that during use of a chemical toilet the private user is not exposed to the disinfectant.

To calculate the exposure of the user during mixing and loading, the ‘evaporation’ model, constant surface, is used for inhalation exposure and the ‘instant application’ model is used for dermal exposure. The latter is described in section 2.2.1.

General

- *Frequency*

During a period of 28 days, the user empties the waste tank every 4 days. This results in a frequency of 7 times a year.

Inhalation exposure: evaporation from a constant surface

- *Molecular weight matrix*

The 'molecular weight matrix' is roughly given by M_w / fraction solvents (see section 2.2.1). If the disinfectant contains for instance 26% g/v formaldehyde (Mw 30 g/mol) and 74% solvents, the molecular weight can be calculated as follows: 30 g/mol / 0.74 = 41 g/mol.

Defaults

Default values for disinfectants chemical toilets: mixing and loading liquid

	Default value	Q	References, comments
General			
Frequency	7 $year^{-1}$	3	See above
Inhalation			
Evaporation, constant surface			
Exposure duration	1.33 min	3	See section 2.2.1
Product amount	500 g	3	See section 2.2.1
Room volume	1 m^3	1	See section 2.2.1
Ventilation rate	0.6 hr^{-1}	1	Unspecified room[3)]
Release area	0.002 m^2	2	See section 2.2.1
Application duration	1.33 min	3	See section 2.2.1
Temperature	20 ˚C	4	Room temperature
Density	1.0 g/ cm^3	3	Density water
Mass transfer rate	Langmuir's method		See help-file ConsExpo
Mol weight matrix			Calculated: see above
Uptake			
Uptake fraction	1	2	Potential dose
Inhalation rate	24.1 L/min	3	Light exercise [62)]
Dermal			
Exposure, instant application			
Exposed area	215 cm^2	3	One palm: ¼ area hands[3)]
Product amount	0.01 g	3	See section 2.2.1
Uptake: diffusion through skin			
Exposure time	3 min	2	See section 2.2.1

7.3 Disinfectants for rubbish bins

Use

To disinfect rubbish bins one product, containing cresol, was registered by the CTB[7)]. The instructions for use state that the surfaces and materials must be cleaned thoroughly and the excess water must be removed. The 'leaving on' duration of the disinfectant is at least 5 minutes and during this time the surfaces must be kept wet. The formulation should be diluted to 3%.

Scenario
The scenario describes a private user who disinfects a rubbish bin 6 times per year (outdoors). The user mixes and loads liquid into a bucket filled with water to produce 5 litres of ready-for-use product. After this, the application is to be carried out on the surface area of a dustbin (volume 240 litres; surface area ca. 2.5 m^2) with the diluted formulation, using a broom. After 5 to 10 minutes, the user puts the rubbish bin on its side for draining off the excess of diluted formulation.

To calculate the dermal exposure of the private user the 'instant application' model is used. This model is used for the dermal exposure during mixing and loading and during application.
As the application is done outdoors, it is assumed that the inhalation exposure during mixing and loading, and application is negligible.

General
- *Frequency*

It is assumed that the user disinfects the rubbish bin every month during springtime and summertime, which results in a frequency of 6 times a year. This is set as default value for frequency.

Mixing and loading
For the defaults for mixing and loading a liquid, see section 2.2.1.

Application

Dermal exposure: instant application
- *Exposed area*

The exposed area is the skin surface area of forearms and hands i.e. 1900 cm^2 (see section 4.3).

- *Product amount*

During dispersing and draining off the diluted product, the user has dermal contact with the diluted formulation. Exposure data regarding this is not available. It is assumed that the spillage during disinfecting rubbish bins is larger than during slightly brushing the pavement (spillage 0.05%; see section 3.3). For estimating the dermal exposure, a percentage of 0.1 is taken as default value for amount of spillage. An amount of 5 litres solution is required for disinfecting a dustbin; the dermal exposure is therefore 5 ml i.e. 5 g diluted formulation (density 1 g/ cm^3).

- *Weight fraction*

The weight fraction is the calculated weight fraction of the *diluted* formulation.

Dermal uptake: diffusion through skin
- *Concentration*

The concentration (g/cm^3) is the calculated weight fraction of the diluted formulation (density water 1 g/cm^3).

- *Exposure time*

The exposure time is total duration for application, i.e. spreading the diluted formulation and draining off the excess of water, which is estimated at 5 minutes.

Defaults

Default values for disinfectants rubbish bins: mixing and loading liquid

	Default value	Q	References, comments
General			
Frequency	6 $year^{-1}$	2	See above
Dermal			
Exposure, instant application			
Exposed area	215 cm^2	3	One palm: ¼ area hands[3)]
Product amount	0.01 g	3	See section 2.2.1
Uptake: diffusion through skin			
Exposure time	3 min	2	See section 2.2.1

Default values for disinfectants rubbish bins: application

	Default value	Q	References, comments
General			
Frequency	6 $year^{-1}$	2	See above
Dermal			
Exposure, instant application			
Exposed area	1900 cm^2	3	Area hands[3)] and forearms; see section 4.3
Product amount $_{dilution}$	5 g	1	See above
Uptake: diffusion through skin			
Exposure time	5 min	1	See above

8 Veterinary hygiene biocidal products

Veterinary hygiene biocidal products are biocides for veterinary hygienic purposes, including products that are used in accommodations in which animals are housed, kept or transported.

To disinfect residences for birds, pigeons and chickens, consumers use veterinary hygiene biocidal products. Residences, feeding and drink troughs are disinfected when the animals have contracted a fungal, viral or bacterial disease. Disinfectant for fumigation with active ingredient paraformaldehyde is permitted as a disinfectant for bird residences. Besides fumigation, disinfection with a diluted formulation takes place as well. Both disinfectant for fumigation and Halamid with active ingredient sodium-p-toluene sulphon chloramide can be used by consumers.

Veterinary hygiene disinfectants are also required to disinfect transport vehicles for the transport of sheep, goats and others, often after each transport which can be done by wiping or spraying diluted disinfectants such as sodium dichloride isocyanuric acid (DCCNa) and Halamid.

Further, veterinary hygiene biocides are used to disinfect milking systems by means of a cycling procedure i.e. a pre-rinse cycle, a cleaning and disinfecting cycle and a post-rinse cycle. In the disinfecting cycle, a veterinary hygiene product such as sodium hypochlorite is necessary to destroy micro-organisms.

The authorized disinfectants (CTB register[7)]) applied in veterinary hygiene biocidal products are restricted to active substances (a.s.) as mentioned in Table 16.

Table 16: Application of active substances in veterinary hygiene biocidal products

Application	Active substance (a.s.)	Type
Fumigation bird residences	Paraformaldehyde [a)]	Tablet
Wiping bird and animal residences, animal transport vehicles	- Sodium dichloride isocyanuric acid [DCCNa] - Sodium-para-toluene sulfon chloroamide	Tablet Powder
Spraying animal residences, animal transport vehicles	- Sodium dichloride isocyanuric acid [DCCNa] - Sodium-para-toluene sulfon chloroamide	Tablet Powder
Disinfecting cycle in milking equipment	- Sodium dichloride isocyanuric acid [DCCNa] - Combination sodium hypochlorite with either sodium hydroxide or potassium hydroxide [Na $(OCl)_2$ plus NaOH or KOH]	Tablet/ powder Liquid

a) a white solid polymer of formaldehyde, $(HCHO)_n$ ($n \geq 6$)

For disinfection, bird residences could be fumigated or wiped (or sprayed); animal residences and animal transport vehicles could both be disinfected by spraying or wiping. In this chapter, the exposure during different treatments with veterinary hygiene biocidal products is described: exposure during fumigation bird accommodations (section 8.1), exposure during wiping animal accommodations (section 8.2), exposure during spraying animal vehicles (section 8.3) and exposure during disinfecting milking machines (section 8.4).

Note
Default values should be adjusted for calculating the exposure during wiping animal transport vehicles instead of animal accommodations, as well as when calculating the exposure during spraying animal accommodations instead of animal transport vehicles.

8.1 Exposure during fumigation bird accommodations

Use
One possibility to disinfect accommodations for domesticate birds is to use a fumigator, which releases formaldehyde gas. Formaldehyde penetrates poorly and its effectiveness is dependent on temperature and humidity. It is most effective above a temperature of 20°C (minimum temperature of 15°C) and a relative humidity of 65% [41)].
Bird quarters should be thoroughly cleaned before fumigation and the excess water should be removed. The room must be kept tightly closed during the disinfection treatment (4- 6 hours; instructions for use) and it must be aired before reuse.
To apply paraformaldehyde, the tablet must first be lighted, releasing formaldehyde gas that fumigates and decontaminates all surfaces in the enclosed room. Liquid disinfectants cannot reach every surface, including crevices, so a fumigant such as paraformaldehyde is used when all surfaces need to be decontaminated[42)].

Scenario
The scenario describes a private user who sets fire to a quarter of a tablet (about 40 grams) containing paraformaldehyde in a dovecot of 20 m^3 measuring 4.30 m (length) x 2.50 m (height) x 1.85 m (depth)[43)]. After the tablet has been lightened, the user leaves the room and after disinfection (4 to 6 hrs), the user opens the windows to ventilate the dovecot (re-entry). The disinfection treatment is done every month[44)].

It is assumed that all paraformaldehyde is converted in formaldehyde gas after the tablet is burned up and that during re-entry after 4-6 hours the inhalation exposure is negligible. To calculate the exposure of the user during lighting the ‘evaporation’ model, instantaneous release, is used for inhalation exposure and the ‘constant rate’ model is used for dermal exposure.

General
- *Frequency*

The use frequency mentioned by pigeon fanciers on the internet were every fortnight, every month, twice a quarter, and every quarter. The frequency is set at once a month.

Inhalation exposure: evaporation, constant rate
- *Exposure duration*

It is assumed that the user leaves the dovecot directly after lightning the tablet. The default value for exposure duration for inhalation is set at 0.5 minute. At re-entry it is assumed that the air concentration of active substance is considerably diminished compared to the air concentration in the beginning of the disinfection.

- *Ventilation*

During the fumigation, the room must be kept tightly closed; it is assumed that the ventilation is 0.6 hr^{-1} which is the ventilation of an unspecified room[3)].

- *Product amount*

One package of 170 grams (one tablet) is sufficient for a room volume of 75 to 100 m^3 that is ¼ of tablet is sufficient for 17.5 – 25 m^3 (directions for use). Consequently, 42.5 grams of product will be applied for a dovecot of 20 m^3.

- *Emission duration*

It is assumed that it takes 30 minutes to burn up the tablet with paraformaldehyde.

Dermal exposure

- *Release duration*

The release duration is the time during which the compound is applied. In section 2.2.3, the release duration for mixing and loading tablets is set at 0.1 minute. In this case, the user has to break and lighten the tablet; the release duration is estimated at 0.5 minute.

Default values for disinfectants bird accommodations: fumigation

	Default value	**Q**	**References, comments**
General			
Frequency	12 $year^{-1}$	2	See above
Inhalation			
Evaporation, constant rate			
Exposure duration	0.5 min	1	See above
Product amount	42.5 g	2	See above
Room volume	20 m^3	2	See above
Ventilation rate	0.6 hr^{-1}	1	Unspecified room[3)]
Emission duration	30 min	1	See above
Uptake			
Uptake fraction	1	2	Potential dose
Inhalation rate	24.1 L/min	3	Light exercise [62)]
Dermal			
Exposure, constant rate			
Contact rate	0.033 mg/min	2	See section 2.2.3
Release duration	0.5 min	1	See above
Uptake, fixed fraction			
Uptake fraction	1	2	Potential dose

8.2 Exposure during wiping animal accommodations

General use

Before starting disinfection animal accommodations, surface areas should be cleaned and excess water should be removed. During the 'leaving on' time to destroy micro-organisms, surfaces should be kept wet, and approximately 250 – 400 ml in-use formulation per m^2 is required depending on the absorption capacity of the surface and the relative atmospheric humidity [45)]. For accommodations in which animals are housed, kept or transported the minimal duration of disinfection is 5-20 minutes. When the formulation is regularly used on

walls and floors, one has to prevent that liquid layers on surfaces dry in; the surfaces should therefore be rinsed with water to remove the residues of the diluted formulation.
One powder product is registered[7)] as disinfectant for animal accommodation/ transport, which contains sodium para-toluene sulfon chloroamide. To disinfect animal accommodations, the instructions of use stated a 1% in-use solution i.e. 50 g per 5L. Further, tablets containing DCCNa (see table 16) are registered[7)].

Scenario
The scenario describes a private user who loads powder or tablet(s) into a bucket, then adds water into the bucket to produce 5 litres of ready-for-use product. Subsequent to mixing and loading, the user washes and wipes a hen house measuring 2 m (length) x 2 m (height) x 1.5 m (depth). The treated surface is set at 20 m^2. After disinfecting the user leaves the hen house. Only when disinfection is required the user will treat the hen house, which is set at two times a year.

To calculate the dermal exposure of the private user during mixing and loading the 'constant rate' model is used.

The active substances used are assumed to be non-volatile due to their salt character. Therefore, it is assumed that the inhalation exposure to the active substances is negligible and it is not described in this section. When another active substance is under consideration, possibility of inhalation exposure should be carefully checked.
To calculate the exposure of the user during application the 'constant rate' model is used for dermal exposure.

Mixing and loading powder
For the defaults for mixing and loading powder, see section 2.2.2.

Mixing and loading tablets
For the defaults for mixing and loading tablets, see section 2.2.3.

Dermal exposure: constant rate
- *Release duration*

The release duration is the time during which the compound is applied. According to different instructions for use, 4, 5 or 10 tablets (DCCNa) in 10 litres should be used for disinfection animal accommodations; for tablets, the release duration is 0.1 minute per tablet (see section 2.2.3). It is assumed that 5 tablets are dissolved in 5 litres of water and the release duration is set at 0.5 min.

Application

Dermal exposure: instant application
- *Weight fraction*

The weight fraction is the calculated weight fraction of the *diluted* formulation.

Dermal uptake: diffusion through skin
- *Concentration*

The concentration (g/cm^3) is the calculated weight fraction of the diluted formulation (density water 1 g/cm^3).

- *Exposure time*

The treated surface area is set at 20 m^2. The application 'wiping' is more a question of spreading the diluted formulation to disinfect the surface than of cleaning. As default for wiping one minute per square meter is taken which results in an exposure duration of 20 min.

Defaults

Default values for disinfectants animal accommodations: mixing and loading powder

	Default value	Q	References, comments
General			
Frequency	2 $year^{-1}$	2	See above
Dermal			
Exposure, constant rate			
Contact rate	0.033 mg/min	2	See section 2.2.2
Release duration	1.33 min	3	See section 2.2.2
Uptake, fixed fraction			
Uptake fraction	1	2	Potential dose

Default values for disinfectants animal accommodations: mixing and loading tablets

	Default value	Q	References, comments
General			
Frequency	2 $year^{-1}$	2	See above
Dermal			
Exposure, constant rate			
Contact rate	0.033 mg/min	2	See section 2.2.3
Release duration	0.5 min	1	See above
Uptake, fixed fraction			
Uptake fraction	1	2	Potential dose

Default values for disinfectants animal accommodations: wiping

	Default value	Q	References, comments
General			
Frequency	2 $year^{-1}$	2	See above
Dermal			
Exposure, instant application			
Exposed area	1900 cm^2	3	Area hands[3)] & forearms; See section 4.3
$Product_{dilution}$	19 g	1	See section 4.3
Uptake: diffusion through skin			
Exposure time	20 min	2	See above

8.3 Exposure during spraying transport vehicles for animals

When transporting sheep, goats and other animals, disinfection of the transport vehicle is required, often after each transport. Presumably, transport vehicles of horses do not need to be disinfected except in case of an infectious disease outbreak.
One powder product is registered[7)] as disinfectant for animal accommodation/ transport, which contains sodium para-toluene sulfon chloroamide. To disinfect animal transport vehicles, the instructions of use stated a 2% in-use solution i.e. 200 g per 10L. Further, tablets containing DCCNa (see table 16) are registered[7)].

Scenario
The scenario describes a private user who mixes and loads formulation into a 5-L knapsack sprayer filled with water to produce 5 litres of ready-for-use product. After this the user sprays as a coarse spray a trailer measuring 3.2 m (length) x 1.6 m (width) x 2.3 m (height)[46)] which is done inside and outside the trailer underneath, wheels and axles. The trailer is used to transport goats 6 times a year.

To calculate the dermal exposure of the private user during mixing and loading, the 'constant rate' model is used. To calculate the exposure of the user during application the 'spray' model is used for inhalation exposure and the 'constant rate' model is used for dermal exposure.

Models
ConsExpo is developed for products applied indoors. As the spraying scenario describes application outdoors, the 'spray' model will overestimate the inhalation exposure. For the scenario, a 'room' volume is defined as 50 m^3, i.e. 20-m^2 surface area (i.e. area around the trailer) multiplied with 2.5 m (standard room) height. For ventilation, the ventilation[3)] of an unspecified room is taken i.e. 0.6 hr^{-1}. The scenario describes a worst-case situation. Consequently, the actual inhalation exposure during spraying outdoors is smaller than the calculated exposure with ConsExpo.

Another option to assess inhalation is to apply UK POEM model[13)] which describes an amateur using a 'home garden sprayer' (5 litre tank) for low-level spraying of pesticides outdoors. The target area of UK POEM differs from the surface area of the trailer i.e. crops versus surfaces; in the case of the latter the bounce back effect is large which might result in smaller droplets.

General
- *Frequency*

Goats are transported when they are sold, when they will be slaughtered or for exhibition. It is assumed that to transport goats by means of a trailer is done 6 times a year.

Mixing and loading

Mixing and loading powder
For the defaults for mixing and loading powder, see section 2.2.2.

Mixing and loading tablets
For the defaults for mixing and loading tablets, see section 2.2.3.

Dermal exposure: contact rate

- *Release duration*

The release duration is the time during which the compound is applied. According to the use instruction, 10 tablets in 10 litres should be used for disinfection animal accommodations. For tablets, the release duration is 0.1 minute per tablet (see section 2.2.3). When dissolving 10 tablets in 10 litres water, the total release duration will be 1.0 minute.

Application

Inhalation and dermal exposure

- *Weight fraction*

The weight fraction is the calculated weight fraction of the *diluted* formulation.

Inhalation exposure: spray model

- *Spray duration and exposure duration*

The default value for exposure duration equals the duration for spraying which is set at 17 minutes i.e. 5 000 ml diluted formulation divided by 300 ml/min (5 g/sec; see section 3.2).

Dermal exposure: constant rate

For dermal exposure, data from UK POEM[13)] is used (see section 3.2).

Defaults

Default values for disinfectants animal transports: mixing and loading powder

	Default value	**Q**	**References, comments**
General			
Frequency	6 $year^{-1}$	2	See above
Dermal			
Exposure, constant rate			
Contact rate	0.033 mg/min	2	See section 2.2.2
Release duration	1.33 min	3	See section 2.2.2
Uptake, fixed fraction			
Uptake fraction	1	2	Potential dose

Default values for disinfectants animal transports: mixing and loading tablets

	Default value	**Q**	**References, comments**
General			
Frequency	6 $year^{-1}$	2	See above
Dermal			
Exposure, constant rate			
Contact rate	0.033 mg/min	2	See section 2.2.3
Release duration	1.0 min	1	Calculated; see above
Uptake, fixed fraction			
Uptake fraction	1	2	Potential dose

Default values for disinfectants animal transports: spraying

	Default value	Q	References, comments
General			
Frequency	6 $year^{-1}$	1	See above
Inhalation			
Exposure, spray model			
Spray duration	17 min	2	See above
Exposure duration	17 min	2	I.e. spray duration
Room volume	50 m^3	1	See above
Room height	2.5 m	1	Standard room height
Ventilation	0.6 hr^{-1}	1	Unspecified room[3)]
Mass release rate	5 g/s	2	See section 3.2
Airborne fraction	0.2	2	See section 2.3.1
Weight fraction non-volatile			See section 2.3.1
Density non-volatile	1.8 g/ cm^3	3	See section 2.3.1
Initial particle distribution			
Median (C.V.)	50 μm (0.6)	2	See section 2.3.1
Inhalation cut-off diameter	15 μm		Default
Uptake			
Uptake fraction	1	2	Potential dose
Inhalation rate	24.1 L/min	3	Light exercise [62)]
Non-respirable (oral) uptake			
Oral uptake fraction	1	2	Potential dose
Dermal			
Exposure, constant rate			
Contact rate	540 mg/ min	2	See section 3.2
Release duration	17 min	2	I.e. spray duration
Uptake, fixed fraction			
Uptake fraction	1	2	Potential dose

8.4 Exposure during disinfecting milking machines

Use

Cleaning of automatic milking systems consists of three cycles: a pre-rinse cycle, cleaning and disinfecting cycle and a post-rinse. To avoid contamination in the subsequent cycle, the system should be drained thoroughly between the different cycles. By pre-rinsing with clean lukewarm water, most of the milk remains can be removed from the system. This is done without circulation i.e. water with milk residues is washed away directly down the drain[47)]. The disinfecting cycle is done by circulation of fluid containing disinfectants and the start temperature is between 50 ^{0}C and 70 ^{0}C. In this cycle, the fluid is circulated through the system for some time. To have sufficient disinfection, the exposure time has to be at least 5 minutes; some instructions for use stated 10 to 15 minutes. At the end of the circulation cycle the temperature of the fluid should be at least 35 ^{0}C to 40 ^{0}C [47)].

Before starting the post-rinse cycle, the diluted disinfectant is drained off. The post-rinse cycle with clean cold water has to remove residuals to avoid contamination of the milk with disinfectant. The remains are washed away directly down the drain[47)].

Scenario
The scenario describes a private user who milks ten goats with an automatic 'mini-milking' machine, which is done two times a day. After each milking, the mini-milking machine is cleaned by a pre-rinse cycle, a disinfecting cycle and by a post-rinse cycle (see use). After the pre-rinse cycle, the user mixes and loads disinfectant (liquid, tablet or powder) in a bucket filled with 8 litres of water (temperature 50 ^{0}C - 70 ^{0}C) and the diluted formulation is circulated for 5 to 15 minutes. Before starting the post-rinse cycle, the diluted disinfectant is drained off. After disinfecting the mini-milking machine, peripheral equipment such as milk can, bucket(s), and sieve is manually disinfected during 5 minutes.

To calculate the exposure of the user during mixing and loading, the 'instant application' model is used for dermal exposure to liquid, and the 'constant rate' model is used for dermal exposure to powder/ tablet(s).
To calculate dermal exposure of the user during disinfecting peripheral equipment the 'instant application' model is used.
Exposure during disinfecting the mini-milking machine is considered negligible, because cycling of the diluted disinfectant takes place in a closed system.

General
- *Frequency*

The system cleaning of the automatic min-milking machine is done two times a day (see scenario). The default value for frequency is set at 730 times a year.

Mixing and loading powder
The used amount of powder is about 30-45 grams per 10 litres water which depends on the degree of hardness of water. For the defaults for mixing and loading powder, see section 2.2.2.

Mixing and loading tablets

Dermal exposure: contact rate
- *Release duration*

The release duration is the time during which the compound is applied. According to the use instruction, one tablet in 10 (8) litres should be used for disinfection milking equipment. For tablets, the release duration is 0.1 minute per tablet (see section 2.2.3).

Defaults

Default values for disinfectants milking machines: mixing and loading liquid

	Default value	Q	References, comments
General			
Frequency	730 $year^{-1}$	3	See above; 2 day^{-1}
Dermal			
Exposure, instant application			
Exposed area	215 cm^2	3	One palm: ¼ area hands[3)]
Product amount	0.01 g	3	See section 2.2.1
Uptake, diffusion through skin			
Exposure time	3 min	2	See section 2.2.1

Default values for disinfectants milking machines: mixing and loading powder

	Default value	Q	References, comments
General			
Frequency	730 $year^{-1}$	3	See above; 2 day^{-1}
Dermal			
Exposure, constant rate			
Contact rate	0.033 mg/min	2	See section 2.2.2
Release duration	1.33 min	3	See section 2.2.2
Uptake, fixed fraction			
Uptake fraction	1	2	Potential dose

Default values for disinfectants milking machines: mixing and loading tablets

	Default value	Q	References, comments
General			
Frequency	730 $year^{-1}$	3	See above; 2 day^{-1}
Dermal			
Exposure, constant rate			
Contact rate	0.033 mg/min	2	See section 2.2.3
Release duration	0.1 min	1	See above
Uptake, fixed fraction			
Uptake fraction	1	2	Potential dose

Default values for disinfectants milking machines: disinfecting peripherals

	Default value	Q	References, comments
General			
Frequency	730 $year^{-1}$	3	See above; 2 day^{-1}
Dermal			
Exposure, instant application			
Exposed area	1900 cm^2	3	Area hands[3)] & forearms; see section 4.3
Weight fraction $_{dilution}$			Calculated
Product $_{dilution}$	19 g	1	See section 4.3
Uptake: diffusion through skin			
Exposure time	5 min	2	See above

9 Drinking water disinfectant products

Drinking water disinfectants are products for disinfecting potable water, pump water, well water and tap water in areas or on locations where there is doubt about the bacteriological quality of drinking water and there is no opportunity to boil the water (instructions for use). During e.g. wild camping, non-professionals treat water with disinfectant products containing sodium hypochlorite as its active substance.
Furthermore, a disinfectant (spray) for water coolers is authorized by CTB[7)], which contains hydrogen peroxide as its active substance. This product is used by private users as well as by professional users. In the next sections disinfectants for drinking water (section 9.1) and disinfectants (spray) for water coolers (section 9.2) will be discussed.

9.1 Disinfectants for drinking water

Use
Disinfectant for drinking water is available in a 30 ml dropping bottle. According to the instructions for use, 5 drops of the formulation should be mixed with one litre of water. After half an hour, the water is potable.

Scenario
The scenario describes a private user who treats drinking water during a fortnight while staying on locations with bacteriological unreliable drinking water. The user drinks every day 2 litres of water[48)].

The application is comparable with mixing and loading. As the application is done with a dropping bottle, the exposure is considered negligible.
To calculate the oral exposure of the user during post-application, the 'direct intake' model is used.

Post-application

Oral exposure: direct intake
- *Weight fraction*

The weight fraction is the calculated weight fraction of the diluted formulation (see Box 2).

Box 2: Estimation weight fraction of sodium hypochlorite for ingestion

The Guidelines for drinking water quality[48)] gives a guideline value of 5 mg/L for chlorine in drinking water. The following remark was made: 'for effective disinfection, there should be a residual concentration of *free chlorine* of ≥ 0.5 mg/ litre after at least 30 min contact time at pH < 8.0'. The minimal concentration of free chlorine (Cl_2; Mw 70.91 g/mol) expressed as sodium hypochlorite (Mw 74.44 g/mol) therefore is assumed to be 0.5 mg/L x 74.44 / 70.91 = 0.52 mg/L.

The two product registered have a concentration of 47.6 g/L sodium hypochlorite. It is assumed that one drop of formulation is about 50 µl; thus, 250 µl is used in one litre water and the dilution is 4000 times. Consequently, the initial concentration of the diluted formulation is 0.012 g/L, i.e. 12 mg/L sodium hypochlorite. During disinfection chlorine will be bound to organic matter and it is more than likely that the concentration of free chlorine will be reduced during the disinfection, i.e. < 12 mg/L. At a pH of 7.5 there is a balance between hypochlorite ion and hypochlorous acid (ratio 1:1; see section 4.1). If hypochlorous acid is bound to organic matter, the concentration will be lowered and sodium hypochlorite acts as a reserve. Below given equilibrium shifts to some extent to the right and the balance between OCl^- and HOCl will be re-established.

$Na^+ + OCl^- + H_2O \leftrightarrow HOCL + Na^+ + OH^-$ neutral conditions

Considering these data, the weight fraction of sodium hypochlorite should be between 0.5 mg/L and 12 mg/L i.e. ranging from $5*10^{-7}$ g/g to $1*10^{-5}$ g/g.

For calculating the oral exposure, the weight fraction can be set at $1* 10^{-5}$ g/g, which is a worst-case assumption. This means that the weight fractions for both hypochlorite ion and hypochlorous acid are $5 * 10^{-6}$ g/g.

Defaults

Default values for post-application disinfectants drinking water: ingestion

	Default value	Q	References, comments
General			
Frequency	14 $year^{-1}$	2	See above
Oral			
Exposure, direct intake			
Amount ingested $_{dilution}$	2000 g	2	See above
Weight fraction $_{dilution}$		2	See Box 2
Uptake, fixed fraction			
Uptake fraction	1	2	Potential dose

9.2 Disinfectants for water coolers

Disinfectant liquids for full hygienic cleaning of the reservoir and the pipes inside the water cooler are particularly intended for the periodic cleaning by professionals. Water cooler associations advise a cleaning frequency of four times per year[49)]
For disinfection spraying of water coolers by both professionals and private users, one product containing 2.5% hydrogen peroxide is registered. The spray is intended as addition to other disinfection methods as mentioned above. It has been developed specifically to hygienically clean the (outside) contact points of the water cooler such as bottle cap, faucets

and water guard. A water guard protects the cooler from water spillage due to bottle crack and it seals the reservoir from dust and other air-borne contamination. The water bottle stands outside the water cooler.

Use
A disinfectant pump-spray is used to clean hygienically the contact points of the water cooler[49)]. According to the instructions for use the water guard, the surface area of the reservoir (circa 1.75 L[49)]) *in* the water cooler, demountable parts and (parts of the) taps should be sprayed every 3 months. To disinfect adequately, the spray should act on the objects for 30 minutes. After disinfecting, two cups with water should be drawn off to eliminate residuals.

Scenario
The scenario describes a private user who sprays the different parts of the water cooler every 3 months (see use). After the 'leaving on' duration of 30 minutes, the user taps two cups of water, which is thrown away. On the day of application, the user drinks one litre water from the water cooler.

To calculate the exposure of the user during spraying the 'spray' model is used for inhalation exposure and the 'instant application' model is used for dermal exposure.
The spray model can be used since hydrogen peroxide concentration is low (< 5%) and the vapour pressure of hydrogen peroxide in the diluted solution with water is low.

To calculate the oral exposure of the user during post-application, the 'direct intake' model is used. The oral exposure is calculated on the day of application; on the days after the application the exposure is considered to be negligible.

Application

Inhalation exposure
- *Exposure duration*

A total time of 4 hours is taken as the default value for exposure duration.

- *Mass generation rate*

For eau de toilette pump sprays, the mass generation rate of eau de toilette spray is given as 0.15 g/s [50)] and the density as 0.84 g/cm^3 [50)]; thus, per second a volume of 0.18 cm^3 is sprayed. With a density of 1 g/cm^3 the 'volume generation rate' of 0.18 cm^3/ sec equals a mass generation rate of 0.18 g/sec.
It is assumed that the mass generation rate of the disinfectant spray is much smaller compared to trigger sprays (1.5 g/sec) and twice as large compared to eau de toilette pump sprays. The default value for mass generation rate is set at 0.36 g/ sec.

- *Spray duration*

With a mass generation rate of 0.36 g/s and an amount of 20 ml per application (appendix II, registration[7)]), the spray duration can be calculated as 0.9 min (density 1 g/cm^3).

Post-application

Box 3: Estimation weight fraction of hydrogen peroxide for ingestion

As 20 ml disinfectant containing 2.5% H_2O_2 is sprayed, the amount of active substance used is 500 mg H_2O_2. After placing the water bottle on the water cooler, the water reservoir of 1.75 L will be filled with water; thus, the concentration of the diluted formulation is maximally 0.286 mg/ml. After disinfecting, two cups of water of about 150 ml/cup is drawn away. Now, the maximum concentration in the water reservoir is 1450 ml * 0.286 mg/ml / 1750 ml = 0.237 mg/ml. It is more than likely that the concentration of 0.237 mg/ml will be reduced during the disinfection.

Hydrogen peroxide disintegrates into water and oxygen if it is in contact with micro-organisms. Every time a cup of water (150 ml) is taken, the reservoir will be filled with fresh water of the water bottle; this means that the concentration of hydrogen peroxid in the water reservoir will be lowered with a factor of 1600 ml/ 1750 ml. On the day of application a private user drinks 1 litres of water which results in about 7 cups of 150 ml water. After 7 cups the end concentration will be 0.13 mg/ml. The mean concentration is estimated at maximally 0.17 mg/ml i.e. $1.7*10^{-4}$ g/g.
For calculating the oral exposure to hydrogen peroxide on the day of application the weight fraction can be set at $1.7 * 10^{-4}$ g/g, which is a worst-case assumption.

Post-application

Oral exposure: direct intake

- *Weight fraction*

The weight fraction is the calculated weight fraction of the diluted formulation (see Box 3).

Defaults

Default values for disinfectants water coolers: spraying

	Default value	Q	References, comments
General			
Frequency	4 $year^{-1}$	3	See above
Inhalation			
Exposure, spray model			
Spray duration	0.9 min	2	See above
Exposure duration	240 min	3	See above
Room volume	20 m^3	3	Unspecified room[3)]
Room height	2.5 m	4	Standard
Ventilation rate	0.6 hr^{-1}	3	Unspecified room[3)]
Mass generation rate	0.36 g/s	2	See above
Airborne fraction	0.2	2	See section 2.3.1
Weight fraction non-volatile			See section 2.3.1
Density non-volatile	1.8 g/ cm^3	3	See section 2.3.1
Initial particle distribution			
Median (C.V.)	50 μm (0.6)	1	See section 2.3.1
Inhalation cut-off diameter	15 μm		
Uptake			
Uptake fraction	1	2	Potential dose
Inhalation rate	24.1 L/min	3	Light exercise [62)]
Non-respirable (oral) uptake			
Oral uptake fraction	1	2	Potential dose
Dermal			
Exposure, constant rate			
Contact rate	46 mg/ min	3	See section 2.3.2
Release duration	0.9 min	2	I.e. spray duration
Uptake, fixed fraction			
Uptake fraction	1	2	Potential dose

Default values for post-application disinfectants water coolers: ingestion

	Default value	Q	References, comments
General			
Frequency	4 $year^{-1}$	3	See above
Oral			
Exposure, direct intake			
Amount ingested $_{dilution}$	1000 g	2	See above
Weight fraction $_{dilution}$		2	See Box 3
Uptake, fixed fraction			
Uptake fraction	1	2	Potential dose

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Appendix: Exposure in public swimming pools

Post application, swimming in a public pool

For assessing the secondary exposure, this appendix describes the exposure via inhalation, ingestion and dermal contact in *public indoor pools*. The inhalation exposure in outdoor pools will be negligible, as atmospheric concentrations above the pool water surface are very low, even when their concentrations in water are high. The exposure in outdoor pools is mainly via the skin or via oral intake[32] (see section 6.5). To calculate the secondary exposure in a public outdoor pool, the default values given for dermal and oral exposure in a public indoor pool are applicable and inhalation exposure could be discarded.
For the secondary exposure in a public indoor pool, the users can be divided in five groups i.e. the baby/ child swimmer, the recreative adult swimmer, the competitive swimmer or athletes, public (indoor non-swimmers) and bath personnel. In this appendix, the occupational exposure of bath personnel such as pool attendants and instructors is not included. The inhalation exposure of the public will be lower than the inhalation exposure of the swimmers, because the concentration of (volatile) chemicals above the pool water surface is higher than the concentration in the ambient air. Furthermore, the public are neither dermally nor orally exposed to pool water. The frequency and the duration of swimming are higher for competitive swimmers than for recreative swimmers. Therefore, competitive swimming is described as worst-case scenario, but high performing athletes are not considered. The following categories will be described: baby 'swimmers', child swimmers and competitive swimmers.

Baby swimming

Swimming for babies is the ability to move through the water, on their own accord for very short distances; the primary manner of forward motion is kicking[51].

Scenario

For a period of 3 months once a week, a baby 4.5 months of age (6.21 kg^3) 'swims' for 30 minutes in an indoor (instruction)pool. The swimming pool measures 10 m (length) x 10 m (width) x 0.5 m (average depth; depth varies between 0 and 1.10 m) i.e. a water surface of 10 m^2 and a water volume of 50 m^3. The pool water has a temperature of 32 ^{0}C.

To calculate the exposure during swimming in a public indoor pool, the 'evaporation model' (constant surface) is used for inhalation exposure and the 'constant rate' model is used for dermal exposure and for oral exposure.

General

- *Age and body weight*

In General Fact Sheet[3], default values for body weight and for body surface are given for adults and children. In the case of a baby/ child swimmer, the age category is chosen for which the highest exposure is expected. The youngest children are the lightest and have the highest uptake per kg of body weight for the same exposure.
Baby swimming lessons can be started at the age of about 12 weeks[52] and the optimal age to start is from 6 to 12 months[51]. Several internet site in the Netherlands stated that baby swimming can start from 6 to 8 weeks (e.g. http://www.ouders.nl/forum/lf00451.htm). For

baby 'swimmers' the age category of 3-6 months is taken with a default value of 4.5 months for age. The corresponding default value for body weight is 6.21 kg[3)].

- *Frequency*

The default value for frequency is set at once per week for a period of 3 months i.e. 13 times a year.

- *Duration*

Internet sites[51,52)] indicate that the 'swimming' time for babies is limited to 30 minutes. This is set as default value for exposure duration for inhalation, exposure time for both dermal exposure and oral exposure.

Inhalation exposure: evaporation from constant surface

- *Product amount*

The 'amount' of pool water that evaporates is set at 50 m^3 (100 m^2 release area and 0.5 m depth) equalling $5*10^7$ grams.

- *Weight fraction*

The weight fraction of the active substance is the concentration in the pool water.

- *Room volume*

For all swimmers, the inhalation exposure mainly occurs above the pool water surface. A height of 0.5 meter is taken and with a release area of 100 m^2, the default 'room' volume is 50 m^3. In this space, the swimmers inhale the chemicals evaporating from the water surface.

- *Ventilation*

There is no data available for the ventilation above the pool water surface. A minimum of two changes per hour should be provided for indoor pool areas[53,54)] which is set as default value. The quality factor Q=1 is assigned.

- *Release area*

It is assumed that an instruction pool has a surface area of 100 m^2 which is taken as default value for release area.

- *Application duration*

It is assumed that there is equilibrium of the disinfectant between water and air above the water surface. To calculate the exposure, the application duration can be set at 30 minutes providing that there is a constant air concentration level.

- *Temperature*

For babies the recommended temperature[52)] is between 29 –30 ^{0}C and the optimal temperature[51)] is 32 ^{0}C. 'The Swimming Information and Documentation Centre' in the Netherlands[63)] stated for baby's younger than 12 months a water temperature of 32 ^{0}C and for baby's older than 12 months a temperature between 30 –32 ^{0}C As default a temperature of 32 ^{0}C is taken.

Dermal exposure: instant application/ diffusion through skin

- *Exposed area*

For a baby of 4.5 months the exposed area of the body[3)] is 3460 cm^2.

- *Product amount*

It is assumed that not the total amount of the swim water is in contact with the skin but only a layer of 1 cm around the exposed skin. With an exposed area of 3460 cm^2, the amount of swim water is 3460 cm^3 or 3460 g. The latter is set as default value for $amount_{dilution}$. The quality factor Q=1 is assigned.

Oral exposure: constant rate

- *Ingestion rate*

For ingestion, two different WHO reports state two different values. According to the WHO[36], a child of 15 kg consumes 250 ml water per event during extensive playing in the water. An ingested rate of 0.5 L per hour (WHO[32]) is given for children while playing and diving. The Standard Operating Procedures for swimming pools[34], gives an assumed mean ingestion rate for adult and children swimmers of 0.05 L per hour. It is assumed that the ingestion rate for baby swimmers equals that of children while playing and diving, which is a worst-case assumption. The default value is set at 0.5 L/hr or 8300 mg/ min.

Child swimmers

Scenario

A child 4.5 years of age (16.3 kg)[3] takes swimming lessons for 60 minutes with a frequency of 2 times a week during the whole year. The swimming indoor pool measures 25 m (length) x 15 m (width) x 1.5 m (average depth; depth varies between 1.0 and 2.0 metres.) i.e. a water surface of 375 m^2 and a water volume of 562 m^3. The pool water has a temperature of 28 ^{0}C.

A number of parameters have the same value as for baby swim. Only the parameters with a different value are mentioned below.

General

- *Age and body weight*

Swimming lessons are available for children aged 4 and up and so, the age category of 3-6 years is taken for child swimmers. The default value for age is set at 4.5 years with a body weight[3] of 16.3 kg.

- *Frequency*

Taking into account that young children take two times a week swimming lessons, the default value for frequency is set at 104 $year^{-1}$.

- *Exposure duration*

For duration the default value is set at 60 minutes in which the duration of swimming lessons (about 30 min) is taken into account. The default value of 60 minutes is set for exposure duration for inhalation, exposure time for both dermal exposure and for oral exposure.

Inhalation exposure: evaporation from constant surface

- *Product amount*

In the Netherlands, a competition swimming pool is 25 or 50 m long and 16 m (6 swimming lanes) or 21 m (8 swimming lanes) wide. The depth varies between the 1.00 and 2.00 (3.80) metres.
Most swimming pools in the Netherlands[55] measure 25 x 15 m. The 'amount' of pool water which evaporate is set at 562 m^3 (25 m x 15 m x 1.5 m), which equals $5.6*10^8$ grams. The quality factor Q=1 is assigned.

- *Room volume*

For swimmers, the inhalation exposure mainly occurs above the pool water surface. A height of 0.5 meter is taken and with a water surface area of 375 m^2, the default 'room' volume is 188 m^3. The quality factor Q=1 is assigned.

- *Release area*

The pool has a surface area of 375 m^2 which is taken as default value for release area.

- *Temperature*

The Swimmers Guide[55)] gives a temperature range from 26 ^{0}C to 34 ^{0}C for swimming pools in the Netherlands. 'The Swimming Information and Documentation Centre' in the Netherlands[63)] stated an ideal water temperature between 28 ^{0}C to 29 ^{0}C and a 'reasonable' water temperature of 10 degrees below body temperature, i.e. 27 ^{0}C.
For temperature, the default value is set at 28 ^{0}C.

Dermal exposure: instant application/ diffusion through skin

- *Exposed area*

For a child of 4.5 years the exposed area of the body[3)] is 7090 cm^2.

- *Product amount*

It is assumed that not the total amount of the swim water is in contact with the skin but only a layer of 1 cm around the exposed skin. Thus, the amount of swim water is 7090 cm^3 or 7090 grams. The latter is set as default value for amount (diluted) product. The quality factor Q=1 is assigned.

Adult swimmers

Scenario

A competitive swimmer (adult 65 kg[3)]) swims for 120 minutes in an indoor pool 5 times a week. The swimming pool measures 25 m (length) x 15 m (width) x 1.5 m (depth) i.e. a water surface of 375 m^2 and a water volume of 562 m^3. The pool water has a temperature of 28 ^{0}C.

A number of parameters have the same value as for baby/ child swim. Only the parameters with a different value are mentioned below.

General

- *Frequency*

According to Mennes[57)] the frequency for a competitive swimmer is 5 times a week or 260 times a year. For competitive swimmers, the latter is taken as default value for frequency.

- *Duration*

The number of hours in a pool is for competitive swimming 2 hours[57)], for a daily training session 2 hours[58)] and for intensive swimming 0.5 hour[59)] with an hour stay.
Using these data, the exposure duration (inhalation exposure) for competitive swimmers is set at 2 hours, which is also applied to exposure time for both dermal exposure and for oral exposure.

Dermal exposure: instant application/ diffusion through skin

- *Exposed area*

The exposed area of the body[3)] is 17 500 cm^2.

- *Product amount*

It is assumed that not the total amount of the swim water is in contact with the skin but only a layer of 1 cm around the exposed skin. Thus, the amount of swim water is 17 500 cm^3 i.e. 17 500 grams. The latter is set as default value for amount (diluted) product. The quality factor Q=1 is assigned.

Oral exposure: constant rate

According to the Standard Operating Procedures for swimming pools[34], the assumed mean ingestion rate for adults is 50 ml/hr. Different WHO reports stated different ingestion rates. WHO[35] gives an assumed volume of water ingestion of 20 to 50 ml water per hour of swimming. WHO[36] indicates an amount of 100 ml consuming per event. Moreover, WHO[32] gives for an adult swimmer and for a competitive swimmer an ingestion rate of 50 and 225 ml/hr, respectively. This is in contrary to the ingestion given for competitive swimmers by Mennes[57]; these expert swimmers ingest hardly any water.
Using these data, it is assumed that competitive swimmers ingest to the same extent water as recreational swimmers do, which is estimated at 50 ml per hour of swimming, i.e. 830 mg/min. (see section 6.5). The quality factor Q=1 is assigned.

Defaults

Default post- application swimming pool disinfectants; indoor public swimming pool

Post- application swimming pool disinfectants	**Baby Swim**	**Q**	**Child Swim**	**Q**	**Adult Swim**	**Q**	**Ref., comments**
Body weight [kg]	6.21	4	16.3	4	65	4	3)
Frequency [$year^{-1}$]	13	4	104	4	260	4	See above
Inhalation							Evaporation from a constant surface
Room volume [m^3]	50	1	188	1	188	1	See above
Ventilation rate [hr^1]	2	1	2	1	2	1	See above
Exposure duration [min]	30	3	60	3	120	3	See above
Application duration [min]	30	1	60	1	120	1	See above
Product amount $_{dilution}$[g]	10^8	1	$5.6 * 10^8$	1	$5.6 * 10^8$	1	See above
Surface area [m^2]	100	3	375	3	375	3	See above
Temperature [^0C]	32	3	28	3	28	3	See above
Density [g/ cm^3]	1	4	1	4	1	4	Water
Mass transfer rate							Langmuir's method
Mol. weight matrix [g/ mol]	18	4	18	4	18	4	Water
Dermal							
Exposed area [cm^2]	3460	3	7090	3	17 500	4	3)
Product amount $_{dilution}$ [g]	3460	1	7090	1	17 500	1	See above
Exposure time [min]	30	3	60	3	120	3	See above
Oral							
Ingestion rate [mg/min]	8300	1	8300	1	830	1	See above
Exposure duration [min]	30	3	60	3	120	3	See above