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Supplement to the methodology for risk evaluation of biocides

Emission scenario document for biocides used as preservatives in the textile processing industry.
(Product type 9 & 18))

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1. INTRODUCTION.

The purpose of this document is to provide a realistic scenario for the releases into the environment of biocides used in the textile industry.
Synthetic fabrics are made of polymers and have a specific preparation. Thus, for biocides added during the formulation (compounding or preparation of master batches) of these polymers, the releases are treated in the scenario for plastic additives (BRE, 1998).

Textile fabrics are made of two or three types of fibres according to their origins:
- natural fibres: cotton, wool, silk, jute, linen
- man-made fibres:
  - natural (cellulosic fibres created by reacting chemicals with wood pulp): acetate, rayon.
  - synthetic (synthesised from organic chemicals): polyester, polyamide.

Blends of these different fibres are frequently used.

Biocides in textile industry are used to prevent deterioration by insects, fungi, algae and micro-organisms and to impart hygienic finishes for specific applications.
Sensitivity of the fibres differs on a case by case basis, but textiles made from natural fibres are generally more susceptible to biodeterioration than synthetic man-made fibres (Hamlyn, 1990).

Synthetic fibres are hardly ever subject to deterioration by micro-organisms or insects, nevertheless two polymers are more sensitive than others: Polyvinyl chloride (PVC) and polyurethanes (PUR) to which biocides are added.
Natural man-made fibres, such as rayon, are readily degraded by mildew and bacteria whereas acetate is more resistant.

Animal fibres (keratin: wool, silk) are susceptible to attack by both micro-organisms and insects. Cellulose fibres (cotton, linen…) are susceptible to attack by micro-organisms, but not by insects (Van der Poel, 1999). Yet, cellulose fibres are more sensitive to rot and mildew than animal fibres.

The treatment with biocides can take place before textile processing (e.g. during storage and transport of the raw fibres) and at various stages of textile processing. Yarns may be treated or the fabrics as such.
Different techniques can be applied according to the fibre used, the end-product, etc. Especially, fabrics exposed to outdoor conditions and carpets are treated with biocides.

The scenarios in this report are presented in the following way:

Input

[Variable/parameter (unit)] [Symbol] [Unit] S/D/O/P

These parameters are the input to the scenario. The S, D, O or P classification of a parameter indicates the status:

S Parameter must be present in the input data set for the calculation to be executed (there has been no method implemented in the system to estimate this parameter; no default value is set).

D Parameter has a standard value (most defaults can be changed by the user)

O Parameter is the output from another calculation (most output parameters can be overwritten by the user with alternative data).

P Parameter value can be chosen from a "pick-list" of values.

^{c} Default or output parameter is closed and cannot be changed by the user.

Output

[Symbol] [Description]

Intermediate calculations

Parameter description (Unit)

[Parameter = equation] (Equation no.)

End calculations

[Parameter = equation] (Equation no.)

2. MAIN PROCESSES.

In the general way, the main process includes four steps as shown in figure 1:

1) Yarn formation;
2) Fabric formation;
3) Wet processing;
4) Fabrication.

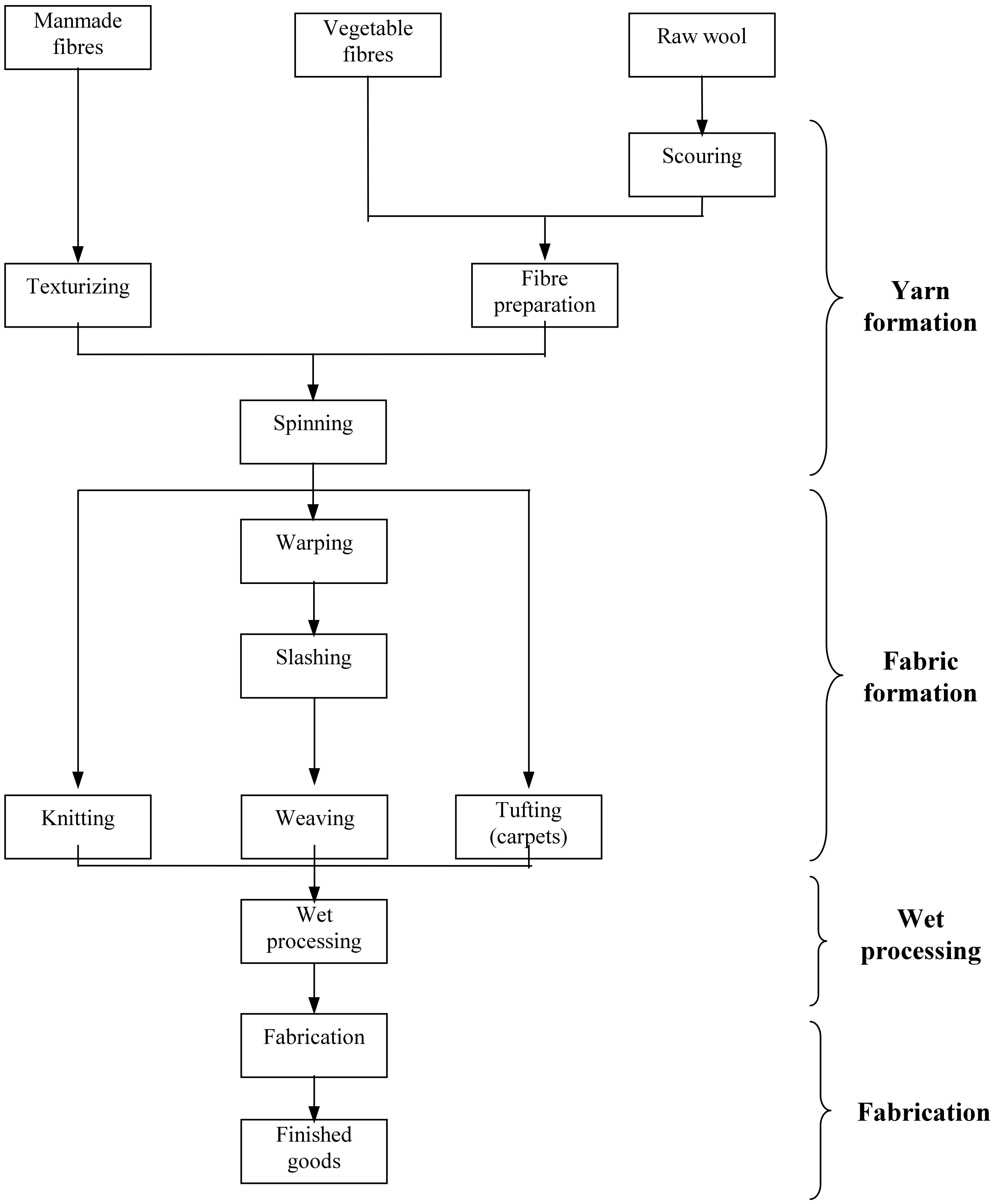

Figure 1: Typical textile processing flow chart (adapted from US-EPA, 1997).

2.1. Yarn and fabric formation.

Raw wool must be cleaned by wet processes before the fibre can be dry processed to produce fibre, yarn or fabric. Neither cotton, nor synthetic fibres require this initial wet cleaning, named scouring or wool scouring, before processing (e.g. since raw sheep wool contains from 25 to 75% suint, the production of 1 kg of scoured wool fibres produces 1.5 kg of waste impurities) (UNEP/IEO, 1994).

Yarn formation: textile fibres are converted into yarn by grouping and twisting operations used to bind them together. Filament yarn can be used directly (knitting) or be further worked. Natural fibres need to go through different preparation steps before being spun into yarn. These steps are: opening / blending, carding, combing, drawing and drafting. Biocides against moths can be added during these steps.
For manmade fibres, just one step of texturizing is needed before spinning (the process used resembles the manufacture of silk). Methods for making spun yarns from manmade fibres are similar to those used for natural fibres.

Fabric formation: the two major methods used are weaving and knitting. Weaving is the most common process and consists of interlacing yarns. Knitting is also frequently used. The main difference between knitting (dry process) and weaving is the sizing / desizing and mercerising operations (wet processes). So, there is no waste water emissions at knitting except for cotton for which there is always wet processing, independent of the method of fabric formation.
Tufting is a process used to make most carpets. One of the fundamental difference between tufting and weaving is that the pile and the carpet back are not formed at the same time. Tufting technique presumes an already constructed grounding layer or ground fabric also known as "primary backing" (US-EPA, 1997; VITO, 1999).

2.2 Wet processing.

Wet processing enhances the appearance, durability and serviceability of fabrics by converting undyed and unfinished goods ("greige" goods) into finished goods. The fabric is definitely stabilised (strength, structure, yarn manufacture, preservatives,...).
For simplification, this stage can be divided in three main steps:

- fabric preparation or pre-treatment (e.g. desizing, scouring, bleaching,...);
- dyeing and/or printing;
- functional finishing.

Use of biocides occurs essentially during the fabric preparation and the finishing processes as shown in figure 2.

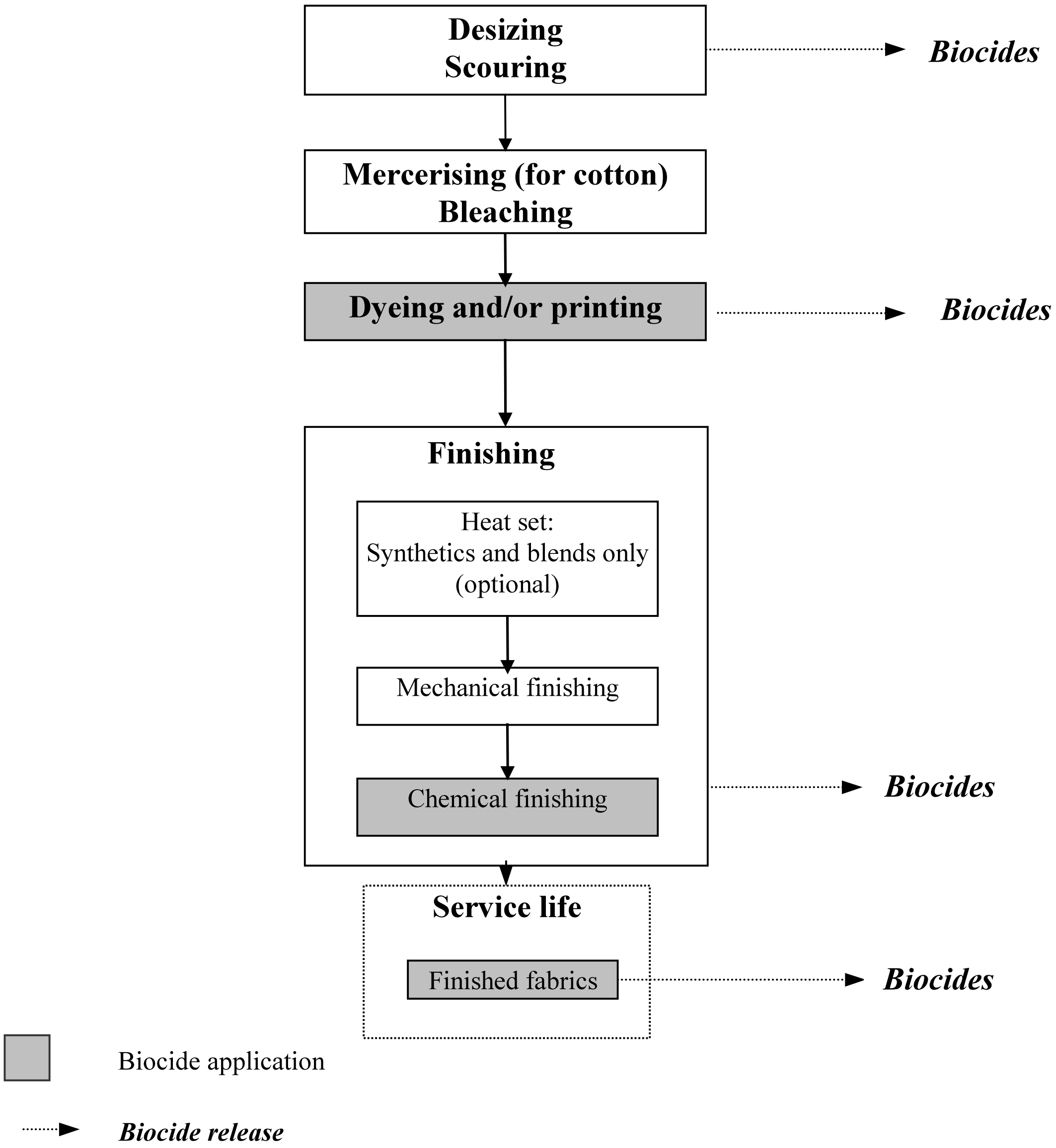

Figure 2: Typical wet processing steps for fabrics and biocides
(adapted from US-EPA, 1997).

2.2.1 Fabric preparation.

Most fabric needs to be prepared for dyeing, printing or finishing. Preparation consists of a series of various treatments and rinsing steps. Depending on the fabric and the fibre type, one or more of the steps described below are not applicable.

Desizing and scouring: these two operations are often combined. The first is a process for removing sizing compounds (e.g. starch, Polyvinyl Alcohol (PVA), Carboxymethyl Cellulose (CMC)) applied to yarns prior to weaving.
Scouring is a cleaning process for removing natural and acquired impurities (including biocides eventually added with size components) from fibres and fabric.

Singeing: dry process used on woven goods that must have a smooth finish. It removes fibres protruding from yarns or fabrics.

Bleaching: process to whiten cotton, wool and some synthetic fibres by treatment in solutions containing hydrogen peroxide, chlorine dioxide, hypochlorite, sodium perborate, etc.

Mercerising: process for increasing dyeability, luster, sheen and appearance of cotton and cotton / polyester goods by impregnating the fabric with a sodium hydroxide solution. Mercerising typically follows singeing and may either precede or follow bleaching (US-EPA, 1997; EU, 1996).

2.2.2 Dyeing and printing.

Dyeing operations are used at various stages of processing and can be performed using continuous or batch processes. Some biocides may be added to dyeing baths in both processes.

Continuous process: textiles are fed continuously into a dye range. Continuous dyeing processes typically consist of dye application, dye fixation with chemicals or heat and washing. Dye fixation on the fibre occurs much more rapidly in continuous dyeing than in batch dyeing (US-EPA, 1997). Biocides against rot and mildew are applied in a continuous process (immersion followed by squeezing the solution from the fabric). It is estimated that 70 – 80% is adsorbed by the fabric (Van der Poel, 1999).

Batch process: also called discontinuous dyeing, it involves applying a dyestuff in solution or suspension at a specific liquor ratio ("ratio of mass of fabric to volume of dye bath" (EU, 1996)) which determines the depth of the colour obtained. The post dyeing stage consist of washing with water to remove unfixed amounts of dyestuff from the textile substrate (EU, 1996). Common methods of batch, or exhaust, dyeing include beam, beck, jet and jig processing (US-EPA, 1997).
Moth repellent treatment (permethrin in most cases) can be applied during dyeing of wool by an exhaustion process.

Recommended environment friendly process for dyeing: one potential improved process for dyeing is pad-batch dyeing. This method is one of the most reliable and controllable available today and has been used quite successfully in a wide variety of applications. Benefits include the limitation of the need for salt or chemical specialities from the dye bath, with associated cost savings and waste reduction.
In the pad-batch dyeing, prepared fabric is impregnated with liquor (water and process chemicals) containing premixed fibre reactive dyestuff and alkali. Excess liquid is squeezed out on a device known as a mangle. The fabric is then batched onto rolls or into boxes and covered with plastic film to prevent absorption of CO_2 from air or evaporation of water. The fabric is then stored for two to twelve hours. The goods can be washed with becks, beams, or other available machines. Pad batch dyeing is more flexible than continuous dyeing methods. The flexibility of pad batch equipment and the use of water soluble dyes minimises cleaning operations.

Use of pad batch (cold) dyeing for cotton, rayon, and blends conserves energy, water, dyes and chemicals, labour, and floor space. While pad batch dyeing is a cost-effective way for facilities to apply reactive dyes to cotton and rayon, this method may not achieve the desired final fabric properties for all cottons. Pad batch dyeing is also not appropriate for dyeing synthetic fabrics (US-EPA, 1997; UNEP/IEO, 1994).
Remark: pad dyeing can also be performed as a continuous process.

Printing differs from dyeing by the pigments, which do not require washing steps and generate little waste.

2.2.3 Finishing.

To meet requests for special "effects" the bleached and/or dyed textile material (fibre, yarn or fabric) is submitted to one or more functional finishes. These processes may be chemical (e.g. stiffening, softening, impregnation for water and soil repellency, mildew-, rot- and mothproofing, antistatic finishing, fire retardant finishing) or mechanical treatment (smoothness, roughness, shining). The finishing substances are used in aqueous solutions and fixed to the material. Chemical finishes are usually followed by drying, curing and cooling steps (US-EPA, 1997; EU, 1996).
Foulard machines with several dipping baths, spraying or printing techniques as well as exhaustion processes or lickroll processes are commonly used. The main process is immersion dipping and usually the application of chemical additives takes place by continuous "padding" (impregnating and pressing out again) (EU, 1996; VITO, 1999).
For rugs and carpets, biocides are added with foam or sprays after the application of the backing layer (BIOEXPO, 1998)
The ideal antimicrobial finish requires no additional process steps. It can be introduced from the same medium as softening agents or crease resisters.

2.3 Water consumption.

Water consumption is 100 up to 150 m^3 per tonne of fabric as shown in table 1 (Personal communication Institut Textile de France (ITF), 1999). This is less than previous data on water use and confirms the decrease of water consumption in the textile industry (EU, 1996; UNEP/IEO, 1994). Natural fibres (e.g. cotton or wool) and their blends need more water than pure synthetic fibres (Polyamides (PA), Polyethylene sulfate, Polyamides carbonate). The amount of water depends also of the ennobled product (spun yarns, fabrics or finished goods) and of the process as shown in table 2.

Table 1: Water consumption during wet processing (Personal communication ITF, 1999).

Substrate	**Water consumption (m^3/t)**	
	Average range	**Maximum**
Cotton	100 – 150 *(250 – 350)*	200
Wool (piece)	50 – 100 *(200 – 300)*	150
Polyamide (piece)	50 – 100 *(125 – 150)*	150
Polyester (piece)	50 – 100 *(100 – 200)*	150
Acrylic (piece)	50 – 100 *(100 – 220)*	150

Values in italic are reported from the TGD (EU, 1996) for water consumption during wet processing.

Table 2: Water use in textile wet processing (UNEP/IEO, 1994)

Sub-category	**Amounts of water typically used in l/kg of fabric treated**		
	Minimum	Median	Maximum
Wool finishing	110.9	283.6	657.2
Dry processing	0.8	9.2	140.1
Woven fabric finishing			
simple processing	12.5	78.4	275.2
complex processing	10.8	86.7	276.9
c. p. plus desizing	5	113.4	507.9
Knit fabric finishing			
simple processing	8.3	135.9	392.8
complex processing	20	83.4	377.8
hosiery products	5.8	69.2	289.4
carpet finishing	8.3	46.7	162.6
stock and yarn finishing	3.3	100.1	557.1

2.4. Production estimation.

Table 3 presents default values for the daily production capacity of a model site, assuming 220 working days per year as in the emission scenario document for the textile processing industry in the Technical Guidance Document (EU, 1996). Biocides are mainly added during the finishing process, therefore the ennobling category is the most concerned sector (Personal communication Ciba Spécialités Chimiques, 1999).

Table 3: Estimation of the daily production per site in France (Personal communication Ciba Spécialités Chimiques, 1999, 2001).

Designation	**Annual production per site (t/y)**	**Daily production per site (t/d)**
Cotton spinning	1 600 – 1 700	7
Wool preparation	150 – 200	1
Wool spinning	500 – 600	2.5
Silk, synthetic	200 – 250	1
Sewing knit	800 – 900	4
Cotton weaving	400 – 500	2
Wool weaving	200 – 250	1
Silk weaving	20 – 25	0.1
Others weaving	300 – 350	1.5
Textile ennobling	1 500 – 1 600	6 - 7
House and furnishing fabric	100 – 120	0.5
Others textile goods	40 – 50	0.2
Carpets	12.10^6 m^2	55 000 to 60 000 m^2
Cords, filets	700 – 800	3
Non woven	800 – 900	4
Mail fabrics	400 – 500	2

According to Ciba Spécialités Chimiques (Personal communication, 2001), the values for France in table 3 might be lower than for other European countries.

Table 4 presents values for the daily production according to German companies. However, these values take into account companies using only one kind of fibre.

Table 4: Generic daily production volumes in Germany (Böhm et al. 1997, 2000)

Textile finishing companies	**$Q_{product}$ [t/d]**
Companies total (generic)	12.8
Dyeing companies total	14.2
Companies using > 90% cotton	23.2
Companies using > 90% natural fibres	18.8
Companies using > 90% synthetic fibres	5.8
Companies using > 90% polyester fibres	0.8
Companies using optical whiteners	12.2

For a first approach, the values in table 4 are used for the default release estimation.
If further information regarding the application at different process steps is available, the values from table 3 can also be used.

3. RELEASE ESTIMATION.

3.1. General comments.

3.1.1. Distribution of releases.

Releases occur to air, waste water and soil. In the textile industry, air emissions are a minor source of pollution compared with many other industries. Emissions to the air are considered to be a negligible pathway, due to the high attachment characteristics of the biocidal compounds (Luttik et al., 1993). Operations that represent the greatest concern are coating, finishing and dyeing (US-EPA, 1997). It is not clear though how these figures relate specifically to biocides. In the absence of further data, this document will focus on releases to waste water.

The waste water is by far the largest waste stream. It is generated by:

- washing and rinsing cycles (major sources);
- bath dumps;
- equipment clean-up (EU, 1996).

3.1.2. Biocides.

Biocides such as pentachlorophenol (PCP) or organo-mercury are not allowed anymore in Europe because of their persistent and cumulative toxic effects. The alternatives compounds are pyrethroids and mixture of pyrethroids, pyrimidine derivates (e.g. chlorophenylid, permethrin and ammoniumfluorosilicates), thiazol derivatives and chlorinated hydroxydiphenylethers (Bioexpo, 1998; Debon, 1999; Personal communication, Ciba Spécialités Chimiques 2001).
Fungicides (e.g. organo copper compounds like copper naphtenate and copper 8 hydroxyquinolinate and tin derivatives) are also frequently used. These biocides are extremely versatile and very effective against fungi, bacteria and algae.

3.1.3. Waste water treatment.

Methods used for waste water treatment can be classified into primary or mechanical, biological or advanced physico-chemical processes. Primary treatment consists of several steps, i.e. screening, neutralisation, equalisation and gravity sedimentation.
According to the fibre and the processes used, differences in the treatments may occur.

3.2. Releases during wet processing.

The wet processing (preparation, dyeing and finishing) accounts for the majority of the waste water.

3.2.1. Desizing and scouring.

The first release occurs during the desizing / scouring step. It is one of the industry's largest sources of waste water pollutants. Biocides applied during sizing (e.g. moth repellents) can be removed in waste water during the desizing step.
In addition, imported fabrics (such as raw wool or cotton) may already contain some biocides applied for preservation during storage and transport. These biocides are removed by rinsing and released with waste water almost completely. Yet, it is very difficult to know which and how many of these biocides / pesticides have been applied and so this will not be included in the scenario. Examples are shown in table 5.

Table 5: Preservative chemicals and their metabolites on imported clothes (CEC, 1993).

Material	Biocides	Concentration range (µg/kg cloth)
Wool	p, p' - DDE	0.07 to 0.38
	PCB – 28/31	0.15 to 0.34
	Heptachlor	0.03 to 0.12
Cotton	p, p' – DDE	0.85 to 4.5
	p, p' – DDD	0.09 to 12.8
	p, p' – DDT	n.d (not detected) to 12.4
	Heptachlor	0.13 to 0.45

For other biocidal substances, comparable contents can be chosen as default values (e.g. 0.4 µg/kg for wool and 10 µg/kg for cotton).

3.2.2. Dyeing and finishing.

Waste water: Dyeing operations generate a large portion of the industry's total waste water. Releases can take place at two stages of the impregnation process, namely at the discharge of the spent bath liquid and at the discharge of the water used for the wash-out (Luttik et al., 1993).
Finishing processes generate waste water containing natural and synthetic polymers and a range of potentially toxic substances (US-EPA, 1997; UNEP/IEO, 1994). Biocides are often incorporated with finishing products such as water repellents, fire retardants, etc. in proportions of 0.5 to 2% (data on moth repellents treatment are presented in table 6). The degree of fixation of biocides has been estimated to be approx. 70 – 80% (Personal communication ITF, 1999).
Moth-repellents are usually applied to wool by exhaust techniques and the degree of fixation can be up to 98% and more (Personal communication, Ciba Spécialités Chimiques, 2001).

Air emissions: Toxic chemicals used in dyeing and finishing operations are emitted from dyeing machines and/or dryers. After dyeing or finishing, products are dried on continuous machines in closed or semi – open conditions.
Other sources of air emissions are from organic solvent vapour releases during and after drying, finishing and solvent processing operations. Yet, the application of finishing products and biocides in an aqueous solution is more and more preferred to a solvent solution.
Some biocides (e.g. moth repellents) are applied by spraying with foulard machines. Spraying is a dry technique in which the moth resistant substance is applied on the pile of the carpet.

Remark: biocidal treatment can take place by foam application during dyeing or finishing, notably on carpets. Zero waste water emissions can be obtained, yet, some products are not suitable for making into foams and the removal of the foams can be very difficult. The use of "mini-bowls" is developing in the UK, for the wash-out steps, to reduce water consumption and limit the risks of releases in the environment.

Table 6 presents the moth repellents applied at the moment (Debon, 1999).

Table 6: Constitution and rates of application of currently applied moth repellents for wool (Debon, 1999).

Active component	Active content of formulation		Amount of active substance applied (% w/w)	Amount of active substance applied (kg/t)
	% w/v	% w/w		
Permethrin	9.00	10.00	0.035 - 0.181	0.35 - 1.81
	10.00	12.05	0.029 - 0.150	0.29 - 1.5
	8.30	10.00	0.035 - 0.181	0.35 - 1.81
Sulcofuron	46.40	40.00	0.800	8
	37.95	33.00	0.970	9.7
Permethrin/HHP*	10.00	10.00	0.055 - 0.0825	0.55 - 0.825

*HHP: Hexahydropyrimidine

As a worst case, a default value of 1% w/w (i.e. 10 kg/t) can be proposed if no further data is available.

Note: Partial degradation of an active substance can occur within the process. This is not considered in this document. If data on degradation within the process is available, they can be taken into account in the release estimation.

3.3. Releases during other life-cycle stages

Releases may occur during other life-cycle stages, e.g. the final use of textile articles and the elimination of textile articles.

The main application of preservatives for textiles is for preservation of textiles for outdoor applications. Preserved textiles are used for tents, tarpaulins, awnings, sunblinds, parasols, sails, waterproof clothing,… Virtually all textiles used for outdoor applications except clothing seem to be preserved with biocides. For indoor applications mainly woollen articles are concerned as well as shower curtains and in some instances mattress ticking.

It is actually only for cotton textiles that the primary function of the preservatives is to preserve the fibres itself. Today cotton seems mostly (apart form clothing) to be used for garden furniture fabric whereas it has been replaced by synthetic fibres for other applications. According to the producers of tents, awnings,… one of the reasons for this substitution is that the biocides on the market today do not provide the necessary protection of the cotton fabric. Cotton fabric was formerly preserved with pentachlorophenol (PCP), which is now prohibited in most EU countries.

Textiles and clothing imported from sub-tropical and tropical areas, especially from Eastern Asia, may contain small amounts of biocides applied for preservation of the textiles during transport and storage in the humid and warm climate. The biocides are applied by spraying the biocides into the containers and can be found in trace amount in textiles. Among the biocides, PCP seems to some extent still to be used in Asia for this purpose.

Based on the present information it is estimated that approximately 600 – 1 400 tonnes preserved textile with tents, awnings, sails… is annually used in Denmark. No data is available for other EU countries. The most common biocides in textiles used for production of tents and awnings in Denmark are applied at about 1.5 $g.kg^{-1}$. Based on this it is estimated that the preserved textiles contain between 0.1 and 0.2% active agents. (Danish Environmental Protection Agency, 2001).

To assess emission, service life of treated articles need to be known. Some preliminary values are presented in table 7.

Table 7: Service life of few articles (Personal communication Ciba Spécialités Chimiques, Serrurerie Luçonnaise, Décorum, Mondial Moquette, St Maclou, Eurotapis, Ecodécoration, Val d'Oise Vacances, Air E Soleil, 2001).

Articles	Service life (years)
Clothes on contact with skin	1
Others clothes and bed linen	2 - 5
Household linen	5 - 10
Bedding (mattress)	10
Carpets	8 - 20
Wall-to-wall carpet	5 -30
Sunblind	8 - 15
Tents	5 - 20
Awning	2

A large part of the biocides remaining in the finished articles can be released to the environment during the service life of the textile articles. For volatile substances, a total release to the atmosphere can be assumed ($F_{atm} = 1$). Furthermore for indoor articles subject to cleaning, a total release to waste water can be assumed ($F_{wat} = 1$). And finally, for outdoor articles, a total release to waste water and soil can be assumed ($F_{wat} = 0.5$ and $F_{soil} = 0.5$). All of these releases will be diffuse and relevant only for a regional exposure assessment. A considerable amount of textiles, mainly clothes, will be exported after use by charity organisations. This is not yet taken into account by the present model.
Regarding waste elimination, a generic model for releases from landfills is under development and might be used once the model is available.

3.4. Emission scenarios.

Release estimation models are presented below.

The release estimation is performed on a local scale except for releases from articles during service life. Only releases to waste water during wet processing are taken into account in the calculation according to the lack of data regarding emissions to air.

3.4.1. Releases from the imported fibres / fabrics.

Imported fabrics may release some biocides during the desizing / scouring step. These biocides are almost completely removed in waste water. Releases can then be estimated with the following model.

Table 8: Emission scenario for calculating the releases from imported fibres / fabrics

Variable/parameter (unit)	Symbol	Unit	Default	S/D/O/P
Input:				
Quantity of fibres / fabrics treated per day (cf. table 3)	Q_{fibres}	$t.d^{-1}$		D/P
Estimated content of active substance present on imported material (cf. section 3.2.1)	C_{active}	$mg.kg^{-1}$	0.01	S/D
Output:				
Local emission of active substance to waste water from imported fibres	$Elocal_{i,water}$	$kg.d^{-1}$		O

Model calculation:

$$Elocal_{i,water} = Q_{fibres} \times C_{active} / 1000$$

Remark: the values of concentration of biocides on imported fabrics are often very low and may be considered as negligible, compared to the releases due to application steps (cf. below).

3.4.2. Releases from the different steps of introduction of biocide.

At each step of application of a biocide, releases may occur. Those steps are: desizing / scouring, dyeing and finishing. In most cases, for these three steps the process used implies essentially releases to waste water. Thus, only the degree of fixation of the substance is considered in the calculation, and for each step the release can be estimated using the model below. Emissions for the whole textile process can then be estimated, in case that the same substance is concerned in each step (which is difficult to know for releases from imported fabrics).

Table 9: Emission scenario for calculating the releases from the different application steps of biocide

Variable/parameter (unit)	Symbol	Unit	Default	S/D/O/P
Input:				
Quantity of fibres / fabrics treated per day (cf. table 3)	Q_{fibres}	$t.d^{-1}$		D/P
Quantity of active substance applied per ton of fibres / fabrics for one treatment step (cf. section 3.2.2)	Q_{x_active}*	$kg.t^{-1}$		S/D
Fixation rate (cf. section 3.2.2)	F_{fix}	-	0.7	S/D
Output:				
Local emission of active substance to waste water for one treatment step	$Elocal_{x,water}$*	$kg.d^{-1}$		O
Total local emission of active substance	$Elocal_{tot,water}$	$kg.d^{-1}$		O

* x represents a treatment step (desizing / scouring, dyeing, finishing).

Model calculation:

$$Elocal_{x,water} = Q_{fibres} \times Q_{x\_active} \times (1 - F_{fix})$$

$$Elocal_{tot,water} = Elocal_{i,water} + \Sigma\ Elocal_{x,water}$$

3.4.3. Releases from articles during their service life.

Articles may have a service life longer than one year. Biocides in such articles may accumulate in society. Thus the release estimation is treated in this scenario.

Table 10: Emission scenario for calculating the releases from articles during their service life

Variable/parameter (unit)	Symbol	Unit	Default	S/D/O/P
Input:				
Annual input of the substance in article k	$Qtot_k$	$t.y^{-1}$		S
Fraction of the continent	F_{cont}	-	0.9	D
Fraction of the region	F_{reg}	-	0.1	D
Service life of article k (cf. table 8)	$Tservice_k$	Y		P
Fraction of tonnage released over one year during service life to compartment j (cf. section 3.3)	F_j	-		D
Emission duration per year	N_d	$d.y^{-1}$	365	D
Output:				
Total release to compartment j	$RELEASEtot_{k,j}$	$t.d^{-1}$		O
Continental release to compartment j	$RELEASEcont_{k,j}$			O
Regional release to compartment j	$RELEASEreg_{k,j}$			

Model calculation:

$$RELEASEtot_{k,j} = \left(F_j \times Qtot_k \times \sum_{y=1}^{Tservice_k} \left(1 - F_j\right)^{y-1} \right) / 365$$

$$RELEASEcont_{k,j} = RELEASEtot_{k,j} \times F_{cont}$$

$$RELEASEreg_{k,j} = RELEASEtot_{k,j} \times F_{reg}$$

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GLOSSARY

Beam: Any of a series of machines for dyeing which use a perforated beam through which the dye bath is circulated.

Beck: Any of a series of machines for scouring (cleaning), dyeing, etc., goods while in the form of rope or continuous belt. A roller gradually moves the cloth through the bath in a slack condition.

Carding: Fibres are separated and aligned in a thin web, then condensed into a continuous, untwisted strand called a 'sliver'.

Combing: Processing cotton or wool stock through a series of needles (or combs) to remove short fibres and foreign matter.

Desizing: Removal of size material from greige (gray) goods to prepare for bleaching, dyeing, etc.

Drafting: A process that uses a frame to stretch the yarn. This process imparts a slight twist as it removes the yarn and winds it onto a rotating spindle.

Drawing: Straightening and paralleling the fibres after combing or carding.

Greige: Fabrics in unbleached, undyed state prior to finishing. Also referred to as "gray" or "grey" goods.

Jet dyeing: A tubular machine utilising water jets to circulate fabric in a dye bath.

Jig: An open vat which passes full width cloth from a roller through a dye liquor and then on to another roller.

Knitting: Process for making a fabric by interlocking in series the loops of one or more yarns. Types include: jersey (circular knits), tricots (warp knits), double knits.

Mercerising: A process given to cotton yarns and fabric to increase lustre, improve strength and dye ability. Treatment consists of impregnating fabrics with cold concentrated caustic soda solution.

Scouring: Removal of natural and acquired impurities from fibres, yarns, or cloth through washing.

Singeing: Cloth is passed across an open gas flame at a high speed to burn off the loose surface fibres.

Sizing: Applying starch, PVA or CMC to warp yarns to minimise aberration during weaving.

Spinning: A process by which a large strand of fibres is drawn out to a small strand and converted into a yarn. After drawing out (or drafting), twist is inserted, and the resulting yarn is wound into a bobbin.

Texturizing: It is often used to curl or crimp straight rod-like filament fibres to simulate the appearance, structure, and feel of natural fibres.

Tufting: A process used to create carpets, blankets, and upholstery.

Warping: A warp is a set of length-wise yarns in a loom through which the crosswise filling yarns (weft) are interlaced.