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Supplement to the methodology for risk evaluation of biocides

Emission scenario document for biocides used in taxidermy and embalming processes (Product type 22)

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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 from taxidermy and embalming installations.
Taxidermy and embalming consist of the preservation of animal and human corpses respectively.

Taxidermy (Greek *taxis*, "arrangement", *derma*, "skin") is the art of mounting or replicating vertebrate animal specimens in a lifelike way for display or study. In some cases the skin is preserved and mounted on an artificial armature. Two types of taxidermists may be distinguished: the museum taxidermists and the professional or commercial taxidermists. In France, there are around 10 museum taxidermists and 425 professionals (Personal Communication Syndicat Naturaliste de France, 2000). The main difference between them seems to be the production which is higher for professionals.

Embalming is the preservation of a human corpse. The preservation may be short term-preservation (thanatopraxis) or long-term preservation (essentially for bodies that have been donated to science). The latter is quite unusual in Europe and most of the time it is short-term preservation which is required (Schuette-Voss, 1997). The objective is to preserve the corpse in different cases : transport across state lines or for a distance of more than 600 km, transport by an airline, burial taking place more than 48 hours after death, or death due to a communicable disease (AFIF, 2000 ; Schuette-Voss, 1997). Embalming can take place also in case of medicine corpse donation. A fluid (in most cases formaldehyde) is injected into the body, while blood is removed. The concentration of formaldehyde is much lower than that for embalming (long-term preservation). The number of embalmers in France is approximately 700 and they treat approximately 40% of the deaths. Most of the universities of medicine practise embalming of corpses used by students. The estimate of corpse donations is approx. 4 000 per year in France (Personal Communication Université d'Angers, 2000).

In both cases, taxidermy and embalming, biocides are applied for the preservation. The main biocide and fixative is formaldehyde. However, insect repellents are also applied in taxidermy on mounted animals subject to degradation.

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.

2.1. Taxidermy.

2.1.1. Process.

The main steps in the process are described in figure 1.

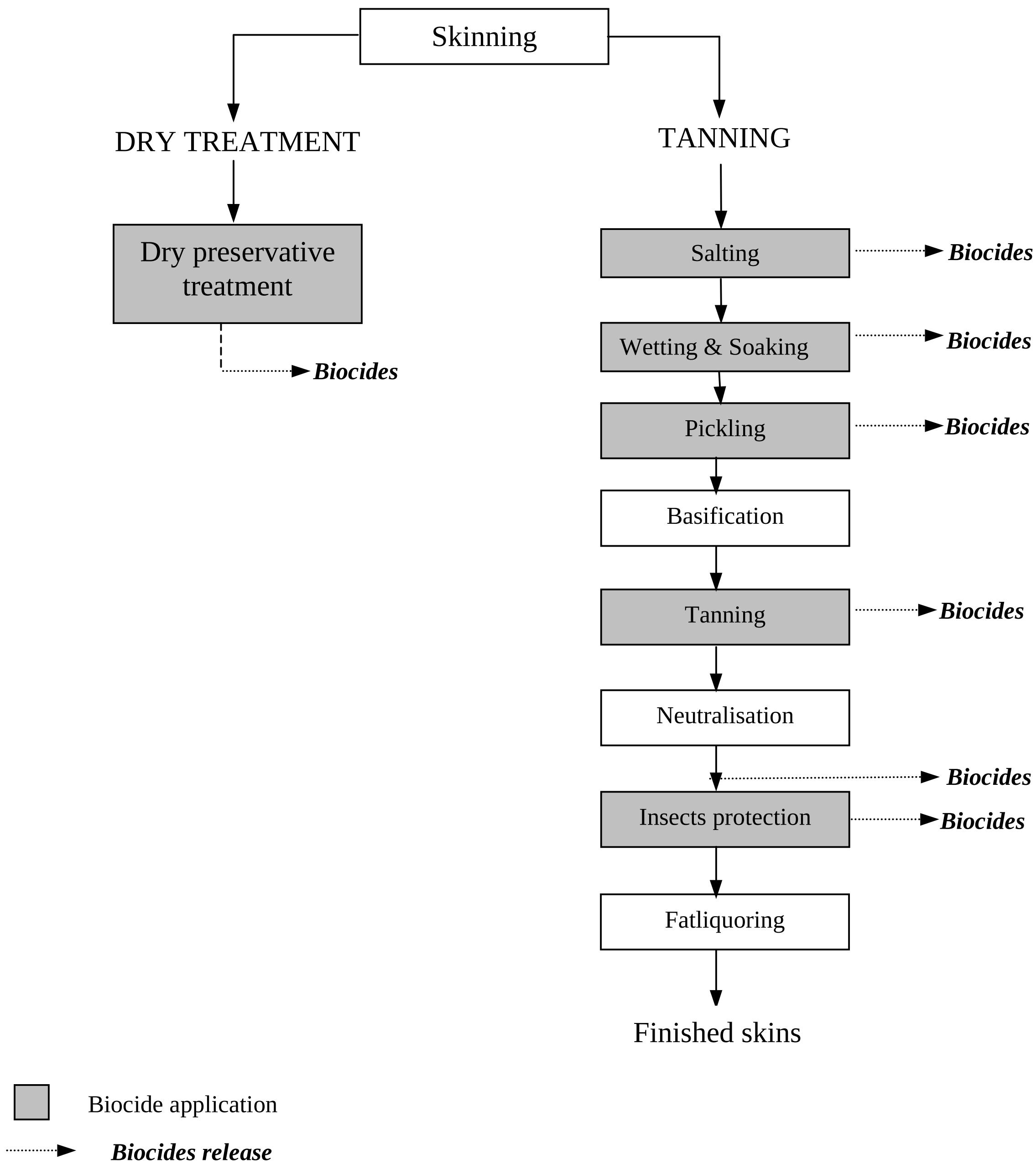

Figure 1 : Main processes and releases from the treatment of animal skins for taxidermy.

The preservation of animals concerns small as well as large mammals, fishes, birds and reptiles. Usually the main steps in preservation of large mammals for example are: skinning, rough fleshing, washing, rinsing, dry-salting, brine / pickle solution, re-fleshing, neutralisation, tanning, rinsing, oiling and breaking the hide. Yet, according to the kind of animal to be preserved, the technique differs slightly. Once the animal is completely skinned, the specimen is boned and the entire skeleton preserved, dried and saved.
When the skin is ready, mounting over a manikin can proceed.

Skin treatment : after skinning and fleshing, the skin is washed in cold water with soft detergent and rinsed. The skin may then be tanned. Yet, for birds, most of the time, the skin is not tanned due to its slimness. A dry preservative treatment against insects may then be applied. This treatment may be preferred by some taxidermists also for fish and small mammals. The best known is the Becoeur soap made of arsenic powder, camphor, tartaric acid and lime in powder. Other products often used are the arsenic soap made of white soap flakes, arsenic salts, potash, camphor, alcohol and water, borax powder (very useful during the skinning and fleshing stages to absorb blood and grease) and other special products.
For large mammals, the skin has to be carefully tanned and goes through the different steps described below.

Salting : after being washed carefully and drained, the skin is salted to preserve it until it is tanned. After almost 12 hours, one may proceed to the tanning or dry the skin for storage until tanning. Taxidermists often work on skins already salted and dried. The skins must then be soaked before going on with the tanning process. The salting process is important for both preventing hair from slippage and preparing the skin for the tanning process.

Soaking *:* it aims at re-hydrating the skin and removing dirt.

Pickling *:* after rinsing the skin, it is plunged in an acid bath (pH around 2). This bath is made of water (200%, related to the weight of the skin), salt (12%), formic acid (2%) and of -bactericidal-formalin (0.5%). The skin soaks in this bath at least three days for a thin skin, but can stay several months if it is stirred regularly. The pH must be controlled often and be stabilised around 2.

Basification *:* the skin is drained and placed in clear water. A small amount of sodium bicarbonate or other neutralising agent is added to help fixing the tanning agent by raising the pH up to 4.

Tanning *:* there are several kinds of tanning products :

- Vegetable tannins.
- Mineral, such as chromium or aluminium salts.
- Organic, such as synthetic tannins or organic compounds (e.g. formalin).

The choice of the tanning agent is made according to the leather destination. It may be added to the pickling bath (2%) or in a new bath (5%). The skin must stay 24 hours in the bath. The skin is then rinsed and drained.

Neutralisation *:* the purpose of this step is to bring back the skin to a pH of 7. Sodium bicarbonate (2%) is diluted in water (200%) and the skin stays in the bath one hour. The pH must be checked and sodium bicarbonate added if the pH is too low. Then the skin is rinsed and drained.

Insects protection *:* the skin is put in a new bath (200%) of warm water (35 – 40°C) in which an insecticide is added (2%). The skin stays in the bath during 30 minutes and then is rinsed with ammoniated water and drained.

Fatliquoring : a variable amount of grease or specific oil is incorporated in the leather to give it flexibility and impermeability. The product is applied by brush. The skin is folded for one night and then drained several hours (Brigot, 1991).

Mothproofing agents may be applied later on new or existing mounted animals. In most cases, the active substances are absorbed into the skin and insect repelling vapours will be slowly released over a period of many years.

2.1.2. Production estimation and water consumption.

For large skins or hides, taxidermists send them for tanning to large scale tanneries. In this case, the releases of biocides during the tanning are taken into account by the emission scenario developed for biocides used as preservatives in the leather industry (product type 9).
On the other hand, small skins or hides are tanned by taxidermists themselves. The amount is low. In France, taxidermists tan themselves an average of 50 skins or hides per year, but this figure varies from 15 to 100 per year according to taxidermists. And out of the 50 tanned skins, 20 weigh about 4 kg, and 30 less than 1 kg.
As a worst case, a figure of 1 tanned skin of 4 kg per day can be proposed. The season of tanning lasts only from September to March.
(Personal communication Syndicat des Naturalistes de France, 2001).

The water consumption depends on the weight of the skin as seen in section 2.1.1. An estimated value of 0.1 m^3 of water per kg of skin seems to be used for the whole process.

2.2. Embalming.

2.2.1. Process before the funeral.

There are three different procedures in embalming which involve the use of biocides :

- Surface disinfection (soaps, solutions).
- Fluids for arterial injection to substitute body fluids.
- Cavity fluids.

First, the body is washed with a disinfectant soap to prevent the spread of germs.

Then, arterial embalming is begun by injecting embalming fluid into an artery while the blood is drained from a nearby vein or from the heart. Before the injection, the solution of arterial fluids must be prepared. There is a high diversity of formaldehyde composition of arterial fluids. According to the preservation desired (short-term or long-term preservation), the age, weight, cause of death and length of time between death and embalming, the amount and type of chemicals used differ. In the case of certain cancers, some diabetic conditions, or because of the drugs used prior to death (where body deterioration has already begun), a stronger or "waterless" solution is likely to be used for better body conservation.
Usually a solution of about 6 l is injected during this first step in cases of short-term preservation and a solution of 10 l is injected for long-term preservation. The solution used is composed

mainly of formaldehyde (2 – 4%) mixed with methanol, glycerine and dyes. Chemicals may also be injected by syringe into other areas of the body (Personal communication Fédération Nationale Services Funéraires Publics-FNSFP, 2000).

The second part of the embalming process is called cavity embalming. The organs in the abdominal and thoracic cavities must be treated separately with a strongly bactericide solution of formaldehyde (22%). Gas and fluids are withdrawn before "cavity fluid" is injected into the torso, by making an incision near the navel. Usually a solution of 0.5 l is injected in both long-term and short-term preservation.

All openings are carefully closed before injecting the fluids.
The body is then entirely washed with a disinfectant solution (e.g. a 75% alcohol solution) for the second time.
For a normal intact body, the average embalming time is approximately two hours (Mao and Woskie, 1994).

The blood and body fluids recovered may be first treated with disinfectant in cases where the person died of a contagious disease, before being released to the sewer or stored in a receptacle.

2.2.2. Process in medicine corpse donation.

Besides the embalming of corpses in funeral cases, embalming can take place also for medicine corpse donations (most of the long-term conservations). An arterial injection with a solution of formaldehyde 5% (mixed with methanol 5%, glycerine 10%, lanolin 1%, potassium nitrate and dyes) is needed, followed by an immersion bath of 15 days in a preservative solution (formaldehyde 3%, methanol 3% and glycerine 5%).
The cleaning step (tools, preparation table and floor) involves the use of a bactericidal solution.

2.2.3. Production estimation and water consumption.

The estimated rate of mortality in 1999 was 9‰ (INSEE, 2000). It seems that approximately 40% need the cares of embalmers. For a town of 10 000 inhabitants, we can then assume a worst case value of 36 embalmed corpses per year. Most of the time the corpse needs only a short-term preservation for adelayed funeral.
The amounts of fluids used depend on the preservation time. For a long-term preservation, a solution of 10 l is injected in the body, whereas for short-term preservation 6 l is needed.
In cases of corpse donation, the amount of solution applied for arterial injection is 6 l and 30 l for the washing steps. The immersion bath contains 2 m^3 of solution. The average annual corpse donations per site (mainly hospitals) is approx. 80 (Personal communication Université d'Angers, 2000).

3. BIOCIDES.

***Taxidermy* :** biocides may be used in different steps of the process such as pickling, soaking and tanning and also on finished mounted animals (dry preservation) as shown in table 1. Formaldehyde is less and less used and replaced by other products most of the time. Example of biocides used are sulfonic acid or sodium dihydrogeno-4-sulfonatophthalate. Arsenic and borax are also commonly applied for dry preservation.

Table 1 : Biocidal agents and the content (% by weight) in the solutions per type of preservation.

Steps of introduction	Type of agent applied	Amount of agent applied (% related to the weight of the drained skin)
Pickling	Formaldehyde	0.5
	Tanning agent	2
Soaking	Bactericide	0.2
Preservation	Insecticide	2
Dry preservation	Arsenic or borax	Information not available

No specific data is available regarding the fixation rate of the applied active substances. In a first approach the same default value of 95% fixation as chosen for leather treatment can be used here.

Embalming : the main biocide used in embalming fluids is formaldehyde. Yet, in some cases, glutaraldehyde is preferred. New products, free of formaldehyde, are under development and may replace it in a few years. The strength of the solution of formaldehyde differs between arterial and cavity fluids. Formaldehyde is usually sold as formalin, a 37% to 55% solution in water, with 0.5% to 15% methyl alcohol.
The formaldehyde solution used in arterial fluid is between 2 to 4% whereas in cavity fluids and for treating problem cases a stronger solution of 22% is used (Personal communication FNSFP, 2000 ; personal communication Université d'Angers, 2000 ; Mao and Woskie, 1994).
The rate of fixation of arterial fluids differs slightly due to the time of preservation desired as shown in table 2. For cavity embalming, rate of retention in the body is 90% in both cases (personal communication FNSFP, 2000).
A batericidal solution is also applied for the cleaning of material.

Table 2: Solutions and amounts of biocide used and degrees of fixation according to the type of preservation (personal communication FNSFP, 2000 ; Université d'Angers, 2000).

Types of preservation	Biocide	Amount of solution applied for one embalming (l)	Degree of retention (%)
Short-term	Formaldehyde 4%	6	90
	Formaldehyde 22%	0.5	90
Long-term	Formaldehyde 4%	10	80
	Formaldehyde 22%	0.5	90

Remark: formaldehyde is the substance most used; in the case of other products, one may assume that the amounts applied are the same as those in table 2.

4. RELEASE ESTIMATION.

4.1. Releases distribution.

4.1.1. Taxidermy.

Waste water : most of the releases occur to waste water from the dipping and washing steps. The main steps of releases are pickling, soaking and tanning.
Air emissions **:** vapours of biocide are also discharged continuously from mounted animals. For volatile substances, the whole applied amount is released to the air over the service life of the mounted animal.

4.1.2. Embalming.

Releases during the embalming process :

The embalming can take place at home or at specialised places (for corpse donation, all procedures take place in the anatomy laboratory of medicine schools and hospitals). The releases are more controlled in the latter case. Most of the time, blood and body fluids go into a receptacle; they are then incinerated in the case of specialised places or released to the municipal sewer system or septic tank and thereupon treated at the municipal waste water treatment plant in the case of funeral home effluents.
The quantity of waste emitted is assumed to be equal to water or fluid consumption.
Vapours of formaldehyde occur as well during the process of embalming. Some samples were collected in embalming rooms and have measured an average formaldehyde concentration of 0.74 ppm (Mao and Woskie, 1994).
In cases of medicine corpses donation the main release comes from the washing steps. This effluent is stored in a tank before being treated with chlorine and released to the municipal sewer. It can be assumed that formaldehyde release is negligible from these steps.

Releases at cemeteries after burial

Once the corpse has been buried, the release at cemeteries has to be taken into account. All the fluids injected in the body for preservation end up in the soil after a period of time. All the fixed active substances in the body are then completely released to the soil.
The corpses from medicine donation are incinerated and have not been taken into account here.

4.2. Waste water treatment.

In both taxidermy and embalming processes, the waste water is released to the sewer system and treated at the municipal waste water treatment plant. As said before a pre-treatment with a disinfectant can be required in the embalming process in the case of contagious disease.

4.3. Release estimation.

A release estimation model is presented below.

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.

4.3.1. Taxidermy.

No data is available regarding the releases from dry treatment. A release estimation technique can therefore be proposed only for tanning processes. Each step of application of a biocide involves a release into waste water. The main steps are soaking, pickling and tanning. The release may then be calculated for each step. The model calculation is presented in the following table:

Table 3: Emission scenario for calculating the releases of biocides used in taxidermy

Variable/parameter (unit)	Symbol	Unit	Default	S/D/O/P
Input:				
Quantity of treated drained skin per day (cf. section 2.1.2.)	Q_{skin}	$kg.d^{-1}$	4	D
Quantity of active substance applied per kg of drained skin (cf. table 1)	Q_{active}	$kg.kg^{-1}$	0.02	S/D
Fixation rate	F_{fix}	-	0.95	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

* represents a treatment step (soaking, pickling, tanning).

Model calculation:

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

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

Air emissions can occur from mounted animals, which could release all the biocide applied over the service life of the mounted animals. At this moment no values are available to estimate the release.

4.3.2. Embalming.

Releases during the embalming process :

The release into waste water for a town of 10 000 inhabitants may be calculated as presented below. As statistically there will be 36 embalmed corpses per year, the releases will be estimated for a treatment rate of one corpse per day, noting that thereby treatment takes place only 36days per year.

Table 4: Emission scenario for calculating the releases of biocides used in the embalming process

Variable/parameter (unit)	Symbol	Unit	Default	S/D/O/P
Input:				
Volume of solution applied per embalmed corpse for arterial injection	$Q_{arterial}$	l		P (table 2)
Volume of solution applied per embalmed corpse for cavity treatment	Q_{cavity}	l		P (table 2)
Specific mass of solution (density)	$RHO_{solution}$	$kg.m^{-3}$	1 000	D
Content of active substance in solution for arterial injection	$C_{arterial}$	$kg.kg^{-1}$		S
Content of active substance in solution for cavity treatment	C_{cavity}	$kg.kg^{-1}$		S
Retention rate of arterial fluid	$F_{ret,arterial}$	-		S/P (table 2)
Retention rate of cavity fluid	$F_{ret,cavity}$	-		S/P (table 2)
Output:				
Local emission of active substance to waste water	$Elocal_{water}$	$kg.d^{-1}$		O

Model calculation:

$$Elocal_{water} = Q_{arterial} \times RHO_{solution} \times C_{arterial} \times (1 - F_{ret,arterial}) \times 10^{-3} + Q_{cavity} \times RHO_{solution} \times C_{cavity} \times (1 - F_{ret,cavity}) \times 10^{-3}$$

Releases in cemeteries :

It is proposed to estimate only the concentration of active substances in groundwater. A simplistic model can be proposed on a preliminary basis. It is assumed that for a town of 10 000 inhabitants, the dimensions of the cemetery is 100 × 100 m. The rate of embalmed corpses is 36 per year (section 2.2.3).

However, cremation is more and more used in Europe. In fact, it seems that the average rate of cremation is 33% in Europe (2000). So, the burial rate of embalmed corpses is 24 per year (AFIF, 2001). This is realistic for small towns. In large cities, mainly in southern Europe, corpses may be buried in niches, and no releases to groundwater will occur. The model presented below therefore can be considered as a realistic worst case.

Assuming an average soil concentration over a depth of 0.5 m (based on casket height and allowing for differences in burial depth), an average annual soil porewater concentration can be estimated with the following model.

Table 5: Emission scenario for calculating the releases in cemeteries

Variable/parameter (unit)	Symbol	Unit	Default	S/D/O/P
Input:				
Volume of solution applied per embalmed corpse for arterial injection	$Q_{arterial}$	l		P (table 2)
Volume of solution applied per embalmed corpse for cavity treatment	Q_{cavity}	l		P (table 2)
Specific mass of solution (density)	$RHO_{solution}$	$kg.m^{-3}$	1000	D
Content of active substance in solution for arterial injection	$C_{arterial}$	$kg.kg^{-1}$		S
Content of active substance in solution for cavity treatment	C_{cavity}	$kg.kg^{-1}$		S
Retention rate of arterial fluid	$F_{ret,arterial}$	-		S/P (table 2)
Retention rate of cavity fluid	$F_{ret,cavity}$	-		S/P (table 2)
Factor for reaction with body	F_{body}	-	0	S
Number of embalmed corpses buried per year	N_{corpse}	y^{-1}	24	D
Length of the cemetery	$LENGTH_{cem}$	m	100	D
Width of the cemetery	$WIDTH_{cem}$	m	100	D
Mixing depth of soil	$DEPTH_{soil}$	m	0.5	D
Bulk density of soil	RHO_{soil}	$kg.m^{-3}$	1 700	D
Soil-water partitioning coefficient	$K_{soil-water}$	$m^3.m^{-3}$		O (TGD, sec 2.3.5, eq; 10)
First order rate constant for removal from soil	k	d^{-1}		O (TGD, sec 2.3.8.5, eq. 41)
Output:				
Yearly average input of active substance to the cemetery	$Ecemetery_{soil}$	$kg.y^{-1}$		O
Average concentration in soil	$Ccemetery_{soil}$	$mg.kg_{ww}^{-1}$		O
Average concentration in soil porewater	$Ccemetery_{porew}$	$mg.l^{-1}$		O

Model calculation:

$$Ecemetery_{soil} = [Q_{arterial} \times RHO_{solution} \times C_{arterial} \times (F_{ret,arterial}) \times 10^{-3} + Q_{cavity} \times RHO_{solution} \times C_{cavity} \times (F_{ret,cavity}) \times 10^{-3}] \times (1 - F_{body}) \times N_{corpse}$$

$$Ccemetery_{soil} = Ecemetery_{soil} \times 10^6 / (LENGTH_{cem} \times WIDTH_{cem} \times DEPTH_{soil} \times RHO_{soil} \times k \times 365)$$

$$Ccemetery_{porew} = (Ccemetery_{soil} \times RHO_{soil}) / (K_{soil-water} \times 1\,000)$$

In a first approach, the concentration in porewater can be used as the concentration in groundwater.

4.4. Example calculation.

4.4.1. Taxidermy.

The estimated release for the step of soaking is:

Q_{skin} = 10 kg.d^{-1}
Q_{active} = 0.02 kg.kg^{-1}
F_{fix} = 0.95

The release is:

$$Elocal_{soaking,water} = 10 \times 0.02 \times (1 - 0.95)$$
$$Elocal_{soaking,water} = 0.01 \text{ kg.d}^{-1}$$

4.4.2. Embalming.

The estimated release for a town of 10 000 inhabitants is:
In case of short-term preservation only

$Q_{arterial}$ = 6 l.
Q_{cavity} = 0.5 l.
$RHO_{solution}$ = 1 000 kg.m^{-3}
$C_{arterial}$ = 0.04 kg.kg^{-1}
C_{cavity} = 0.22 kg.kg^{-1}
$F_{ret,arterial} = F_{ret,cavity}$ = 0.9

The release is:

$$E_{\textit{waste water}} = 6 \times 1\,000 \times 0.04 \times (1 - 0.9) \times 10^{-3} + 0.5 \times 1\,000 \times 0.22 \times (1 - 0.9) \times 10^{-3}$$
$$E_{\textit{waste water}} = 0.035 \text{ kg.d}^{-1}$$

In case of long-term preservation only :

$Q_{arterial}$ = 10 l.
Q_{cavity} = 0.5 l.
$RHO_{solution}$ = 1 000 kg.m^{-3}
$C_{arterial}$ = 0.04 kg.kg^{-1}
C_{cavity} = 0.22 kg.kg^{-1}
$F_{ret,arterial}$ = 0.8
$F_{ret,cavity}$ = 0.9

The release is:

$$E_{\textit{waste water}} = 10 \times 1\,000 \times 0.04 \times (1 - 0.8) \times 10^{-3} + 0.5 \times 1\,000 \times 0.22 \times (1 - 0.9) \times 10^{-3}$$
$$E_{\textit{waste water}} = 0.091 \text{ kg.d}^{-1}$$

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