National Institute for Public Health
and the Environment
Ministry of Health, Welfare and Sport

Water quality standards related to human exposure in the Water Framework Directive

Considerations on fish consumption and swimming

RIVM Letter Report 601357011/2012

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Abstract

Water quality standards related to human exposure in the Water Framework Directive

Water quality standards for human exposure
Chemical substances may affect water quality and which may be harmful for humans and ecosystem health. The Water Framework Directive (WFD) requires derivation of water quality standards for substances. For this, guidance has been developed at the European level. Three routes are considered: direct effects on water organisms, effects on predatory birds and mammals that feed on water organisms, and effects on humans via consumption of fish. The most critical route determines the final standard. The Dutch Ministry of Infrastructure and Environment has commissioned RIVM to investigate whether the input for calculation of the human intake via fish is relevant for the Netherlands.

Fish consumption: do we use the right figures?
A default value for fish consumption of 115 gram per day is used for calculations. This is a reasonable estimate for several European countries, but a recent food consumption survey shows that the average Dutch person eats far less. Furthermore, fish is not on the menu every day. Consequently, the estimates for intake of substances might be too high and resulting quality standards too strict. It should be noted, however, that there are people that typically like fish and eat a lot more than the average person. It is a policy decision to define the protection goal for setting water quality standards. RIVM therefore does not propose an alternative for the default consumption value, but offers several possibilities for further refinement of quality standards. An option is to include in the assessment of water quality whether or not a water body is actually used for fishing.

Exposure via swimming
The potential relevance of swimming as an additional exposure route was investigated. For this, the oral and dermal intake resulting from swimming was estimated by model calculations for a series of compounds, including industrial chemicals and pesticides. Under the current assumptions, the model indicates that risks from swimming are not to be expected. There is no need to include swimming as an additional route for standard setting.

Keywords:
Water Framework Directive, Environmental Quality Standards, Fish consumption, Swimming

Rapport in het kort

Waterkwaliteitsnormen voor humane blootstelling binnen de Kaderrichtlijn Water

Waterkwaliteitsnormen voor blootstelling van mensen
Chemische stoffen kunnen de kwaliteit van oppervlaktewater aantasten, wat schadelijk kan zijn voor mens en dier. Daarom wordt vanuit de Kaderrichtlijn Water (KRW) bepaald hoeveel van een stof maximaal in oppervlaktewater mag zitten. Deze normen worden volgens Europese voorschriften afgeleid. Hierbij worden de effecten onderzocht van drie ‘routes’ waarlangs mensen en dieren in contact met de stof kunnen komen: de directe effecten van een stof op waterorganismen, de effecten op vogels en zoogdieren die waterdieren eten, en de effecten op mensen via het eten van vis uit oppervlaktewater. Dit levert drie veilige concentraties op; de laagste bepaalt de norm. Het ministerie van Infrastructuur en Milieu (IenM) heeft in dit verband het RIVM gevraagd om te onderzoeken of de Europese uitgangpunten om te berekenen in welke mate mensen aan stoffen blootgesteld worden via het eten van vis, relevant zijn voor Nederland.

Visconsumptie te hoog ingeschat?
Het Europese voorschrift gaat ervan uit dat mensen dagelijks 115 gram vis eten. Voor een aantal Europese landen lijkt dit een reële aanname. De gemiddelde Nederlander eet echter veel minder vis, zo blijkt uit recente consumptiegegevens voor ons land. Ook eet lang niet iedereen dagelijks vis. Dit zou kunnen betekenen dat van een te hoge inname van stoffen wordt uitgegaan bij de bepaling van de milieunormen, en dat deze normen te streng zijn. Er zijn echter ook fervente viseters die wél veel meer vis eten. Het is uiteindelijk een beleidskeuze van welke doelgroepen wordt uitgegaan om normen voor een veilige waterkwaliteit te bepalen. Het RIVM doet daarom geen nieuw voorstel voor de hoeveelheid vis die wordt geconsumeerd. Wel worden enkele opties geboden om te onderzoeken of er daadwerkelijk sprake is van een risico als de norm wordt overschreden. Onder andere kan bij de beoordeling van de waterkwaliteit worden meegewogen of het water daadwerkelijk als viswater wordt gebruikt.

Blootstelling door zwemmen onderzocht
Tevens is onderzocht of bij de afleiding van waternormen meegenomen moet worden dat mensen aan stoffen staan blootgesteld als zij in oppervlaktewater zwemmen. Dat blijkt niet nodig te zijn. Hiervoor zijn modelberekeningen uitgevoerd voor een aantal stoffen, waaronder gewasbeschermingsmiddelen en industriële chemicaliën. Het nu gebruikte model geeft aan dat er geen risico’s zijn te verwachten als gevolg van zwemmen.

Trefwoorden:
Kaderrichtlijn Water, Milieukwaliteitsnormen, Visconsumptie, Zwemwater

Contents

Summary

The derivation of water quality standards in the context of the Water Framework Directive (WFD) includes three aspects: direct ecotoxicity to aquatic organisms, secondary poisoning of predatory birds and mammals and exposure of humans via consumption of fish or fishery products. The latter two are included in case bioaccumulation in fish is relevant. For human fish consumption, it is assumed that a person has a daily intake of fish of 115 gram. This default originates from the guidance document for risk assessment under the former European new and existing substances directive, and is also used for the assessment of chemicals under REACH and for biocide authorisation. The background of this default value is not clear and for the Netherlands, seems to be rather high in view of data published by the European Food Safety Authority (EFSA).

The inclusion of fish consumption as a potential exposure route often leads to low water quality standards. A too high default for fish consumption might lead to quality standards that are too strict. For bioaccumulative compounds, it is logical that quality standards in water should be relatively low, to prevent concentrations in fish exceeding the level that is acceptable from the viewpoint of human health. However, advanced analytical chemistry is often needed for compliance checking. Moreover, if the standards are not met, measures have to be taken to improve water quality and this may be very demanding in terms of financial costs and technical efforts. It is thus very important that the water quality standard is as accurate as possible and is not overprotective. Therefore, the default value was evaluated using data from recent food consumption surveys in Europe and the Netherlands.

The default value of 115 g per day is not well documented. The value might be realistic for some European member states, but with 17 g per day, the average Dutch person has a much lower consumption. However, it was also noted that people that typically like fish might eat much more, although probably not every day. In addition, fish caught in one country may be exported to another country with a different consumption pattern. It is a policy decision to what extent generic water quality standards should be protective for situations in which individual people eat relatively high quantities of fish on a regular basis. Furthermore, other variables that are used for derivation of quality standards might have an even larger impact on the final outcome than the choice of the default for fish consumption. Uncertainty around the human-toxicological risk limit, and the contribution of other routes to the total intake are factors that should be taken into account for further refinements. The report present options for further refinement of water quality standards and for taking the actual use of a water body into account for compliance check.

It is clear that more attention should be paid to the derivation of representative defaults, for fish consumption as well as for other (consumption) parameters. Harmonisation between different frameworks is considered necessary. A major drawback is that the methods for collecting food consumption data differ between countries. EFSA is working on collecting reliable and comparable consumption data. It is advised that the defaults for human consumption will be thoroughly evaluated upon revision of the REACH- and WFD-guidance and that the results of EFSA will be used by then.

At present, exposure via swimming is not taken into account as an exposure route when deriving water quality standards. To investigate the potential relevance of this route, the oral and dermal intake resulting from swimming was calculated using the ConsExpo Factsheets swimmodel for a series of compounds, including industrial chemicals and pesticides. Under the current assumptions of the model, the preliminary calculations presented here do confirm the statement in the WFD-guidance that the current WFD-methodology is protective for potential exposure of swimmers. At the level of the current water quality standards a risk to swimmers is not identified. Moreover, the calculations can be considered to represent a worst case with respect to duration of swimming and defaults used for dermal absorption. Several aspects of the exposure model used here need further attention. A more realistic modelling of dermal uptake in relation to substance specific properties is considered most important. It is the intention of the authors that a research project will be started in the near future to adequately address these issues, and to adapt or extend the model where possible. It is advised that this evaluation of the relevance of swimming is repeated when an improved model becomes available in order to further underpin the conclusions reached so far.

Samenvatting

Bij het afleiden van waterkwaliteitsnormen volgens de Kaderrichtlijn water (KRW) worden drie routes in beschouwing genomen: directe effecten op waterorganismen, effecten op vogels en zoogdieren via het eten van prooidieren, en effecten op mensen via het eten van vis. De twee laatstgenoemde zijn van belang voor stoffen die zich in het weefsel van vis ophopen. Voor visconsumptie is de aanname dat iemand dagelijks 115 gram vis eet. Deze standaardwaarde komt uit de Europese richtsnoeren voor de risicobeoordeling van stoffen onder de voormalige nieuwe en bestaande stoffen verordening en wordt ook toegepast onder REACH en bij de toelating van biociden. De herkomst van de waarde is niet duidelijk en lijkt voor Nederland aan de hoge kant gezien de gegevens die door de Europese voedsel en warenautoriteit (EFSA) zijn gepubliceerd.

Het meenemen van visconsumptie als een mogelijke blootstellingsroute leidt vaak tot lage waterkwaliteitsnormen. Als bij het vaststellen van milieunormen wordt uitgegaan van een te hoge inname van stoffen, zouden de normen die worden afgeleid te streng kunnen zijn. Voor stoffen die vanuit het water door vissen worden opgenomen is een relatief lage norm op zichzelf logisch. Er moet immers worden voorkomen dat in de vis concentraties optreden die hoger zijn dan wat vanuit het oogpunt van gezondheidsnormen wenselijk is. Om aan te tonen dat water aan deze lage normen voldoet, zijn echter geavanceerde chemische analyses nodig. Als niet aan de normen wordt voldaan, zijn er bovendien kostbare maatregelen nodig om de waterkwaliteit te verbeteren. Het is dus van groot belang dat de norm op een goede manier wordt afgeleid en niet ten onrechte laag is. Daarom is in dit rapport de Europese standaardwaarde voor visconsumptie nader bekeken in relatie tot recente gegevens van voedselconsumptiepeilingen in Europa en Nederland.

De waarde van 115 gram per dag blijkt slecht gedocumenteerd. Het getal is mogelijk realistisch voor een aantal Europese landen, maar de gemiddelde Nederlander eet met 17 gram per dag aanmerkelijk minder. Toch zijn er ook in Nederland mensen die veel grotere hoeveelheden vis eten, hoewel waarschijnlijk niet dagelijks. Bovendien moet rekening worden gehouden met de mogelijke export van vis naar landen met een ander consumptiepatroon. Het is aan het beleid om te beslissen in welke mate de generieke waterkwaliteitsnormen bescherming moeten bieden voor situaties waarin individuele personen regelmatig veel vis eten. Daarbij moet worden bedacht dat de andere gegevens die bij het afleiden van normen worden gebruikt, mogelijk een grotere invloed hebben op de hoogte van de norm dan de gekozen waarde voor visconsumptie. Onzekerheid rond de humaan-toxicologische norm en de bijdrage van andere opnameroutes aan de totale inname van een stof, zijn voorbeelden van factoren die moeten worden meegenomen in een verdere verfijning van de normafleiding. Een optie is om bij het beoordelen van de waterkwaliteit mee te wegen of het water daadwerkelijk als viswater wordt gebruikt.

Het is duidelijk dat er meer aandacht nodig is voor het afleiden van representatieve standaardwaarden, zowel voor visconsumptie als voor andere (voedings)parameters. Daarbij zou bij voorkeur afstemming tussen verschillende kaders moeten plaatsvinden. Een groot nadeel is dat de methodes voor het verzamelen van gegevens over voedselconsumptie van land tot land verschillen. EFSA werkt aan het verzamelen van betrouwbare en vergelijkbare consumptiegegevens. Het advies is dan ook dat de keuze van standaardwaarden voor humane consumptie bij de toekomstige herziening van de REACH- en KRW-guidance grondig wordt geëvalueerd. De resultaten van EFSA moeten daarbij worden meegenomen.

Dit rapport gaat ook in op de mogelijke relevantie van zwemmen als blootstellingsroute. Met het ConsExpo Factsheets zwemmodel is de mogelijke inname bij zwemmen geschat voor een serie stoffen, waaronder gewasbeschermingsmiddelen en industriële chemicaliën. In de huidige KRW-methodiek wordt gesteld dat deze route wordt afgedekt door het meenemen van visconsumptie bij het afleiden van waterkwaliteitsnormen. Onder de aannames van het huidige model bevestigen de berekeningen in dit rapport deze stelling en er zijn geen aanwijzingen dat er bij de huidige waterkwaliteitsnormen een risico voor zwemmers bestaat. De aanname dat een stof volledig wordt opgenomen via de huid en via het inslikken van water, worden bovendien beschouwd als *worst case*. Dit geldt ook voor de tijd dat er gezwommen wordt. Een aantal onderdelen van het model moet nog verder worden uitgewerkt voordat meer definitieve conclusies kunnen worden getrokken. Het belangrijkste is dat de opname via de huid en de invloed van stofeigenschappen op dat proces, beter worden uitgewerkt. De auteurs hebben de bedoeling om dit deel van het model in de nabije toekomst te verbeteren, zeker gezien het feit dat dit model ook wordt gebruikt voor de toelatingsbeoordeling van biociden. Er wordt aanbevolen om deze evaluatie van de zwemroute te herhalen als er een verbeterd model beschikbaar is, om zo de conclusies van dit moment beter te onderbouwen.

1 Introduction: Human exposure in the derivation of water quality standards

The Water Framework Directive 2000/60/EC (WFD; [1]) aims at maintaining and improving water quality. Environmental quality standards are used to evaluate the status of a water body with respect to the protection of human and ecosystem health. When deriving a quality standard for surface water in general, three aspects are considered: direct ecotoxicity of aquatic organisms, secondary poisoning of predatory birds and mammals and exposure of humans via consumption of fish or fishery products. A separate quality standard is derived for surface water that is used for drinking water production. This report focuses on two aspects of human exposure as part of the derivation of water quality standards: the input parameters that are used to calculate standards for human fish consumption, and the potential relevance of swimming as an additional exposure route for humans.

2 Water standards based on fish consumption by humans

2.1 Methodology of derivation of water standards

For carcinogenic and/or mutagenic substances, and substances that affect reproduction, a water quality standard which accounts for human consumption of fish ($QS_{water,\ hh\ food}$) is always derived. In other cases, the hazard classification with respect to human toxicology in combination with the potential to accumulate in fish determines whether or not human consumption of fish is considered relevant for water quality standard derivation. When derivation of the $QS_{water,\ hh\ food}$ is triggered, and the resulting value is lower than the quality standard (QS) for direct ecotoxicity ($QS_{water,\ eco}$) and secondary poisoning ($QS_{water,\ secpois}$), it will be used to set the final QS for water.

The derivation of the $QS_{water,\ hh\ food}$ is described in the technical guidance for derivation of environmental quality standards within the context of the WFD [2]. Starting point is a human toxicological threshold limit (TL_{hh}, in mg/kg body weight per day) such as the *Acceptable* or *Tolerable Daily Intake* (ADI, TDI), or Reference dose (RfD). It is assumed by default that an average adult person of 70 kg has a daily fish consumption of 115 g. Furthermore, fish consumption should contribute for at most 10% to the TL_{hh}, thus accounting for the fact that other routes (e.g. inhalation, drinking water, other food items) may contribute as well. The maximum concentration in fish ($QS_{biota,\ hh\ food}$, in mg/kg_{fish}) is then calculated as

$$QS_{biota,\ hh\ food} = TL_{hh} \times 0.1 \times 70 / 0.115 \qquad \text{(Eq. 1)}$$

The concentration in fish is converted to a concentration in water by dividing the $QS_{biota,\ hh\ food}$ by the bioconcentration factor (BCF) and biomagnification factor (BMF), or by a field bioaccumulation factor (BAF). Written in formula:

$$QS_{water,\ hh\ food} = (TL_{hh} \times 0.1 \times 70) / (0.115 \times BCF \times BMF) \qquad \text{(Eq. 2)}$$

or

$$QS_{water,\ hh\ food} = (TL_{hh} \times 0.1 \times 70) / (0.115 \times BAF) \qquad \text{(Eq. 3)}$$

Using this methodology, relatively low values for $QS_{water,\ hh\ food}$ have been derived during the last years, e.g. for PFOS, hexachlorobenzene and hexachlorobutadiene [3,4].

In view of the strong bioaccumulation of these compounds, it is logical that quality standards in water should be relatively low, to prevent concentrations in fish exceeding the level that is acceptable from the viewpoint of human health. However, these low values require advanced analytical chemistry, since for compliance checking it is necessary to be able to detect the compounds at the level of the water quality standard. Moreover, if the standards are not met, measures have to be taken to improve water quality and this may be very demanding in terms of financial costs and technical efforts. It is thus very important that the water quality standard is as accurate as possible and is not overprotective.

Therefore, the information that is the basis for the derivation of the $QS_{biota,\ hh\ food}$ (TL_{hh}, BCF, BMF and/or BAF) is evaluated thoroughly. The default value for fish consumption, 115 g per day, is however taken for granted. It was noted before that a lifetime consumption of 115 g fish per day is likely to be far above the average for the general Dutch population [4]. In this chapter, this default value is evaluated using data from recent food consumption surveys in Europe and the Netherlands.

2.2 History

A default value of 115 g/day is used in the WFD guidance [2] and the REACH guidance [5], and was also included in the former WFD guidance [6] and the technical guidance document for risk assessment of new and existing substances under the former Directive 93/67/EEC and Regulation 1488/94, and for biocides under Directive 98/8/EC [7]. In the TGD, an ECETOC document [8] is given as reference for this value. In this ECETOC report however, an average fish consumption of 0.5 g/kg bodyweight per day is reported, which has been calculated using a European yearly average consumption of 10.1 kg per person. This value is then recalculated to 27.6 g/day for humans with a bodyweight of 58 kg. The value of 115 g/day is not reported in this report. It possibly originates from a table in the report with the consumption per country, where for Denmark the highest consumption of fish in all EU countries is reported: 41.8 kg/person per year. This can be recalculated to 115 g/day. However, this seems erroneously high when compared to the current average fish consumption in Denmark, which is 18.2 g/day (see Table 1). Thus, the background of the value of 115 g/day cannot be retrieved from the documents underlying the recent WFD guidance [2].

2.3 Current fish consumption in Europe

An overview of the food consumption for 13 European countries is available from EFSA (http://www.efsa.europa.eu/en/datex/datexfooddb.htm; accessed on January 23, 2012). The information for adults is summarised in Table 1. For the Netherlands, an average fish consumption of 9.1 g/day for adults is reported. The 95^{th} percentile in this database is 71.6 g/day, which means that 5% of the people have eaten on average 71.6 grams of fish or more on the two days they were surveyed. Note that these data are not based on the most recent data that are presented in section 2.4 below. The mean fish consumption of adults in other European countries ranges from 8.8 to 75.3 g/day, with an overall mean of 26 g/day. Within Europe, the 95^{th} percentile ranges from 54.7 to 194.3 g/day, with an average of 100 g/day. All values include the days on which no fish is consumed.

Table 1 Data from the European Food Surveys, for countries for which data for adults were available (www.efsa.europa.eu/en/datex/datexfooddb.htm; ; accessed on January 23, 2012). Where available, the year of the survey on which the data are based is given between brackets.

Country	**Fish and seafood consumption (g/day)**	
	Mean	**P95**
Netherlands (2003)	9.1	71.6
Belgium (2004)	26.6	124
Czech republic	16.7	112.5
Denmark	18.2	54.7
Finland (2007)	25.9	117.5
France	30.1	85.0
Germany	16.7	100.0
Hungary	8.8	66.7
Ireland	21.3	71.8
Italy (2005-2006)	46.4	150.0
Sweden (1997-1998)	27.7	76.4
Spain (2005)	64.5; 75.3	183; 194.3
United Kingdom	26.9	80.0
Mean	**26**	**100**

2.4 Current fish consumption in the Netherlands

2.4.1 Methods

In the Netherlands, a general food survey was performed in 2007 – 2010 by the Dutch National Food Consumption Survey (DNFCS), indicated as *Voedsel Consumptiepeiling* (VCP) in Dutch [9]. From this general database, data on fish consumption were retrieved for adults from 18 until 69 years. The following methodology was used:

- The fish consumption is based on a food consumption survey of two not-consecutive 24 hours per person. A total of 2230 adults in the age of 18 until 69 years were surveyed.
- Fish consumption is defined as EPIC-Soft group 8 (fish and shellfish), and includes all fish and fishery products, shellfish and crustaceans.
- The DNFCS 2007-2010 provided 2-day dietary intake data concerning observed consumptions. The variance in consumption comprises both the intra-individual (or day to day) variance and the inter-individual (or between subjects) variance. To correctly evaluate the intakes, not the observed consumption but the long term consumption, the habitual consumption, is needed. The habitual consumption is defined as the average consumption over a longer period, e.g., years. The habitual consumption distribution of fish is estimated using the software package SPADE (version 2.09). This software is used to filter out the within-person variation, to obtain a distribution of the habitual consumption.
- Results are weighed for small differences in social-demographic characteristics compared to the Dutch population in 2008, and for season and day of the week.
- Using SAS, the percentiles of fish consumption on the days at which fish was consumed were calculated .

- More information on the methodology can be found in the underlying report [9]. Please note that in the tables in that report (table 4.4-4.11), the average fish consumption over the two surveyed days is reported instead of the habitual long-term consumption.
- In the present report, the data are re-evaluated with specific attention to the value of 115 g/day which is at present used in risk assessment.

2.4.2 *Results*

Of the 2230 people surveyed, 1607 had not eaten fish on any of the two days, 531 persons had eaten fish on one day, and 92 persons had eaten fish on both days. Thus, fish was consumed on 16% of the occasions.
In Table 2, the habitual fish consumption per day is reported. The mean habitual fish consumption is 17 g/day. Since the distribution is rather skewed, the median consumption is 12 g/day. The 99th percentile is 77 g/day, which is still lower than 115 g/day.

Table 2 Mean and percentile values for the habitual fish consumption by Dutch adults of 18 – 69 years over all surveyed days (with and without fish consumption). Based on values from the VCP 2007-2010 [9].

Characteristic	Fish consumption (g/day)
Mean	17
P50	12
P95	49
P97	58
P99	77

When only the days at which fish was actually consumed are taken into account (16% of the survey days), the 50th percentile habitual fish consumption is 90 g/day and the 95th percentile is 190 g/day. The value of 115 g/day would correspond to the 70th percentile of the habitual intake.

Table 3 Mean and percentile values for the habitual fish consumption by Dutch adults of 18 – 69 years on consumption days of fish. Based on values from the VCP 2007-2010 [9].

Characteristic	Fish consumption (g/day)
Mean	
P50	90
P70	115
P95	190

2.5 Discussion

2.5.1 *Differences between countries*

The figures from the EFSA overview show that there is a substantial variation in fish consumption over the European countries represented in the EFSA survey. The mean daily fish consumption ranges from 8.8 g/day in Hungary to 75.3 g/day in Spain, which is a factor of 8.5 difference. Judged on the basis of the 95th percentile, the differences are smaller with a factor of 3.5 difference between the lowest and highest reported values of 54.7 and 194.3 g/day. It should be noted that according to EFSA the use of these data for direct country-to-country comparisons is not advisable because the database comprises data collected using different methodologies [10].

Within countries, the variation among the population is also large. For instance in the Netherlands and Hungary, there is an 8-fold difference between the mean (around 9 g/day), and the 95th percentile (about 70 g/day), indicating that the majority of people has a relatively low fish consumption, but a small proportion of the population consumes considerable amounts when eating fish. In other countries, e.g. Spain, Sweden and UK, people in general eat more fish, but the spread in consumption is smaller.

2.5.2 *Importance of data evaluation*

The mean and 95th percentile value for the Netherlands from the EFSA overview are 9.1 and 71.6 g/day, respectively (see Table 1). From the DNFCS over 2007-2010, values of 17 and 49 g/day were obtained (Table 2). It is not clear whether these data can be compared directly, since the methods for statistical evaluation and corrections for long-term dietary patterns, socio-demographic factors and other variables may differ. Another important issue is whether or not the data are corrected for the proportion of days on which fish is eaten. The data reported in the EFSA overview have been corrected for the days on which no fish is eaten. When doing so for the DNFCS data, the calculated 50th percentile drops from 90 to 12 g/day (Table 2 and 3). This correction is considered appropriate, because assuming that fish is on the menu every day during lifetime would mean an overestimation of exposure.

2.5.3 *Comparison of the WFD-default with other data*

The origin of the default of 115 g/day that is used in the WFD-guidance could not be traced back. The value is more or less similar to the mean of the 95th percentile values from the EFSA-overview, which is calculated as 100 g/day. Standard setting within the context of the WFD serves as a tool for the enhanced protection and improvement of the aquatic environment. Environmental quality standards are defined as “the concentration of a particular pollutant or group of pollutants in water, sediment or biota which should not be exceeded in order to protect human health and the environment” [1]. Given this wide scope, environmental water quality standards should also be protective for the use of water bodies for specific purposes, e.g. the consumption of self-caught fish on a daily basis which may be typical for local fishermen. In addition, fish caught in one country may be exported to another country with a different consumption pattern. In that respect, using a worst case default value is justified for standard setting on a European level, i.e. for priority and priority hazardous substances. As can be seen from Table 1, the WFD-default is lower than the 95th percentile in 3 out of 13 countries. This probably also holds for other EU countries not included in the EFSA overview, e.g. Portugal. Taking this into account, it can be argued that the WFD-default does not represent a worst case, and an even higher value might be necessary to ensure that human health is fully protected.

2.5.4 *Selecting an appropriate value for the Netherlands*

Based on the DNFCS data, the mean daily fish consumption is 17 g/day, the 95th percentile is 49 g/day and the 99th percentile is 77 g/day (Table 2). In view of this, a lifetime daily consumption of 115 g/day which is now used for derivation of water quality standards might be considered too high for the Netherlands. It should be noted that the Dutch Food and Consumer Products Safety Authority (VWA) has also used lower consumption values than 115 g/d when advising on the potential risks of intake of PFOS and dioxins via fish. In the latter case, which was specifically aimed at wild caught eel, it was assumed that anglers consume 150 g eel once a month [11]. In the advice on PFOS, it was assumed

that the average consumer eats 25 g fish per week, while for people that specifically like fish 400 g per week (57 g/day) was used [12]. For the risk assessment of ballast water disinfection systems, the International Maritime Organization (IMO) uses 65 g/day[1]. However, these latter cases are examples of specific risk assessments in reaction to incidents or authorisation procedures. As argued above, the WFD water quality standards have a broader scope and should be protective for all situations.
An important question when considering adaptation of the default is which level of protection is considered necessary. This determines which percentile the default for fish consumption should be based upon, i.e. 50^{th}, 95^{th}, 99^{th} or another level. This is not a scientific decision, but belongs to the policy domain. It can be argued, though, that the protection of humans refers to the individual level, which should be reflected in the choice of the default.
This does not necessarily mean that the highest percentile should be used, because in the calculation of the $QS_{water,\ hh\ food}$ (see Eq. 2 and 3), the default for fish consumption is not the only variable that contributes to the protection level that is finally achieved. The selection of the BCF and BMF (or BAF) are also important, as well as the TL_{hh}, which may be derived using relatively large uncertainty factors. Furthermore, by setting the contribution of fish consumption to a maximum of 10% of the TL_{hh}, it is implicitly assumed that the uptake of a compound via other routes is of major importance. If in reality the contribution of other routes is negligible, this assumption may lead to a more stringent quality standard than needed.
The difference between the current default of 115 g/day and the 50^{th} , 95^{th} and 99^{th} percentile obtained from the DNFCS, is a factor of 9.5, 2.3 and 1.5, respectively. It may be well possible that the other variables mentioned above have an even larger influence on the outcome. Probabilistic modelling is a way to gain insight into the uncertainty associated with each of these factors and their relative importance for the derivation of the $QS_{water,\ hh\ food}$.

2.6 Conclusions and recommendations on fish consumption

Based on the above, some conclusions are drawn in this section and recommendations are made with respect to the way fish consumption may be dealt with in derivation and compliance check of quality standards.

It is not considered appropriate to adapt the default for fish consumption without taking into account the other variables. Furthermore, the level of protection that is needed should first be properly defined. It is therefore proposed to maintain the default value of 115 g/day.

If the $QS_{water,\ hh\ food}$ derived with this default is higher than the $QS_{water,\ eco}$ or $QS_{water,\ secpois}$, the final QS_{water} is determined by one of these latter two and there is no need for further refinement. In contrast, whenever human consumption of fishery products delivers the critical value and the QS_{water} is exceeded in the field, it may be worthwhile to revisit the derivation of the $QS_{water,\ hh\ food}$. This should include an evaluation of the uncertainty associated with the BCF/BMF or BAF and TL_{hh}. It may also be an option to investigate whether or not the 10% cut-off for the contribution of fish consumption is realistic. For arsenic, it has

[1] Model developed by the Ballast Water Working Group of GESAMP (GESAMP-BWWG). GESAMP stands for Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection. GESAMP is an advisory body that advises the United Nations (UN) system on the scientific aspects of marine environmental protection. This methodology has been approved by the Marine Environment Protection Committee (MPEC) of the International Maritime Organization (IMO) during its 63rd meeting. Information made available by Jan Linders.

been demonstrated that the relative contribution of fish to the total intake is higher [13] and this can be used to refine the $QS_{water,\ hh\ food}$.

It is a policy decision whether or not the $QS_{water,\ hh\ food}$ should apply to all water bodies. If the policy aim is that *all* water bodies are of sufficient quality to allow for consumption of fish from that area on a regular basis, the $QS_{water,\ hh\ food}$ should indeed apply everywhere. In that case, non-compliance with standards would imply that measures have to be taken to improve water quality, irrespective of the question whether or not that water body is effectively used for fishing.

Like for drinking water abstraction, a certain differentiation might be possible with respect to the relevance of a water body for fish consumption. One could think of locations where the $QS_{water,\ hh\ food}$ is exceeded, but the chance of consumption of fish being caught in that area is negligible. If the measured concentrations then meet the quality standards for the other routes (direct ecotoxicity and/or secondary poisoning), this could be taken into account for the river basin management plans. If it cannot be excluded that the water body is used for fishing, an option could be to further analyse the consumption patterns in that area. If for instance the area is specifically used for eel fishing, the chances are high that large amounts of fish will be consumed. Targeted monitoring may then be an option to check whether levels in fish exceed the biota standards.

Finally, it is obvious that the current European default for fish consumption is inadequately documented and probably outdated. This may apply as well to other defaults that have been taken over from the TGD. Since these defaults are used in different regulatory settings, harmonisation between frameworks will be a major issue. A major drawback is that the methodology for collection food consumption data differs between countries [14]. EFSA has identified the collection of accurate and detailed food consumption data derived from a harmonised methodology across Europe as a primary long term objective and considers this as a top priority for collaboration with the EU Member States [10,15]. EFSA is therefore working on a project for the establishment of an EU-wide standardised food consumption data collection system. It is advised that the selection of defaults for human consumption will be thoroughly evaluated upon a future revision of the REACH- and/or WFD-guidance and that the results obtained by EFSA will then be taken into account.

3 Relevance of swimming

3.1 Background

When commenting on the draft technical guidance for derivation of environmental quality standards within the context of the WFD, the European Scientific Committee on Human and Environmental Risks (SCHER) advised that swimming should be taken into account as a potential route of human exposure, and at least to evaluate its relevance for the derivation of water quality standards [16]. In the final published guidance [2], the following is stated with respect to this: "*In the derivation of QSs to protect human health two major exposure routes are considered (consumption of fishery products and consumption of drinking water). There may be other routes of exposure, such as exposure during recreation (dermal exposure, ingestion of water). These routes are of minor importance compared to the other routes considered (see for example Albering et al, 1999) and are therefore not considered in this guidance*."

In the cited study [17], human exposure was modelled taking account of oral and dermal contact with water and sediment, and consumption of fish. It was concluded that given the assumptions of the model the contribution of water to the total exposure was small. Routes dominating average exposure were ingestion of fish for adults or ingestion of sediment for children.

In 2011, concerns were also raised in the Netherlands after pesticides were detected in recreational waters in the Province of Zuid-Holland. RIVM was requested to evaluate the risks for humans resulting from swimming and other recreational activities at these locations [18]. In addition, RIVM performed a risk assessment for humans for one particular insecticide, imidacloprid, which was detected at relatively high concentrations in surface water [19]. In both reports, the potential risks of swimming were evaluated using an exposure model that is applied for biocide authorisation in Europe, adapting some of the model parameters to recent information on behaviour of Dutch swimmers. For imidacloprid it was concluded that swimming could potentially contribute to the intake of pesticides, given the assumptions of the model. It was also noted that the International Maritime Organization (IMO) includes swimming in the risk assessment of biocides that are used for ballast water treatment. Although the model calculations did not point at an unacceptable risk for imidacloprid and the other pesticides [18,19], it was decided to further evaluate the relevance of swimming for derivation of water quality standards within the context of the WFD. In this chapter, this is done for a series of different compounds, including industrial chemicals with different physico-chemical properties.

3.2 Methods

The potential relevance of swimming was determined for a series of compounds for which water quality standards (QS_{water}) have been derived recently according to the current methodology of the WFD. For these compounds, the QS_{water} was determined as the lowest of three routes, direct ecotoxicity ($QS_{water,\ eco}$), and human consumption of fish ($QS_{water,\ hh\ food}$) and secondary poisoning ($QS_{water,\ secpois}$) where relevant. The compounds include industrial chemicals, pesticides, a PAH and PFOS and cover a range of physico-chemical properties.

Using an exposure model, the intake resulting from swimming was calculated and compared with the TL_{hh} (ADI, TDI, RfD, etc.). In line with the derivation of the $QS_{water,\ hh\ food}$, starting point for the evaluation is that swimming should not contribute for more than 10% to the TL_{hh}. From this it follows that at the level of the QS_{water}, swimming should not lead to exposure that is above 10% of the TL_{hh}.

3.3 ConsExpo modelling

3.3.1 Information on the model and parameters

Several models exist which allow for the estimation of exposure by humans to substances upon swimming. Examples of these are the SWIMMODEL of the US EPA [20], the IMO-model used for the assessment of ballast water treatment[1] and the ConsExpo Factsheets swimmodel [21]. Use of the latter is advised for the European assessment of biocides within the context of Directive 98/8/EC [22].

The ConsExpo model refers to scenarios for indoor swimming pools and takes account of exposure via inhalation, dermal uptake and oral ingestion of water. For indoor pools, the air volume and refreshment rate are known and can be used to estimate exposure by inhalation. This is not the case for outdoor swimming, and the model cannot be used in this case. It is assumed that if volatilisation from water occurs, the concentration of the substances will be diluted in the outdoor air and that contribution via inhalation is negligible. The IMO-model takes account of inhalation, and calculations for the compounds under consideration (see Appendix 1) confirm that this route is negligible as compared to oral and dermal uptake. Inhalation is therefore not included in the calculations, but it is recognised that this needs further verification (see 3.5.3)

In the original factsheets, default values for swimming time and oral ingestion of water were based on expert judgement. Experimental data for the Netherlands have been reported recently [23]. Based on a large questionnaire the following data for swimming frequency, duration and ingested water volume have been derived as presented in Table 4.

Table 4 Frequency and duration of swimming and ingested water volume in the Netherlands, data from [23] for outdoor freshwater. Data represent average values, 95% confidence intervals between brackets. Bold values have been used for calculations.

Parameter	Men (>15 years old)	Women (>15 years old)	Children (<15 years old)
frequency (events per year)	7 (0-25)	7 (0-23)	8 (0-**25**)
duration (minutes per event)	54 (7-200)	54 (6-220)	79 (12-**270**)
ingested volume (mL)	27 (0.016-140)	18 (0.022-86)	37 (0.14-**170**)

To estimate dermal uptake, the thickness of the water layer around the swimmer is needed in order to calculate the water volume and the amount of a substance that is available for uptake via the skin. According to the TGD [7], the layer thickness for dermal contact is 0.01 cm. Using this parameter and the dermal surface of the swimmer, the amount of water around the skin per swimming event can be calculated. In the ConsExpo factsheet [21] a layer thickness of 1 cm is used. The layer thickness of the TGD of 0.01 cm is valid for each event, irrespective of the duration. The duration of the swimming event is

long (up to 270 min.), which would be an argument to use a thicker layer. In previous biocide assessments, however, it was argued by the experts that 1 cm is too worst case. Therefore, a layer thickness of 0.1 cm is used in the current evaluation, but it is recognised that this needs further substantiation (see 3.5.3).
Calculations were performed for a child of about 4.5 years old, with a body weight of 16.3 kg that ingests 170 mL water is while playing/swimming for 270 min. in shallow water. The number of swim events is assumed to be 25 times per year. The child has a skin surface area of 7090 cm^2, with a layer thickness of 0.1 cm (see above) this results in a total exposure volume of water around the skin of 709 cm^3 (709 g). It is further assumed that 100% of the compound present in the water is available for dermal and oral uptake.

3.4 Results

The results of the evaluation are summarised in Table 5, which shows the compounds, the daily intake corresponding with 10% of the TL_{hh}, the current QS_{water}, and the intake at the level of the QS_{water} calculated with ConsExpo. It is also indicated whether or not human exposure via fish consumption is included in the derivation of the QS_{water}. The ratio between the calculated intake via swimming, and 10% of the TL_{hh} is presented. If this ratio is above 1, this means that at the level of the QS_{water}, swimming might lead to unacceptable exposure under the assumptions of the model. Similar calculations are performed for fish consumption. The last column shows the intake via swimming relative to that via fish consumption. If the ratio is above 1, intake via swimming is higher than via fish. Examples of the ConsExpo calculations are included in Appendix 2.

Table 5 Comparison of modelled intake at the level of the QS_{water} and allowed intake at 10% of the human toxicological threshold limit for swimming and fish consumption.

Name	10% of TL_{hh} [µg/kg_{bw}.d]	QS_{water} [a] [µg/L]	fish route included in QS?	ConsExpo intake at QS_{water} [µg/kg_{bw}.d]	Ratio intake via swimming/ 10% TL_{hh}	Intake via fish at QS_{water} [µg/kg_{bw}.d]	Ratio intake via fish/ 10% TL_{hh}	Ratio intake via swimming/ intake via fish
4-chloro-3-methylphenol	10	6.4	n.r.	0.024	0.002	0.17	0.02	0.1
2,4-dichlorophenol	0.3	0.54	yes	0.002	0.01	0.30	1.0	0.01
3-chlorophenol	0.3	4.0	n.r.	0.015	0.05	0.12	0.39	0.1
2,3,4-trichlorophenol	0.3	0.54	yes	0.002	0.01	0.30	1.00	0.01
chlorothalonil	2.7	0.06	yes	0.000221	0.0001	0.01	0.003	0.03
benzyl chloride	0.0006 [b]	0.02 [e]	yes	0.00007	0.1	0.0006	0.99	0.1
bromoxynil octanoate	1	0.25	yes	0.0009	0.001	0.09	0.09	0.01
prosulfocarb	0.5	0.55	yes	0.00204	0.004	0.50	1.0	0.004
novaluron	1	0.0006	n.r.	0.0000022	0.000002	0.02	0.02	0.0001
chrysene	0.005 [b]	0.0012 [e]	yes	0.000004	0.001	0.0033	0.67	0.001
epoxiconazole	0.8	0.19	yes	0.0007	0.001	0.02	0.03	0.03
imidacloprid	6	0.067	n.r.	0.00024	0.00004	0.0001	0.00001	**4**
diflufenican	0.3	0.010	yes	0.00004	0.0001	0.03	0.09	0.002
1,3-dichloropropene	0.001 [b]	0.18 / 0.087 [d]	n.r. [d]	0.00066 / 0.00032	0.66 / 0.3	0.0009 / 0.001	0.89 / 1.0	0.7 / 0.3
1,1,2,2-tetrachloroethane	5	8.0	n.r.	0.03	0.01	0.45	0.09	0.07
1,1,1-trichloroethane	200	21.0	n.r.	0.078	0.0004	0.90	0.004	0.1
2-chlorobutadiene	0.0041 [b,c]	0.19 [e]	yes	0.0007	0.2	0.0041	1.0	0.2
PFOS	0.015	0.00065	yes	0.0000024	0.0002	0.0030	0.20	0.001
1,2-dichloroethylene	3	6.8	n.r.	0.025	0.01	0.11	0.04	0.2

n.r. = not relevant, derivation of $QS_{water, biota, hh}$ not needed according to triggers WFD
a: value refers to most recently derived risk limit; it is indicated by an additional footnote when a value has not been set officially
b: TL_{hh} derived on the basis of an additional cancer risk of 10^{-6} for lifetime exposure
c: TL_{hh} considered less reliable; included in QS-derivation because of genotoxicity
d: 1,3-dichloropropene is not classified as genotoxic carcinogen in the EU and does not meet the triggers for derivation of the $QS_{water, biota, hh}$; since the TL_{hh} is based on additional cancer risk, fish consumption may be taken into account, leading to a QS_{water} of 0.087 µg/L
e: most recently proposed value [24-26]

3.5 Discussion

3.5.1 *Is the current QS_{water} protective for swimming?*

From the data in Table 5 it follows that under the assumptions of the model for none of the 19 compounds swimming at the level of the QS_{water} would potentially lead to uptake that is higher than 10% of the human toxicological threshold limit. This indicates that inclusion of swimming in the way it was done here, does not require a more stringent QS_{water} than derived according to the WFD-methodology.
Additional calculations (not shown) were performed assuming daily swimming instead of 25 times per year. Using this unlikely high frequency, a potential risk of swimming is identified for only 3 out of the 19 compounds. These compounds (benzyl chloride, 1,3-dichloropropene and 2-chlorobutadiene) are considered as genotoxic carcinogens, for which in line with the WFD- and REACH-guidance, the TL_{hh} is based on one additional cancer incident in 10^6 persons after lifetime daily exposure [2,27]. For these compounds, the hazardous properties are generally reflected in low TL_{hh} values. However, because bioaccumulation is relatively low, the calculated intake resulting from life-time daily swimming is higher than from daily fish consumption.

3.5.2 *Relevance of swimming as compared to fish consumption*

In the lasts two columns, the intake via fish consumption at the level of the current QS_{water} is compared with the intake via swimming. Of course, the intake via fish at the level of the current QS_{water} should never exceed 10% of the TL_{hh}, because otherwise the QS_{water} was not derived in a correct way. The last column shows that only for imidacloprid, the potential uptake via swimming according to the ConsExpo model is higher than via fish consumption. It should be noted that swimming at the level of the QS_{water} leads to negligible intake as compared to the TL_{hh} (see column 6). The current QS_{water} is thus protective for swimming, which is due to the fact that the compound is also highly toxic to aquatic organisms. As was already shown in a previous risk assessment, this is also the case when daily swimming is assumed instead of 25 times per year [19].
From the comparison between uptake via swimming and via fish. it follows that at a BCF of 2.0-2.2 L/kg, the QS_{water} based on fish consumption is always protective for swimming, given the assumptions underlying both routes. Imidacloprid has a BCF-value of 0.57 L/kg [28] and this explains why fish consumption in this case leads to a less critical value than swimming.

3.5.3 *Uncertainties in input values and model*

It should be noted that the TL_{hh} for 2-chlorobutadiene is considered as less reliable since the oral TL_{hh} is extrapolated from inhalatory data [24]. However, adapting the TL_{hh} would also affect the current QS_{water}, which is based on fish consumption and uses the same TL_{hh} as input and this does not change the relative importance of the uptake routes.

As already indicated in section 3.3.1, the choice of a default for layer thickness needs further attention as well as the assumption that 100% of the compound present in that layer is available for dermal uptake. In reality, dermal uptake is a complex process and the model should take account of factors such as skin permeability, depletion of the water layer, refreshment of the water layer and duration of the contact. Substance specific properties such as molecular weight, log K_{ow} and water solubility are expected to play an important role [29,30].

Since the ConsExpo Factsheets swimmodel is also used for the risk assessment of biocides in the context of European authorisation, it is important that these uncertainties are addressed in due time. It is the intention of the authors that a research project will be started in the near future to adequately address these issues, and to adapt or extend the where possible.

3.6 Conclusions and recommendations on swimming

Under the current assumptions of the model, the preliminary calculations presented here do confirm the statement in the WFD-guidance that the current WFD-methodology is protective for potential exposure of swimmers. The conclusion that the current water quality standards are protective for swimmers is further confirmed by the fact that for several reasons the calculations can be considered to represent a worst case. First of all, the abovementioned limitations of the model with respect to the calculation of the dermal uptake are considered to result in worst case estimates rather than an under-estimation of the exposure. Furthermore, the calculations are performed for children, which have a higher surface to weight ratio than adults. This means that the contribution of dermal uptake is relatively high. This also holds for the ingestion of water, which for a child is about 10 mL per kg bodyweight as compared to 1-2 mL/kg for adults. In addition, the upper 95 confidence limits for average duration and average ingested water volume are used as input instead of mean values. It should also be noted that even when daily swimming is considered, the current QS_{water} is still protective in the majority of cases.
The ConsExpo swimmodel needs to be improved. It is expected that a refined model will lead to lower estimated dermal uptake. It is advised that this evaluation is repeated when an improved model becomes available to check whether the results of a new model still confirm the conclusions reached so far.

4 References

1. EC. 2000. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy.
2. EC. 2011. Common Implementation Strategy for the Water Framework Directive (2000/60/EC). Technical guidance for deriving environmental quality standards. Guidance Document No. 27. Brussels, Belgium. European Communities.
3. Moermond CTA, Verbruggen EMJ, Smit CE. 2010. Environmental risk limits for PFOS. A proposal for water quality standards in accordance with the Water Framework Directive. Bilthoven, the Netherlands. RIVM. Report nr. 601714013.
4. Moermond CTA, Verbruggen EMJ. 2011. Environmental risk limits for hexachlorobenzene and hexachlorobutadiene. Using bioaccumulation data to convert biota standards into water risk limits. Bilthoven, the Netherlands. RIVM. Report nr. 601714015.
5. ECHA. 2010. Guidance on information requirements and chemical safety assessment Chapter R.16: Environmental Exposure Estimation. Helsinki, Finland. European Chemicals Agency.
6. Lepper P. 2005. Manual on the methodological framework to derive environmental quality standards for priority substances in accordance with Article 16 of the Water Framework Directive (2000/60/EC) Schmallenberg, Germany. Fraunhofer Institute for Molecular Biology and Applied Ecology.
7. EC. 2003. Technical Guidance Document (TGD) in support of Commission Directive 93/67/EEC on Risk Assessment for new notified substances, Commission Regulation (EC) No 1488/94 on Risk Assessment for existing substances and Directive 98/8/EC of the European Parliament and the Council concerning the placing of biocidal products on the market. Edition 2. EUR 20418 EN/2. Ispra, Italy. European Commission Joint Research Centre.
8. ECETOC. 1994. Assessment of non-occupational exposure to chemicals. Technical Report No. 58. Brussels, Belgium. European Centre for Ecotoxicology and Toxicology of Chemicals.
9. Van Rossum CTM, Fransen HP, Verkaik-Kloosterman J, Buurma-Rethans E, Ocké MC. 2011. Dutch National Food Consumption Survey 2007-2010. Diet of children and adults aged 7 to 69 years. Bilthoven, the Netherlands. RIVM. Report nr. 350050006.
10. EFSA. 2011. Guidance of EFSA. Use of the EFSA Comprehensive European Food Consumption Database in Exposure Assessment. EFSA Journal 9, 2097.
11. VWA. 2007. Advies van de directeur Bureau Risicobeoordeling. Dioxines en dioxineachtige PCB's in paling. Voedsel en Waren Autoriteit – Bureau Risicobeoordeling. Reference VWA/2007/BuR/60693, 14 maart 2007 (in Dutch).

12. VWA. 2008. Advies van de directeur Bureau Risicobeoordeling aan de inspecteur-generaal van de Voedsel en Warenautoriteit. Advies inzake PFOS in vis afkomstig uit Rijnland. Voedsel en Waren Autoriteit – Bureau Risicobeoordeling. Reference VWA/BuR/2008/40127, 12 November 2008 (in Dutch).
13. ICBR. 2009. Afleiding van milieukwaliteitsnormen voor Rijnrelevante stoffen. Koblenz, Germany. Internationale Commissie ter Bescherming van de Rijn. Report nr. 164.
14. EFSA. 2005. Opinion of the Scientific Committee on a request from EFSA related to Exposure Assessments (Request No EFSA-Q-2003-107) (adopted on 22 June 2005). The EFSA Journal 249, 1-26.
15. EFSA. 2010. 11-12 February 2010 Seville declaration of the Advisory Forum on the PAN-European Food Consumption Survey. What's on the menu in Europe? A PAN-European Food Consumption Survey (EU-menu).
16. SCHER. 2010. Opinion on the Chemicals and the Water Framework Directive:Technical Guidance for Deriving Environmental Quality Standards, October 2010. Scientific Committee on Health and Environmental Risks
17. Albering HJ, Rila J-P, Moonen EJC, Hoogewerff JA, JCS K. 1999. Human health risk assessment in relation to environmental pollution of two artificial freshwater lakes in the Netherlands. Environ Health Persp 107, 27-35.
18. Van der Ree J, Te Biesebeek JD, Wolterink G, Smit E, Van Vlaardingen P. 2011. Humane risico's van gewasbeschermingsmiddelen in zwemwater. Analyse van metingen in Provincie Zuid-Holland. Bilthoven, the Netherlands. RIVM. Report nr. 609033007 (in Dutch).
19. Smit CE. 2011. Risico's van imidacloprid in zwemwater voor de mens. Bilthoven, the Netherlands. RIVM. Report nr. 601712008 (in Dutch).
20. US EPA. 2003. User’s manual Swimmer Exposure Assessment model (SWIMMODEL) version 3.0. United States Environmental Protection Agency, Office of Pesticide Programs, Antimicrobials Division.
21. Prud’homme de Lodder LCH, Bremmer HJ, Pelgrom SMGJ, Park MVDZ, Van Engelen JGM. 2006. Disinfectant Products Fact Sheet - To assess the risks for the consumer. Bilthoven, the Netherlands. RIVM. Report nr. 320005003.
22. EC. 2007. Directive 98/8/EC of the European Parliament and of the Council of 16 February 1998 concerning the placing of biocidal products on the market.
23. Schets MF, Schijven JF, De Roda Husman AM. 2011. Exposure assessment for swimmers in bathing waters and swimming pools. Wat Res 45, 2392-2400.
24. Fleuren RHLJ, Janssen PJCM, De Poorter LRM. 2009. Environmental risk limits for twelve volatile aliphatic hydrocarbons. An update considering human-toxicological data. Bilthoven, the Netherlands. RIVM. Report nr. 601782013.
25. Smit CE. 2010. Environmental risk limits for benzyl chloride and benzylidene chloride. Bilthoven, the Netherlands. RIVM. Report nr. 601714016.
26. Verbruggen EMJ, Van Herwijnen R. 2011. Environmental risk limits for chrysene. Bilthoven, the Netherlands. RIVM. Report nr. 601357008.
27. ECHA. 2010. Guidance on information requirements and chemical safety assessment Chapter R.8: Characterisation of dose [concentration]-response for human health. Helsinki, Finland. European Chemicals Agency.

28. EFSA. 2008. Conclusion on the peer review of imidacloprid. EFSA Scientific Report 148, 1-120. Parma, Italy. European Food Safety Authority.
29. Ten Berge W. 2009. A simple dermal absorption model: Derivation and application. Chemosphere 75, 1440-1445.
30. Ten Berge W. 2012. Dermal absorption of chemicals: semi-quantitative estimation by means of IH Skinperm, 10 April 2012.

Appendix 1. Calculations for inhalation with the IMO model

The Ballast Water Working Group of GESAMP[2] (GESAMP-BWWG) has developed a methodology for the evaluation of the potential risks for humans resulting from swimming in treated ballast water. This methodology was accepted by the Marine Environment Protection Committee of the International Maritime Organization during its 63rd meeting. The inhalatory intake is calculated as:

$$U_{si} = \frac{\mathrm{C_{bw}} \cdot H \cdot \mathrm{RespR} \cdot \mathrm{n} \cdot \mathrm{D} \cdot \mathrm{BIO_{inh}}}{\mathrm{R} \cdot \mathrm{T} \cdot \mathrm{Dil} \cdot \mathrm{BW}}$$

Where:

U_{si}	=	inhalatory intake of chemical during swimming (mg/kg/d)
C_{bw}	=	concentration in ballast water according to MAMPEC (mg/m^3)
H	=	Henry's Law coefficient (Pa m^3/mole)
RespR	=	respiration rate - light activity assumed (1.25 m^3/h)
n	=	number of swims per day (5/d)
D	=	duration of each swim (0.5 h)
BIO_{inh}	=	fraction of chemical absorbed through the lungs (1)
R	=	gas constant (8.314 Pa m^3/mole K)
T	=	temperature (K)
Dil	=	Dilution factor because of wind, turbulence and time to reach equilibrium (default 100)
BW	=	body weight (60 kg)

For the present calculations, C_{bw} is set at the current QS_{water} and temperature is assumed to be 20 °C (293 K). Table A1.1 shows the calculated intake at the level of the $QS_{water.}$ The calculations show that under the assumptions of the IMO-model inhalatory intake does not lead to exposure above 10% of the TL_{hh} for any of the substances. The duration of the swimming event in the IMO-model (total 150 minutes per day) is somewhat lower than used in the ConsExpo factsheet model (270 minutes), but with a correction for this difference, the inhalatory intake is still negligible as compared to oral and dermal uptake.

[2] GESAMP stands for Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection. GESAMP is an advisory body that advises the United Nations (UN) system on the scientific aspects of marine environmental protection.

Table A1.1 Calculated intake by inhalation according to the model of GESAMP-BWWG

Name	10% of TL_{hh} [µg/kg_{bw}.d]	QS_{water} [a] [µg/L]	Henry's law constant [Pa.m^3/mole]	Intake at QS_{water} via inhalation [µg/kg_{bw}.d]	Ratio intake/ 10% TL_{hh}
4-chloro-3-methylphenol	10	6.4	0.5	6.84E-07	6.84E-08
2,4-dichlorophenol	0.3	0.54	0.5	5.77E-08	1.92E-07
3-chlorophenol	0.3	4.0	0.2	1.71E-07	5.70E-07
2,3,4-trichlorophenol	0.3	0.54	0.66	7.62E-08	2.54E-07
chlorothalonil	2.7	0.06	2.50E-02	3.21E-10	1.19E-10
benzyl chloride	0.0006[b]	0.02[e]	41.7	1.78E-07	2.97E-04
bromoxynil octanoate	1	0.25	1.30E-03	6.95E-11	6.95E-11
prosulfocarb	0.5	0.55	1.50E-02	1.76E-09	3.53E-09
novaluron	1	0.0006	2	2.57E-10	2.57E-10
chrysene	0.005[b]	0.0012[e]	0.247	6.34E-11	1.27E-08
epoxiconazole	0.8	0.19	3.1	1.26E-07	1.57E-07
imidacloprid	6	0.067	1.70E-10	2.44E-18	4.06E-19
diflufenican	0.3	0.010	0.034	7.27E-11	2.42E-10
1,3-dichloropropene	0.001[b]	0.18 / 0.087[d]	900	3.46E-05 / 1.67E-05	3.46E-02 / 1.67E-2
1,1,2,2-tetrachloroethane	5	8.0	34	5.82E-05	1.16E-05
1,1,1-trichloroethane	200	21.0	1669	7.49E-03	3.75E-05
2-chlorobutadiene	0.0041[b,c]	0.19[e]	5684	2.31E-04	5.63E-02
PFOS	0.015	0.00065	4.30E-07	5.98E-17	3.98E-15
1,2-dichloroethylene	3	6.8	959	1.39E-03	4.65E-04

a: value refers to most recently derived risk limit; it is indicated by an additional footnote when a value has not been set officially
b: TL_{hh} derived on the basis of an additional cancer risk of 10^{-6} for lifetime exposure
c: TL_{hh} considered less reliable; included in QS-derivation because of genotoxicity
d: 1,3-dichloropropene is not classified as genotoxic carcinogen in the EU and does not meet the triggers for derivation of the $QS_{water,\ biota,\ hh}$; since the TL_{hh} is based on additional cancer risk, fish consumption may be taken into account, leading to a QS_{water} of 0.087 µg/L
e: most recently proposed value (Fleuren et al., 2009; Smit, 2010; Verbruggen and Van Herwijnen, 2011)

Appendix 2. Examples of ConsExpo calculations

ConsExpo 4.1 report

file name: \\alt.rivm.nl\users\home\brasserp\Documents\Zwemwater\Kind 4-chloro-3-methylphenol 6.4 ug p l.Ce4
Report date: 10/14/2011

Product

zwemwater

Compound

Compound name :	4-chloro-3-methylphenol	
CAS number :	59-50-7	
molecular weight	143	g/mol
vapour pressure	6.7	Pascal
KOW	3.1	10Log

General Exposure Data

exposure frequency	25	1/year
body weight	16.3	kilogram

Dermal model: Direct dermal contact with product : instant application

weight fraction compound	6.4E-9	fraction
exposed area	7.09E3	cm2
applied amount	709	gram

Uptake model: fraction

uptake fraction	1	fraction

Oral model: Oral exposure to product : direct intake

weight fraction compound	6.4E-9	fraction
amount ingested	170	gram

Uptake model: Fraction

uptake fraction	1	fraction

Output

Dermal : point estimates

dermal load :	6.4E-7	mg/cm2
dermal external dose :	0.000278	mg/kg
dermal acute (internal) dose :	0.000278	mg/kg
dermal chronic (internal) dose :	0.000019	mg/kg/day

Oral : point estimates

oral external dose :	6.67E-5	mg/kg
oral acute (internal) dose :	6.67E-5	mg/kg

oral chronic (internal) dose :	6.67E-5	mg/kg/day

Integrated (point estimates)

total external dose:	0.000345	mg/kg
total acute dose (internal):	0.000345	mg/kg
total chronic dose (internal):	0.000024	mg/kg/day

ConsExpo 4.1 report

file name: \\alt.rivm.nl\users\home\brasserp\Documents\Zwemwater\Kind 4-chloro-3-methylphenol 10% ADI.Ce4
Report date: 10/14/2011

Product

zwemwater

Compound

Compound name :	4-chloro-3-methylphenol	
CAS number :	59-50-7	
molecular weight	143	g/mol
vapour pressure	6.7	Pascal
KOW	3.1	10Log

General Exposure Data

exposure frequency	25	1/year
body weight	16.3	kilogram

Dermal model: Direct dermal contact with product : instant application

weight fraction compound	2.7E-6	fraction
exposed area	7.09E3	cm2
applied amount	709	gram

Uptake model: fraction

uptake fraction	1	fraction

Oral model: Oral exposure to product : direct intake

weight fraction compound	2.7E-6	fraction
amount ingested	170	gram

Uptake model: Fraction

uptake fraction	1	fraction

Output

Dermal : point estimates

dermal load :	0.00027	mg/cm2
dermal external dose :	0.117	mg/kg
dermal acute (internal) dose :	0.117	mg/kg
dermal chronic (internal) dose :	0.00804	mg/kg/day

Oral : point estimates

oral external dose :	0.0282	mg/kg
oral acute (internal) dose :	0.0282	mg/kg
oral chronic (internal) dose :	0.00193	mg/kg/day

Integrated (point estimates)

total external dose:	0.146	mg/kg
total acute dose (internal):	0.146	mg/kg
total chronic dose (internal):	0.00997	mg/kg/day

ConsExpo 4.1 report

file name: \\alt.rivm.nl\users\home\brasserp\Documents\Zwemwater\Kind 2,4-dichloorphenol 0.54 ug p
l.Ce4
Report date: 10/14/2011

Product

Zwemwater

Compound

Compound name :	2,4-dichloorphenol	
CAS number :	120-83-2	
molecular weight	163	g/mol
vapour pressure	15	Pascal
KOW	3.06	10Log

General Exposure Data

exposure frequency	25	1/year
body weight	16.3	kilogram

Dermal model: Direct dermal contact with product : instant application

weight fraction compound	5.4E-10	fraction
exposed area	7.09E3	cm2
applied amount	709	gram

Uptake model: fraction

uptake fraction	1	fraction

Oral model: Oral exposure to product : direct intake

weight fraction compound	5.4E-10	fraction
amount ingested	170	gram

Uptake model: Fraction

uptake fraction	1	fraction

Output

Dermal : point estimates

dermal load :	5.4E-8	mg/cm2
dermal external dose :	2.35E-5	mg/kg
dermal acute (internal) dose :	2.35E-5	mg/kg
dermal chronic (internal) dose :	1.61E-5	mg/kg/day

Oral : point estimates

oral external dose :	5.63E-6	mg/kg
oral acute (internal) dose :	5.63E-6	mg/kg
oral chronic (internal) dose :	3.85E-7	mg/kg/day

Integrated (point estimates)

total external dose:	2.91E-5	mg/kg
total acute dose (internal):	2.91E-5	mg/kg
total chronic dose (internal):	1.99E-6	mg/kg/day

ConsExpo 4.1 report

file name: \\alt.rivm.nl\users\home\brasserp\Documents\Zwemwater\Kind 2,4-dichloorphenol 10% ADI.Ce4
Report date: 10/14/2011

Product

Zwemwater

Compound

Compound name :	2,4-dichloorphenol	
CAS number :	120-83-2	
molecular weight	163	g/mol
vapour pressure	15	Pascal
KOW	3.06	10Log

General Exposure Data

exposure frequency	25	1/year
body weight	16.3	kilogram

Dermal model: Direct dermal contact with product : instant application

weight fraction compound	8.1E-8	fraction
exposed area	7.09E3	cm2
applied amount	709	gram

Uptake model: fraction

uptake fraction	1	fraction

Oral model: Oral exposure to product : direct intake

weight fraction compound	8.1E-8	fraction
amount ingested	170	gram

Uptake model: Fraction

uptake fraction	1	fraction

Output

Dermal : point estimates

dermal load :	8.1E-6	mg/cm2
dermal external dose :	0.00352	mg/kg
dermal acute (internal) dose :	0.00352	mg/kg
dermal chronic (internal) dose :	0.000241	mg/kg/day

Oral : point estimates

oral external dose :	8.45E-4	mg/kg
oral acute (internal) dose :	8.45E-4	mg/kg
oral chronic (internal) dose :	5.78E-5	mg/kg/day

Integrated (point estimates)

total external dose:	0.00435	mg/kg
total acute dose (internal):	0.00435	mg/kg
total chronic dose (internal):	0.00435	mg/kg/day

ConsExpo 4.1 report

file name: \\alt.rivm.nl\users\home\brasserp\Documents\Zwemwater\Kind 3-chloorphenol 4 ug p l.Ce4
Report date: 10/14/2011

Product

Zwemwater

Compound

Compound name :	3-chloorphenol	
CAS number :	108-43-0	
molecular weight	129	g/mol

vapour pressure	39	Pascal
KOW	2.5	10Log

General Exposure Data

exposure frequency	25	1/year
body weight	16.3	kilogram

Dermal model: Direct dermal contact with product : instant application

weight fraction compound	4E-9	fraction
exposed area	7.09E3	cm2
applied amount	709	gram

Uptake model: fraction

uptake fraction	1	fraction

Oral model: Oral exposure to product : direct intake

weight fraction compound	4E-9	fraction
amount ingested	170	gram

Uptake model: Fraction

uptake fraction	1	fraction

Output

Dermal : point estimates

dermal load :	4E-7	mg/cm2
dermal external dose :	0.000174	mg/kg
dermal acute (internal) dose :	0.000174	mg/kg
dermal chronic (internal) dose :	0.000012	mg/kg/day

Oral : point estimates

oral external dose :	4.17E-5	mg/kg
oral acute (internal) dose :	4.17E-5	mg/kg
oral chronic (internal) dose :	2.86E-6	mg/kg/day

Integrated (point estimates)

total external dose:	0.000216	mg/kg
total acute dose (internal):	0.000216	mg/kg
total chronic dose (internal):	0.000015	mg/kg/day

ConsExpo 4.1 report

file name: \\alt.rivm.nl\users\home\brasserp\Documents\Zwemwater\Kind 3-chloorphenol 10% ADI.Ce4
Report date: 10/14/2011

Product

Zwemwater

Compound

Compound name :	3-chloorphenol	
CAS number :	108-43-0	
molecular weight	129	g/mol
vapour pressure	39	Pascal
KOW	2.5	10Log

General Exposure Data

exposure frequency	25	1/year
body weight	16.3	kilogram

Dermal model: Direct dermal contact with product : instant application

weight fraction compound	8.1E-8	fraction
exposed area	7.09E3	cm2
applied amount	709	gram

Uptake model: fraction

uptake fraction	1	fraction

Oral model: Oral exposure to product : direct intake

weight fraction compound	8.1E-8	fraction
amount ingested	170	gram

Uptake model: Fraction

uptake fraction	1	fraction

Output

Dermal : point estimates

dermal load :	8.1E-8	mg/cm2
dermal external dose :	0.00352	mg/kg
dermal acute (internal) dose :	0.00352	mg/kg
dermal chronic (internal) dose :	0.000241	mg/kg/day

Oral : point estimates

oral external dose :	8.45E-4	mg/kg
oral acute (internal) dose :	8.45E-4	mg/kg
oral chronic (internal) dose :	5.78E-5	mg/kg/day

Integrated (point estimates)

total external dose:	0.00437	mg/kg
total acute dose (internal):	0.00437	mg/kg
total chronic dose (internal):	0.000299	mg/kg/day

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