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

FRONT OFFICE FOOD AND PRODUCT SAFETY

REVISED RISK ASSESSMENT OF GENX AND PFOA IN FOOD PART 2: TRANSFER OF GENX , PFOA AND PFOS IN DITCH WATER AND SILAGE TO EDIBLE PRODUCTS OF FOOD PRODUCING ANIMALS

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Subject

In the past, the companies Chemours in Dordrecht and Custom Powders in Helmond emitted the substances GenX[1] and perfluorooctanoic acid (PFOA) into the air and surface water. The emission of GenX by Chemours is ongoing. Consequently, the area in the vicinity of these companies (soil, water and vegetation) became polluted, as communicated by the National Institute for Public Health and the Environment (RIVM) with the city council of Dordrecht in July and September 2018. One of the conclusions was that ditch water contained high levels of GenX and PFOA. This might be a potential concern for livestock drinking from that ditch water. At that moment no firm conclusions were drawn regarding the transfer of GenX and PFOA to milk and edible tissue of livestock consuming this ditch water.

The Office for Risk Assessment and Research (BuRO) has requested the Front Office Food and Product Safety (FO) in 2018 to address three questions related to the transfer of GenX and PFOA in ditch water to lactating cows and sheep. A fourth question related to the transfer of GenX and PFOA from silage to lactating cows was added at a later stage to the request in 2019 (RIVM & WFSR, 2019b).

In 2020, the European Food Safety Authority (EFSA) established a health-based guidance value (HBGV) for the sum of 4 perfluoroalkyl substances (PFAS) (PFOA, perfluorononanoic acid [PFNA], perfluorohexane sulfonic acid [PFHxS], perfluorooctane sulfonic acid [PFOS]) based on new scientific information (EFSA, 2020). This new HBGV is lower, thus stricter, and takes other PFAS into account. BuRO has therefore requested the FO to update the previous assessment. In addition to that, BuRO has requested the FO to add additional PFAS to the assessment where possible.

New in this revision is the mixture approach. As described in Part 1 of the FO assessment (RIVM, 2021b), RIVM recommends to use EFSA's HBGV, a tolerable weekly intake (TWI), together with relative potency factors (RPFs) for PFAS, after it discussed scientific arguments and weighed several options for implementation of the TWI (RIVM, 2020a; 2020b; 2021a). In this assessment, RPFs are used to calculate PFOA-equivalent (PEQ) concentrations in milk and meat instead of individual PFAS concentrations (RIVM, 2021a), to be able to include combined exposure to PFOA, PFOS and GenX detected in

[1] GenX refers to hexafluoropropyleneoxide dimer acid (HFPO-DA), or to its ammonium salt, as used in the GenX technology.

ditch water/grass (silage). The transfer of PFOA, PFOS and GenX was analysed individually.

Other PFAS (besides the originally requested PFOA and GenX) that were measured above the LOQ included PFOS, PFHxA, PFHpA, PFNA, PFDA, PFUnDA, PFBS, PFHxS, PFHpS, and NaDONA (in ditchwater) and PFHxA[2] (in silage).Only PFOS transfer analysis was included in this mixture exposure approach, because it was the only other substance for which a transfer model was readily available. Finally, for the purpose of reverse dosimetry, previously used analytical LOQs were replaced by the most recent analytical LOQs.

Questions

Given the new HBGV derived by EFSA, BuRO asked the FO to update the 2019 FO risk assessment of GenX and PFOA. For Part 2 of this risk assessment BuRO has asked to update the answers to the questions with respect to the transfer of GenX and PFOA in ditch water and silage to lactating cows and/or sheep and to add additional PFAS to the assessment for those substances with transfer models readily available.

1. Model the transfer of GenX, PFOA and additional PFAS from ditch water to edible products from lactating cows and sheep (milk and meat);
2. Estimate the intake of GenX, PFOA and additional PFAS for consumers based on the theoretical (modelled) concentrations in milk and meat of dairy cattle and lactating sheep;
3. Calculate the possible concentrations of GenX, PFOA and additional PFAS in ditch water when concentrations of GenX and PFOA occur at the analytical LOQ of 0.01 ng/g in cow's milk (based on reversed dosimetry modelling);
4. Estimate the transfer of GenX, PFOA and additional PFAS from silage to milk and meat from lactating cows and sheep.

Conclusions

1) *Note that for PFOA and GenX the transfer calculations to milk and meat were not revised, but updated by conversion to PFOA-equivalent (PEQ) concentrations. The PFOS transfer calculation to milk and meat (including conversion to PEQ concentration) was added. Other PFAS could not be added due to lack of transfer models readily available.*

An available transfer model for PFOS in dairy cows was adapted to model the transfer of PFOA from ditch water to cow's milk and meat. The highest intake of PFOA through the chronic consumption of contaminated ditch water (514 µg per day) resulted in a modelled concentration of 0.06 ng PFOA/g milk and 0.28 ng PFOA/g meat. This corresponds to a concentration of 0.06 ng PEQ/g milk and 0.28 ng PEQ/g meat.

For this revised version of the risk assessment BuRO has requested the FO to add additional PFAS. In this revised version, transfer for PFOS was also calculated based on the availability of contamination data and a transfer model for PFOS. Other PFAS were not included due to the lack of transfer models. Using a transfer model for PFOS for dairy cows and the highest intake of PFOS through the consumption of contaminated ditch water (0.63 µg per day) resulted in a modelled concentration of 0.02 ng PFOS/g milk and 0.11 ng PFOS/g meat. This corresponds to a concentration of 0.04 ng PEQ/g milk and 0.22 ng PEQ/g meat.
The expected GenX concentration in dairy cattle is equal to or lower than 0.01 ng GenX/g milk and 0.06 ng GenX/g meat, i.e. 0.0006 ng PEQ/g milk and 0.004 ng PEQ/g meat.

[2] Abbreviations refer to following PFAS: PFOS: PFHxA: perfluorohexanoic acid; PFHpA: perfluoroheptanoic acid; PFDA: perfluorodecanoic acid; PFUnDA: perfluoroundecanoic acid; PFBS: perfluorobutane sulfonic acid,PFHpS: perfluoroheptane sulfonic acid; and NaDONA: sodium 4,8-dioxa-3H-perfluorononanoate.

Only one pilot study described the kinetics of PFOA and PFOS in sheep (n=2) after exposure from grass (silage) and the information does not allow us to develop a transfer model for these compounds in sheep. The reported transfer of PFOA to the carcass was (more or less) similar for sheep and dairy cattle, whereas the reported transfer of PFOA and PFOS to milk was possibly higher in sheep. These data need experimental confirmation before the relevance of the transfer of PFOA, PFOS (and GenX) to milk and meat of sheep for human exposure can be evaluated.

2) *Note that this answer is revised, since a chronic dietary exposure estimate was made instead of using the 20% TDI approach.*

Based on the modelled concentrations in milk and meat of dairy cattle, and high consumption statistics (95th percentile of consumption) of dairy products and meat from the Dutch National Food Consumption Survey of 2012-2016, the weekly intake was calculated. The maximum weekly intakes for consumers for the different age-sex groups (1-79 years) varied from 6.3-36.5 PEQ/kg body weight (bw) per week for the consumption of dairy products and from 2.7-5.4 PEQ/kg bw per week for the consumption of meat.

For milk and meat of sheep, more data on transfer are needed before a chronic dietary intake can be estimated

Consumption over a long period of time of dairy products and meat from cows solely exposed to contaminated ditch water and silage exceeds the EFSA TWI of 4.4 ng PEQ/kg bw per week, and may pose a health risk. However it should be noted that the exposure assessment is based on a worst case scenario, i.e. based on a P95 intake of meat and dairy products derived from cows consuming solely contaminated ditch water and grass (silage).

3) *Note that the PFOA reverse dosimetry calculation was revised using the current analytical LOQ in milk (Berendsen et al., 2020). The PFOS reverse dosimetry calculation was added.*

Reverse dosimetry could be performed for PFOA but not for GenX. For this revised version of the assessment, also a reverse dosimetry was added for PFOS. A PFOA concentration in milk at the current analytical LOQ level (0.005 ng PFOA/g) leads to a modelled intake of 44.6 µg PFOA per dairy cow per day. This intake corresponds to a calculated PFOA concentration in ditch water of (approximately) 400-550 ng/L.

For PFOS, the concentration in milk at the current analytical LOQ level (0.025 ng PFOS/g) leads to a modelled intake of 0.63 µg PFOS per dairy cow per day. This intake corresponds to a calculated PFOS concentration in ditch water of (approximately) 5.7-7.9 ng/L.

4) *Note that the text was revised to indicate that transfer of PFOS from grass (silage) to milk and meat at the measured exposure levels is considered negligible in dairy cows and cannot be assessed in sheep.*

The intake of PFOA through grass (silage) is approximately 20 times lower than the intake through ditch water, for dairy cattle resulting in modelled PFOA concentrations of 0.003 ng/g milk or 0.01 ng/g meat.
As levels of GenX and PFOS in grass (silage) were below the current analytical LOQs, the transfer from grass (silage) to milk and meat of dairy cattle is considered negligible.

As mentioned under 1) calculations for the transfer of PFOA, PFOS and GenX from grass (silage) to milk and meat from lactating sheep could not be performed.

Introduction

As a result of long-lasting emissions from the Chemours chemicals company in Dordrecht, the substances GenX and PFOA have been emitted into the environment via the air and surface water. Consequently, the area in the vicinity of the factory (soil, water and vegetation) became polluted. In July 2018 the National Institute for Public Health and Environment (RIVM) has informed the city council of Dordrecht in a letter on the provisional results of research carried out in soil and irrigation water (RIVM 2018a). One of the conclusions was that ditch water contained high levels of GenX and PFOA. This might be of concern for livestock consuming that ditch water. In this letter it was mentioned that watering livestock at the observed high levels of GenX and PFOA in ditch water should be avoided. In September 2018 a final report and an accompanying letter were sent to the city council of Dordrecht (RIVM 2018b). In the report, amongst others, concentrations of GenX and PFOA in ditch water at five different locations in the vicinity of the Chemours factory were given. At that moment no conclusions were drawn regarding the transfer of GenX and PFOA to milk and meat of livestock consuming that ditch water.

In 2019 BuRO requested the FO to address the above-mentioned questions related to the transfer of GenX and PFOA from ditch water to lactating cows and sheep and the transfer of GenX and PFOA from silage to lactating cows and sheep (RIVM & WFSR, 2019b). In 2020, EFSA established an HBGV, i.e. an TWI for the sum of 4 PFAS (PFOA, PFNA, PFHxS, PFOS) based on new scientific information (EFSA, 2020). This new HBGV is lower, thus stricter, and takes other PFAS into account. BuRO has therefore requested the FO to update the previous assessment and to add additional PFAS to the assessment for those substances with transfer models readily available.

In this revision of the risk assessment, the previously individually modelled transfer of PFOA and GenX was converted into PEQ concentrations in milk and meat and a chronic intake by consumers was estimated using consumption statistics available from the DNFCS 2012-2016. In addition, from all measured PFAS exposure via ditch water/ grass (silage), an individual PFOS transfer analysis was included in this mixture exposure approach, because it was the only other substance for which a transfer model was available. Finally, for reverse dosimetry calculations previous analytical LOQs in milk were replaced by the most recent ones.

In 2019, calculations were performed to obtain concentrations in products that would lead to an exposure equal to 20% of the TDI ('20% TDI concentrations'). The calculations were based on estimates relevant for acute exposure (high consumption on one exposure day). Those 20% TDI concentrations were used to assess whether the GenX- and PFOA-concentrations analysed were likely to pose a health risk for GenX and for PFOA (RIVM & WFSR, 2019a). Considering that the current TWI is a factor 20 lower than the former TDI for PFOA and that a cumulative risk assessment should be performed, no such concentrations were derived in the current assessment. Instead a risk assessment was performed for the chronic human dietary exposure resulting from the consumption of milk or beef from cows exposed to PFOA, GenX and PFOS via contaminated ditch water and grass (silage).

<u>Revised risk assessment strategy for PFAS:</u>
RIVM uses the EFSA tolerable weekly intake (TWI) for risk assessment of PFAS and recommends to use this TWI together with relative potency factors (RPFs) for PFAS (RIVM, 2021a). RIVM recommends this after it discussed scientific arguments and weighed several options for implementation of the TWI (RIVM, 2020a; 2020b; 2021a), which are summarized in Annex B of RIVM & WFSR (2021b). Consequently, the RIVM tolerable daily intake (TDI) for PFOA (Zeilmaker et al., 2016) and the tentative TDI (t-TDI) for GenX (Janssen, 2017), have become obsolete when assessing combined exposure to PFOA, GenX, and other PFAS.

By using the TWI in combination with RPFs, it is possible to assess the risk to also other combinations of PFAS than the four considered by EFSA, as well as to single PFAS. RPFs[3] describe the toxic potency of individual PFAS relative to PFOA, the index compound, and thus take into account differences in potency between PFAS. The RPFs for PFOS and GenX are 2 and 0.06 respectively, meaning that PFOS is twice as toxic and GenX is 17 times less toxic compared to PFOA (RIVM, 2021a).

Hence, the strategy allows application of the EFSA TWI to various PFAS mixtures. As mentioned above, the RPF method is also used to estimate chronic intake (RIVM, 2021a) by combining the calculated PEQ concentrations transferred to milk and meat and consumption statistics from the DNFCS 2012-2016. For more details regarding the revised risk assessment strategy, please see the response to Question 1 of Part 1 (RIVM, 2021b).

Ditch water and silage sampling of GenX, PFOA and PFOS

Single samples of ditch water were taken at five different sites within a distance (radius) of four kilometres from the Chemours factory (Van Poll, 2018). In addition, ten samples of grass (silage) were taken in the vicinity of Dordrecht and Helmond. Initially the samples were analysed (in duplicate) for GenX and PFOA only. However, in 2021 for this revision, the samples were reanalysed on 17 PFAS in ditch water and 15 PFAS in grass (silage) (see Annex 2, note that all concentrations measured in grass (silage) were below or close to the current analytical LOQ). Besides detectable values of PFOA, PFOS, and GenX, also concentrations of PFHxA, PFHpA, PFNA, PFDA, PFUnDA, PFBS, PFHxS, PFHpS, and NaDONA in ditch water, and PFHxA in silage, were measured above LOQ. These PFAS were not taken into account, because no transfer models for these PFAS are readily available and are therefore also not taken into account in this revised version. Although also no transfer model is available for GenX, the approach used in the 2019 assessment is included in the calculations of the present assessment.

Only the average concentrations for PFOA, PFOS and GenX at these sites (including their distance from the factory) are provided (Table 1). The analysis done in 2019 was repeated and ditch water concentrations for GenX and PFOA were similar. Therefore the transfer calculations for GenX and PFOA were not repeated and based on the first dataset used in the 2019 assessment (RIVM & WFSR, 2019b), i.e. concentrations from samples, at the geographical location <1 km from the manufacturing site in Dordrecht.

Table 1. Average concentrations of GenX and PFOA in ditch water (in ng/L) at five different locations (codes and distances of locations are given) around Dordrecht. Values in bold refer to the analysis done in 2021, other values were analysed previously[1]

Location code	Sub code	Location Number	Distance (km)	GenX (ng/L)	PFOA (ng/L)	PFOS (ng/L)
G3LOC4	WA2	8	<1	**946.5**/956.5	**4377**/4670	**5.7**
G2LOC3	WA1	6	1-2	**121.0**/133.5	**868.5**/660.5	**3.8**
G2LOC1	WA2	4	1-2	**121.0**/97.5	**747**/566	**3.3**
G1LOC3	WA2	3	2-3	**30.5**/24.5	**164**/172.5	**2.6**
G3LOC3	WA2	10	3-4	**9.2**/9.7	**53.5**/40.5	**2.2**

[1] Analytical results provided by WFSR

In the ten samples of grass (silage) taken in the vicinity of Dordrecht and Helmond, no PFOS or GenX was detected (current analytical LOQ for both <250 ng/kg) by WFSR. Only in two samples PFOA was detected, with concentrations of 540 and 600 ng/kg (measurement on basis of whole product (RIVM & WFSR, 2019b)). Other PFAS were also measured in a similar fashion in 2021, but most were below their current analytical LOQ of 250 ng/kg) (see Annex 2, Table 2-2). The only exception was PFHxA for which

[3] These RPFs are derived from effects of various PFAS on the liver of rodents. Knowing that PFAS are not equipotent for other effects (for example liver effects). It is, however, recommended that the RPFs derived from liver effects are validated for immune effects in due course. See also Annex B in RIVM & WFSR (2021b) for a more elaborate discussion on this aspect.

concentrations just above their current analytical LOQ (1000 ng/kg) were measured in three samples, i.e. of 1130, 1580 and 1090 ng/kg.

Literature search: Transfer models

Different PubMed search strings were used to obtain information on the transfer of GenX, PFOA or PFOS in dairy cows, cattle, sheep or lamb. The search initially addressed GenX and PFOA. However, as information on GenX and PFOA appeared limited, the search was extended to also include PFOS. For dairy cattle only a transfer model for PFOS was found. In the case of lactating sheep no transfer model was found for PFOS, PFOA, GenX or other PFAS.

Rationale of transfer assessment

This assessment focuses on the transfer of GenX, PFOA and PFOS from contaminated ditch water or grass (silage) to milk and meat from dairy cattle and lactating sheep. PFOA and PFOS were included, because in dairy cows only a transfer model was available for PFOS and a scaled transfer model for PFOA. Although no transfer model is available for GenX, the approach used for GenX in the previous assessment (RIVM & WFSR, 2019b) is also included. Quantifying such transfer needs experimentally observed transfer, ideally in conjunction with a quantitative transfer modelling analysis describing the experimental observations (the latter enabling extrapolation of the experimental settings across dosage, matrix and exposure time duration, etc.).

<u>PFOA/PFOS: Dairy cattle (modelling approach)</u>

Note that the approach for PFOA was not revised. The approach for PFOS was added.
As shown below, an experimental study on the transfer of PFOA and PFOS from contaminated grass (silage) and hay to milk and meat of dairy cattle (n=6) is available (Kowalczyk et al., 2013). Initially, only a PFOS transfer model based on this study was available. However, the PFOA transfer data of this study enabled the scaling of the PFOS model to PFOA (RIVM & WFSR, 2019b; for details, see Annex 1). Next to the PFOS model, this scaled PFOA model was used to quantify the transfer of PFOA from ditch water or grass (silage) to milk and meat of dairy cattle after long-term exposure (not taking into account other sources of exposure) (RIVM & WFSR, 2019b). Transfer of PFOA reaches steady state within a few days. In contrast, PFOS steady state is reached after prolonged exposure, i.e. approximately 500 days.

<u>PFOA/PFOS: Lactating sheep (experimental approach)</u>

Note that the approach for PFOA was not revised, but a similar approach was also applied for PFOS.
With regard to lactating sheep, only a pilot study with two sheep on the transfer of PFOS and PFOA from contaminated (corn) silage and hay to milk and meat is available (see below). The results of this study are insufficient for the development of a transfer model for these PFAS. Furthermore, in livestock, allometric scaling of PFAS kinetics does not apply (indicated by comparing for example, data from dairy cattle (Kowalczyk *et al*., 2013) with data from pigs (Numata *et al.*, 2014). Therefore, the PFOA/PFOS transfer model in dairy cattle was not allometrically scaled from this species to sheep. In this assessment the transfer of PFOA and PFOS from ditch water or grass (silage) to milk and meat of lactating sheep was based on the available experimental data (not taking into account other sources of exposure). The available study being a pilot, urges to consider the assessed transfer only as indicative (RIVM & WFSR, 2019b).

<u>GenX (reasoning approach)</u>

Dairy cattle and lactating sheep show comparable, extensive renal clearance of PFOA. GenX and PFOA show comparable renal clearance in rodents and monkeys (Butenhoff *et al.*, 2004; Gannon *et al.*, 2016). Due to lack of information on the transfer of GenX to farm animals it was assumed that dairy cattle and lactating sheep also show extensive renal clearance of GenX (RIVM & WFSR, 2019b).

Exposure scenarios for lactating cow and lactating sheep

Note that for PFOA and GenX concentrations in ditch water and grass (silage), the measurements analysed in 2019 were considered within an acceptable margin as compared to the 2021 re-analysis, and the intake calculations for PFOA and GenX in dairy cow and dairy sheep were not revised. The PFOS intake calculations in dairy cow and dairy sheep were added. The PFOA reverse dosimetry calculation was revised using the current analytical LOQ in milk (Berendsen et al., 2020). The PFOS reverse dosimetry calculation was added.

<u>Lactating cow: PFOA, GenX and PFOS exposure from ditch water or grass (silage)</u>
As shown in Table 1 the originally measured concentration of PFOA in ditch water ranged from 40.5 to 4670 ng/L. Similarly, the originally measured GenX concentration ranged from 9.7 to 956.5 ng/L. The measured concentration of PFOS in ditch water was lower and had a smaller range, i.e. from 2.2-5.7 ng/L.

Regarding the drinking water intake, lactating cows consume different volumes of drinking water per day, with (total) water intake depending on factors like ambient temperature, body weight, dry matter intake, milk production, etc. (Kume *et al.*, 2010; Meyer *et al.*, 2004; Murphy MR, 1992; National Research Council, 2001). Average and maximum drinking water consumption was used in combination with the conservative assumption that cows solely consume contaminated ditch water. As model input for PFOA transfer model calculations, an average drinking water intake of 80 L per day for (mature) lactating cows (weighing 600 kg; milk yield: 29.5 kg) ranging to a maximum drinking water intake of 110 L per day (weighing 600 kg; milk yield: 35 kg per day) was used (Kume *et al.*, 2010; Meyer *et al.*, 2004; National Research Council, 2001). Then, given the maximal measured GenX, PFOA and PFOS concentrations, the highest ditch water intake for lactating cows is calculated at 110*956.5 ≈ 110,000 ng GenX per day; 110*4670 ≈ 514,000 ng PFOA per day and 110*5.7 ≈ 630 ng PFOS per day. These values were detected in the same sample, at the geographical location <1 km from the manufacturing site in Dordrecht.

PFOA, but not GenX or PFOS, was detected in two samples of grass (silage) at comparable concentrations of 540 and 600 ng/kg. On average, dairy cows consume 25 to 38.5 kg wet weight grass (silage) per day (Berende, 1998; Vestergren et al., 2013). As worst case (winter) scenario, the highest average intake of PFOA through grass (silage) for lactating cows is approximately 38.5*600 ≈ 23,000 ng PFOA per day. For PFOS and GenX, the average intake could not be determined, because measured levels were below their current analytical LOQ (RIVM & WFSR, 2019b and Annex 2, Table 2-2).

<u>Lactating cow: PFOS and PFOA transfer (modelling)</u>
Van Asselt *et al.* (2013) described a transfer model for PFOS in dairy cows. This model represents the body to be composed of blood and carcass (consisting of liver, kidney and muscle), with PFOS being eliminated by milk clearance from the blood compartment. The model was calibrated on experimental results of a transfer experiment in which dairy cows were exposed to contaminated hay/grass silage for a 28-day period, followed by a 22-day wash-out period (Kowalczyk *et al.,* 2013; intake: 7.6 $\pm$ 3.2 µg PFOS/kg bw per day). Note that the modal calibration resulted in complete absorption of PFOS from the grass (silage) matrix, which is assumed to also be the case for ditch water. Model output consists of the PFOS concentration in the blood, carcass (=weighed mean PFOS concentration for muscle, liver and kidney), milk and urine.

Next to PFOS, Kowalczyk *et al.* (2013) also provide PFOA transfer data in dairy cows. These data allowed the scaling of the PFOS model to PFOA (RIVM & WFSR, 2019b and Annex 1). In concordance with the differences of PFOS and PFOA kinetics in dairy cows this scaling consisted of introducing renal clearance as the major route of excretion (while maintaining milk clearance as a minor PFOA route of excretion) in conjunction with minimizing the PFOA partition coefficient from the blood to the carcass. Carcass is assumed to consist of mainly muscle, liver and kidney. Concentrations in muscle are expected to be approximately half of the carcass concentrations (Kowalczyk *et al.*, 2013). Furthermore, as reported for PFOS, the model describes complete absorption of PFOA from grass (silage) and ditch water. As shown in Annex 1, Figure 4, this scaling resulted in an acceptable description of PFOA transfer data in dairy cows, including milk and meat (muscle).

<u>Lactating cow: PFOA and PFOS reverse dosimetry (modelling back calculation from concentration in cow's milk to corresponding ditch water concentration)</u>
In order to calculate the possible concentrations of PFOA in ditch water based on reversed dosimetry modelling (Question 3), the above mentioned RIVM PFOA transfer model was used. An analytical LOQ of PFOA in cow's milk, of 0.01 ng/g, was initially used as model input for the reverse dosimetry calculation (RIVM & WFSR, 2019b). However, lower analytical LOQs are currently available. In this calculation the cow's model was used to calculate the PFOA and PFOS intake through ditch water which would lead to a milk concentration corresponding with the current analytical LOQs in milk during steady state conditions of 0.005 and 0.025 ng/g, respectively for PFOA and PFOS (Berendsen *et al.*, 2020). Applying the above mentioned water consumption of lactating cows, the corresponding concentration of PFOA and PFOS in ditch water was calculated (assuming no additional exposure from other sources than ditch water).

<u>Lactating cow: GenX transfer (assumption)</u>
In rodents and monkeys, GenX and PFOA preferentially, partition in the blood, liver and kidney (Butenhoff *et al.*, 2004; Gannon *et al.*, 2016). Though renal clearance is the major excretion pathway for both compounds, GenX is removed from the blood faster than PFOA (Gannon *et al.*, 2016 and references therein). From this it is concluded that, due to a more efficient renal clearance of GenX, GenX levels in blood to partition to milk and tissues are relatively low, resulting in lower levels of GenX in milk and tissues than that of PFOA. Therefore, in species that show extensive renal PFOA clearance such as dairy cattle (and lactating sheep) it was assumed that comparable exposure of GenX and PFOA leads to lower concentrations of GenX in tissues and milk than PFOA (RIVM & WFSR, 2019b). Based on current knowledge it is not possible to quantify this further.

<u>Lactating sheep: PFOA, PFOS and GenX exposure from ditch water and grass (silage)</u>
Given a body weight of around 60 kg for lactating sheep (Kowalczyk *et al.*, 2012) and a daily drinking water consumption of 6 L per day, i.e. 10% of body weight, a (maximal) concentration of 4670 ng PFOA/L corresponds with a maximum intake of $6*4670 \approx 28,000$ ng PFOA per day, i.e. $28,000/60 \approx 500$ ng PFOA/kg bw per day (thereby excluding all other exposure sources) (RIVM & WFSR, 2019b). Similarly, taking a (maximum) concentration of 956.5 ng GenX/L corresponds to a maximum intake of $6*956.5 \approx 5700$ ng GenX per day, i.e. $5700/60 \approx 95$ ng GenX/kg bw per day (RIVM & WFSR, 2019b). Idem, for PFOS a maximum intake of $6*5.7 \approx 34$ ng PFOS per day, i.e. $34/60 \approx 0.57$ ng PFOS/kg bw per day was calculated.

Kemme *et al.* (2005) mention for dairy sheep a yearly meadow grass consumption of 364 kg dry matter plus 58 kg of wet weight grass silage. Assuming meadow grass to contain 40% dry matter (http://eurofins-agro.com/nl-nl/wiki/droge-stof) to $364/0.40 + 58 \approx 970$ kg wet weight grass (silage) per year, i.e. around 2.7 kg wet weight grass (silage) daily. With a PFOA concentration of 600 ng PFOA/kg grass (silage) (see above) this results in a daily intake of $2.7 * 600 \approx 1600$ ng PFOA, i.e. $1600/60 \approx 27$ ng PFOA/kg bw per day (RIVM & WFSR, 2019b). As PFOS and GenX levels in grass (silage) were below their current analytical LOQ, no PFOS or GenX intake from grass (silage) was calculated.

<u>Lactating sheep: PFOA and PFOS transfer (experimental)</u>
As mentioned above, Kowalczyk *et al.* (2012) describe a pilot experiment in two sheep on the transfer of PFOA and PFOS from contaminated corn silage and hay to milk and meat.

PFOA levels in milk amounted on average 0.2 µg PFOA/L (sheep 1, SD = 0.1 (n=15), range: <LOD-0.5 µg/L) or 0.7 µg/L (sheep 2, SD= 0.5 (n=15), range: <LOD-1.3). In muscle tissue the PFOA concentrations were <LOD (sheep 1) resp. 0.23 µg/kg (sheep 2).

At the end of the 21-day exposure period, PFOS levels in milk amounted on average 3.4 µg/L (sheep 1, SD = 2.3 (n=15), range: 0.2-6.9 µg/L) or 8.9 µg/L (sheep 2, SD= 6.6 (n=15), range: 0.3-19.2). In muscle tissue, 24.4 µg/kg (sheep 1) and 35.1 µg/kg (sheep 2) were found.

Lactating sheep: GenX transfer (assumption)
As in dairy cattle it was assumed that comparable exposure of GenX and PFOA to lactating sheep leads to lower concentrations of GenX in tissues and milk than PFOA. Again, based on current knowledge it is not possible to quantify this further/ make it more quantitative.

Point estimates of chronic dietary exposure by human consumers
As explained in the response to Question 1 in the revision of Part 1 (RIVM & WFSR, 2021b), the TWI should prevent mothers from reaching a body burden that results in PFAS-levels in breastmilk that would lead to serum levels in the infant that are associated with decreases in vaccination response. Therefore, dietary exposure should preferably be calculated for lactating women and taking into account their exposure from birth onwards. As a first indication of dietary exposure, point estimates of exposure were calculated based on consumption statistics for different age-sex groups available from the DNFCS 2012-2016.

To assess the dietary exposure to PFOA, GenX and PFOS in milk or meat, we combined the individually modelled transfer concentrations of PFOA, GenX and PFOS in milk or meat, expressed as the sum of PFOA-equivalents, with the consumption data among 4313 individuals aged 1 to 79 of DNFCS 2012-2016 for these products. As described in the revision of Part 1 (RIVM & WFSR, 2021b), in this survey, individuals, or their caretakers in case of young children, recorded what and how much they consumed on two arbitrary days. In Annex 3 the high (95^{th} percentile) consumption of dairy products and meat (beef) are listed for different age-sex groups for all days in the survey and for only those days on which the consumption of these products was reported ("consumption days").

PFAS may be harmful when ingested at high amounts over a long period of time. Therefore, we used the consumed amounts of dairy product and meat that best reflect long consumed amounts of these products for the risk assessment. The best estimate for this is the consumed amounts based on 'all days' (irrespective of whether dairy products or meat (beef) were consumed or not), assuming that individuals are not likely to consume locally produced dairy products or meat every day. We used the high (95^{th} percentile) consumed amounts to estimate the summed intake of PFOA, GenX and PFOS to also protect possible high consumers of these products. The 95^{th} percentile was based on mean consumed amounts across the two consumption days per individual.

Based on the summed concentrations of PFOA, GenX and PFOS, expressed as PFOA-equivalents (PEQ), in dairy products, or meat (beef) (Table 3) and high consumed amounts of the particular food, the summed intake of PFOA, GenX and PFOS was estimated per age-sex group using the following equation as described in the revision of Part 1 (RIVM & WFSR, 2021b):

$$Intake = \frac{Consumption \times Concentration}{Body\ weight} * 7$$

Intake	= Intake of PFOA-equivalents in ng/kg bw per week
Consumption	= High (P95) consumption of dairy products and meat (beef), in gram across two days (Annex 3)
Concentration	= Modelled concentration of PFOA-equivalents in milk or meat (beef) in ng/g (Table 3)
Body weight	= Body weight in kg (Annex 4)
7	= to extrapolate from a daily intake into a weekly intake

Results

<u>Dairy cattle</u>
Note that for PFOA and GenX the transfer calculations to milk and meat were not revised, but updated by conversion to PEQ concentrations. The PFOS transfer calculation to milk and meat (including conversion to PEQ concentrations) was added. Calculations for PFOA and GenX in dairy cow and dairy sheep were not revised. The PFOA reverse dosimetry calculation was revised using the current analytical LOQ in milk (Berendsen et al., 2020). The PFOS reverse dosimetry calculation was added.

<u>Dairy cattle: PFOA</u>
PFOA transfer from ditch water to cow's milk and meat
In the PFOA transfer model a (maximum) intake of 514 µg per day from ditch water leads to PFOA concentrations of 0.06 ng/g milk and 0.28 ng/g meat (0.54 ng/g carcass) (see Annex 1). This low transfer to milk and meat is mainly due to a high renal excretion of PFOA in dairy cows.

With the RPF method, a PEQ concentration can be determined by multiplying a sample concentration with an RPF of each PFAS respectively. As PFOA is the index compound, it has an RPF of 1 (RIVM, 2021a). This results in PEQ concentrations of 0.06 ng/g milk and 0.28 ng/g meat (0.54 ng/g carcass).

PFOA transfer from grass (silage) to cow's milk and meat
The intake of PFOA through consumption of contaminated grass (silage) of approximately 23 µg per day is much lower than the intake of PFOA through ditch water, i.e. 514 µg per day. The modelled transferred PFOA and PEQ concentration to milk and meat from grass (silage) is 23/514* 0.06 ≈ 0.003 ng/g milk and 23/514*0.28 ≈ 0.01 ng/g meat.

PFOA reverse dosimetry (back extrapolation from cow's milk to ditch water)
When the (analytical) LOQ of PFOA in milk (0.005 ng/g from Berendsen et al., 2020) was used in the model to back extrapolate the (theoretical) intake of dairy cows, a dose of 44.6 µg per day was calculated. This results in a calculated PFOA concentration in ditch water of (approximately) 550 ng/L (for a ditch water intake of 80 L per day) and 400 ng/L (for a ditch water intake of 110 L per day). This means that whenever the concentration of PFOA in ditch water is below (approximately) 400 ng/L, it is likely that concentrations in milk will not exceed the (analytical) LOQ of PFOA in milk.

<u>Dairy cattle: PFOS</u>
PFOS transfer from ditch water to cow's milk and meat
In the PFOS transfer model a (maximum) intake of 0.63 µg per day from ditch water leads to PFOS concentrations 0.02 ng/g milk and 0.11 ng/g meat (0.21 ng/g carcass), respectively. Because PFOS accumulates, this steady state concentration was reached after approximately 500 days of exposure (see Annex 1). In the previous assessment from 2019, PFOS was not taken into account. Milk and meat PEQs for PFOS can be calculated by multiplying with its RPF, which is 2 (RIVM, 2021a). This results in PEQ concentration of 0.04 ng/g milk and 0.22 ng/g meat (0.42 ng/g carcass). Note that

although the (maximal) exposure to PFOS via ditch water is about 800-fold lower than the (maximal) PFOA intake, i.e. 0.63 vs. 514 µg per day, the resulting PEQ concentrations in milk and meat are only about 1.3 and 1.5-fold lower, i.e. 0.04 vs. 0.06 ng/g milk and 0.22 vs. 0.28 ng/g meat.

PFOS reverse dosimetry (back extrapolation from cow's milk to ditch water)
The same back extrapolation that was done for PFOA was also done for PFOS using a current analytical LOQ of 0.025 ng/g in milk (Berendsen et al., 2020) and the PFOS transfer model. For PFOS a dose of 0.63 µg per day was determined. This in turn results in a calculated PFOS concentration in ditch water of (approximately) 7.9 ng/L (for a ditch water intake of 80 L per day) and 5.7 ng/L (for a ditch water intake of 110 L per day). This means that whenever the concentration of PFOS in ditch water is below (approximately) 5.7 ng/L, it is likely that concentrations in milk will not exceed the (analytical) LOQ of PFOS in milk.

<u>Dairy cattle: GenX</u>
GenX transfer from ditch water to cow's milk and meat
The (maximal) exposure to GenX via ditch water is almost five-fold lower than the (maximal) PFOA intake, i.e. 110 vs. 514 µg per day. The resulting *assumed* GenX concentrations in milk and in meat are *lower* than 0.06/5 ≈ 0.01 ng/g resp. 0.28/5 ≈ 0.06 ng/g (RIVM & WFSR, 2019b). Milk and meat PEQs for GenX can be calculated by multiplying with its RPF, which is 0.06 (RIVM, 2021a). This results in PEQ concentrations in milk lower than 0.0006 ng/g and in meat lower than 0.004 ng/g.

<u>Sheep: PFOA, PFOS and GenX</u>
Note that for PFOA and GenX the transfer calculations to milk and meat were not revised, but updated by conversion to PEQ concentrations. The PFOS transfer calculation to milk and meat (including conversion to PEQ concentration) was added.

As mentioned above, the exposure to PFOA from ditch water was calculated at 500 ng PFOA/kg bw per day (thereby excluding all other exposure sources). This exposure is close to experimental exposure of sheep 2 in the pilot study mentioned above. At this exposure level the PFOA concentration in milk is expected to be approximately 0.2-0.7 ng/g resp, and in meat 0.2 ng/g (Table 2) (RIVM & WFSR, 2019b).This corresponds to 0.2-0.7 ng PEQ/g milk and 0.2 ng PEQ/g meat.

Table 2. Comparison of the concentration (µg/g wet weight, ± SD) of PFOA and PFOS in two lactating sheep exposed for 21 days to PFOA and PFOS from contaminated hay/corn silage (sheep 1 and 2), followed by a wash-out period (sheep 1) (data from Kowalczyk et al. 2012; 2013)

	Cow	Sheep	
	PFOA	PFOA	PFOS
Experimental dose (µg PFAS/kg bw per day)	2.0 + 1.1	S1: 0.43 S2: 0.53	S1: 1.16 S2: 1.45
Liver (µg/kg)	10.1 ± 1.9[1,3]	S2: 2.6[3]	S2: 1172[3]
Kidney (µg/kg)	8.7 ± 3.9[1,3]	S2: 4.8[3]	S2: 286[3]
Muscle (µg/kg)	0.6 ± 0.3[1,3]	S2: 0.2[3]	S2: 35.1[3]
Milk (µg/L)	0.14 ± 0.05[1]	S1: 0.2 ± 0.1[2] S2: 0.7 ± 0.5[2]	S1: 3.4 ± 2.3[2] S2: 8.9 ± 6.6[2]

bw: body weight
[1] Figure 3B, Table 2 (Kowalczyk *et al.*, 2013., obtained from LOD is 0.1 µg/kg).
[2] LOD PFOA and PFOS is 0.2 µg/L, average of 15 samples during the 21 day exposure period (ranges PFOA: sheep 1: <LOD-0.5 µg/L; sheep 2: <LOD-1.3 µg/L; ranges PFOS: sheep 1: 0.2-6.9 µg/L; sheep 2: 0.3-19.2 µg/L).
[3] LOD PFOS and PFOA is 0.2 µg/kg.

The exposure to PFOA from grass (silage) was calculated at 27 ng PFOA/kg bw per day. The corresponding PFOA concentration range in milk is estimated to be ≈ 0.01 ng/g

(27/500*0.2)-0.04 ng/g (27/500*0.7). In meat this is approximately 0.01 ng/g (27/500*0.2) (RIVM & WFSR, 2019b). This corresponds to 0.01-0.04 ng PEQ/g milk and 0.01 ng PEQ/g meat.

In sheep 2 an exposure to 1.45 µg PFOS/kg bw per day resulted in an average milk concentration of 8.9 µg/L and a meat concentration of 35.1 µg/kg. The exposure to PFOS from ditch water was calculated at 0.0057 µg PFOS/kg bw per day. The corresponding PFOS concentration range in milk is estimated to be ≈ 0.0035 (0.0057/1.45*8.9) ng/g. In meat this is approximately 0.08 (0.0057/1.45*35.1) ng/g. This corresponds to ≈ 0.007 ng/g (0.0035*2) PEQ/g milk and 0.16 (0.08*2) ng PEQ/g meat.

The exposure to GenX from ditch water was calculated at 95 ng GenX/kg bw per day (approximately one fifth of the PFOA exposure). The GenX concentration in sheep milk is expected to be lower than 0.2/5-0.7/5 ≈ 0.04-0.14 ng GenX/g and in meat lower than 0.2/5 ≈ 0.04 ng/g. These GenX concentrations are at or below the analytical LOQ of 0.1 ng/g for GenX currently achievable in milk. The expected concentrations correspond to <0.0084 ng PEQ/g milk (0.14*0.06) and <0.0024 (0.04*0.06) ng PEQ/g meat.

Consequences for human exposure
Note that this part is revised, since 20% TDI concentration was replaced by point estimates of chronic dietary exposure by human consumers. The sum of PFOA, PFOS and GenX were taken into account.

Table 3 provides an overview of the calculated PFOA, PFOS and GenX transfer to milk and meat of dairy cattle as well as the corresponding PEQ concentrations. The total transfer can be calculated by adding all PEQs in Table 3 after intake of ditch water and grass (silage), assuming the animals consume solely contaminated grass (silage) and ditch water. The contribution of the PEQ concentration resulting from exposure to GenX is negligible. The data in Table 3 were used as input for point estimates of chronic dietary exposure by human consumers.

Table 3. Overview of calculated PFOA, PFOS or GenX concentrations (ng/g) and their PEQ concentrations (ng PEQ/g) in milk and meat of dairy cattle after exposure to these chemicals via contaminated ditch water or grass (silage)

Dairy cattle product	PFOA		PFOS		GenX		Sum
	ng/g	ng PEQ/g	ng/g	ng PEQ/g	ng/g	ng PEQ/g	ng PEQ/g
Milk							
Ditch water	0.06[1]	0.06	0.02[1]	0.04	<0.01[2]	<0.0006	0.10
Silage	0.0031[1]	0.0031	X[3]		X[3]		0.003
Sum PEQ's milk		0.06		0.04		<0.0006	**0.10**
Meat							
Ditch water	0.28[1]	0.28	0.11[1]	0.22	<0.06[2]	<0.0036	0.50
Grass (silage)	0.011[1]	0.011	X[3]		X[3]		0.01
Sum PEQ's meat		0.29		0.22		<0.0036	**0.51**

PEQ: PFOA-equivalent = concentration PFAS*RPF. For PFOA, GenX and PFOS the RPFs are 1, 0.06 and 2, respectively (RIVM, 2021a).
[1] Modelled
[2] Reasoned assumption, i.e. assuming less efficient transfer of GenX relative to PFOA at comparable exposure.
[3] X: negligible, in other words: below the current analytical LOQ

However, next to PFOA, PFOS and GenX, other PFAS were detected (above LOQ) in grass (silage) collected in the vicinity of Dordrecht and Helmond (PFHxA) and in ditch water samples collected in the vicinity of Dordrecht (PFHxA, PFHpA, PFNA, PFDA, PFUnDA, PFBS, PFHxS, PFHpS, NaDONA). These PFAS were not taken into account in this revised assessment, because no transfer models of these PFAS are available. It may nevertheless be that these PFAS are transferred to milk and meat. PFHxS can be found in milk and meat after exposure to contaminated feed. For PFBS, the transfer is very low to both muscle meat and milk, although it can be found in organ meat (Kowalczyk et al., 2013). In addition, Ehlers (2012) reports that next to PFHxS, PFOA and PFOS, PFHpS can be detected in milk and meat.

Contribution of these PFAS to the final PEQ concentration in milk or meat depends on the transfer of each substance, and the RPF of the individual PFAS. If the substances would transfer from grass (silage) or ditchwater to milk or meat they would, per definition, contribute to the total sum calculated transfer. In other words, it is anticipated to result in even higher PEQ concentrations in milk and meat than when considering only PFOA, PFOS and GenX.

Table 4 provides an overview of the calculated PFOA, PFOS and GenX transfer in sheep as well as the sum of the PEQ concentrations, assuming the animals consume solely contaminated grass (silage) and ditch water. In interpreting the sheep transfer calculations it should be noted that the transfer to milk was observed in only two sheep showing variable PFOA and PFOS kinetics. Moreover, taking Table 2 as a reference, the available transfer data in dairy cattle and lactating sheep indicate that PFOA transfer to organs and tissues is comparable in both species, but transfer to milk not. Regarding the latter, the limited available data suggest a much higher transfer, i.e. up to 6-20 fold, of PFOA from the blood to milk in lactating sheep than in dairy cattle. For this reason, it is concluded that the observed transfer of PFOA and PFOS to milk in lactating sheep needs to be confirmed beyond the pilot experiment in which it was assessed in order to draw a more definitive conclusion on the relevance of such transfer for human exposure assessment. Consequently, the data in Table 4 were evaluated as too uncertain to serve as input for point estimates of chronic dietary exposure by human consumers.

Point estimates of chronic dietary exposure for human consumers and risk characterisation

Table 5 and Annex 4 show the summed intake results of PFOA, PFOS and GenX, expressed as ng PEQ/kg bw per week for dairy products and meat from dairy cows solely exposed to contaminated ditch water and grass (silage), i.e. based on the modelled concentrations in milk and meat of dairy cattle. For the exposure calculation, we assumed that the PFOA, GenX and PFOS concentrations in all dairy products were similar to that in milk, i.e., 0.10 ng PFOA-equivalents/g (Table 3).

For the risk assessment, the summed exposure estimates of GenX, PFOS and PFOA, expressed as ng PEQ/kg bw per week per product for the different age-sex groups were compared with the EFSA TWI of 4.4 ng/kg bw per week. For dairy product consumption all exposure estimates per age-sex group were above the TWI varying from a weekly intake of 6.3 to 36.5 ng PEQ/kg bw from the oldest to the youngest age group. For beef consumption the weekly intake for the different age and sex-groups varied from 2.7-5.4 PEQ/kg bw. For beef the weekly estimated intake only exceeded the TWI for the age groups 1-3 year and 4-8 year, i.e. 5.4 and 5.3 ng PEQ/kg bw (Table 5).

Table 4. Overview of calculated PFOA, PFOS or GenX concentrations (ng/g) and their PEQ concentrations (ng PEQ/g) in milk and meat of sheep after exposure to these chemicals via contaminated ditch water or grass (silage)

Sheep product	PFOA		PFOS		GenX		Sum
	ng/g	ng PEQ/g	ng/g	ng PEQ/g	ng/g	ng PEQ/g	ng PEQ/g
Milk							
Ditch water	0.2-0.7[1]	0.2-0.7	0.0035[1]	0.007	<0.04-0.14[2]	<0.0084	0.21-0.71
Grass (silage)	0.01-0.04[1]	0.01-0.04	X[3]		X[3]		0.01-0.04
Sum PEQ's milk		0.21-0.74		0.007		<0.0084	0.22-0.75
Meat							
Ditch water	0.2[1]	0.2	0.08[1]	0.16	<0.04[2]	<0.0024	0.36
Grass (silage)	0.01[1]	0.01	X[3]		X[3]		0.01
Sum PEQ's meat		0.21		0.16		<0.0024	0.37

PEQ: PFOA-equivalent = concentration PFAS*RPF. For PFOA, GenX and PFOS the RPFs are 1, 0.06 and 2, respectively (RIVM, 2021a)
[1]Assumption based on study of n=2.
[2] Reasoned assumptions assuming less efficient transfer of GenX relative to PFOA at comparable exposure.
[3] X: negligible, in other words: below the current analytical LOQ

Table 5. Intake of the sum of PFOA, GenX and PFOS (expressed as PFOA-equivalents (PEQ)) through a high (95th percentile) consumption of dairy products and meat (beef) from dairy cows solely exposed to contaminated ditch water and grass (silage)[1]

Age group (year) + sex	Exposure to the sum of PFOA, GenX and PFOS ng PFOA-equivalents/ kg bw per week	
	Dairy products[2]	Meat (beef)[3]
1-3	36.5	5.4
4-8	22.9	5.3
9-18; male	11.0	3.5
9-18; female	9.7	2.7
19-50; male	7.7	3.8
19-50; female	7.0	4.4
51-79; male	6.7	3.3
51-79; female	6.3	3.6
35; female[4]	12.6	4.1

bw: body weight; PEQ: PFOA-equivalents
[1] Exposure was based on a high mean consumption across two days considering all consumption days within the food consumption survey, irrespective of whether the particular food was consumed or not (Annex 3, Table 3-1 and 3-2).
[2] Based on simulated concentration in milk from dairy cows solely exposed to contaminated ditch water and grass (silage) (Table 3).
[3] Based on simulated concentration in meat (beef) from dairy cows solely exposed to contaminated ditch water and grass (silage) (Table 3).
[4] Weekly intake assessed for 35-year old women. For female adults, 17 years of exposure (from the age of 19 up to 35 years) was included. For dairy products the intake is calculated by considering a woman is part of certain age groups for a certain amount of years multiplied by the intake from dairy products by that age group divided by 35 years, i.e. (3* 36.5)+(5* 22.9)+(10*9.7)+(17*7.0)/35= 12.6 ng PFOA-equivalents/kg bw per week. Idem for meat (3*5.4)+(5*5.3)+(10*2.7)+(17*4.4)/35 = 4.1 ng PFOA-equivalents/kg bw per week.

If exposure estimates exceeded the TWI for one or more age groups, further calculations were performed to assess the exposure for 35-year old lactating women, the age group on which the TWI was based (RIVM & WFSR, 2021b). For this, 35 exposure years were taken into account. This was done by multiplying the exposure of a certain age group by the number of years represented in that age group (3 years for toddlers, 5 years for other children, 10 years for female adolescents and 17 years for adult women) and divided by 35. It should be noted that this is a conservative estimate, because it is based on summation of P95 dairy consumption. By this conservative estimate, it is assumed that all females are high consumers of dairy products and meat (beef) throughout their life up to the age of 35.

When looking at the exposure of 35-year women from childhood onwards, the intake estimate for dairy products from a dairy cow solely exposed to contaminated ditch water and grass (silage) was 12.6 ng PEQ/kg bw per week. This is above the TWI of 4.4 ng/kg bw per week. When the same was done for beef, the intake estimate was 4.1 ng PEQ/kg bw per week.

Consumption over a long period of time of dairy products and meat from cows solely exposed to contaminated ditch water and silage may pose a health risk. However, the exposure assessment is based on a worst case scenario, i.e. based on a P95 intake of meat and dairy products derived from cows consuming solely contaminated ditch water and grass (silage). This has led to an overestimation of the exposure of the consumer.

It is noted that the population is also exposed to GenX and PFOA via other dietary and non-dietary sources. When assessing the risk of GenX and PFOA intake from locally produced or caught foods from animal origin, this background exposure should be taken into account. RIVM recently performed an indicative dietary exposure assessment according to the RPF approach, based on data from 2009, which showed that exposure to the EFSA-4 via drinking water and food exceeded the TWI. It was concluded that recent concentration data in food were needed for an up to date exposure assessment. For drinking water, concentration data were up-to-date (van der Aa et al., 2021).

Answers
Based on the results described above the answers to the four questions asked by the Office for Risk Assessment and Research are given underneath.

Question 1
Model the transfer of GenX, PFOA and additional PFAS from ditch water to edible products from lactating cows and sheep (milk and meat).

Answer 1
1) *Note that for PFOA and GenX the transfer calculations to milk and meat were not revised, but updated by conversion to PFOA-equivalent (PEQ) concentrations. The PFOS transfer calculation to milk and meat (including conversion to PEQ concentration) was added. Other PFAS could not be added due to lack of transfer models readily available.*

An available transfer model for PFOS in dairy cows was adapted to model the transfer of PFOA from ditch water to cow's milk and meat. The highest intake of PFOA through the chronic consumption of contaminated ditch water (514 μg per day) resulted in a modelled concentration of 0.06 ng PFOA/g milk and 0.28 ng PFOA/g meat. This corresponds to a concentration of 0.06 ng PEQ/g milk and 0.28 ng PEQ/g meat.

For this revised version of the risk assessment BuRO has requested the FO to add additional PFAS. In this revised version, transfer for PFOS was also calculated based on the availability of contamination data and a transfer model for PFOS. Other PFAS were not included due to the lack of transfer models. Using a transfer model for PFOS for dairy cows and the highest intake of PFOS through the consumption of contaminated ditch water (0.63 µg per day) resulted in a modelled concentration of 0.02 ng PFOS/g milk and 0.11 ng PFOS/g meat. This corresponds to a concentration of 0.04 ng PEQ/g milk and 0.22 ng PEQ/g meat.

The expected GenX concentration in dairy cattle is equal to or lower than 0.01 ng GenX/g milk and 0.06 ng GenX/g meat, i.e. 0.0006 ng PEQ/g milk and 0.004 ng PEQ/g meat.

Only one pilot study described the kinetics of PFOA and PFOS in sheep (n=2) after exposure from grass (silage) and the information does not allow us to develop a transfer model for these compounds in sheep. The reported transfer of PFOA to the carcass was (more or less) similar for sheep and dairy cattle, whereas the reported transfer of PFOA and PFOS to milk was possibly higher in sheep. These data need experimental confirmation before the relevance of the transfer of PFOA, PFOS (and GenX) to milk and meat of sheep for human exposure can be evaluated.

Question 2
Estimate the intake of GenX, PFOA and additional PFAS for consumers based on the theoretical (modelled) concentrations in cow's milk and meat.

Answer 2
Note that this answer is revised, since a chronic dietary exposure estimate was made instead of using the 20% TDI approach.

Based on the modelled concentrations in milk and meat of dairy cattle, and high consumption statistics (95th percentile of consumption) of dairy products and meat from the Dutch National Food Consumption Survey of 2012-2016, the weekly intake was calculated. The maximum weekly intakes for consumers for the different age-sex groups (1-79 years) varied from 6.3-36.5 PEQ/kg body weight (bw) per week for the consumption of dairy products and from 2.7-5.4 PEQ/kg bw per week for the consumption of meat.

For milk and meat of sheep, more data on transfer are needed before a chronic dietary intake can be estimated

Consumption over a long period of time of dairy products and meat from cows solely exposed to contaminated ditch water and silage exceeds the EFSA TWI of 4.4 ng PEQ/kg bw per week, and may pose a health risk. However it should be noted that the exposure assessment is based on a worst case scenario, i.e. based on a P95 intake of meat and dairy products derived from cows consuming solely contaminated ditch water and grass (silage).

Question 3
Calculate the possible concentrations of GenX, PFOA and additional PFAS in ditch water when concentrations of GenX and PFOA occur at the current limit of quantification of GenX and PFOA in cow's milk (based on reversed dosimetry modelling).

Answer 3
Note that the PFOA reverse dosimetry calculation was revised using the current analytical LOQ in milk (Berendsen et al., 2020). The PFOS reverse dosimetry calculation was added.

Reverse dosimetry could be performed for PFOA but not for GenX. For this revised version of the assessment, also a reverse dosimetry was added for PFOS. A PFOA concentration in milk at the current analytical LOQ level (0.005 ng PFOA/g) leads to a modelled intake of 44.6 µg PFOA per dairy cow per day. This intake corresponds to a calculated PFOA concentration in ditch water of (approximately) 400-550 ng/L.

For PFOS, the concentration in milk at the current analytical LOQ level (0.025 ng PFOS/g) leads to a modelled intake of 0.63 µg PFOS per dairy cow per day. This intake corresponds to a calculated PFOS concentration in ditch water of (approximately) 5.7-7.9 ng/L.

Question 4
Estimate the transfer of GenX, PFOA and additional PFAS in silage to milk and meat from lactating cows and/or sheep.

Answer 4
Note that the text was revised to indicate that transfer of PFOS from grass (silage) to milk and meat at the measured exposure levels is considered negligible in dairy cows and cannot be assessed in sheep.

The intake of PFOA through grass (silage) is approximately 20 times lower than the intake through ditch water, for dairy cattle resulting in modelled PFOA concentrations of 0.003 ng/g milk or 0.01 ng/g meat.

As levels of GenX and PFOS in grass (silage) were below the current analytical LOQs, the transfer from grass (silage) to milk and meat of dairy cattle is considered negligible.

As mentioned under 1) calculations for the transfer of PFOA, PFOS and GenX from grass (silage) to milk and meat from lactating sheep could not be performed.

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Annex 1. Transfer models for contaminants in dairy cows: PFOS and PFOA *Note that text was revised in paragraph 1 and 4.*

1. Introduction

In dairy cows PFAS show quite different kinetics. For example, in the case of PFOS milk is found the major route of excretion, with urinary excretion being negligible. Milk clearance, however, does not prevent PFOS accumulation in the blood and the carcass (as represented by muscle, liver and kidney), with the concentration in blood ≈ liver > kidneys >> muscle>> milk. In contrast, PFOA is only marginally detected in milk, i.e. levels just up to twofold above the LOD used in the study of Kowalczyk et al. (0.1 µg/L). Levels in tissues were negligible when compared to an equal PFOS dosing. PFOA excretion occurs mainly via the urine with concentrations in urine >> plasma >> milk (Kowalczyk *et al.*, 2013). In literature, transfer for other PFAS have been described. For example, PFBS seems to act similarly to PFOA and transfer to milk and meat is negligible. For PFHxS milk is also a route of excretion, however, PFHxS is also excreted in urine. However, these clearance routes do not necessarily prevent PFHxS accumulation during chronic exposure in blood and the carcass with the concentration in blood >> kidney ≈ liver > muscle >> milk. Unfortunately, the currently available models are only for PFOS.

The modeling of PFOS has been addressed before (Van Asselt *et al.*, 2013 and specifications herein). Here the basics of the PFOS model are summarized and its scaling to PFOA is described. Currently no transfer models are available for other PFAS. Using the existing model for other PFAS is currently not possible even when transfer seems similar. More development of transfer models is needed to correctly describe transfer. Although, transfer of Genx is included in the calculations, these are uncertain and only a statement that transfer is more limited compared to that of PFOA could be made.

2. PFOS transfer model

The PFOS transfer model for dairy cows describes the uptake of PFOS from a feed matrix into the (free) PFOS fraction of blood serum. Circulating blood PFOS may be distributed into the cow's carcass or cleared towards bound serum PFOS, which in turn is cleared into the milk or urine (Van Asselt *et al.*, 2013). The model contains six unknown parameters, i.e. the fraction PFOS absorbed from hay/grass silage feed matrix, the free → bound clearance in the serum, the bound serum → milk clearance, the bound serum → urinary clearance, the serum flow-rate to the carcass and the serum-carcass partition coefficient. Analogous to Derks *et al.* (1993) the modeled cow's net body weight was set at 600 kg, the liver percentage of net body weight at 1.9%, the kidney fraction of net body weight at 0.3%, the blood volume fraction of net body weight at (9.3%) and the muscle fraction of net body weight at 35%. The carcass PFOS concentration was calculated as the weighted mean of the muscle, liver and kidney concentrations.

The PFOS transfer model was calibrated/verified on the basis of experimental results of Kowalczyk *et al.*(2013). In this study dairy cows (Holstein Friesian, body weight: 583 kg; n=6) were continuously exposed to hay-grass silage obtained from contaminated farmland for 28 days (upload phase, for intake data see Figure 1, n=3) or for 28 days followed by a wash-out period of 22 days (n=3). During the upload phase the overall average was 7.6 ± 3.2 µg/kg bw per day. As shown in Figure 1 for PFOS and Figure 3 for PFOA the intake during the 28 day upload phase showed a relative high intake between day 8 to 14, probably reflecting a quite high variability in the contamination level of different farmland batches. The experimental results of the exposure + wash out period for 3 cows were used to estimate unknown model parameters, whereas the results of the upload phase for the other 3 cows were used for validation purposes.

Of the six unknown parameters, three, i.e. the fraction PFOS absorbed from hay/grass silage feed matrix and the milk and urinary clearances could unconditionally be identified. The remaining three parameters, i.e. the free → bound clearance in the blood, the blood flow-rate to the carcass and the blood-carcass partition coefficient appeared conditionally identifiable (for details, see Van Asselt *et al.*, 2013). As shown in Van Asselt *et al.* (2013, Figures 2 and 3, corresponding model specifications: see Table 1-1) the model clearly indicated PFOS to accumulate in blood serum, milk and carcass, with urinary excretion being negligible, eventually leading to a “steady state” situation (Figure 2). Note that, as expected for bioaccumulating compounds, the time course of the accumulation does not visually reflect the time course of the daily intake.

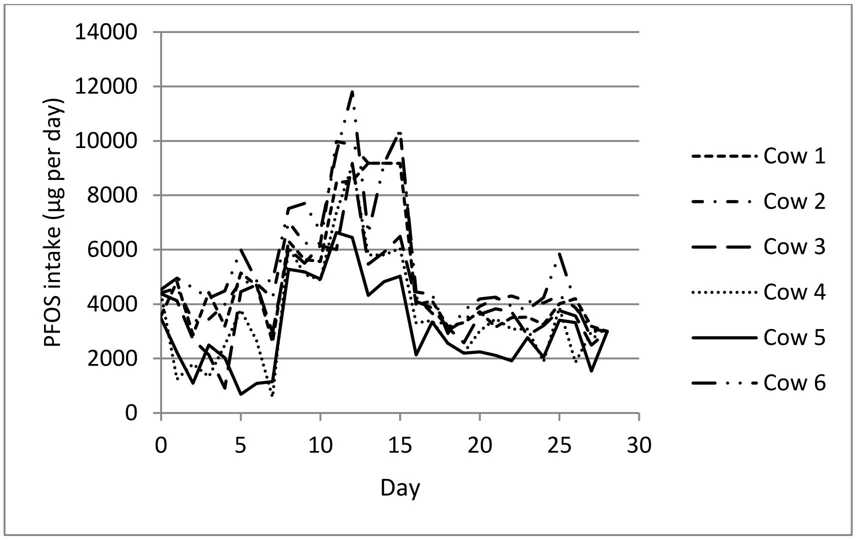


Figure 1. The daily intake (µg per day) of PFOS from contaminated hay-grass silage for a period of 28 days in dairy cows (individual data corresponding with Kowalczyk et al. (2013) supplied by WUR/RIKILT).

Table 1-1. PFOS model specifications (Van Asselt *et al.*, 2013).

Daily intake: Individual intake as specified in Kowalczyk *et al*. (2013) (µg per day)
Milk yield: Individual milk yield as specified in Kowalczyk *et al*. (2013) (L per day)

Fraction PFOS absorbed	1
$Serum_{free}$ → $Serum_{bound}$ clearance (CL_a)[1]	3.6 L per day
$Serum_{bound}$ → Milk clearance (CL_m)	0.017 L per day
$Serum_{bound}$ → Urine clearance (CL_u)	0 L per day
Carcass ↔ $Serum_{free}$ blood flow (Q_c)	13.4 L per day
$Serum_{free}$ -carcass partition coefficient (P_c)	28

[1] nomenclature as in Van Asselt *et al.* (2013)

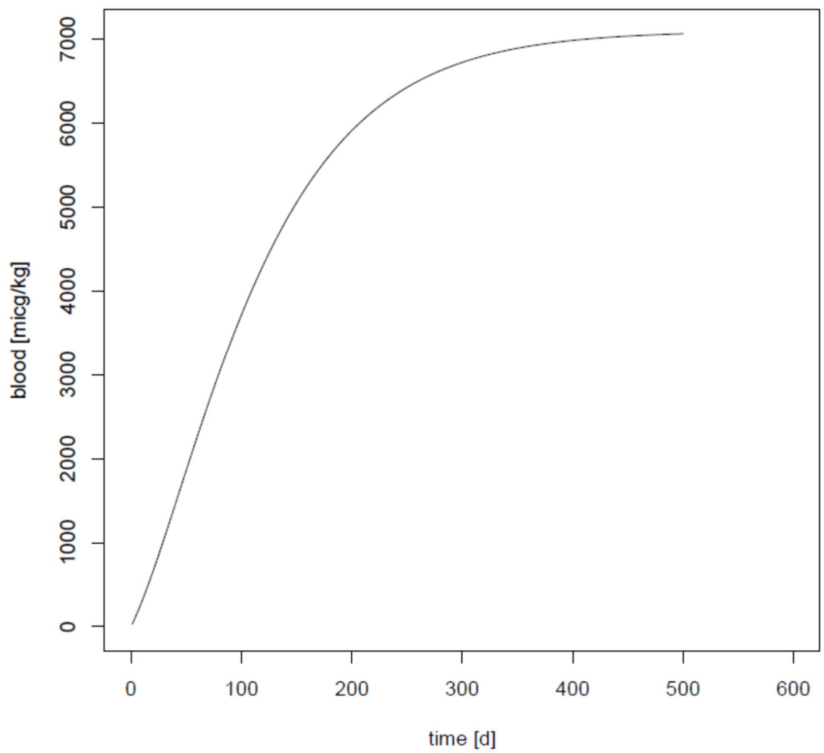


Figure 2. The time-course of the accumulation of PFOS in blood serum after continuous intake of 3000 µg per day from contaminated hay-grass silage in dairy cows. PFOS model specifications as described in Table 1-1.

3. PFOA transfer model

Next to PFOS the cows in Kowalczyk *et al.* (2013) were concomitantly exposed to (on average) 2.0 ± 1.2 µg PFOA/kg bw per day (Figure 3).

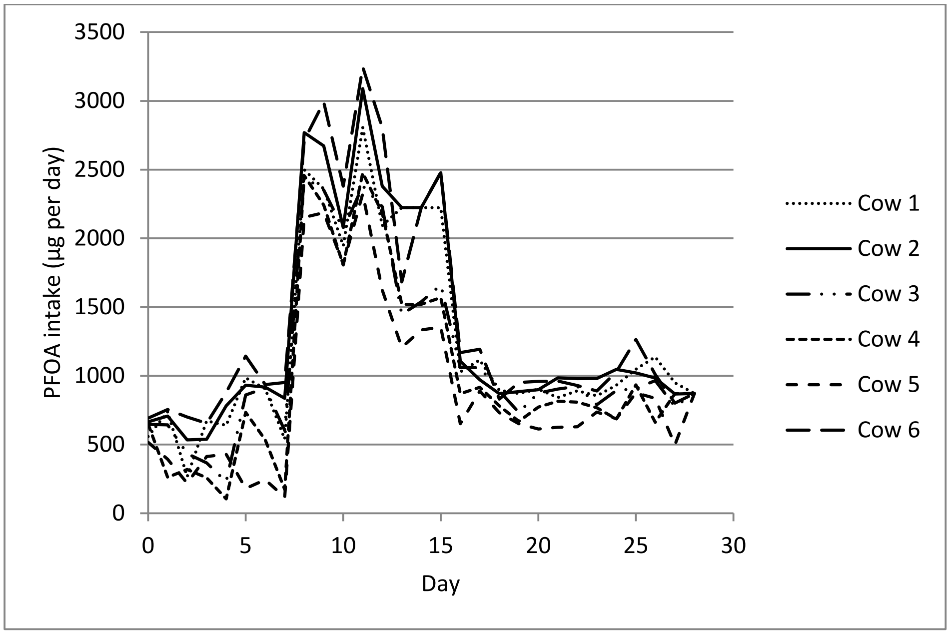


Figure 3. The daily intake (µg per day) of PFOA from contaminated hay-grass silage for a period of 28 days in dairy cows (individual data corresponding with Kowalczyk et al. (2013) supplied by WUR/RIKILT).

PFOA was excreted in the urine, with urinary concentrations ranging from 20 to 80 µg/L (to be compared with negligible PFOS urine levels). Observed levels in milk were at or just above the Limit of Detection of 0.1 µg/L. Moreover, in contrast to PFOS, the simulation characteristics closely follow PFOA intake characteristics, thereby reflecting instantaneous absorption and elimination kinetics of PFOA in dairy cows. At the end of the 28 day exposure period, levels in the liver, kidneys and muscle amounted 10.1, 8.7 and 0.6 µg/kg, corresponding with a carcass concentration around 1 µg/kg (to be compared with 295 µg PFOS/kg). Corresponding levels in blood ranged from 9 to 16 µg/L (to be compared with around 2000 µg/L in the case of the PFOS exposure).

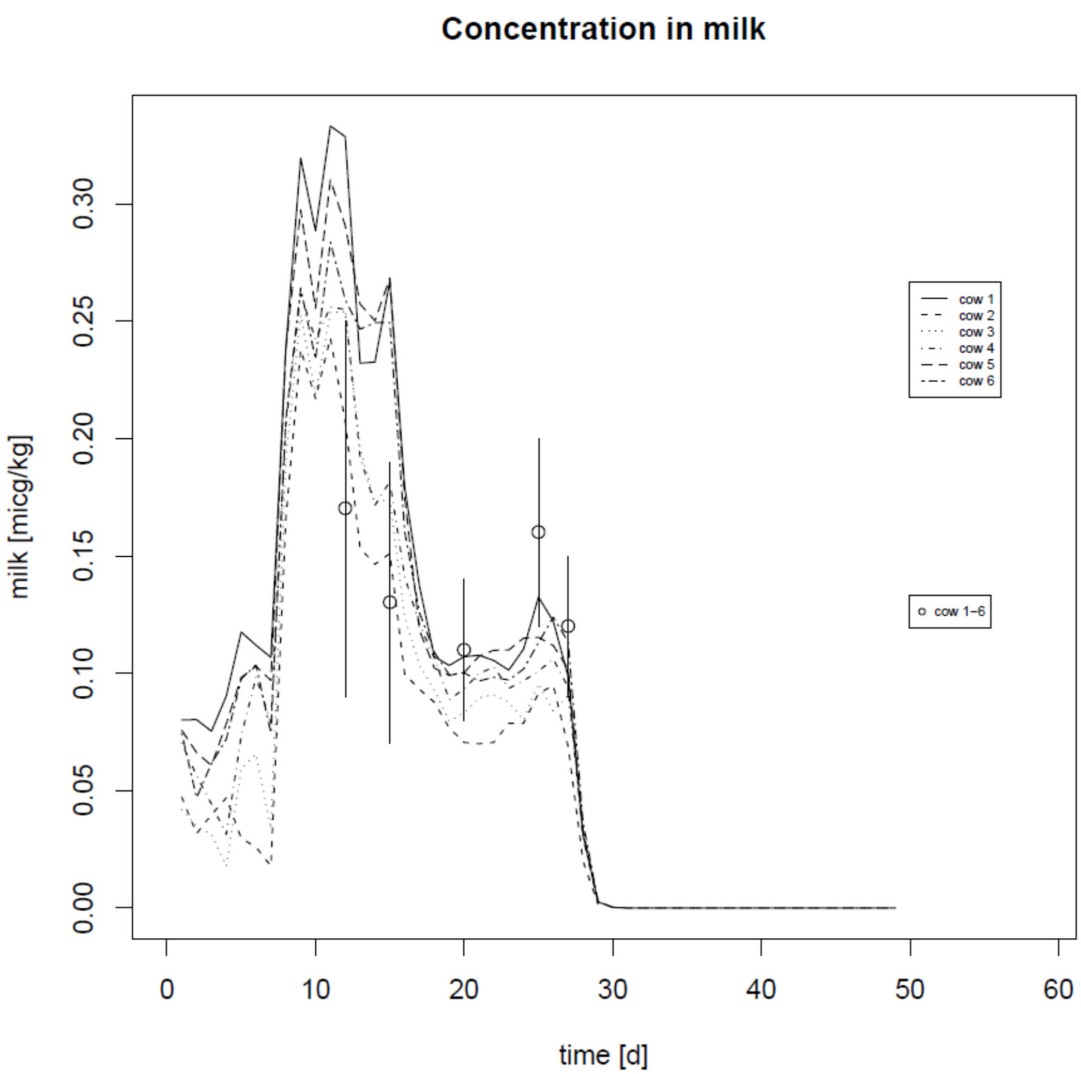
Clearly, describing PFOA kinetics within the same model concept as PFOS needs re-calibration of the latter, i.e. a decrease of the transfer of PFOA from the serum to the carcass, and an increase of the mass-flow towards urinary clearance (while maintaining clearance via milk).

The PFOA re-calibration was performed as follows. The decrease of the transfer of PFOA to the carcass was simulated by lowering the serum carcass partition coefficient from 28 (PFOS) to 0.25 (PFOA). To increase the mass-flow towards urinary clearance the free → bound clearance in blood serum was increased from 3.6 L per day (PFOS) to 10 L per day (PFOA) and the bound blood serum → urine clearance from 0 L per day (PFOS) to 15 L per day (PFOA), thereby enabling a relative high PFOA mass flow to the urine. The corresponding bound blood serum → milk clearance was found to be 0.040 L per day (PFOA, to be compared with 0.017 L per day for PFOS) (Table 1-2). As shown in Figure 4A and 4B, this re-calibration a vu led to a satisfactory description of the observed transfer of PFOA from feed to milk.

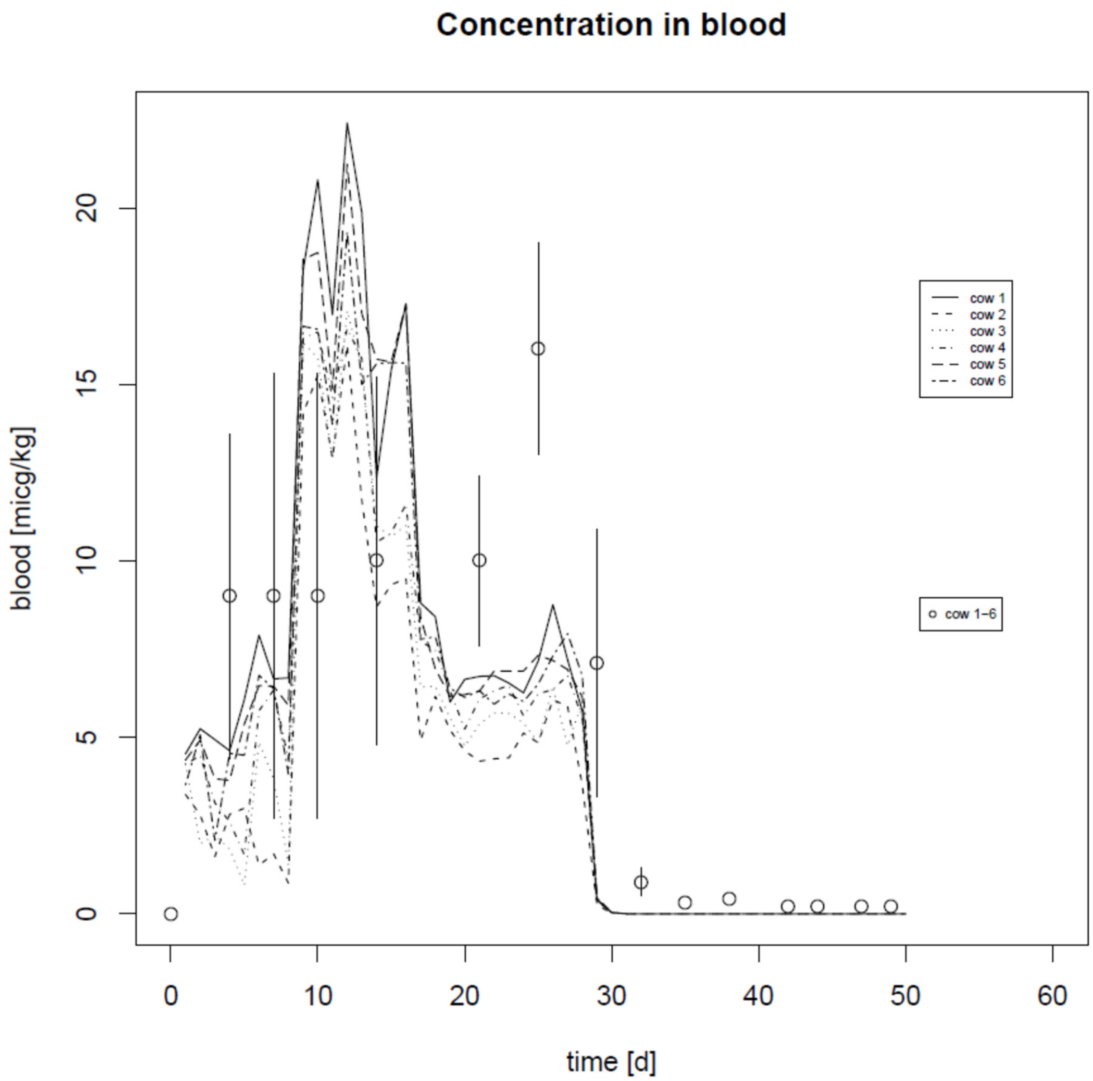
Table 1-2. PFOA model specifications.

PFOA intake: Individual intake as specified in Kowalczyk *et al*. (2013) (µg per day)	
Milk yield: Individual milk yield as specified in Kowalczyk *et al*. (2013) (L per day)	
$Serum_{free}$ → $Serum_{bound}$ clearance (CL_a)	10 L per day
$Serum_{bound}$ → Milk clearance (CL_m)	0.040 L per day
$Serum_{bound}$ → Urine clearance (CL_u)	15 L per day
$Serum_{free}$ ↔ carcass partition coefficient (P_c)	0.25

A.



B.


Concentration in blood
blood [micg/kg]
time [d]
0
5
10
15
20
0
10
20
30
40
50
60
cow 1
cow 2
cow 3
cow 4
cow 5
cow 6
cow 1–6

C.

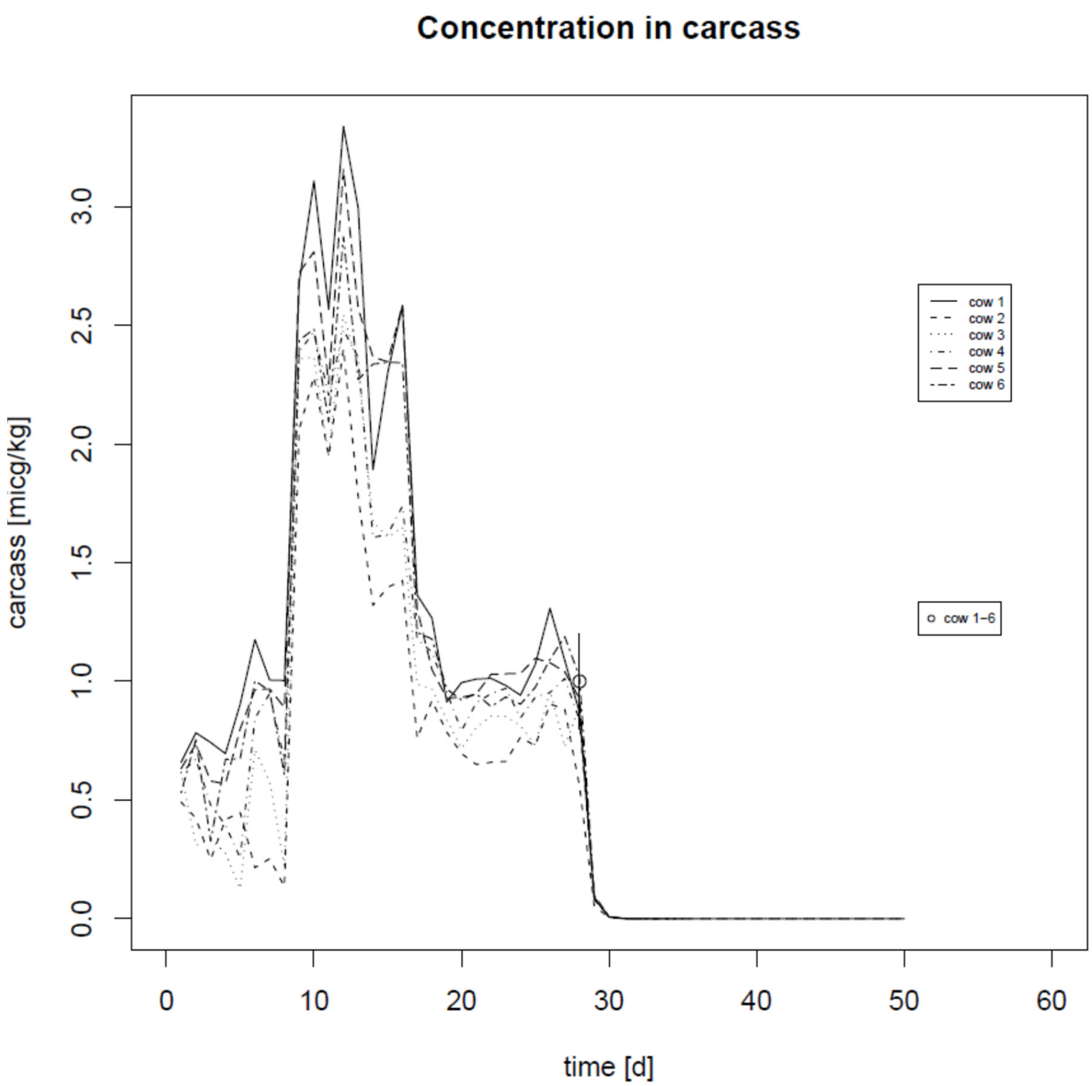


Figure 4. Model simulation of the transfer of PFOA from contaminated hay-grass silage to milk (A), blood serum (B) and carcass (C). PFOS transfer model recalibrated as specified in Table 1-2. Lines: cow specific individual kinetics. Symbols: experimental data (milk: upload phase, mean ± SD, to be compared with Kowalczyk et al., 2013, Figure 3 ; blood: upload + wash out phase, mean ± SD, to be compared with Kowalczyk et al., 2013, Figure 1).

4. Application of PFOS and PFOA transfer model: FO question

In 2018 Dutch milk cows on average produced 28.1 kg milk per day (https://www.cooperatie-crv.nl, dd. 21-03-2019). The corresponding drinking water consumption was obtained from the study of Kume *et al.* (2010). In this study the drinking water consumption and corresponding milk yield were experimentally determined in lactating Holstein cows (body weight: 609 kg, n=16, water consumption and milk yield determined in a metabolic chamber during a 4-day time period). The average milk yield was determined at 29.5 kg per day (minimum: 21.9 kg per day; maximum: 35.3 kg per day). Similarly, the average drinking water intake was determined at 77.6 L per day (minimum: 57.0 L per day; maximum: 110.3 L per day).

Taking the drinking water consumption of Kume as representative for Dutch dairy cows the transfer of PFOS and PFOA in drinking water in such cows to milk and meat was calculated given a daily intake of 80 liter water (corresponding with a daily milk yield of 29.5 kg per day) resp. 110 liter water (corresponding to a daily milk yield of 35 kg per day) For ditch water containing 5.727×10^{-3} µg PFOS/L, this results in a total daily intake of 0.458 µg resp. 0.630 µg PFOS. For intake of ditch water contaminated with 4.67 µg PFOA/L., this results in a total daily intake of 374 µg resp. 514 µg PFOA. Given 600 kg for a cow's net body weight this corresponds with an intake of 0.76×10^{-3} µg resp. 1.05×10^{-3} µg PFOS/kg bw per day and 0.62 µg resp. 0.86 µg PFOA/kg bw per day. Note that such intake exceeds the PFOA intake of dairy cows under naturally contaminated pasture conditions, i.e. around 0.6 µg per day (Vestergren *et al.*, 2013) and is somewhat lower than in Kowalczyk *et al.* (2013). PFOS intake, however is clearly lower than in Kowalczyk et al. (2013) and higher than PFOS intake of dairy cows under naturally contaminated pasture conditions, i.e. around 0.3 µg per day (Vestergren et al., 2013)

For the exposure of 0.76×10^{-3} µg PFOS/kg bw per day the PFOS transfer model calculates a concentration of 0.02 µg/kg for milk and 0.08 µg/kg for muscle, i.e. meat, after repeated exposure. For the 1.05×10^{-3} µg PFOS/kg bw per day exposure corresponding concentrations are 0.02 µg/kg for milk and 0.11 µg/kg for muscle. For the exposure of 0.62 µg PFOA/kg bw per day the PFOA transfer model calculates a concentration of 0.04 µg/kg for milk and 0.21 µg/kg for muscle, i.e. meat, after repeated exposure. For the 0.86 µg PFOA/kg bw per day exposure corresponding concentrations are 0.06 µg/kg for milk and 0.28 µg/kg for muscle.

Given a level of 0.005 µg/L in milk the scaled PFOA model back-calculates a daily PFOA intake of 44.6 µg, corresponding with a ditch water concentration ranging from 44600/110 ≈ 400 ng/L to 44600/80 ≈ 550 ng/L, at a milk yield of 25 kg per day. Using a level of 0.025 µg/L in milk the PFOS model back-calculates a daily PFOS intake of 0.63 µg, corresponding with a ditch water concentration ranging from 630/110 ≈ 5.7 ng/L to 630/80 ≈ 7.9 ng/L, at a milk yield of 25 kg per day.

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Annex 2. PFAS concentrations in ditch water and grass (silage)

Table 2-1. Average concentrations of PFAS in ditch water (in ng/L) at five different locations (codes and distances of locations are given) around Dordrecht analysed in 2021[1]

Location code/ subcode	Location number	Distance (km)	GenX (ng/L)	PFOA (ng/L)	PFOS (ng/L)	PFBA (ng/L)	PFPA (ng/L)	PFHxA (ng/L)	PFHpA (ng/L)	PFNA (ng/L)	PFDA (ng/L)	PFUnDA (ng/L)	PFDoDA (ng/L)	PFTrDA (ng/L)	PFBS (ng/L)	PFHxS (ng/L)	PFHpS (ng/L)	PFDS (ng/L)	NaDONA (ng/L)
G3LOC4/ WA2	8	<1	946.5	4377	5.7	<5	<1.0	29.5	60.0	11.9	<0.125	<0.125	<0.125	<0.5	17.1	1.6	<0.125	<0.125	<0.125
G2LOC3/ WA1	6	1-2	121.0/	868.5	3.8	<5	<1.0	19.3	21.9	4.4	4.8	0.3	<0.125	<0.5	13.1	2.3	0.2	<0.125	0.13
G2LOC1/ WA2	4	1-2	121.0	747	3.3	<5	<1.0	19.2	19.6	2.8	2.2	0.5	<0.125	<0.5	16.4	2.8	0.2	<0.125	0.2
G1LOC3/ WA2	3	2-3	30.5	164	2.6	<5	<1.0	14.5	11.3	1.7	0.8	0.2	<0.125	<0.5	7.8	1.5	<0.125	<0.125	<0.125
G3LOC3/ WA2	10	3-4	9.2	53.5	2.2	<5	<1.0	7.8	4.6	0.7	0.5	<0.025	<0.125	<0.5	10.8	1.4	<0.125	<0.125	<0.125
LOQ			0.125	0.125	0.125	5	1	0.125	0.125	0.125	0.125	0.125	0.125	0.5	0.125	0.125	0.125	0.125	0.125

[1] Analytical results provided by WFSR

Table 2-2. Concentrations of other PFAS in grass (silage) (in ng/g) from ten samples taken in the vicinity of Dordrecht and Helmond[1,2]

Sample	PFOS (ng/g)	PFBA (ng/g)	PFPA (ng/g)	PFHxA (ng/g)	PFHpA (ng/g)	PFNA (ng/g)	PFDA (ng/g)	PFUnDA (ng/g)	PFDoDA (ng/g)	PFTrDA (ng/g)	PFBS (ng/g)	PFHxS (ng/g)	PFHpS (ng/g)	PFDS (ng/g)	NaDONA (ng/g)
510646	<0.25	NA	NA	<1	<0.25	<0.25	NA	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
510731	<0.25	NA	NA	1.13	<0.25	<0.25	NA	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
510732	<0.25	NA	NA	1.58	<0.25	<0.25	NA	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
510763	<0.25	NA	NA	<1	<0.25	<0.25	NA	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
510764	<0.25	NA	NA	1.09	<0.25	<0.25	NA	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
510765	<0.25	NA	NA	<1	<0.25	<0.25	NA	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
510766	<0.25	NA	NA	<1	<0.25	<0.25	NA	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
517236	<0.25	NA	NA	<1	<0.25	<0.25	NA	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
517237	<0.25	NA	NA	<1	<0.25	<0.25	NA	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
517238	<0.25	NA	NA	<1	<0.25	<0.25	NA	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
LOQ	0.25	NA	NA	1	0.25	0.25	NA	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25

NA: Not applicable

[1] Analytical results provided by WFSR

[2] In 2019, PFOA and GenX were reported. GenX measurements were below the current analytical LOQ (<0.25 ng/g). Only for PFOA concentrations of 0.540 and 0.600 ng/g could be determined. The rest was below the current analytical LOQ.

Annex 3. High (95th percentile) consumed amounts of dairy products and beef

*Table 3-1. High (95th percentile) consumed amounts of dairy products[1] per age-sex group based on DNFCS 2012-2016**

Age group (year) + sex	Consumed amount (gram per day)		Percentage consumption days[4]
	All days[2]	Consumption days only[3]	
1-3	725	751	99
4-8	789	826	96
9-18 man	872	966	91
9-18 female	734	849	92
19-50 man	933	997	93
19-50 female	762	860	93
51-79 man	853	897	96
51-79 female	688	736	97

DNFCS: Dutch National Food Consumption Survey
* Same data as reported in RIVM & WFSR (2021b).
[1] Based on consumed amounts of dairy products reported in DNFCS 2012-2016.
[2] Based on all days, irrespective of whether dairy products were consumed or not. High (95th percentile) consumed amounts were calculated based on mean consumed amounts across the two consumption days per individual.
[3] Based on only the days on which the consumption of dairy products was reported. High (95th percentile) consumed amounts were calculated based on consumed amounts per consumption day per individual.
[4] Percentage of the days on which consumption of dairy products was reported.

Table 3-2. High (95th percentile) consumed amounts of beef[1] per age-sex group based on DNFCS 2012-2016

Age group (year) + sex	Consumed amount (gram per day)		Percentage consumption days[4]
	All days[2]	Consumption days only[3]	
1-3	21	75	12
4-8	36	106	12
9-18 man	54	219	14
9-18 female	41	137	11
19-50 man	90	277	15
19-50 female	93	185	13
51-79 man	83	182	19
51-79 female	78	178	19

DNFCS: Dutch National Food Consumption Survey
[1] Based on consumed amounts of beef reported in DNFCS 2012-2016.
[2] Based on all days, irrespective of whether beef was consumed or not. High (95th percentile) consumed amounts were calculated based on mean consumed amounts across the two consumption days per individual.
[3] Based on only the days on which the consumption of beef was reported. High (95th percentile) consumed amounts were calculated based on consumed amounts per consumption day per individual.
[4] Percentage of the days on which consumption of beef was reported

Annex 4: Exposure to the sum of PFOA, GenX and PFOS via dairy products and beef

Table 4-1. Intake of the sum of PFOA, GenX and PFOS (expressed as PFOA-equivalents (PEQ)) through a high (95th percentile) consumption of dairy products[1] from dairy cows solely exposed to contaminated ditch water and grass (silage)

Age group (year) + sex	High consumption of dairy products (gram per day)[2]	Body weight (kg)	Exposure to the sum of PFOA, GenX and PFOS (ng PEQ/kg bw per week)
1-3	725	13.9	36.5
4-8	789	24.1	22.9
9-18; man	872	55.6	11.0
9-18; female	734	53.2	9.7
19-50; man	933	84.6	7.7
19-50; female	762	75.7	7.0
51-79; man	853	88.8	6.7
51-79; female	688	76.9	6.3

bw: body weight; PEQ: PFOA-equivalents

[1] Simulated concentration in milk from dairy cows solely exposed to contaminated ditch water and grass (silage) (Table 3 of main text).

[2] High consumption based on all consumption days within the food consumption survey, irrespective of whether dairy products were consumed (Annex 3, Table 3-1).

Table 4-2. Intake of the sum of PFOA, GenX and PFOS (expressed as PFOA-equivalents (PEQ)) through a high (95th percentile) consumption of meat (beef)[1] from dairy cows solely exposed to contaminated ditch water and grass (silage)

Age group (year) + sex	High consumption of beef (gram per day)[2]	Body weight (kg)	Exposure to the sum of PFOA, GenX and PFOS (ng PEQ / kg bw per week)
1-3	21	13.9	5.4
4-8	36	24.1	5.3
9-18; man	54	55.6	3.5
9-18; female	41	53.2	2.7
19-50; man	90	84.6	3.8
19-50; female	93	75.7	4.4
51-79; man	83	88.8	3.3
51-79; female	78	76.9	3.6

bw: body weight; PEQ: PFOA-equivalents

[1] Simulated concentration in meat (beef) from dairy cows solely exposed to contaminated ditch water and grass (silage) (Table 3 of main text).

[2] High consumption based on all consumption days within the food consumption survey, irrespective of whether beef was consumed (Annex 3, Table 3-2).