Supporting information for

Are cosmetics a significant source of PFAS in Europe? Product inventories, chemical characterization and emission estimates

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S1 Cosmetic database and purchased cosmetic samples

CosmEthics was founded in 2013 and its app was launched in 2014. The CosmEthics App provides users with a traffic light system (suitable/safe product, potential allergen, high concern) following scanning a cosmetic product's barcode. The basic app is free of charge but can be upgraded/customised with advanced functions such as searching for specific substance, allergens, vegan products, etc. Manufacturers, retailers and importers input half of the data regarding products while consumers contribute the other half via crowdsourcing digital data submissions. The raw data is sent to the back-office system, which subsequently links the submission to the scanned barcode. CosmEthics' data processing team then inputs the digital raw data by transcribing the ingredients on the product label into their database. In emissions where the barcode does not exist in the database, the app user is asked to take picture of the product and ingredient list and submit this to the app. Quality checks are conducted as part of the transcription process, whereby each submission is controlled for input errors and a second quality check is conducted in the report generation stage.

As of 2020, CosmEthics app has been downloaded by more than 300000 EU users since then. In 2020, app users contributed to approximately 60 % of the database input, giving the largest machine-readable cosmetic ingredient database worldwide, with a product scanning hit rate of approximately 77 % within the EU.

The CosmEthics databased was searched for approx. 190 PFAS/INCI in August 2020. The PFAS-containing product share in the entire CosmEthics database was 1.4 % and 1.1% considering bar code information of the products (EU/EEA countries only). The total share of INCI names that were identified as PFAS was 0.061 % (entire database). Considering the entire database, make-up consisted of the highest percentage of products with PFAS INCI names (4.1 %), followed by Facial care products and Male grooming products (each 1.2 %). Baby and children's products had a share of 0.03 % PFAS containing products and the two main product categories Fragrances and Foot care, had no products listing a PFAS INCI.

The products of the CosmEthics database were even split for some of our analyses into EU/EEA countries and non-EU/EEA countries based on the barcode starting sequence (i.e. GS1 country prefix within the EAN-13) of the scanned product (country code). The country code indicates the country where the manufacturer is registered. As EU/EEA countries in the database extract counted the barcodes of: Austria, Belgium/Luxembourg, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark/Faroe Islands/Greenland, Estonia, Finland, France/Monaco, Germany, Greece, Hungary, Iceland, Ireland, Italy/San Marino/Vatican City, Latvia, Lithuania, Malta, Netherlands, Norway, Poland, Portugal, Rumania, Slovakia, Slovenia, Spain/Andorra, Sweden. Note that Lichtenstein was not included as it has the same barcodes as Switzerland (non-EU/EEA country), which was assumed to have the higher product share.

All information on the app and database are received by personal communication with Katariina Rantanen (2020).[1]

Table S1. Overview of selected versus purchased samples per product category based on the CosmEthics database. A total of 11 product categories exist within the CosmEthics database but no PFAS-containing products were found within the categories "Fragrances" and "Foot care"; therefore, these are not shown in this table. Note that product categories shown here are not the same as product categories used for emission calculations, which were based on classification from Cosmetics Europe.

	Facial care	Mouth	Bath and Body Products	Hair care	Make up	Baby and Children's Products	Male grooming	Hands and Nails	Tanning	sum
Number of PFAS-containing products per product category	169	1	15	6	490	1	16	22	3	723
Number of intended samples	14	1	1	1	34	1	1	2	1	56
Number of purchased samples	13	0	0	6	24	0	2	0	0	45

Table S2. Overview of cosmetic products purchased from different stores in Stockholm (Sweden) in September 2020 for analysis in the present study.

Sample name (Sub Category)	Product name	Brand/ Company	Fluorinated Ingredient (PFAS INCI)
Decorative Cosmetics			
Blush/Bronzer/Contour 1	Hot MAMA! Shadow/Blush	The Balm cosmetics	PTFE
Blush/Bronzer/Contour 2	CINDY-LOU MANIZER AKA "The Con-tour Artist"	The Balm cosmetics	PTFE
Blush/Bronzer/Contour 3	FREEDOM SYSTEM Face Blush 25	INGLOT	POLYPERFLUOROMETHYLISOPROPYL ETHER
Blush/Bronzer/Contour 4	Lasting Finish Soft Color Blush	RIMMEL LONDON	PTFE
Concealer 1	CC C'est Magic anti-redness skin enhancer	L'Oréal Paris	PERFLUOROOCTYL TRIETHOXYSILANE

Concealer 2	CC+ Color Correcting Full Coverage Cream + Hydrating and Anti-Aging Concealer, Neutral Tan	IT Cosmetics	PERFLUORODECALIN, PERFLUOROHEXANE, PERFLUOROMETHYLCYCLOPENTANE
Eyeliner pen 2	Crayon Yeux Impact Couleur Tenue 16H* Color Eye Pencil 4	Yves Saint Laurent	PERFLUORONONYL DIMETHICONE
Eye shadow 1	Eyeshadow Fard à paupières	URBAN DECAY	PTFE
Eye shadow 2	Eye Color Bar	IsaDora	PTFE
Eye shadow 3	Smoke Balm	The Balm cosmetics	PTFE
Eye shadow 4	Color Sensational	MAYBELLINE New York	PTFE
Eye shadow 5	FREEDOM SYSTEM Eye Shadow Matte NF 298	INGLOT	POLYPERFLUOROMETHYLISOPROPYL ETHER
Eyeliner liquid/gel	AMC Eyeliner Gel 94	INGLOT	POLYPERFLUOROMETHYLISOPROPYL ETHER
Foundation/BB Cream 1	BB C'est Magic BB cream 5 in 1 skin perfecter	L'Oréal Paris	PERFLUOROOCTYL TRIETHOXYSILANE
Foundation/BB Cream 2	Flawless Satin Foundation SPE 20	SENSAI	TRIFLUOROPROPYL DIMETHICONOL
Foundation/BB Cream 3	C Super balanced makeup	CLINIQUE	C9-15 FLUOROALCOHOL PHOSPHATE
Foundation/BB Cream 4	Fresh Nude Foundation SPF 15, Sahara Light 030	THE BODY SHOP	AMMONIUM C6-16 PERFLUOROALKYLETHYL PHOSPHATE
Lip liner pen 1	Crayon Levres 01	CLARINS PARIS	PERFLUORONONYL DIMETHICONE
Lip liner pen 2	Mood Crayon Anger	LINDA HALLBERG	POLYETHYLENE PERFLUORONONYL DIMETHICONE
Loose powder	Loose powder	INGLOT	POLYPERFLUOROMETHYLISOPROPYL ETHER
Mascara	Chubby Lash Fattening Mascara	CLINIQUE	PTFE
Pressed Powder 1	FREEDOM SYSTEM Pressed Powder round 30	INGLOT	POLYPERFLUOROMETHYLISOPROPYL ETHER
Pressed Powder 2	Smooth Finish Foundation Powder	LAURA MERCIER	POLYPERFLUOROETHOXYMETHOXY DIFLUOROETHYL PEG PHOSPHATE
		Hair Care	
Hair spray 1	Blowout Styling & Finishing spray	Living proof.	OCTAFLUOROPENTYL METHACRYLATE (OFPMA)
Hair spray 2	Superfine Hair Spray fixatifix	ORIBE	HYDROFLUOROCARBON 152a
Shampoo	Frizz Shampoo	Living proof.	OCTAFLUOROPENTYL METHACRYLATE (OFPMA)
Styling cream	Balm d'Or Heat Styling Shield	ORIBE	C4-18 PERFLUOROALKYLETHYL THIOHYDROXYPROPYLTRIMONIUM

			CHLORIDE
Treatment 1	Prime Style Extender	Living proof.	OCTAFLUOROPENTYL METHACRYLATE (OFPMA)
		Skin Care	
After shave	Ultra Confort Moisturizing Balm Soothing After Shave	Biotherm Homme	POLYPERFLUOROMETHYLISOPROPYL ETHER
Anti-age cream 1	Revitalift Night Cream	L'Oréal Paris	ACETYL TRIFLUOROMETHYLPHENYL VALYLGLYCINE
Anti-age cream 2	Snake serum O2	Rodial	PERFLUOROHEXANE, PERFLUOROPERHYDROPHENANTHREN, PERFLUORODECALIN
Anti-age cream 3	Age Fitness Advanced Toning Anti-aging care	Biotherm Homme	POLYPERFLUOROMETHYLISOPROPYL ETHER
Exfoliator	Scrub & Mask	FILORGA	PERFLUOROHEXANE, PERFLUORODECALIN, PERFLUOROMETHYLCYCLOPENTANE
Eye moisturiser 1	Advanced Génifique Yeux	LANCÔME	PTFE
Eye moisturiser 2	Pep-start Eye Cream	CLINIQUE	TRIFLUOROACETYL TRIPEPTIDE-2
Facial moisturiser	Facial Fuel Energizing Moisture Treatment For Men	Kiehl's	POLYPERFLUOROMETHYLISOPROPYL ETHER
Mask 1	Instamud 60-Second Pore refining treatment	GLAMGLOW	ETHYL PERFLUOROBUTYL ETHER, ETHYL PERFLUOROISOBUTYL ETHER
Mask 2	Water Drench Hyaluronic Micro-Bubbling Cloud Mask	PETER THOMAS ROTH	METHYL PERFLUOROBUTYL ETHER, METHYL PERFLUOROISOBUTYL ETHER, PERFLUOROHEXANE, PERFLUOROPERHYDROPHENANTHRENE, PERFLUORODECALIN, PERFLUORODIMETHYLCYCLOHEXANE
Mask 3	Bubblesheet Oxygenating Deep Cleanse Mask	GLAMGLOW	METHYL PERFLUOROBUTYL ETHER
Moisturiser/Face cream 1	REVITALIFT Day Cream SPE 30	L'Oréal	ACETYL TRIFLUOROMETHYLPHENYL VALYLGLYCINE
Moisturiser/Face cream 2	Ultra Facial Oil-free Lotion	Kiehl's	POLYPERFLUOROMETHYLISOPROPYL ETHER
Serum and treatment 1	Beauty Lift Illuminating V-Shaping Serum	LUMENE	TRIFLUOROACETYL TRIPEPTIDE-2
Serum and treatment 2	Blue therapy red algae uplift	Biotherm	ACETYL TRIFLUOROMETHYLPHENYL VALYLGLYCINE
Blank samples (no PFAS on the ingredient list)			

Eyeliner pen 1	Color Essence Eye Pencil (celestial)	H&M	-
Treatment 2	Perfect Hair Day	Living proof.	-

S2 Analytical standards and parameters

Standards and reagents

A fluoride standard (1000 mg/L NaF) was obtained from Thermo Scientific and used for calibration. Certified reference material (BCR®-461, fluorine in clay) was obtained from Sigma-Aldrich. Solvents and reagents used for extraction and analytical procedures were of analytical grade and purchased as follows: methanol, acetonitrile and ammonium acetate from Merck, sodium hydroxide, acetic acid and hydrochloric acid (37 %) from Sigma Aldrich. Supelclean™ ENVI-Carb™ powder obtained from Supelco, Sigma Aldrich. Argon and oxygen gases were of purity grade 5.0 and MilliQ water obtained from Millipore (Merck, TOC of 3 ppb, conductivity of 18.2 MΩ).

Sample extraction for EOF and targeted PFAS analysis

Samples analysed for EOF and targeted PFAS were extracted with methanol according to a procedure previously reported in Schultes et al. (2018). Briefly, sodium hydroxide solution (NaOH, 0.5 mL of 0.2 M) and methanol (5 mL) were added to a ~0.1 g sample of cosmetic product. Thereafter, samples were vortexed and ultrasonicated for 30 minutes, at room temperature. The supernatant was transferred into a new test tube following centrifugation (2000 rpm, 5 minutes). The extraction was repeated with 5 mL methanol and the extract was centrifuged (3000 rpm, 20 minutes). The supernatants were combined and neutralised with hydrochloric acid (HCl, 50 µL of 2 M). Thereafter, the methanol was evaporated under a gentle stream of nitrogen to approximately 1 mL. About 500 µL of the concentrated extract were transferred to a 1.5 mL Eppendorf tube containing 25 mg graphitized carbon (Supelclean ENVI-carb) and 50 µL glacial acetic acid. The tubes were vortexed and centrifuged (10000 rpm, 10 minutes) before transferring the supernatant to a new Eppendorf tube. At this point, the extract was divided into two portions: about 500 µL was set aside for EOF analysis. About 100 µL of the extract was spiked with 50 µl of an isotopically labelled standard solution (20 pg/µL) for target PFAS quantification. 10 % of the samples were replicated (n = 3) and all sample extracts were stored in a freezer until the day of analysis.

TF and EOF instrumental analysis

Approximately 0.1-1 mg of cosmetic product for TF analysis and 10-100 µL of extract for EOF analysis were weighed into a ceramic boat containing glass wool. To minimize background contamination, all boats (containing glass wool) were baked out prior to analysis of real samples. The samples were combusted at 1100°C under a flow of oxygen (400 L/min) and argon mixed with water vapor (200 L/min) for about 6 minutes. Combustion gases were collected in MilliQ water in an absorber unit (GA-210, Mitsubishi), after which an aliquot of the absorption solution

(100 mL) was injected onto the ion chromatograph (IC; Dionex Integrion, Thermo Fisher Scientific), which was equipped with an anion exchange column (Dionex IonPac AS19 2 × 50 mm guard column and 2 × 250 mm analytical column, 7.5 mm particle size) operated at 30°C. Chromatographic separation was achieved by running a gradient of aqueous hydroxide mobile phase ramping from 8 mM to 60 mM at a flow rate of 0.25 mL/min. The fluoride was detected by a conductivity detector.

Targeted PFAS analysis (LC-MS/MS)

Extracts (5 µL) were injected onto an Acquity ultra performance liquid chromatography (UPLC) (Waters Corp., Milford, MA) equipped with a BEH C18 guard (5×2.1 mm, 1.7 mm particle size) and an analytical (50×2.1 mm, 1.7 mm) column operated at 40°C. The composition of the mobile phase and details on the gradient and the flow rate are adopted from Schultes et al. (2018) and can be found in Table S4. Detection of PFAS was carried out using a Xevo TQ-S triple quadrupole mass spectrometer (Waters Corp, Milford, MA) operated in negative electrospray ionisation mode. The capillary voltage was set to 3 kV and the desolvation and source temperature were set to 350˚C and 150˚C, respectively. The desolvation and cone gas flows were set to 150 L/h and 650 L/h, respectively. Further information on MS parameters are presented in Table S3. Quantification of individual PFAS was performed using MassLynx 4.1 (Waters), via an 8-point calibration curve ranging from 0.02 to 100 pg/µl. Analytes lacking an analogous labelled standard were quantified using the internal standard with the closest retention time. In emissions where a sample contained polyfluoroalkyl phosphate esters (PAPs), a ten-fold fortification of internal standard was performed and the concentrations were diluted prior to analysis in order to fall within the uppermost concentration of the calibration curve.

Table S3: PFAS (native and internal standards (IS)) included in this study and mass spectrometer (MS) detection/quantification parameters.

Target Analyte	Precursor Ion	Quantitative Product ion	Qualitative product ion	Internal standard	Internal standard transition
PFBA	213	169	n.a.	$^{13}C_4$ -PFBA	217>172
PFPeA	263	219	169	$^{13}C_5$-PFPeA	266>223
PFHxA	313	269	119	$^{13}C_2$-PFHxA	315>270
PFHpA	363	319	169	$^{13}C_4$-PFHpA	367>322
PFOA	413	169	369	$^{13}C_4$-PFOA	417>372
PFNA	463	419	219	$^{13}C_5$-PFNA	468>423
PFDA	513	469	269	$^{13}C_2$-PFDA	515>470
PFUnDA	563	519	269	$^{13}C_2$-PFUnDA	565>520
PFDoDA	613	569	169	$^{13}C_2$-PFDoDA	615>570
PFTriDA	663	619	169	$^{13}C_2$-PFDoDA	615>570
PFTeDA	713	669	169	$^{13}C_2$-PFDoDA	615>570
PFHxDA	813	769	169	$^{13}C_2$-PFDoDA	615> 570
PFOcDA	913	869	169	$^{13}C_2$-PFDoDA	615> 570
PFBS	299	80	99	$^{18}O_2$-PFHxS	403>84
PFHxS	399	80	99	$^{18}O_2$-PFHxS	403>84
PFOS	499	80	99	$^{13}C_4$-PFOS	503>80
PFDS	599	80	99	$^{13}C_4$-PFOS	503>80
FOSA	498	78	169	$^{13}C_8$-FOSA	506>78
6:2/6:2 diPAP	789	443	97	$^{13}C_4$-6:2/6:2	793>445
6:2/8:2 diPAP	889	443	543	$^{13}C_4$-6:2/6:2	793>445
8:2/8:2 diPAP	989	543	97	$^{13}C_4$-8:2/8:2	993>545

n.a. not applicable

Table S4. Mobile phase gradient profile for PFAS measured by LC-MS/MS.

	LC Gradient Program		LC Flow Rate
Time (min)	**Mobile phase A (%)**	**Mobile phase B (%)**	**(ml/min)**
0.0	90	10	0.4
0.5	90	10	0.4
5	20	80	0.4
5.1	0	100	0.4
6.6	0	100	0.4
8	0	100	0.55
10	90	10	0.4

Mobile phase A: 90 % water and 10 % acetonitrile containing 2 mM ammonium acetate.

Mobile phase B: 100 % acetonitrile containing 2 mM ammonium acetate.

S3 Emissions

S3.1 Concentration of PFAS in the cosmetic products

Low, average, and high emissions estimates were performed using each of the three analytical measurements, i.e. total fluorine (TF), extractable organic fluorine (EOF) and targeted PFAS. Firstly, concentrations were sub-grouped according to the type of cosmetic product. For example, all samples of eye shadow were considered as one subgroup. Then, the average, minimum and maximum concentration (i.e. for TF, EOF, or target PFAS) within each subgroup was determined (Table S5-S7). Finally, the overall average, minimum, and maximum concentration for each product category (Decorative Cosmetics, Hair Care and Skin Care) was calculated (note that there were no samples among the product categories "Perfumes and Fragrances" or "Toiletries") and used as the product concentration in the emission calculations of the average, low and high emission scenarios, respectively. For PFCAs, concentrations were summed for each sample prior to calculating the average, minimum and maximum concentrations.

In order to prevent underestimated emissions, concentrations that were below LOD for TF and EOF measurements were set equal to the actual LOD because at least one PFAS was listed as the intended ingredient in measured products which in theory can contribute to fluorine amount. While the concentrations that were below the for ∑PFCA were set equal to zero to avoid unrealistic overestimation by taking the actual value of the LOD due to following reasons: (i) none of the PFCAs was listed as an ingredient (i.e. the measured PFCAs occur as impurities). Thus, they are unlikely to occur in all products and concentrations are expected to be low; (ii) in emissions where several PFCA concentrations in a same sample were <LOD, the sum of the LOD concentrations would result in an overestimate for the emissions calculation (LOD dependents on the method and the instrument of the measurement); (iii) the minimum, average and maximum ∑PFCA concentration per product category (which in the extreme emission would be equal to the ∑LOD-values, if all PFCAs have concentrations <LOD) will be set off against tonnes of products in the emission calculations. Therefore, even low LOD (ng/g) values (especially their sum) would contribute greatly to the final calculated emitted ∑PFCA amounts.

Further, hardly any sample concentrations fell below the LOD (for TF only one hair spray and one mask <LOD; for EOF one eye shadow and one exfoliator <LOD). Therefore, the influence of assuming zero or taking the LOD values was negligible for the total averages of the cosmetic product categories. For TF, only within the product category Hair Care, the minimum concentration was equal to the LOD value of one Hair Spray product and taken as the minimum concentration for the low emission scenario. For EOF, the value of the LOD was taken as the minimum concentration for both Skin Care and Decorative Cosmetics in the low emission scenario.

The concentrations were assumed to be equal to zero for “Perfumes and Fragrances” for all measurements (TF, EOF and PFAS) and emission scenarios because only one in 3637 products (i.e. 0.027 %) in the “Perfumes and Fragrances” product category contained a listed PFAS as an ingredient (CosmEthics database).

223 **Table S5.** Average (± standard deviation), minimum and maximum of the TF concentration (ng F/g) per product (sub-)category

Product Category	Sub-Category	Measured TF (mg F/g)	LOD (mg F/g)	(Sub-)Category	Average (mg F/g)	min (mg F/g)	max (mg F/g)
				Decorative Cosmetics	1.77	0.02	6.01
Decorative Cosmetics	Blush/Bronzer/Contour 1	5.14	0.022	Blush/Bronzer/Contour	2.95	0.90	5.14
Decorative Cosmetics	Blush/Bronzer/Contour 2	3.26 ±1.76	0.012				
Decorative Cosmetics	Blush/Bronzer/Contour 3	0.90	0.310				
Decorative Cosmetics	Blush/Bronzer/Contour 4	2.49	0.014				
Decorative Cosmetics	Concealer 1	0.80	0.002	Concealer	0.42	0.03	0.80
Decorative Cosmetics	Concealer 2	0.03	0.016				
Decorative Cosmetics	Eye liner, pen 2	0.17	0.004		0.17	0.17	0.17
Decorative Cosmetics	Eye shadow 1	2.21	0.021	Eye shadow	2.23	0.72	5.35
Decorative Cosmetics	Eye shadow 2	5.35	0.028				
Decorative Cosmetics	Eye shadow 3	0.72	0.020				
Decorative Cosmetics	Eye shadow 4	0.99	0.011				
Decorative Cosmetics	Eye shadow 5	1.90±1.05	0.015				
Decorative Cosmetics	Eyeliner liquid/gel	0.35	0.028	Eyeliner liquid/gel	0.35	0.35	0.35
Decorative Cosmetics	Foundation/BB Cream 1	0.02	0.001	Foundation/BB Cream	1.23	0.02	3.31
Decorative Cosmetics	Foundation/BB Cream 2	0.18	0.002				
Decorative Cosmetics	Foundation/BB Cream 3	1.41	0.042				
Decorative Cosmetics	Foundation/BB Cream 4	3.31	1.310				
Decorative Cosmetics	Lip liner, pen 1	0.52	0.010	Lip liner, pen	0.73	0.52	0.94
Decorative Cosmetics	Lip liner, pen 2	0.94	0.004				
Decorative Cosmetics	Loose powder	6.01	0.028	Loose powder	6.01	6.01	6.01
Decorative Cosmetics	Mascara	3.54	0.063	Mascara	3.54	3.54	3.54
Decorative Cosmetics	Pressed Powder 1	0.23±0.13	0.012	Pressed Powder	0.13	0.02	0.23
Decorative Cosmetics	Pressed Powder 2	0.02	0.007				

				Hair Care	0.19	0.0012	0.50
Hair Care	Hair spray 1	0.01	0.0003	Hair spray	0.01	0.0012	0.01
Hair Care	Hair spray 2	<LOD	0.0012				
Hair Care	Shampoo	0.50	0.231	Shampoo	0.50	0.50	0.50
Hair Care	Styling cream	0.20	0.011	Styling cream	0.20	0.20	0.20
Hair Care	Treatment 1	0.03	0.012	Treatment	0.03	0.03	0.03
				Skin Care	3.83	0.01	13.79
Skin Care	After shave	3.67	0.007	After shave	3.67	3.67	3.67
Skin Care	Anti-age cream 1	0.077±0.023	0.019	Anti-age cream	1.35	0.08	3.80
Skin Care	Anti-age cream 2	0.18	0.014				
Skin Care	Anti-age cream 3	3.80	0.023				
Skin Care	Exfoliator	13.80±2.66	0.715	Exfoliator	13.79	13.79	13.79
Skin Care	Eye moisturiser 1	4.24±0.19	0.022	Eye moisturiser	2.12	0.01	4.24
Skin Care	Eye moisturiser 2	0.01	0.002				
Skin Care	Mask 1	<LOD	0.035	Mask	3.74	<LOD	10.58
Skin Care	Mask 2	10.60±0.90	0.042				
Skin Care	Mask 3	0.60	0.038				
Skin Care	Facial moisturizer	2.58	0.006	Facial moisturizer	2.03	0.05	3.47
Skin Care	Moisturiser/Face cream 1	0.05	0.034	Moisturiser/Face cream			
Skin Care	Moisturiser/Face cream 2	3.47±0.26	0.074				
Skin Care	Serum and treatment 1	0.069±0.027	0.001	Serum and treatment	0.08	0.07	0.10
Skin Care	Serum and treatment 2	0.10	0.013				
Blank samples							
Decorative Cosmetics	Eye liner, pen 1	0.024±0.024	0.007				
Hair Care	Treatment 2	<LOD	0.033				

LOD=limit of detection.

Note: "Facial moisturizer" (name of a male product sub-category) falling under the "Male grooming" product category in CosmEthics has been pooled with the female according products (Moisturiser/Face cream, falling under "Facial Care" as a product category in CosmEthics), as these both would fall under Skin Care in Cosmetics Europe.

228 **Table S6.** Overall average, minimum and maximum of the EOF concentration (ng F/g) per
229 product category

Product category	Sub Category	Measured EOF (ng F/g)	LOD (ng F/g)	(Sub)Category	Average (ng F/g)	min (ng F/g)	max (ng F/g)
				Decorative Cosmetics	**549516**	**325**	**4925752**
Decorative Cosmetics	Concealer 1	3912	325	Concealer	2118	325	3912
Decorative Cosmetics	Concealer 2	<MDL	325				
Decorative Cosmetics	Eye liner, pen 2	11423	325	Eye liner, pen	11423	11423	11423
Decorative Cosmetics	Eye shadow 5	<MDL	325	Eye shadow	325	325	325
Decorative Cosmetics	Foundation/BB Cream 3	1584131	325	Foundation/BB Cream	3254941	1584131	4925752
Decorative Cosmetics	Foundation/BB Cream 4	4925752	325	Foundation/BB Cream			
Decorative Cosmetics	Lip liner, pen 1	9417	325	Lip liner, pen	9417	9417	9417
Decorative Cosmetics	Pressed Powder 2	18870	325	Pressed Powder	18870	18870	18870
				Hair Care	**102228**	**14654**	**189803**
Hair Care	Shampoo	14654	325	Shampoo	14654	14654	14654
Hair Care	Styling cream	189803	325	Styling cream	189803	189803	189803
				Skin Care	**5358**	**162**	**36583**
Skin Care	After shave	374	325	After shave	374	374	374
Skin Care	Anti-age cream 2	1258	325	Anti-age cream	1258	1258	1258
Skin Care	Exfoliator	<MDL	162	Exfoliator	162	162	162
Skin Care	Mask 1	2695	325	Mask	19639	2695	36583
Skin Care	Mask 2	36583.16 (±12199.1)	162				

230 *LOD=limit of detection.*

Table S7. Overall average, minimum and maximum of the ∑PFCA concentration (ng ∑PFCA/g) per product category

Product category	Sub Category	Measured ∑PFCAs (ng/g)	(Sub)Category	Average ∑PFCAs (ng/g)	min ∑PFCAs (ng/g)	max ∑PFCAs (ng/g)
			Decorative Cosmetics	51.2	0.00	341
Decorative Cosmetics	Concealer 1	77.4	Concealer	38.7	0.00	77.4
Decorative Cosmetics	Concealer 2	0.00				
Decorative Cosmetics	Eye liner, pen 2	0.00	Eye liner, pen	0.00	0.00	0.00
Decorative Cosmetics	Eye shadow 5	10.2	Eye shadow	10.2	10.2	10.2
Decorative Cosmetics	Foundation/BB Cream 3	341	Foundation/BB Cream	252	163	341
Decorative Cosmetics	Foundation/BB Cream 4	163				
Decorative Cosmetics	Lip liner, pen 1	5.93	Lip liner, pen	5.93	5.93	5.93
Decorative Cosmetics	Pressed Powder 2	0.00	Pressed Powder	0.00	0.00	0.00
			Hair Care	0.00	0.00	0.00
Hair Care	Shampoo	0.00	Shampoo	0.00	0.00	0.00
Hair Care	Styling cream	0.00	Styling cream	0.00	0.00	0.00
			Skin Care	1248	0.00	9559
Skin Care	After shave	0.00	After shave	0.00	0.00	0.00
Skin Care	Anti-age cream 2	0.00	Anti-age cream	0.00	0.00	0.00
Skin Care	Exfoliator	0.00	Exfoliator	0.00	0.00	0.00
Skin Care	Mask 1	425	Mask	4992	425	9559
Skin Care	Mask 2	9559				

LOD=limit of detection

Note: average concentrations equal to zero, if all PFCA concentrations of the ∑PFCA were below the limit of detection (<LOD).

S3.2 The total amount of cosmetic products sold per year

To our knowledge, the yearly tonnages of the products within the trading market of interest is not available.[2–4] Therefore, the yearly tonnage of produced cosmetic products was derived based on the following data and assumptions:

- The Retail Sales Price of the European cosmetic products market (Table S9).
- The market share of the different product categories (Table S8).
- An assumed average product price per product category (Table S10).
- An assumed average product size (in g) per product category (Table S11).

The two first parameters were obtained from the Cosmetics Europe report[5]. For each product category the following equation resulted into the total amount of cosmetic products sold per year ($A_{products}$):

Eq. S1

$$A_{products}\left[\frac{t}{year}\right] = \frac{RSP_{market}\,[Euro] \times f_{market}}{RSP_{product}\,[Euro]} \times M_{product}\,[g]$$

The number of sold products within each product category was calculated, assuming an average product price per product category ($RSP_{product}$ in Euro) and relating this to the Retail Sales Prices (including VAT) per product category (based on the total market Retail Sales price (RSP_{market} in Euro) and the market share (f_{market}). The latter two parameters originating from Cosmetics Europe's the annual report.[5] This has been translated into the tonnage of products produced within each product category per year in the EEA, in combination with the average product size per product category ($M_{product}$ in g).

The "product size" and "product price" are sensitive parameters and have a considerable influence on the data and overall emission. For instance, an increase of all average product sizes by 10 % would result in a 10 % increase in the total quantity (i.e. mass in t) of products and hence the total emissions. The estimated tonnage (total volume of 2.64 million tonnes, Norway and Switzerland data are excluded) agrees well, but are on the lower end of previous estimated amounts of the total volume of 3-5 million tonnes for the European market (EU28, in 2015).[6]

The following sections explain the different parameters in more detail.

Table S8: Calculated total amount (metric tonnes) of cosmetic products sold per year in 2019 in the EEA

Product category	Estimated total amount of products (thousand tonnes/year in 2019)
Skin Care	273
Toiletries	1110
Hair Care	838
Perfumes and Fragrances	77.6
Decorative Cosmetics	18.8
Total EEA market*	2320

**EU27 and Norway (i.e. EEA without Lichtenstein and Iceland)*

S3.2.1 Retail Sales Prices and market share per product category

Table S9 shows Retail Sales Price (EEA) obtained from Cosmetics Europe (2020) on European market subtracting the RSP (not include Iceland and Lichtenstein) from the United Kingdom and Switzerland. Based on the total Retail Sales Price (EEA) and the market share by product category (%), both Cosmetics Europe (2020), the Retail Sales Price per product category was calculated.

Table S9: EEA cosmetic products market 2019, Retail Sales Prices (RSP including VAT) and market share by product category

	Product category	Percent (%)	Retail Sales Price (bn Euro)
Market share 2019 by product category	Skin Care	27.1	18.22
	Toiletries	24.8	16.67
	Hair Care	18.7	12.57
	Perfumes and Fragrances	15.4	10.35
	Decorative Cosmetics	14	9.41
Total EEA market*	all product categories	100	67.22

**EU27 and Norway (EEA without Lichtenstein and Iceland)*

S3.2.2 Product price

Table S10 shows the average product price per product category in Sweden (assuming 100 SEK equal to approximately 10 Euros).

Estimation for price was necessary since there was no information available on product prices confirmed by personal communications.[2,4] Firstly, the average product price adopted from Hansson et al. (2020) in Sweden per product category (assumed 100 SEK, i.e. approximately 10 Euros as average product price for product categories).[7] Cosmetic products in Sweden are generally more expensive than in other EEA countries. Assuming a more expensive product price

will result in a lower number of products sold per product category (because the product price is related to the overall retail sales price) and consequently lower emissions (Eq. 2). Due to this assumption the Swedish prices were taken for the low emission scenario only (Table S10). Perfumes and Fragrances were not considered in the previous report but were assumed to cost 30 Euro per product in the low emission scenario (Table S10). For the average and high emission scenario, the same prices, but lower than in the low emission scenario were assumed. The assumptions were based on personal experience and after screening prices on a webpage of one popular drugstore in Germany (https://www.dm.de/ beginning of January 2021). The drugstore has a price filter option that lists the number of products in different price categories. The search was done for different sub-product categories (e.g. shampoo, eyeshadow etc.) within the different product categories. However, the frequency of products in the different price categories and for the different sub-categories were not recorded and no mathematical averages were calculated among the products to obtain the average price per product category. Nevertheless, the assumed average prices were based on these insights and after weighing e.g. probable frequently big sellers within the product categories.

Table S10: Estimated average product price (Euro) per product category for the emission calculations.

Product category	Price (Euro)- for low emission	Price (Euro)- for average emission	Price (Euro)- for high emission
Decorative Cosmetics	10	5	5
Hair Care	10	3	3
Perfumes and Fragrances	30	10	10
Skin Care	10	5	5
Toiletries	10	3	3

S3.2.3 Product size

Table S11 shows the average of the product size based on rounded vales and assumptions after calculation of the average product size for each sub-category.

No information was available on average product sizes confirmed based on personal communications. [2,4] In order to extract the product size within each product category and sub-category, the CosmEthics database for the PFAS containing products was consulted (both EU/EEA and non-EU/EEA barcode products, 2016-2020 data). However, product size information was missing for many products and sometimes the entire sub-categories.

To address this issue, the sub-categories and size information were classified into the main product categories according to Cosmetics Europe (i.e. Skin Care, Hair Care, Decorative Cosmetics, Perfumes and Fragrances, as well as Toiletries). The product sizes of products in sub-categories that existed in serval main product categories were treated as belonging to one sub-category. For

example, in emission of Toiletries, the sub-category Deodorant was considered as an overall sub-category within Cosmetics Europe's for both Bath and Body (female) and Male grooming in CosmEthics product categories. Product sizes given in mL were assumed to be the corresponding size in g (i.e. assumption 1 mL=1 g) and one oz was treated as 30 mL and then accordingly expressed in grams. For products with size information like 5×1.2 g (i.e. products such as eyeshadow pallets containing e.g. 5 different coloured products of each 1.2 g), the actual value was calculated (i.e. 6 g) and given for this product. The average of the product size was calculated for each sub-category. For each of the big five Cosmetics Europe product categories, several averages of the product sizes were calculated (Table S11):

a) the average [g] over all single products

b) the average [g] based on the different sub- categories' size averages

c) the average [g] including all products only in the sub-categories in which samples for chemical analysis existed

d) the average [g] based on the different sub-categories' size averages in the sampled sub-categories only.

Table S11: Average product sizes [g] for the different product categories; final average product size for the emission calculations assumed after considering different averages based on product sizes from the CosmEthics database (PFAS INCI containing products 2016-2020 with listed product size information only) and making assumptions on product sub-categories with missing product size data.

Product category	**Final average product size [g] for emission calculations**	average [g] (over all products with sizes)	average [g] (over the different categories' size averages)	average [g] (including all products in the sampled categories only)	average [g] (over the different categories' size averages in the sampled categories only)	number of products (with PFAS INCI) with product size in the CosmEthics database
Decorative Cosmetics	**10**	13.5	8.8	14.0	9.9	673
Hair Care	**200**	189	166	197	171	79
Skin Care	**75**	47.2	76.8	38.6	41.9	181
Perfumes and Fragrances	**75**	152	152			1
Toiletries	**200**	167	158			21

As some data on size were scares and sub-categories where over- or underrepresented within some of the categories, assumptions for the product size were made based on calculated averages and weighing the importance of certain product types within categories. Also values where rounded and evened out. As an example, for Toiletries, a larger size (200 g) than the averages were

assumed, as product sizes for body wash were non-existent (presumably a large product size sub-category and popular selling item). The product size of 200 g for Toiletries is also in accordance with a previous assumption.[7,8] .

S3.3 The share of products containing PFAS

Table S12 shows the share of cosmetic products and product versions that contain PFAS (%) sorted according to the Cosmetics Europe categories. The sub-categories from CosmEthics were regrouped into the product categories from Cosmetics Europe. To avoid an overestimation of the emitted PFAS amounts, only the share of the PFAS-containing products within each product category was considered.

Table S12: Share of cosmetic products and product versions that contain PFAS (%) based on CosmEthics sorted according to the Cosmetics Europe categories.

Product category (Cosmetics Europe)	Total number of products and product versions	Total number of cosmetic products and product versions containing PFAS	Share of cosmetic products and product versions containing PFAS (%)
Decorative cosmetics	29118	1068	3.67
Hair care	21938	142	0.65
Perfumes and Fragrances	3637	1	0.03
Skin care	40103	314	0.78
Toiletries	17844	49	0.27
Total	112639	1574	1.40

S3.4 The fraction of PFAS released from cosmetic products

Table S13 shows consumer habits for the removal of cosmetic products and the calculated fraction released into the wastewater (based on Kantar TNS, survey commissioned by Cosmetics Europe among 8000 female and male consumers in eight European countries)[9]. The total released into the wastewater (%) is calculated using equation S2:

Eq. S2 $$WashedOff + ((Cotton, pads, wipes \times Disposed\ into\ toilet)/100)$$

Table S13: Consumer habits for the removal of cosmetic products and calculated total release into wastewater; data based on Kantar TNS (2018) commissioned by Cosmetics Europe[9]

Product category	Sub-category	Washed-off (%)	Cotton, pads, wipes (%)	Other (%)	Cotton etc. disposed into bin (%)	Cotton etc. disposed into toilet (%)	Total release into wastewater (%)
Decorative Cosmetics	Make-up	24	75*	1	93	5	27.8
	Nail varnish/remover	15	76	9	95	4	18
	Lip stick	29	69	2	94	5	32.5
	Lip balm	52	37	11	93	6	54.2
Skin Care	Skin Care	75	20	5	94	4	75.8
	Sun lotion	86	13	2	93	6	86.8
Hair Care	Hair styling	91	6	3	88	8	91.5
Toiletries	Deodorant/ antiperspirant	89	8	3	89	8	89.6

** out of the consumers removing their Makeup with cotton/wipes/tissues (75 %): 48 % remove their makeup with cotton/pads/wipes only and 27 % use both, cotton/pads/wipes and water.*

For the cosmetic products fraction released into the wastewater, we considered the total percentage of both, the percentage of the "wash-off" answers and the "cotton/pads/wipes" fraction that were discarded into the toilet. For instance, the Decorative Cosmetic products removal involved (i) using water (i.e. "wash-off") or (ii) using "cotton, pads, wipes" and/or the alike, or (iii) neither of the first two choices, i.e. "other". Following the cotton/wipes answer, participants could provide an answer on if these were thrown into the municipal trash or disposed into the toilet (or other).

Table S14 shows release emission scenarios ($f_{release}$) of cosmetics into the wastewater (after their usage) that are considered for emission calculations in the low, average and high scenario.

Table S14. Release scenarios ($f_{release}$ %) of cosmetics into the wastewater for emission calculations in the low, average and high emission scenarios after cosmetic product use

Product category	Low emission (%)	Average emission (%)	High emission (%)
Decorative Cosmetics	17.8	53.4	100
Skin Care	65.8	75.8	100
Hair Care	81.5	91.5	100
Toiletries	79.6	89.6	100
Perfumes and Fragrances	80	90	100

**Percentage of product type emitted to wastewater, expressed as a percentage of total quantity.*

In emissions where removal statistics (Table S13) for several product subcategories within one product category were available, the presumably largest and most relevant subcategory's data were used for the entire product category. No removal statistics were available for Perfumes and Fragrances; therefore, assumptions were made for the different emissions (average emission 90 % release into wastewater, low emission 80 % and high emission 100 %, Table S14). For the average emission scenario of Decorative Cosmetics, all consumers among the ones using cotton, pads and/or wipes (27 % out of 75 %, Table S13), but still washing their face, were counted as purely "wash-off", i.e. assuming 100 % removal with water (therefore release of 53.4 % in Table S14).

For all low emissions it was assumed that the average emission into wastewater could be lowered by 10 %, i.e. assuming that some of the products are disposed before they are used up and that some fraction of the cosmetic products stays inside the package and is thus disposed into solid waste. For Decorative Cosmetics in the low emission scenario, the consumers using cotton, pads or wipes, but still washing their face, were counted into the statistics as purely cotton, pads and wipe users, i.e. assuming 100 % removal with the aid and no removal by water (27.8 % (Table S13) and removing 10 % as for all other product categories resulted in 17.8 %, Table S14).

For the high emission scenario, the emission to wastewater was assumed to be 100 % for all product categories.

PFAS emissions during the production of cosmetic products are not considered in this report. Furthermore, potential releases of volatile PFAS into the air from the products themselves or the consumers' body surfaces following the product application were not considered. The volatile PFAS were rather considered going into wastewater or solid waste, to avoid introducing a great uncertainty based on several additional unknown parameters for the air emission calculations

391 **Table S15.** Overview of the different parameters and their origin going into the emission calculations, with the example for TF (other
392 analysis, accordingly, only exchanging the measured concentrations for the different product categories, Table S5, S6, S7).

Parameter **Data origin**	**Retail Sales Price (bn Euro)** Cosmetics Europe Market share and and sales price (removing the United Kingdom and Switzerland), i.e. EU 27 and Norway, or EEA, but missing Lichtenstein and Iceland	**Product price (Euro/product)** assumption of product price	**Number of products (bn)** calculated (based on previous two orange parameters)	**Average product size (g)** assumptions partly based on averages (CosmEthics), except for Perfumes and Fragrances (only assumption)	**Total weight products (tonnes)** calculated	**Share of PFAS containing products (%)** from CosmEthics, regrouped into Cosmetics Europe categories	**TF average/product category (mg/g)** equals kg/ton measured TF/EOF/PFAS (average, min, max; for Toiletries same concentrations assumed as for Hair Care)	**TOTAL Emission TF (kg F/year) EEA Calculated output**	**Emission fraction to wastewater (i.e. 1=100%)** assumptions based on consumer removal habits (Kantar TNS/Cosmetics Europé)	**Emission to wastewater TF (kg F/year) EEA Calculated output**	**Emission to solid waste TF (kg F/year) EEA Calculated output (total emissions minus emission to wastewater)**

varying/ constant for different emission scenarios	constant	**varying between low scenario and the two others (those are identical)**	varying, dependent on the product price	constant	varying, depended on the product price and size of product	constant	**varying for each scenario and product category**		**varying for all product categories and in all scenarios**	**varying for all product categories and in all scenarios**

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394 **Table S17:** Values going into the emission calculations for the low emission scenario; example for TF (other analysis, accordingly,
395 only exchanging the measured concentrations for the different product categories, Table S5, S6, S7).

Low emission scenario: Minimal emissions to wastewater (TF minimal value in each product category)											
	Retail Sales Price (bn Euro)	**Product price (Euro/product)**	**Number of products (bn)**	**Average product size (g)**	**Total weight products (tonnes)**	**Share of PFAS containing products (%)**	**TF min/product category (mg/g)** equals kg/ton	**TOTAL Emission TF (kg F/year) EEA**	**Emission fraction to wastewater (i.e. 1=100%)**	**Emission to wastewater TF (kg F/year) EEA**	**Emission to solid waste TF (kg F/year) EEA**
Skin Care	18.22	10	1.822	75	136621	0.78	**0.0075**	**8.02**	0.658	**5.28**	**2.74**
Toiletries	16.67	10	1.667	200	333401	0.27	**0.0012**	**1.04**	0.796	**0.82**	**0.21**
Hair Care	12.57	10	1.257	200	251395	0.65	**0.0012**	**1.88**	0.815	**1.53**	**0.35**
Perfumes and Fragrances	10.35	30	0.345	75	25879	0.027	**0**	**0**	0.800	**0**	**0**
Decorative Cosmetics	9.41	10	0.941	10	9411	3.67	**0.0162**	**5.61**	0.178	**1.00**	**4.61**
Total	67.218							**16.55**		**8.63**	**7.92**

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Table S18: Values going into the emission calculations for the high emission scenario; example for TF (other analysis. accordingly. only exchanging the measured concentrations for the different product categories. Table S5. S6. S7).

High emission scenario: Maximal emissions to wastewater (TF maximal value in each product category)											
	Retail Sales Price (bn Euro)	**Product price (Euro/product)**	**Number of products (bn)**	**Average product size (g)**	**Total weight products (tonnes)**	**Share of PFAS containing products (%)**	**TF max/product category (mg/g)** equals kg/ton	**TOTAL Emission TF (kg F/year) EEA**	**Emission fraction to wastewater (i.e. 1=100%)**	**Emission to wastewater TF (kg F/year) EEA**	**Emission to solid waste TF (kg F/year) EEA**
Skin Care	18.22	5	3.643	75	273241	0.78	**13.785**	**29381**	1	**29381**	**0**
Toiletries	16.67	3	5.557	200	1111338	0.27	**0.499**	**1498**	1	**1498**	**0**
Hair Care	12.57	3	4.190	200	837984	0.65	**0.499**	**2718**	1	**2718**	**0**
Perfumes and Fragrances	10.35	10	1.035	75	77637	0.027	**0**	**0**	1	**0**	**0**
Decorative Cosmetics	9.41	5	1.882	10	18821	3.67	**6.006**	**4149**	1	**4149**	**0**
Total	67.218							**37745**		**37745**	**0**

S4 Limitations and uncertainties of the study

This study was subject to a number of limitations and uncertainties related to inventory development. product sales estimates. analytical characterization. and emission estimates. These factors are summarized in detail here:

S4.1 Inventory development

The total number of PFAS occurring in cosmetic products and/or existing as INCI names identified in this report is likely an underestimate for the following reasons:

- One INCI name can include several different PFAS;
- It is unlikely that all PFAS INCI names in CosIng were captured during the database searches. For example. another PFAS INCI name (polyvinylidene difluoride) was found by chance while checking CosIng for the functions in cosmetics of another INCI name (vinylidene difluoride);
- Some ingredient names on the labels of cosmetic products are not part of the CosIng database. i.e. CosIng does not reflect all ingredient names and is therefore not a complete list;
- The PFAS searches within the cosmetic database (CosmEthics) considered the exact PFAS/INCI name from the list. on which the received database extracts in this study are based on. However. typing errors of the ingredient names can occur both on the package labels. or when transferring the ingredient names into the database. Some examples of altered/missing parts of the INCI name on the packaging labels. that were discovered by a database administrator: - INCI “C9-15 fluoroalcohol phosphate” found in the plural wordform. i.e. “C9-15 fluoroalcohol phosphates” on the label; - INCI “Hydrofluorocarbon 152A” found without the “A”. i.e. “Hydrofluorocarbon 152” on the label.

The aforementioned factors have the potential to contribute to an underestimation of the total number of PFAS in cosmetic products. There is also the risk of missing PFAS which occur unintentionally (i.e. as impurities not listed among the ingredients). but which are nevertheless detected by targeted PFAS analysis. At the same time. the products listed in the cosmetic databases reflect the product information as entered into the system. meaning that there could be even an overestimation of PFAS. The below uncertainties could lead to both an. over- and underestimation of the number of PFAS in cosmetic products:

- Outdated products. which were either removed from the market or for which ingredients had changed might still be part of the databases. although some CosmEthics is actively updating this information. The targeted sampling showed that some products previously listing PFAS as ingredients did not contain PFAS INCIs anymore.
- The latest products might still be missing in the current database extracts due to missing or too few scans.
- It is unlikely that all products available at the EEA market are in the databases

Products in the CosmEthics database were assumed to be representative of the entire EEA market. However. this is only true in cases where the products are sold in all EEA countries and where product scans/registrations are not conducted by app users located outside EEA countries. Producers may have different products in different countries. depending on consumer preferences (e.g. Nordic countries prefer less perfume than other European countries). When it comes to cosmetic legislation. there are very few country-specific laws for chemical ingredients (among the exemptions is Denmark's restriction on parabens). which might influence the ingredient lists.

While the share of products containing PFAS is considered more certain compared to other parameters. there are some sources of error which are worth noting.:

- A slight over- or underestimation of the share of products containing PFAS might arise from missing PFAS or including replaced products. although it is the best estimate possible based on the biggest cosmetic database and the different databases seem to match (at least for the product share over all products);
- Potentially uncertain. when taking the same current product share in future due to changes in production/products placed of the market (new database information should be considered in a few years for emission calculations);
- A possible underestimation of the product share containing PFAS and the emissions due to a share of products that contain PFAS as impurities. but that are not listing PFAS as ingredients;
- A slight deviation of the product share in the different categories may occur due to rearrangement of sub-categories from CosmEthics' into Cosmetics Europe's classification (unlikely to have a big influence at all; also, probably a very minor source of failure. especially as a terminology and classification list provided by Cosmetics Europe was used for this)

S4.2 Product sales estimates

Ideally the amount or volume of cosmetic products sold per year would exist as a recorded tonnage value. As this information is not available. several assumptions were made in order to estimate product sales. which could lead to large differences in emission estimates. The two parameters with the biggest influence on the cosmetic product amount sold per year are likely the price per product and the size of a product. A 10 % change in the two parameters would each result in a corresponding 10 % change in the total emission estimates. The uncertainties that have to be considered in connection with the total amount of cosmetic products sold per year are as follows:

- Assumption on an average price per product category (based on estimates and price screening) might be flawed due to a great price span among and within different product sub-categories. which also might be of different importance for the overall product categories;
- An average price assumption cannot reflect country specific prices. which might vary greatly and might have a huge influence on the average price. or the related tonnages sold per country;
- Assumption on an average size of a product (mL or g) might be flawed due to a great span among and within different product sub-categories.
- Products bought outside the EEA and are directly imported by the customers are not captured by the sales data;

- Retail Sales Price statistics were missing for Lichtenstein and Iceland. thus the EEA emission estimates are just an approximation and are likely a slight underestimation;
- It is assumed that all products sold per year are used during a year;
- Retail Sales Price data do not necessarily reflect the product volume (tonnages). especially over time. i.e. an increase in Retail Sales Price could also show an increase in value of the products.

S4.3 Analytical Characterization

With regards to characterization of PFAS in cosmetic products. the following uncertainties and limitations were identified:

- The low number of samples analysed compared to the vast number of cosmetic products.
- Missing measurements within the product category "Toiletries" (for which the same concentrations as in "Hair Care" were assumed in the different scenarios) might result in a greater uncertainty of emissions from all cosmetic products.
- Products were not measured from all sub-categories within the different product categories and important sub-categories might be missed out.
- The assumption that all products within the sub-category contain an equal concentration of PFAS as the average/min/max of the measured products may be an oversimplification.
- Emissions estimates based on ∑PFAS or ∑PFCA concentrations are likely to be underestimated. because target PFAS analysis only covers a fraction of PFAS which may be present in a product (and in most cases none of the listed PFAS ingredients).
- Emission estimates derived from EOF measurements may be underestimated in products containing polymers and other highly non-polar PFAS. that are not extractable with methanol.
- Inorganic fluorine is expected to occur at low or negligible concentrations relative to organic fluorine (in PFAS-containing products). but it cannot be ruled out that TF emission estimates may be overestimated in cases when large quantities of inorganic fluorine are present.
- A potential underestimation of PFAS as impurities in the share of products not listing PFAS as ingredients. which could increase the share of products containing PFAS (one of the two blank samples not listing any PFAS contained TF); measurement of a wider range of supposedly PFAS-free product could be helpful here.
- A potential underestimation of Perfumes and Fragrances (assumed concentration 0. as so few products contained PFAS(s) as ingredients). if of relevance. likely only for PFAS as impurities.
- Analytical uncertainties. which in comparison to the above mentioned are quantifiable and appear within an acceptable range.

S4.4 Emission from cosmetic products

- Since emissions during production were not included. overall emissions estimates are likely underestimated.
- PFAS release to other compartments (such as air. while the product is applied) or skin-uptake and ingestion by consumers (the latter especially in the case of lip-products) was considered zero.

- Total emissions of PFAS were split between solid waste and wastewater and were based partly on assumptions. so the emissions might be shifted towards either;
- Statistics for consumer habits on cosmetics' removal were not available for all product categories. for which assumptions had to be made;
- Statistics for consumer habits on cosmetics' removal were paired with assumptions to obtain one value per cosmetic product category only and also for the different emission scenarios;
- Data on product disposal before they are completely used up and on the fraction of the cosmetic product which remains inside the package when used up could improve the emission estimates to wastewater and solid waste; i.e. likely lower the emissions to wastewater and increase the emissions to solid waste (only in the low emission scenario. there was the attempt to account for these additional disposal fractions: by lowering the wastewater fraction by 10 % compared to the average-case scenario and considering this to go into solid waste instead);
- Emissions to wastewater and solid waste might be flawed. as the consumer habits on cosmetics' removal date a few years back. There is an upcoming trend towards multiple-use and washable pads/whips for make-up removal instead of single-use cotton/pads/whips. The multiple-use products are promoted as more environmentally friendly compared to single-use products in terms of saving water/resources during cotton production. However. this ensures that the products are released into the wastewater when washing the reusable pads. In future. consumer habit studies on cosmetic removal should include the use of multiple-use/washable removal products as an additional answer option in questionnaires.

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