PFAS IN CLOTHING

STUDY IN INDONESIA, CHINA, AND RUSSIA SHOWS BARRIERS FOR NON-TOXIC CIRCULAR ECONOMY

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PFAS IN CLOTHING: STUDY IN INDONESIA, CHINA, AND RUSSIA SHOWS BARRIERS FOR NON-TOXIC CIRCULAR ECONOMY

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for a toxics-free future

IPEN is a network of non-governmental organizations working in more than 120 countries to reduce and eliminate the harm to human health and the environment from toxic chemicals.

www.ipen.org

Arnika is a Czech non-governmental organisation established in 2001. Its mission is to protect nature and a healthy environment for future generations both at home and abroad.

www.arnika.org

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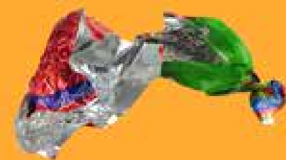
ABBREVIATIONS

PFAS	per- and polyfluoroalkyl substances
PFCA	perfluorinated carboxylic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonate
FTOHs	fluorotelomer alcohols
FTCA	fluorotelomer carboxylic acids
FTACs/FMACs	fluorotelomer acrylates and methacrylates
FTSA	fluorotelomer sulfonamides
FTMAP	fluorotelomer mercaptoalkyl phosphate esters

PRODUCTS THAT MAY CONTAIN PFAS

COSMETICS

BAKING PAPER



CANDY WRAPPERS

POPCORN BAGS

CLOTHING

NONSTICK PANS

DENTAL FLOSS

STAIN-RESISTANT

WATERPROOFING

PAINT & SEALANTS

FOOD CONTAINERS

CLEANING PRODUCTS

THE PFAS PROBLEM

PFAS (per- and polyfluoroalkyl substances) are a large group of more than 4700 synthetic organic substances[1] used ubiquitously in consumer and professional products. They are used to make products water-, grease- and stain-resistant, and are commonly found in waterproof rain gear and food packaging, as well as in non-stick cookware and firefighting foams. However, most of the PFAS uses are not essential for the functioning of society and have safer alternatives that could be used instead [2]. All PFAS contain very strong chemical bonds between the carbon (C) and fluorine (F) atoms. These bonds provide the high stability of the PFAS molecules and earn them the metaphoric name of 'Forever Chemicals'.

Their stability makes PFAS very persistent to decomposition and leads to their accumulation in the environment [3, 4]. PFAS or 'Forever Chemicals' have been detected in air [5], soil [4], water [4, 6], including drinking water sources [6, 7], and household dust [8, 9]. Studies have shown that PFAS are emitted to the environment at every stage of their life cycle, including production [10-12], while used in products [13], and after final disposal [14-16]. When released, they are able to disperse over long distances and can be found far from the places of their origin, including in the Arctic [17-19].

Humans are also continuously exposed to PFAS. Drinking water and diet have been established as the main exposure routes to PFAS; however, exposures from dust, indoor environments, and personal care and consumer products are also important [20]. To date, human biomonitoring studies have detected PFAS in human breast milk, urine, and blood samples, including serum, plasma, and whole blood [21-26]. Scientific studies of PFAS concentrations in human blood show that marginalized communities living in contaminated and industrialized areas are especially exposed to PFAS [25]. Moreover, a recent study detected PFAS in breast milk of all 50 investigated mothers from the United States [27].

PFAS have been shown to be associated with a range of negative health impacts, including negative impacts on fertility, fetal development [28] and thyroid hormone function [29, 30]. The accurate functioning of thyroid hormones is important in several stages of life; it is, for example, a vital factor for development of the fetal and neonatal brain during pregnancy and a critical factor for menopausal symptoms during post-menopausal age. The negative impacts of PFAS on the immune system and the ability to make vaccines less effective [31-33] have been especially highlighted in the context of the COVID-19 pandemic. Also, elevated blood levels of PFAS were found to be associated with an increased risk of a more severe course of COVID-19 infection [34].

Given that 1) PFAS are continuously emitted to the environment where they persist to a level that has earned them the epitome of 'Forever Chemicals', 2) biomonitoring studies regularly detect PFAS in humans, and 3) PFAS have been associated with a wide range of negative environmental and health effects, their wide usage creates a challenge in relation to the circular economy. When PFAS-treated products are recycled, PFAS can spread uncontrollably and contaminate new products, extending the toxic legacy of these chemicals and undermining the ability to transition to a clean circular economy.

PFAS USE IN OUTDOOR TEXTILES

PFAS use in the textile sector accounts for about 50% of the total global use [16]. Textile manufacturers utilize the oil- and water-resistant properties of PFAS to produce stain- and rain-proof materials [35, 36]. Thus, PFAS are widely used as water and dirt repellents and impregnations [13, 37, 38] in outdoor wear and in accessories for outdoor sports (e.g., waterproof shoes, jackets, backpacks, tents) [13, 39, 40]. PFAS are also used to treat leather [13] and household textiles such as carpets and tablecloths [13]. Most of the PFAS uses in textile products are not essential and alternatives exist [35, 41]. Paraffin and silicone-based chemicals can serve as substitutes that provide water repellence [16]. Non-chemical alternatives for textiles include tightly woven fabrics and plant-based materials [42].

> WHEN PFAS-TREATED PRODUCTS ARE RECYCLED, PFAS CAN SPREAD UNCONTROLLABLY AND CONTAMINATE NEW PRODUCTS… UNDERMINING THE ABILITY TO TRANSITION TO A CLEAN CIRCULAR ECONOMY.

Yet, a wide range of PFAS are frequently used in textiles, as shown by studies that identified several PFAS in textile products, such as fluorotelomer alcohols (FTOHs), fluorotelomer (met)acrylates (FTACs/FMACs), perfluoroalkyl carboxylic acids (PFCAs) and fluorotelomer carboxylic acids (FTCAs), perfluoroalkane sulfonic acids (PFSAs) and fluorotelomer sulfonic acids (FTSAs), and PFAS derivates (e.g., sulfonamide, sulfonamidoethanol) [13, 16].

The usage of PFAS in textiles and outdoor wear increases both environmental pollution and human exposure, as PFAS are emitted to the envi-

ronment at every stage of the textile product (i.e., during production, use and final disposal). During the production phase, textile factories pollute the surrounding environment through air and wastewater emissions [11] and expose workers to PFAS [43]. PFAS are volatilized, weathered, and washed out from the textile products during their use [39]. Up to 30 times higher FTOH concentrations were determined in the interior of sportswear stores compared to outdoor stores [44]. Unfortunately, conventional wastewater treatment plants do not typically have technologies for PFAS capture and destruction, thus PFAS coming with the laundry water are being emitted into the waterways [45-47]. Short-chain PFAS are even more widely detected, more persistent and mobile in water than long-chain PFAS, and thus may pose more risks for the environment and human health [48]. When PFAS-treated articles are disposed of at the end of life, PFAS migrate from the waste into the landfill leachates [14, 49], are emitted with incineration fumes and ashes [49, 50], or are recycled into new products [51, 52].

REGULATORY FRAMEWORK

Two members of the PFAS group have been widely used: perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA), both consisting of a chain of eight perfluorinated carbon atoms (C8) and two carbon atoms without fluorine. The Stockholm Convention added PFOS to its global restriction list in 2009 and PFOA to its list for global elimination in 2019. The PFOS listing entered into force in Indonesia and China in 2010 and 2014, respectively. PFOS in China is allowed to be used for 7 acceptable purposes until now. The PFOA listing entered into force for most countries, including Indonesia, on 3 December 2020. It has not yet been implemented in China. Neither of the two listings have been approved in Russia.

The Stockholm Convention allowed a five-year exemption for PFOA use in textiles, but only for, "the protection of workers from dangerous liquids that comprise risks to their health and safety." In the EU, the global restrictions on PFOS and PFOA were implemented along with a provision limiting the use of PFOA and PFOS to 1 microgram per square meter ($\mu g/m^2$) on textiles and other coated products [53].

As PFOS and PFOA substances have come under regulatory pressure, the industry has shifted to less-regulated PFAS with similar properties. In 2019, the Stockholm Convention expert committee recommended addition of a PFOS substitute (perfluorohexane sulfonic acid or PFHxS) to the treaty for global elimination without exemptions. A decision is expected at the Conference of the Parties to the Stockholm Convention in 2022.

Because of the gradual regulation of long-chain PFAS, these have increasingly been replaced with short-chain PFAS substitutes. Despite their lower bioaccumulation potential, short-chain PFAS are of increasing concern as they are ubiquitous in the environment, including remote areas [54]. Studies on side-chain fluorotelomer-based polymers have shown that these are inappropriate substitutes in paper and textile consumer products because they can release PFAS into the environment [55].

Outside the provisions of the Stockholm Convention, Indonesia and Russia have not adopted any additional regulatory control over PFAS. In China, PFOS, its salts and PFOSF (perfluorooctanesulfonyl fluoride) were listed on the List of Priority Control Chemicals in 2017 and is on the List of Strictly Restricted Toxic and Hazardous Chemicals. PFOA and its salts were listed on the List of Priority Control Chemicals in 2020.

OBJECTIVE AND SCOPE

This study was conducted to assess PFAS utilization in synthetic outdoor clothing and sportswear products in China, Indonesia and Russia, by analysing the presence of 55 targeted PFAS in waterproof and stain-resistant clothes. It was conducted by IPEN together with partner organizations Arnika (Czech Republic), Toxics-Free Corps (China), Nexus 3 (Indonesia), and EcoAccord (Russia).

This study aims to contribute to the discussion on the integrity of a non-toxic circular economy and overall recyclability of the consumer products containing hazardous 'Forever Chemicals'.

METHODOLOGY

SAMPLE COLLECTION

IPEN's partner organizations Nexus 3 (Indonesia), EcoAccord (Russia) and Toxics-Free Corps (China) purchased synthetic winter gloves or other outdoor wear (for adults and children) that are expected to be water or stain resistant. In total, 41 items of synthetic textile products were collected during October-November 2020 in China (18 pairs of winter gloves), Russia (15 pairs of winter gloves), and Indonesia (2 pairs of sport gloves and 6 additional samples of outdoor wear). All items were bought in popular clothing stores or e-shops.

For budgetary reasons, 25 out of the 41 collected items were selected for laboratory analysis. The selection covered different countries and different types of products. A summary of lab-analysed items is given in Table 1.

Some of the samples tested included gloves from Russia and China and a head covering (hijab) from Indonesia.

TABLE 1: SUMMARY OF LAB-ANALYSED SAMPLES

	China	Russia	Indonesia
Sport/winter gloves	10	10 (incl. 7 children's gloves)	2
Sport T-shirt	-	-	1
Hijab	-	-	1
Sport trousers	-	-	1

DETECTION AND QUANTIFICATION OF SELECTED PFAS

The 25 items were sent for analysis to the Department of Food Analysis and Nutrition of the University of Chemistry and Technology in Prague, Czech Republic. 100 cm^2 of fabric was cut off from each item and analysed. 55 PFAS substances were selected for target analysis based on the availability of standards (the full list of analysed PFAS with respective limits of quantification is provided in Annex 1).

The analysis involved extraction with a methanol: ethyl-acetate mixture and was carried out using ultra-high-performance liquid chromatography interfaced with tandem mass spectrometry with electrospray ionization in negative mode (UHPLC-ESI-MS/MS) for all PFAS except FTOHs.

The selected FTOHs were analysed using gas chromatography coupled to tandem mass spectrometry operated in positive ion chemical ionization (GC-PICI-MS/MS).

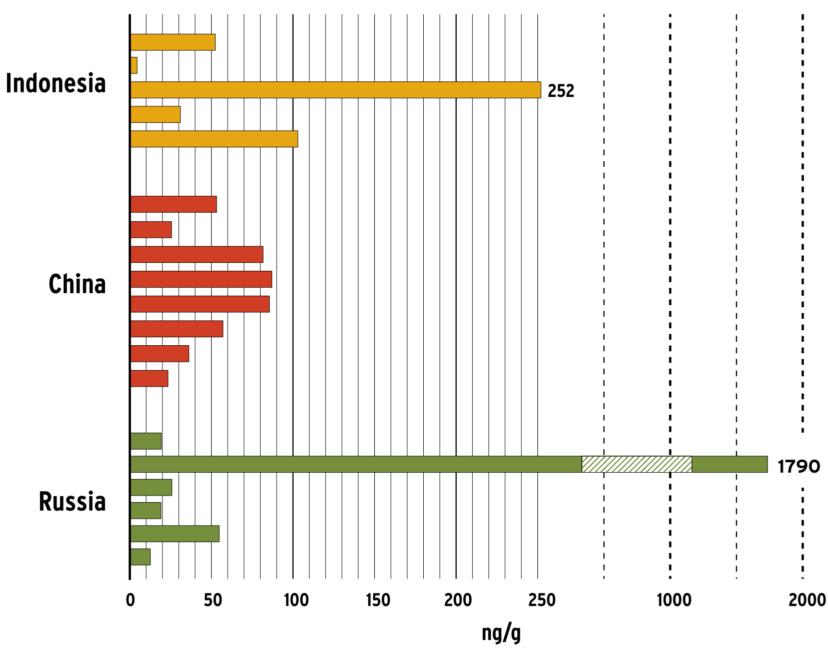
RESULTS

At least one of the 55 targeted PFAS was detected in 84% (21/25 samples) of the analysed outdoor clothing and sportswear products. PFAS presence was confirmed in all samples of winter gloves from China, in all samples of sport gloves and outdoor wear (hijab, trouser, t-shirt) from Indonesia, in all samples of adult winter gloves from Russia and in 57% (4/7) of the children's winter gloves from Russia.

Of the 55 targeted PFAS chemicals, 3 substances (8:2 FTOH, 12:2 FTOH and 6:2 diPAP) were found to exceed their limit of quantification (LOQ) (1.6 ng/g for 8:2 FTOH and 26 ng/g for 12:2 FTOH and 6:2 diPAP) in the analysed samples. One more PFAS (6:2/8:2 diPAP) was detected (not quantified) in the samples. For the complete analytic results (ng/g), see Table 2 below.

The most abundant PFAS was 8:2 FTOH, found in 84% of all synthetic textile samples. It was present in all analysed samples except in four pairs

Graph 1: Concentrations of 8:2 FTOH in synthetic wear



of winter gloves for children from Russia. 8:2 FTOH concentrations ranged 4.46-1791 ng/g (with median value of 52.4 ng/g). The highest concentration of 8:2 FTOH (1 791 ng/g) was quantified in winter gloves from Russia (RUS-PFAS-03) (see Graph 1 for more details).

In 4 glove samples, 8:2 FTOH was accompanied by 12:2 FTOH. In addition to 8:2 FTOH, 6:2 diPAP and 6:2/8:2 diPAP were both present in elevated amounts (30 178 and 679 ng/g respectively) in the hijab bought in Indonesia (IND-PFAS-05).

TABLE 2: PFAS QUANTIFIED AND DETECTED IN THE ANALYSED OUTDOOR CLOTHING AND SPORTSWEAR PRODUCTS

Sample origin	Sample ID	Sample type	Material	8:2 FTOH (ng/g)	12:2 FTOH (screening)	6:2 diPAP (ng/g)	6:2/ 8:2 diPAP (ng/g)
Russia	RUS-PFAS-01	Teen/adult winter glove	Polyester	19.3	Not detected	<LOQ	<LOQ
Russia	RUS-PFAS-03	Teen/adult winter glove	Polyester	1 790	Not detected	<LOQ	<LOQ
Russia	RUS-PFAS-04	Child's winter glove	Polyester	25.8	Not detected	<LOQ	<LOQ
Russia	RUS-PFAS-05	Child's winter glove	Polyester	<LOQ	Not detected	<LOQ	<LOQ
Russia	RUS-PFAS-07	Child's winter glove	Polyester	<LOQ	Not detected	<LOQ	<LOQ
Russia	RUS-PFAS-08	Child's winter glove	Polyester	<LOQ	Not detected	<LOQ	<LOQ
Russia	RUS-PFAS-10	Child's winter glove	Polyester	19.1	Detected	<LOQ	<LOQ
Russia	RUS-PFAS-11	Teen/adult winter glove	Polyester	54.8	Not detected	<LOQ	<LOQ
Russia	RUS-PFAS-12	Child's winter glove	Polyester	<LOQ	Not detected	<LOQ	<LOQ
Russia	RUS-PFAS-15	Child's winter glove	Polyactam	12.6	Not detected	<LOQ	<LOQ
Indonesia	IND-PFAS-01	Adult T-shirt	Premium cotton	52.4	Not detected	<LOQ	<LOQ
Indonesia	IND-PFAS-04	Hiking glove	Polyester	4.47	Not detected	<LOQ	<LOQ
Indonesia	IND-PFAS-05	Hijab	Polyester	252	Not detected	**30 178**	**679**

Sample origin	Sample ID	Sample type	Material	8:2 FTOH (ng/g)	12:2 FTOH (screening)	6:2 diPAP (ng/g)	6:2/ 8:2 diPAP (ng/g)
Indonesia	IND-PFAS-06	Sport trousers	Taslan wa-terproof	31.0	Not detected	<LOQ	<LOQ
Indonesia	IND-PFAS-07	Adult glove	Fleece+ Polyester	103	Detected	<LOQ	<LOQ
China	CHN-PFAS-02	Adult winter glove	Cotton	53.2	Not detected	<LOQ	<LOQ
China	CHN-PFAS-03	Adult winter glove	Polyester	25.6	Not detected	<LOQ	<LOQ
China	CHN-PFAS-04	Adult winter glove	The surface is Taslan and the palm is non-slip cloth	81.7	Not detected	<LOQ	<LOQ
China	CHN-PFAS-07	Adult winter glove	Cotton	87.1	Not detected	<LOQ	<LOQ
China	CHN-PFAS-08	Adult winter glove	The surface is Taslan and the palm is PU	85.6	Not detected	<LOQ	<LOQ
China	CHN-PFAS-09	Adult winter glove	Taslan[1]	57.1	Not detected	<LOQ	<LOQ
China	CHN-PFAS-11	Adult winter glove	Waterproof breathable fabric[2]	36.2	Not detected	<LOQ	<LOQ
China	CHN-PFAS-12	Adult winter glove	Cotton	23.4	Not detected	<LOQ	<LOQ
China	CHN-PFAS-14	Adult winter glove	Taslan	129	Detected	<LOQ	<LOQ
China	CHN-PFAS-18	Adult winter glove	Taslan	31.0	Detected	<LOQ	<LOQ

1 TASLAN is a fabric made of polyamide filament and polyamide air textured filament
2 The webpage information is only marked as waterproof fabric, there is no specific material description

DISCUSSION

FLUOROTELOMER ALCOHOLS (FTOHS) AND POLYFLUOROALKYL PHOSPFATE DIESTERES (DIPAPS) IN SYNTHETIC OUTDOOR- AND SPORTSWEAR – SOURCES OF CONSUMER CONCERNS

8:2 FTOH was quantified in 21 out of 25 samples (84 %) of the analysed outdoor- and sportswear. Fluorotelomer alcohols are starting chemicals and intermediate degradation by-products in production of the majority of commercial PFAS, including fluorotelomer-based polymers. Their presence is an indication of treatment with PFAS compounds even if the identity of the PFAS is not known.

FTOHs have been shown to be released from products similar to those investigated here [56] and there are multiple toxicological concerns regarding FTOHs themselves and their degradation products. Both are associated with hepatotoxicity, mammary gland cancer, negative impacts on the reproductive system, and developmental disorders [57]. The results in this study are therefore particularly concerning regarding the children's winter gloves from Russia, since children can be exposed to FTOHs in the gloves to a greater extent than adults, due to more hand-to-mouth contact [58].

Specifically, during wearing and aging of water repellent clothes, 8:2 FTOH degrades to perfluorocarboxylic acids (PFCAs; including the globally banned perfluorooctanoate (PFOA)) [39]. In the long run, FTOHs present in waste may also degrade into PFCAs and pollute the environment [55, 59].

In addition to 8:2 FTOH, 6:2 diPAP and 6:2/8:2 diPAP were presented in a hijab bought in Indonesia (30 178 and 679 ng/g respectively). As Euro-American studies have not reported the presence of diPAPs in textile and clothing for many years, the use of diPAPs seems to be geographically limited. 6:2 diPAP degrades to PFHxA and PFHpA, and 8:2 diPAP to globally restricted PFOA and PFNA [60]. As diPAPs are among the less-studied PFAS, their toxicological concerns are so far mainly related to the toxic properties of their degradation products (see the information above on the toxicological concerns regarding FTOH degradation products).

The limited number of identifiable PFAS in the textile samples is consistent with previous studies [16, 40, 61]. This highlights both the current limitations of the employed analytical methods, which are not able to identify PFAS such as fluorinated polymers, and the lack of commercially available

Although most tested items in this study were designed for repelling snow, high level of PFAS, especially diPAPs, were found in a hijab from Indonesia, where outerwear may be designed for stain resistance. Photo: istimewa

standards to allow identification and quantification of all relevant PFAS used for treating textiles [62-65]. In this regard, the four identified PFAS are only the tip of the iceberg. Despite not being identified individually, the other potentially present PFAS cause concern due to their ability to persist and accumulate in the environment. It is not only challenging to identify them, but also to control and remove them once they are in the environment.

NATURE OF THE PFAS TREATMENT – POTENTIAL CONTRADICTION TO THE STOCKHOLM CONVENTION INTENTION

Our findings of fluorotelomer alcohol 8:2 FTOH suggest that the water repellence of the tested outdoor textiles from China, Indonesia and Russia was achieved by the application of side-chain fluorotelomer-based polymers (FTPs), consisting of a non-fluorinated backbone with C8 polyfluoroalkyl side chains [66]. FTPs are responsible for the 8:2 FTOH presence in the analysed samples. 8:2 FTOH can further degrade into PFOA. The use of FTPs therefore undermines the intention of the Stockholm Convention to globally stop emissions of PFOA, its salts and PFOA-related compounds via measures to eliminate the production and use of the chemicals under the scope, as it results in environmental exposure to PFOA.

PFAS consisting of a chain of eight perfluorinated carbon atoms (C8) have been indicated in textiles in former studies by Swerea IVF in 2009 [67] and Greenpeace in 2013 [40], but this practice seems to have been replaced in recent years by the application of polymers with short-chain polyfluoroalkylated side chains in Europe and the U.S. [16, 68] The results in this study, however, indicate that the shift to shorter-chain substitutes seems to be slower in China, Indonesia and Russia than in countries where PFAS are under public scrutiny. Those countries have the chance to skip the phase of long-chain PFAS substitution with short-chain alternatives as short-chain PFAS are also associated with a wide range of environmental and health issues. Short-chain PFAS should be phased out together with all other PFAS globally.

PFAS IN SYNTHETIC OUTDOOR CLOTHING AND SPORTSWEAR: A BARRIER TO A NON-TOXIC CIRCULAR ECONOMY

As only a fraction of the post-consumer synthetic outdoor clothing and sportswear is recycled, the type of garments investigated here would mostly end up in landfills or be incinerated [69]. Disposal of PFAS-treated clothing and apparel in municipal incinerators likely leads to emissions of PFAS, fluorinated greenhouse gases and other products of incomplete combustion to the surrounding environment [70]. Additionally, some PFAS remain in the after-incineration fly ash [49, 50].

However, there is an increasing demand for recycled textiles overall due to the increased pressure to move towards a more circular economy. When polyester materials are mechanically recycled, the end-of-life products will likely be down-cycled (i.e. converted into products of lower value such as filler materials for furniture and insulation) [71] and contribute to the contamination of the recycling chain with PFAS [72]. As a consequence, their presence in consumer products would be difficult to trace, thus legacy PFAS may find their way into products despite their restricted use.

Theoretically, polyester might be chemically recycled (depolymerized), but it is important to note that in addition to other problems with chemical recycling [73], no depolymerization facility currently operates on a large-scale commercial basis [73]. The presence of PFAS [74] in the post-consumer textile waste stocks constitutes a barrier to the recyclability of such products, especially because it is difficult to remove PFAS from the fibres once it has been added [71]. Therefore, recycling PFAS treated textiles would lead to uncontrolled exposure to these *forever chemicals*, without any possibility of tracing their presence in other consumer products made of recycled materials.

CONCLUSIONS AND RECOMMENDATIONS

This study indicates that water repellence of the analysed synthetic outdoor clothing and sportswear from China, Indonesia, and Russia was achieved by the application of side-chain fluorotelomer-based polymers. The most-frequently identified fluorotelomer alcohol 8:2 FTOH can degrade to the highly persistent pefluorocarboxylic acid PFOA that is listed for global elimination under the Stockholm Convention. To avoid PFOA formation, release and build-up in the environment during the lifecycle of PFAS treated products, application of 8:2 FTOH and other PFOA-related substances needs to be immediately abandoned in the targeted countries.

Even if only 4 PFAS were identified in this specific study, it is important to note that because many more PFAS than the 55 selected for target analysis are used in textiles, their presence cannot be excluded. As the use of PFAS in outdoor wear is not essential and suitable non-PFAS alternatives are available, a class-based approach to phase out all non-essential uses of PFAS is the only adequate response to prevent further irreversible harm to human health and the environment.

Based on the findings and conclusions of this survey, we call on:

National Governments:

- To enter PFOS and PFOA listing of the Stockholm Convention into force nationally.
- To implement bans on PFOS and PFOA in national regulations.
- To support the development of a broad and protective restriction on PFAS and thereafter to fully implement it.

Parties to the Stockholm Convention:

- To ratify the amendments listing PFOS and PFOA and to support the removal of all exemptions and acceptable purposes.
- To implement bans on PFOS and PFOA in national regulations.

- To support the listing of PFHxS for global elimination without exemptions.
- To work for a class-based approach of listing all PFAS for global elimination under the Stockholm Convention.

Parties to the Basel Convention:

- To define all PFAS-contaminated waste as hazardous waste based on their H11 (delayed or chronic toxicity) characteristics.
- To ratify the Basel Ban amendment, ensuring no export and import of PFAS-contaminated waste to non-OECD countries.
- To acknowledge that polymeric fluorotelomer-based products (i.e., side-chain fluorinated polymers), as well as PFAS-contaminated products, are non-recyclable, and hence non-circular, in the technical guidelines on the identification and environmentally sound management (ESM) of plastic wastes and for their disposal.
- To work for a class-based approach when determining maximum limits for PFAS content in waste (the so-called "low POPs content" levels).

SAICM stakeholders:

- To significantly increase efforts towards transitioning to safe, non-PFAS alternatives, including establishing ambitious deadlines for phasing out PFAS as a class for all uses not essential for the functioning of society. To significantly increase availability of information to support this effort, including analytical methods, hazard data for PFAS and information about non-PFAS alternatives.
- To work towards full transparency of PFAS content in products and support consumers' right to know and choose PFAS-free products. Sufficient information on PFAS in products, waste streams and recycled materials will improve monitoring of compliance of recycled materials and articles produced within existing legislation.

ANNEX

Category	PFAS	Full name	CAS number	Units	LOQ
Perfluorinated carboxylic acid (PFCA)	PFBA	Perfluorobutanoic acid	375-22-4	ng/g	1.70
	PFPeA	Perfluoropentanoic acid	2706-90-3	ng/g	1.70
	PFHxA	Perfluorohexanoic acid	307-24-4	ng/g	1.70
	PFHpA	Perfluoroheptanoic acid	375-85-9	ng/g	1.70
	PFOA	Perfluorooctanoic acid	335-67-1	ng/g	1.70
	PFNA	Perfluorononanoic acid	375-95-1	ng/g	1.70
	PFDA	Perfluorodecanoic acid	335-76-2	ng/g	1.70
	PFUnDA	Perfluoroundecanoic acid	2058-94-8	ng/g	1.70
	PFDoDA	Perfluorododecanoic acid	307-55-1	ng/g	1.70
	PFTrDA	Perfluorotridecanoic acid	72629-94-8	ng/g	1.70
	PFTeDA	Perfluorotetradecanoic acid	376-06-7	ng/g	1.70
	PFHxDA	Perfluorohexadecanoic acid	67905-19-5	ng/g	1.70
	PFODA	Perfluorooctadecanoic acid	16517-11-6	ng/g	1.70
Perfluoroalkyl sulfonic acid (PFSA)	PFPrS	Perfluoropropane sulfonic acid	423-41-6	ng/g	1.70
	PFBS	Perfluorobutane sulfonic acid	375-73-5	ng/g	1.70
	PFPeS	Perfluoropentanesulfonic acid	2706-91-4	ng/g	1.70
	PFHxS	Perfluorohexane sulfonic acid	355-46-4	ng/g	1.70
	PFHpS	Perfluoroheptanesulfonic acid	375-92-8	ng/g	1.70
	br-PFOS	Branched isomer of perfluorooctanesulfonic acid	1763-23-1	ng/g	0.30
	L-PFOS	Linear-chain isomer of perfluorooctane sulfonic acid	1763-23-1	ng/g	1.30
	PFNS	Perfluorononanesulfonic acid	68259-12-1	ng/g	1.70
	PFDS	Perfluorodecane sulfonic acid	335-77-3	ng/g	1.70
	PFDoS	Perfluorododecane sulfonic acid	120226-60-0	ng/g	1.70
	PFOSA	Perfluorooctanesulfonamide	754-91-6	ng/g	1.70

Category	PFAS	Full name	CAS number	Units	LOQ
Perfluoroalkane sulfonamide and derivates (FASA)	N-MeFO-SA	N-Methylperfluorooctanesul-fonamide	31506-32-8	ng/g	1.70
	N-EtFOSA	N-Ethyl-perfluorooctane sul-fonamide	4151-50-2	ng/g	1.70
Perfluoroether carboxylic acid (PFECA)	ADONA	Ammonium 4,8-dioxa-3H-per-fluorononanoate	958445-44-8	ng/g	1.70
Perfluoroalkyl ether carboxylic acids	HFPO-DA	Hexafluoropropylene oxide-dimer acid	13252-13-6	ng/g	1.70
Chlorinated poly-fluorinated ether sulfonate	9Cl-PF3ONS	9-Chlorohexadecafluoro-3-oxa-nonane-1-sulfonate	73606-19-6	ng/g	1.70
	11Cl-PF3OUDS	11-Chloroeicosafluoro-3-oxaun-decane-1-sulfonate	83329-89-9	ng/g	1.70
(n:2) Fluorotel-omer alcohols (FTOH)	4:2 FTOH	4:2 Fluorotelomer alcohol	2043-47-2	ng/g	0.80
	6:2 FTOH	6:2 Fluorotelomer alcohol	647-42-7	ng/g	1.60
	8:2 FTOH	8:2 Fluorotelomer alcohol	678-39-7	ng/g	1.60
	10:2 FTOH	10:2 Fluorotelomer alcohol	865-86-1	ng/g	16.0
	12:2 FTOH	12:2 Fluorotelomer alcohol	39239-77-5	screening	detected/ND
	14:2 FTOH	14:2 Fluorotelomer alcohol	60699-51-6	screening	detected/ND
	16:2 FTOH	16:2 Fluorotelomer alcohol	65104-67-8	screening	detected/ND
	18:2 FTOH	18:2 Fluorotelomer alcohol	65104-65-6	screening	detected/ND
	20:2 FTOH	20:2 Fluorotelomer alcohol		screening	detected/ND
(n:2) Fluorotel-omer sulfonic acids (FTSAs)	4:2 FTS	4:2 Fluorotelomer sulfonic acid	757124-72-4	ng/g	5.20
	6:2 FTS	6:2 Fluorotelomer sulfonic acid	27619-97-2	ng/g	26.0
	8:2 FTS	8:2 Fluorotelomer sulfonic acid	39108-34-4	ng/g	26.0
	10:2 FTS	10:2 Fluorotelomer sulfonic acid	120226-60-0	ng/g	26.0
	12:2 FTS	12:2 Fluorotelomer sulfonic acid	120226-60-0	screening	detected/ND
	14:2 FTS	14:2 Fluorotelomer sulfonic acid	149246-64-0	screening	detected/ND
	16:2 FTS	16:2 Fluorotelomer sulfonic acid	1377603-17-2	screening	detected/ND

Category	PFAS	Full name	CAS number	Units	LOQ
(n:2) Fluorotelomer phosphate monoester (PAP)	6:2 PAP	6:2 Polyfluoroalkyl phosphoric acid monoester	57678-01-0	ng/g	260
	8:2 PAP	8:2 Polyfluoroalkyl phosphoric acid monoester	57678-03-2	ng/g	260
(n:2) Fluorotelomer phosphate diester (diPAP)	6:2 diPAP	6:2 Fluorotelomer phosphate diester	57677-95-9	ng/g	26.0
	6:2 8:2 diPAP	6:2 8:2 Fluorotelomer phosphate diester	943913-15-3	ng/g	26.0
	8:2 diPAP	8:2 Fluorotelomer phosphate diester	678-41-1	ng/g	26.0
Perfluoro phosphonic acid (PFPA)	PFBPA	2,3,4,5,6-Pentafluorobenzylphosphonic acid	52299-24-8	ng/g	260
	PFHxPA	Perfluorohexyl phosphonic acid	40143-76-8	ng/g	26.0
	PFOPA	Perfluorooctyl phosphonic acid	40143-78-0	ng/g	26.0
	PFDPA	Perfluorodecyl phosphonic acid	52299-26-0	ng/g	26.0

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