ENGAGING THE TEXTILE INDUSTRY AS A KEY SECTOR IN SAICM

A REVIEW OF PFAS AS A CHEMICAL CLASS IN THE TEXTILE SECTOR

2021

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Executive Summary

Many of the chemicals used in textile production are known to have adverse health and environmental impacts. Hazardous chemicals found in effluents from textile processing facilities include some known to cause cancer and disrupt hormonal systems in humans and animals. Toxic chemicals, such as alkylphenols and per- and polyfluoroalkyl substances (PFAS) are particularly problematic, as they cannot be removed by wastewater treatment plants. Flame retardants, including brominated and chlorinated organic compounds, are another particularly hazardous class of chemicals used in the production of some textiles. Many dyes contain heavy metals—such as lead, cadmium, mercury, and chromium (VI)—known to be highly toxic due to their irreversible bioaccumulative effects, while azo dyes contain carcinogenic amines.[1]

Unsound practices and poor wastewater management impact not only the health of textile workers but also communities living near facilities, consumers of textile products, waste collectors and secondary processers, and the environment. The cost to the textile industry of poor chemical management, as indicated by the value opportunity of eliminating occupational illnesses by 2030, is estimated at €7 billion per year.[2]

A number of industry initiatives have made some headway in addressing the sound management of chemicals in the textiles sector, including by developing transparency standards, guidelines, and restricted substances lists. Nevertheless, more needs to be done and there is an opportunity to scale up actions and mainstream sound management of chemicals across all value chain actors in the textiles sector.

Adopted by the First International Conference on Chemicals Management in 2006 in Dubai, the Strategic Approach to International Chemicals Management (SAICM) is a policy framework to promote chemical safety around the world and provide a high-level international forum for multi-stakeholder and multi-sectoral discussion on chemicals management issues. SAICM's overall objective is to achieve the sound management of chemicals throughout their life cycle so that chemicals are produced and used in ways that minimize significant harms to the environment and human health.

To date, SAICM's efforts around the textiles sector have extended across the textiles' life cycle, including the production of ingredients, chemical-critical stages of textile manufacturing, retail, consumption, and waste management. SAICM—with its multi-sectoral focus and platform for engagement with industry players—is well positioned to foster cooperation among actors across the textiles value chain, promoting a circular economy approach. This report looks closely at the example of managing PFAS as a chemical class in the textiles industry in order to inform stakeholder dialogue, support decision-making for the Strategic Approach and sound management of chemicals and waste beyond 2020, and encourage other relevant chemicals management discussions (such as chemical-related Multilateral Environmental Agreements or MEAs).

For over a decade, under both SAICM and the Stockholm Convention on Persistent Organic Pollutants (POPs), the class of chemicals known as PFAS has gained increasing international attention.[3] Since 2009, chemicals in products have been identified as an Emerging Policy Issue and PFAS as an Issue of Concern by SAICM. The textiles sector is currently considered by SAICM through the "Chemicals in Products Programme", which focuses on four priority sectors: textiles, toys, building products, and electronics. The activities focus on increasing the availability and access to information on chemical use throughout the product's life cycle.

Furthermore, identifying PFAS as an issue of concern under SAICM has enhanced efforts to gather and exchange information on PFAS chemicals and supported the transition to safer alternatives. This work has been coordinated by the Global Perfluorinated Chemicals Group, which is supported by the Organisation for Economic Cooperation and Development (OECD) and United Nations Environment Programme (UNEP).

In addition, initial steps to control the production and trade of a subset of PFAS have been taken under the Stockholm Convention, targeting long-chain PFAS such as PFOA and PFOS. PFOS, its salts, and PFOSF were listed in Annex B to the Convention in 2009, and PFOA, its salts, and PFOA-related compounds were listed in Annex A to the Convention in 2019. One set of alternatives to those substances—PFHxS, its salts, and PFHxS-related compounds—is recommended for listing in Annex A to the Convention for consideration by the Conference of the Parties in 2021. Still, challenges remain on the implementation of this part of the Convention, including various applications allowed as exemptions, identification of articles containing those substances or processes using those substances, introduction of alternatives, identification of environmentally sound disposal, and delays in enforcing the restrictions at the national level.

More importantly, the chemical-by-chemical approach typically associated with regulatory frameworks appears ill-equipped to address the thousands of chemicals in this class. There may be a need for a more comprehensive approach, given the number of PFAS, their myriad uses, and the known and potential harms associated with this class of chemicals.[4] Accordingly, the concept of approaching PFAS as a class of chemicals for control purposes and phasing out non-essential uses has been advanced as an alternative framework.[5] Filling knowledge gaps is an important challenge regardless of the approach.

The report examines the class approach for PFAS as it applies to the textile sector, which covers a wide variety of consumer products and connects two important issues covered in the SAICM context. The textile sector is an appropriate choice given the environmental significance of the sector and the scope of PFAS used within it. Both the quantity of PFAS in use and the variety of uses make this sector a priority for action. Furthermore, the nature of the sector—with a long and global value chain that includes companies of all sizes—can provide significant lessons for capacity building and enabling conditions, which can extend to other sectors as well.

The report also examines the scientific basis and the practical and policy reasons for approaching PFAS as a class, reviews relevant private sector commitments regarding supply chain management, and then discusses two corporate case studies where supply chain management and PFAS control intersect. Based on this information, enabling conditions are identified for advancing improved public health and environmental protection in the textiles sector for consideration by SAICM and other stakeholders.

Background

The textile industry, one of SAICM's priority sectors, uses and releases a large amount of chemicals throughout the life cycle of its products. Many of these chemicals are toxic to human health or hazardous to the environment. These chemicals of concern are found in textile products all over the world, resulting in the potential exposure of many people, including workers in manufacturing, recycling, and disposal of products and consumers during use, including vulnerable populations such as women and children.

It has been reported that more than 8,000 chemical substances are potentially used in the textile industry.[6] While not all these chemicals have been assessed, the Swedish Chemicals Agency looked into 2,450 substances and found 750 classified as hazardous for human health and 440 as hazardous for the environment.[7] Some of these hazardous chemicals have been identified as additives in textiles for past or current use in Stockholm Convention risk profiles, including PFOS, PFOA, PFHxS, hexabromobiphenyl (HBB), tetra- and pentabromodiphenyl ether (c-pentaBDE), hexa- and heptabromdiphenyl ether (c-octaBDE), decaBDE, hexabromocyclododecane (HBCD), and short-chain chlorinated paraffins (SCCPs).[8]

As illustrated in Figure 1, chemicals that are intentionally added to achieve various appearances, quality, and special effects in textile products are called functional chemicals. Chemicals used to aid in the manufacturing process are called auxiliary chemicals.[9] In addition to these intentionally added chemicals, some chemicals of concern can also occur as impurities or by-products.

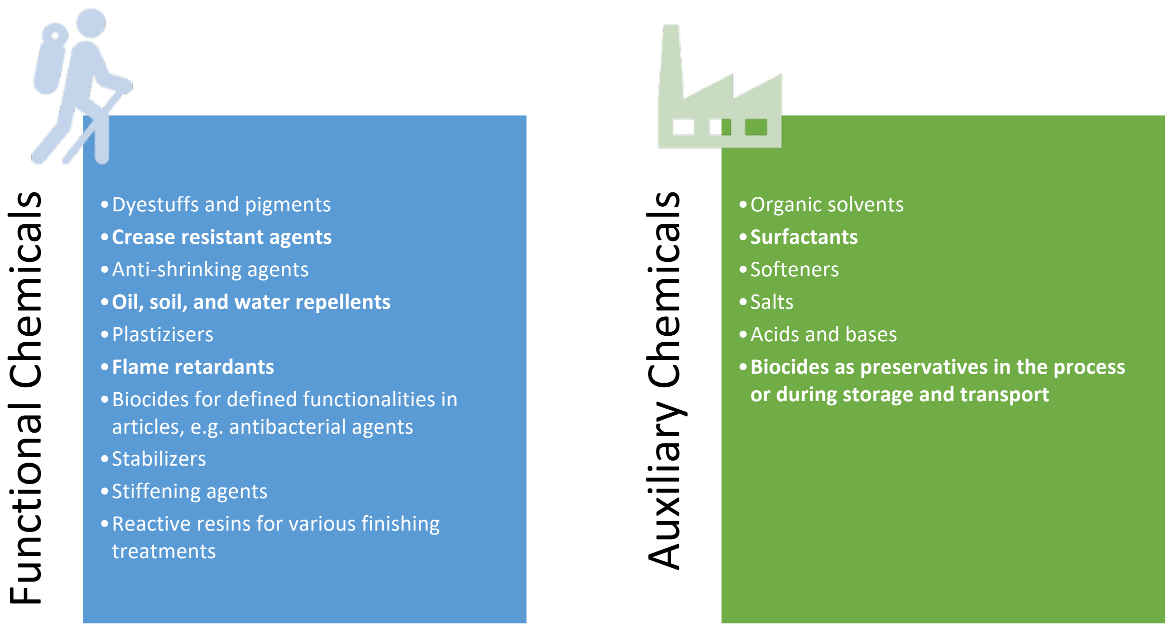


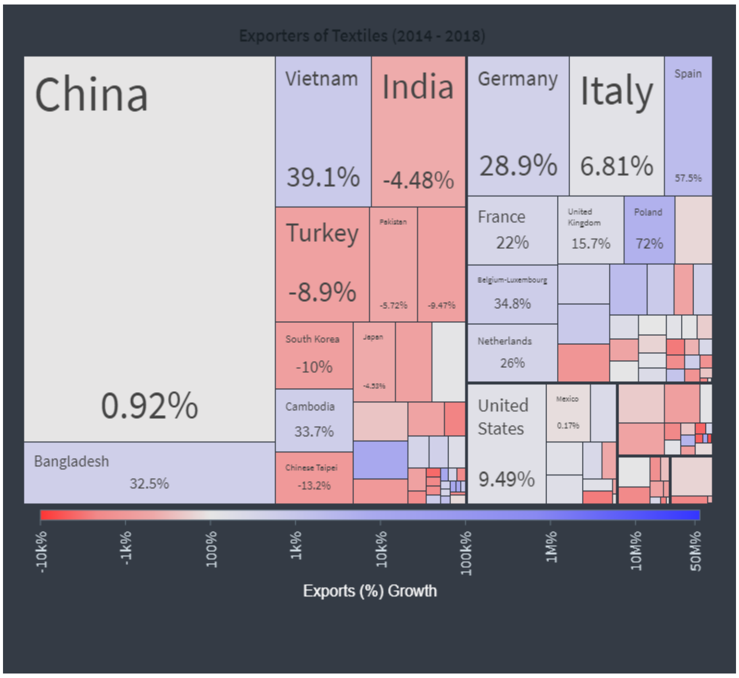
Figure 1: Types of Chemicals Used in the Textile Industry

Modified from: Amec Foster Wheeler Environment & Infrastructure GmbH (now part of Wood), The Use of PFAS and Fluorine-Free Alternatives in Textiles, Upholstery, Carpets, Leather and Apparel, October 2020, https://echa.europa.eu/documents/10162/13641/pfas_in_textiles_final_report_en.pdf/0a3b1c60-3427-5327-4a19-4d98ee06f041.

The total value of global textile product trade has grown from $381 billion in 2000 to $719 billion in 2017.[10] The second edition of the Global Chemicals Outlook predicted that the textile industry will see continuous growth in the next decade, leading to an increased amount of chemical consumption in the sector.[11] The fastest growth in the industry is predicted to occur in the Asia-Pacific region.

Despite the widely acknowledged concern over the enormous amount of chemicals used in the textile sector, it is still challenging to identify all the industrial chemicals used and emitted due to limited capacity, lack of transparency, and poor tracking systems. Many factories do not have comprehensive knowledge of what substances are included in the feedstocks they purchase for production. The key source of information—the material safety data sheets—are often in poor quality or outdated.[12]

Market shifts over the past years have made this even more challenging. The industry first moved manufacturing facilities out of developed countries in North America and Europe to countries such as China and India. However, the location of manufacturing facilities continues to change. For instance, more and more wet-processing mills, which are the most intensive chemical users in the textile supply chain, have moved from China and India to other emerging economies such as Bangladesh, Pakistan, and Vietnam. These market shifts are likely due to increased operational costs and strengthened national and regional regulations.[13] Figure 2 presents how the global textile export market changed from 2014 to 2018. The data show that although China still held the largest share of textile exports in 2018, its export value did not change significantly since 2014. Instead, the export market has grown rapidly in other Asia-Pacific countries including Bangladesh, Cambodia, Myanmar, and Vietnam.



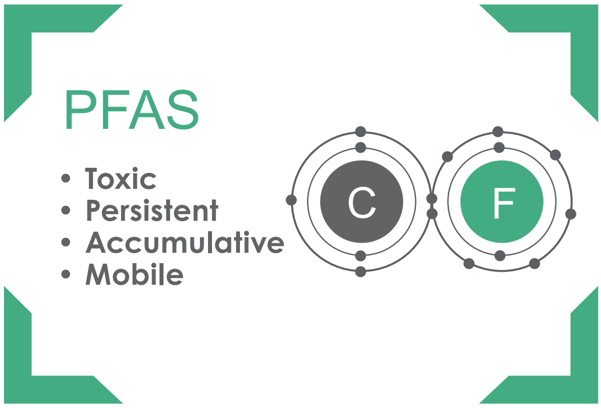
Market share presented with the size of the block; labeled percentage number indicates the change in export value from 2014 to 2018.

Figure 2: The Market Dynamic of Textile Global Trade from 2014 to 2018

Source: Observatory of Economic Complexity, "Textiles," accessed January 19, 2021, https://oec.world/en/profile/hs92/textiles?growthSelector=value2&yearSelector2=tradeYear6&yearSelector5=tradeYear2.

What are PFAS?

The term PFAS, short for per- and polyfluoroalkyl substances, describes a family of thousands of highly persistent synthetic chemicals that are widely used throughout society. The U.S. Environmental Protection Agency (EPA) CompTox Chemicals Dashboard now indicates there are over 9,200 unique PFAS structures.[14] These chemicals are virtually ubiquitous in our environment, contaminating air, soil, water, plants, wildlife, and even our own bodies.



Health effects associated with well-studied PFAS include cancer, hormone disruption, liver and kidney damage, developmental and reproductive harm, changes in lipid levels, and immune system toxicity. Some of these effects can occur at extremely low levels of exposure. Drinking water standards for individual PFAS have been set in the single-digit parts-per-trillion range. Figure 3 shows an overview of known adverse health impacts associated with exposure to evaluated PFAS chemicals.

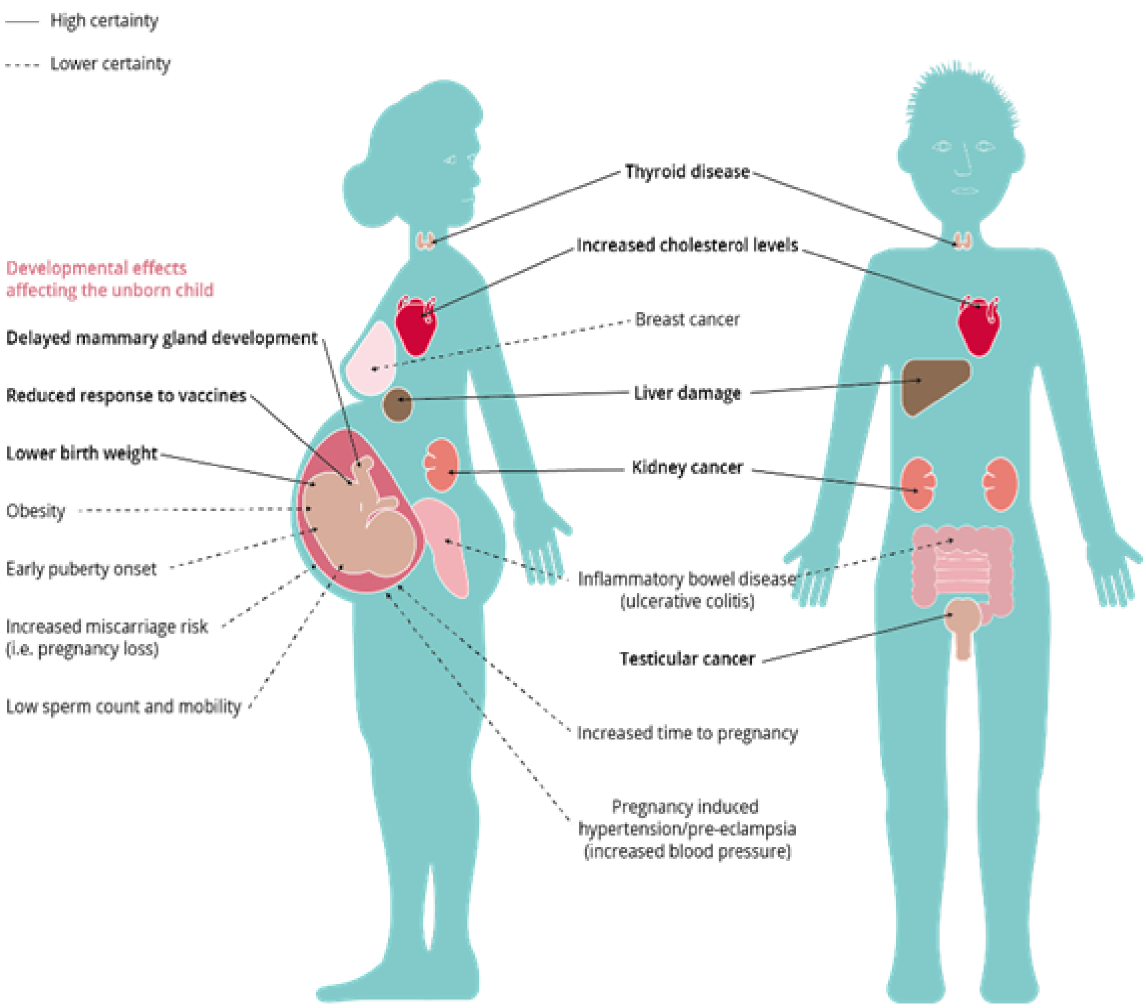


Figure 3 Effects of PFAS Exposure in Human Health

Source: European Environment Agency, "Emerging Chemical Risks in Europe—'PFAS'", December 12, 2019, https://www.eea.europa.eu/themes/human/chemicals/emerging-chemical-risks-in-europe.

PFAS are extremely persistent, often referred to as "forever chemicals." They do not break down easily and can accumulate in our bodies, as well as in our surrounding environment. The United States has reported that PFAS chemicals have been detected in the serum of nearly all people tested in the National Biomonitoring Program, indicating widespread PFAS exposure within the U.S. population.[15]

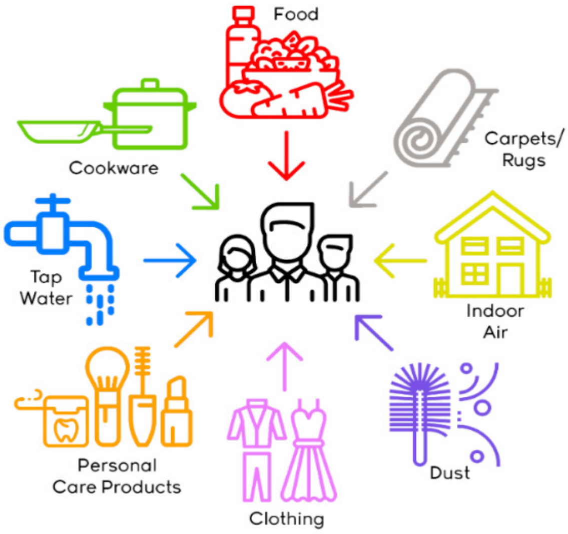


Figure 4 PFAS exposure routes

Some PFAS are highly mobile in the environment. Once PFAS are released, they can spread quickly, making contamination difficult to contain. Both legacy PFAS and replacement PFAS have been detected as far away as the Arctic.[16] The continued use of PFAS will lead to increasing exposures and associated impacts on health and environmental globally.

Figure 4 demonstrates various PFAS exposure pathways, including contaminated food, water, air, consumer products, and household dust. In Europe alone, it is estimated that PFAS account for the following:

- 84,000 to 273,000 workers at risk of getting kidney cancer due to a high level of occupational PFAS exposure
- 12.5 million residents living close to chemical plants at risk of premature mortality
- 156,344 babies at risk of low birth weight
- 785,000 children at risk for infections that also cause fever
- 207.8 million people at risk for hypertension every year

These PFAS exposures are linked to an estimated annual health cost of €52 billion to €84 billion.[17]

PFAS Uses in Textiles

The textile industry has been identified as the biggest user of fluorotelomers,[i] a main subgroup of PFAS. As shown in Figure 5, PFAS market research identified the textile industry as the biggest user of fluorotelomers, making up approximately 36 percent of the total market and projected to continue on the top of the list in the coming years.[18] Further, continued growth of the global fluorotelomers market is predicted, with the Asia-Pacific market forecast to be leading by 2026 due to the "presence of well-established textile firms."[19]

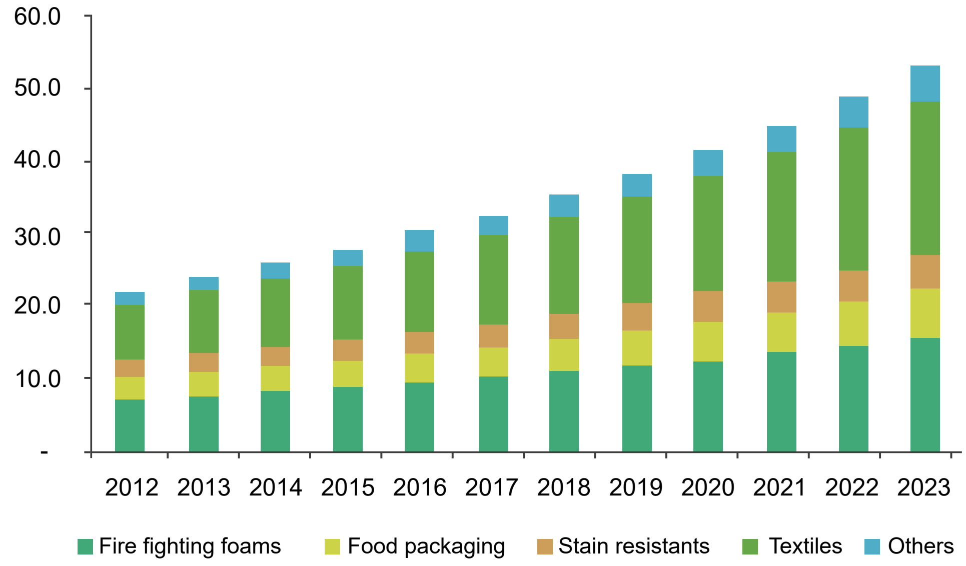


Figure 5: Global Fluorotelomers Market Forecast.
Source: Kunal Ahuja and Kritika Mamtani, Fluorotelomers Market Size by Product (Fluorotelomer Iodide, Fluorotelomer Acrylate, Fluorotelomer Alcohols), by Application (Textiles, Stain Resistant, Food Packaging, Fire Fighting Foams), Industry Analysis Report, Regional Outlook, Application Potential, Price Trends, Competitive Market Share & Forecast, 2016–2023, Global Market Insights, April 2016, accessed January 20, 2021, https://www.gminsights.com/industry-analysis/fluorotelomers-market. Color modified for better representation of this report.

Despite concerning evidence of adverse downstream effects, few textile companies are making meaningful efforts to eliminate the use of PFAS chemicals. Efforts to phase out PFAS in other product categories—such as aqueous firefighting foams, food packaging, and cookware—are much more significant, even though they use PFAS much less than the textile sector. For instance, the annual amount of PFAS used in firefighting foams is estimated at 480 to 560 metric tons in the European Union (EU), which is about 100 times less than the amount used in textile sector.[20]

[i] Fluorotelomers, a subgroup of the PFAS class, are polyfluorinated (partially fluorinated) substances. They are often referred to as perfluoroalkyl acid precursors because they can transform into perfluoroalkyl acid, such as PFOA and PFOS, over time in the environment and in human bodies. Market research suggest that fluorotelomers are currently the main type of PFAS used in the textile industry.

PFAS are widely used in textile products, including fashion apparel, uniforms, sportswear, outdoor gear, footwear, carpets and rugs, bed and bath products, backpacks, swimwear, and upholstery. A recent report prepared by the Wood Institute, which looked into PFAS use in the textile industry, has identified the technical functions of PFAS in various textile products, including water repellence, oil repellence, stain resistance, soil protection, and flame-retardancy.[21] Figure 6 presents an overview of the technical functions of PFAS in each textile product category. In addition, PFAS-based impregnation agents are used in textile products to provide alcohol repellence and a high level of washing and dry-cleaning durability.[22]

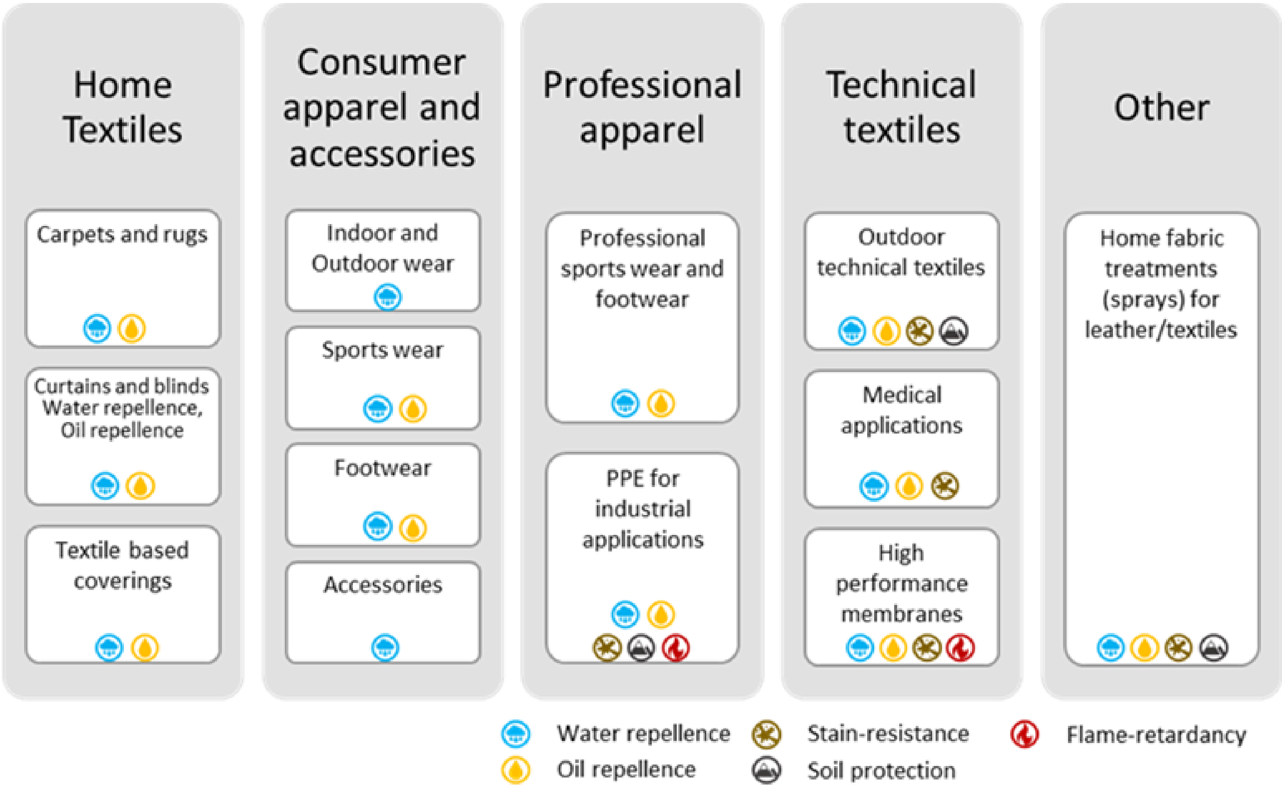


Figure 6: PFAS Use in Different Categories of Textile Products

Modified from: Amec Foster Wheeler Environment & Infrastructure GmbH (now part of Wood), The Use of PFAS and Fluorine-Free Alternatives in Textiles, Upholstery, Carpets, Leather and Apparel, October 2020, https://echa.europa.eu/documents/10162/13641/pfas_in_textiles_final_report_en.pdf/0a3b1c60-3427-5327-4a19-4d98ee06f041.

Based on available data, the Wood Institute report estimates that 45,000 to 76,000 metric tons of select PFAS[ii] are used for textile products in the EU annually. Among these uses, home textiles and consumer apparel are the two dominant categories. Home textiles—including carpets and rugs, curtains, and upholstery products—account for more than half of total PFAS use in the textile sector, while consumer apparel—covering indoor and outdoor gear, sportswear, and footwear products—consumes up to 39 percent of total PFAS use.[23]

Figure 7 illustrates the proportion of PFAS use in each textile category, with the inner circle presenting the minimum estimation and the outer circle representing the maximum estimation based on available data.

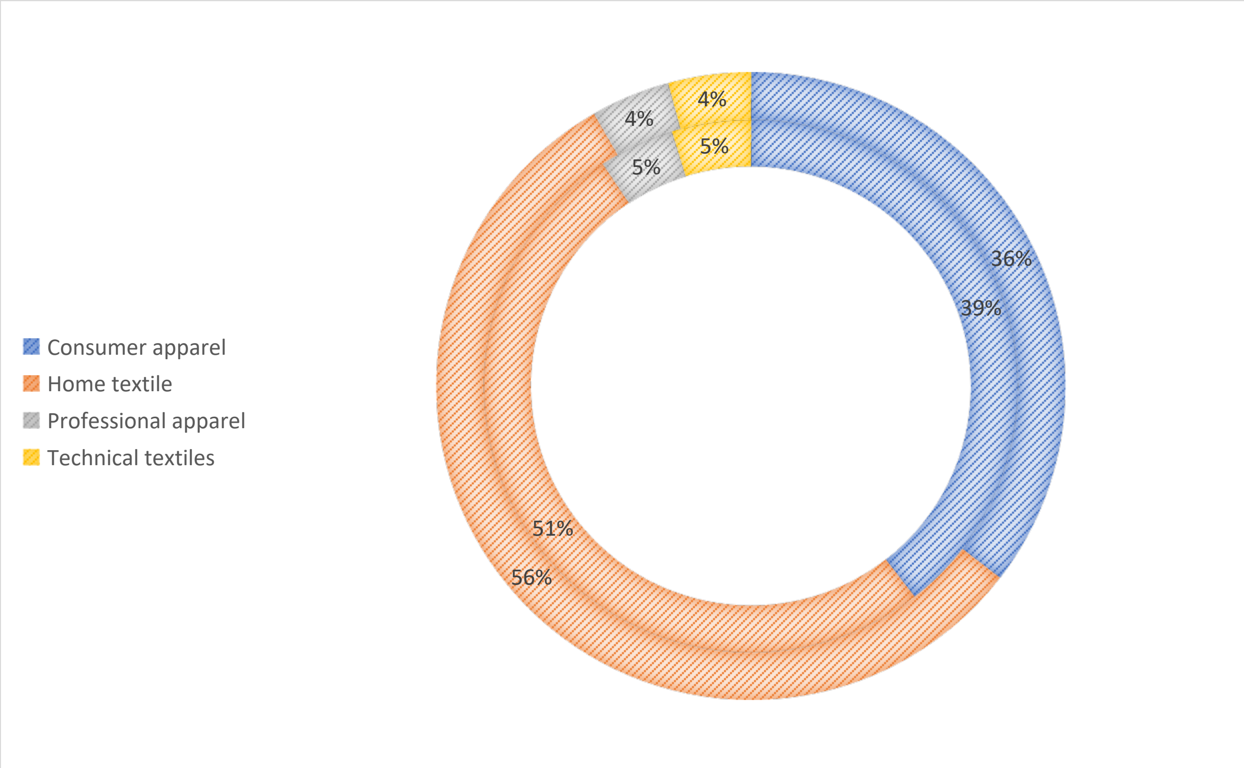


Figure 7: Estimated Range of Total Amount of PFAS Contained in Textile Products in the EU

Data source: Amec Foster Wheeler Environment & Infrastructure GmbH (now part of Wood), The Use of PFAS and Fluorine-Free Alternatives in Textiles, Upholstery, Carpets, Leather and Apparel, October 2020, https://echa.europa.eu/documents/10162/13641/pfas_in_textiles_final_report_en.pdf/0a3b1c60-3427-5327-4a19-4d98ee06f041.

[ii] This report only includes data on 15 different PFAS chemicals.

Accounting for the Whole Product Life Cycle

Use of products containing PFAS can lead to PFAS exposure via ingestion, inhalation, and dermal contact, as well as emission of PFAS into the environment (for example, laundry wastewater discharge). However, product use only accounts for a portion of PFAS emissions and exposure. Other stages in a product's life cycle—including chemical manufacturing and formulation, product manufacturing and production, and product disposal—all contribute significantly to PFAS emissions, and therefore exposure, due to the extreme persistence, high mobility, and accumulation potential of PFAS.[24]

For example, Figure 8 demonstrates how fluoropolymers emit PFAS into the environment at each stage of a product's life cycle, including chemical production and product manufacturing, use, and disposal. It shows that, in addition to consumers being exposed to PFAS during product use, PFAS production and its industrial use can lead to worker exposure during on-site production; pollution of the environment and local communities near facilities that produce PFAS or use PFAS to manufacture products; and global PFAS pollution due to the extreme persistence, mobility, and accumulation potential of these chemicals.

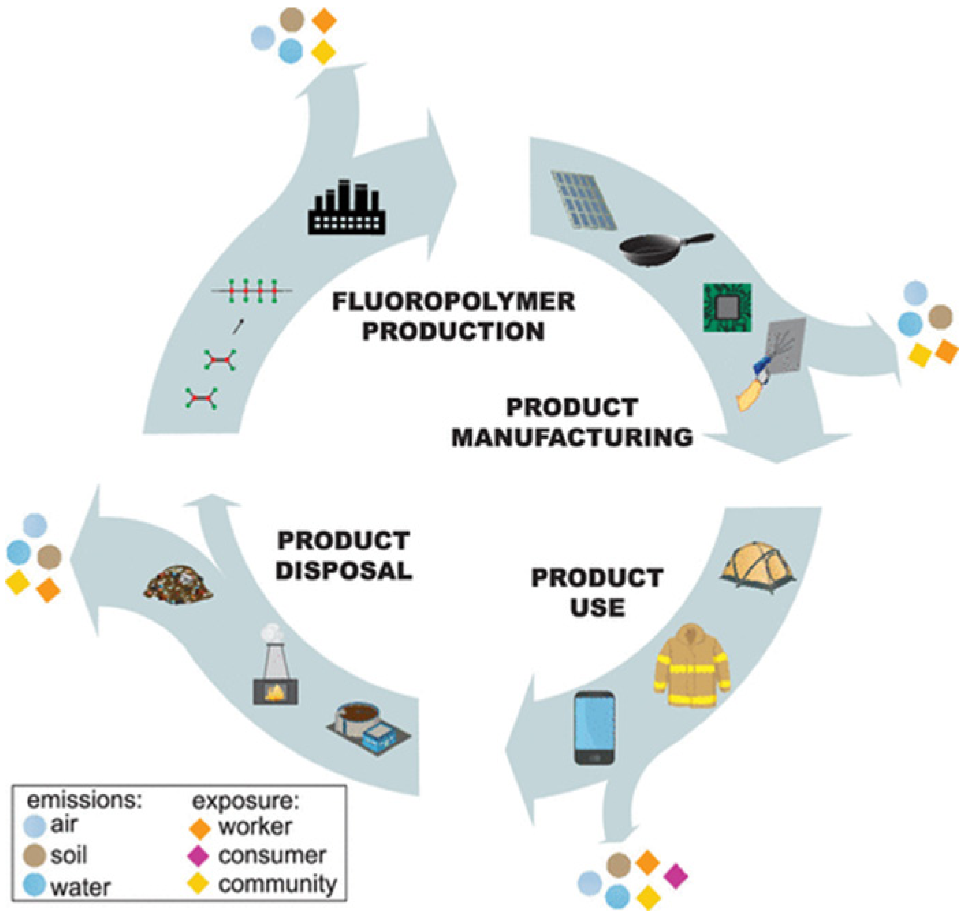


Figure 8: Exposure and Emission Pathway of PFAS (Using Fluoropolymer as Proxy) in a Product's Life Cycle

Source: Rainer Lohmann et al., "Are Fluoropolymers Really of Low Concern for Human and Environmental Health and Separate from Other PFAS?," Environmental Science & Technology 54, no. 20 (2020), https://pubs.acs.org/doi/10.1021/acs.est.0c03244.

The Wood Institute report also investigates the emission of some PFAS chemicals during the life cycle of textile and leather products.[25] The report divided these products' life cycles into the following stages:

- ES 1: Chemical manufacturing
- ES 2: Chemical formulation
- ES 3: Industrial application to textile (during the product manufacturing)
- ES 4: Industrial application to leather (during the product manufacturing)
- ES 5: Consumer application (applying treatment spray)
- ES 6: Widespread use of articles over their service life, for products that are subject to frequent cleaning/washing
- ES 7: Widespread use of articles over their service life, for products that are subject to infrequent cleaning/washing (e.g., carpets, rugs, and curtains)
- ES 8: Widespread use of articles not included in the above two categories
- ES 9: Waste: landfill
- ES 10: Waste: incineration

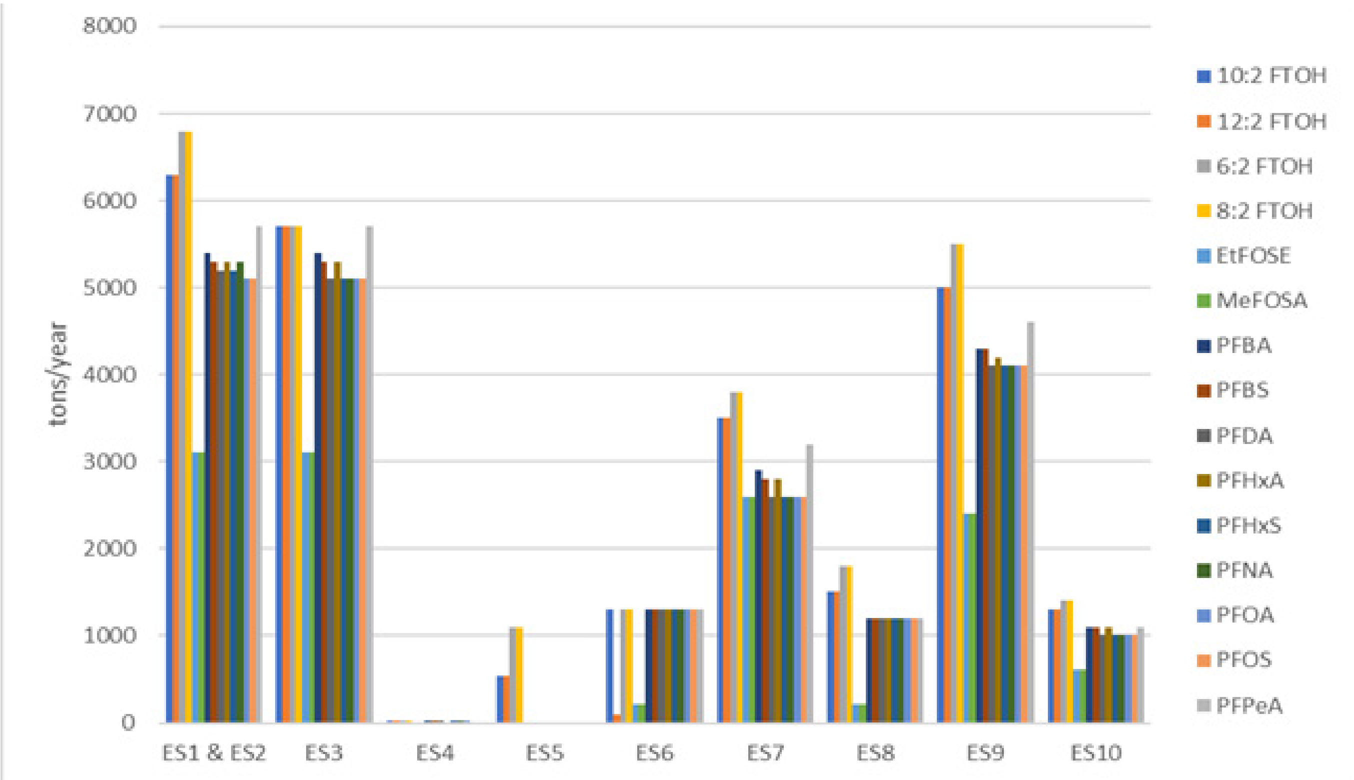


Figure 9: PFAS Input in Each Life Cycle Stage

Data source: Amec Foster Wheeler Environment & Infrastructure GmbH (now part of Wood), The Use of PFAS and Fluorine-Free Alternatives in Textiles, Upholstery, Carpets, Leather and Apparel, October 2020, https://echa.europa.eu/documents/10162/13641/pfas_in_textiles_final_report_en.pdf/0a3b1c60-3427-5327-4a19-4d98ee06f041.

As Figure 9 and Figure 10 indicate, PFAS are used and released throughout the whole life cycle of textile products.

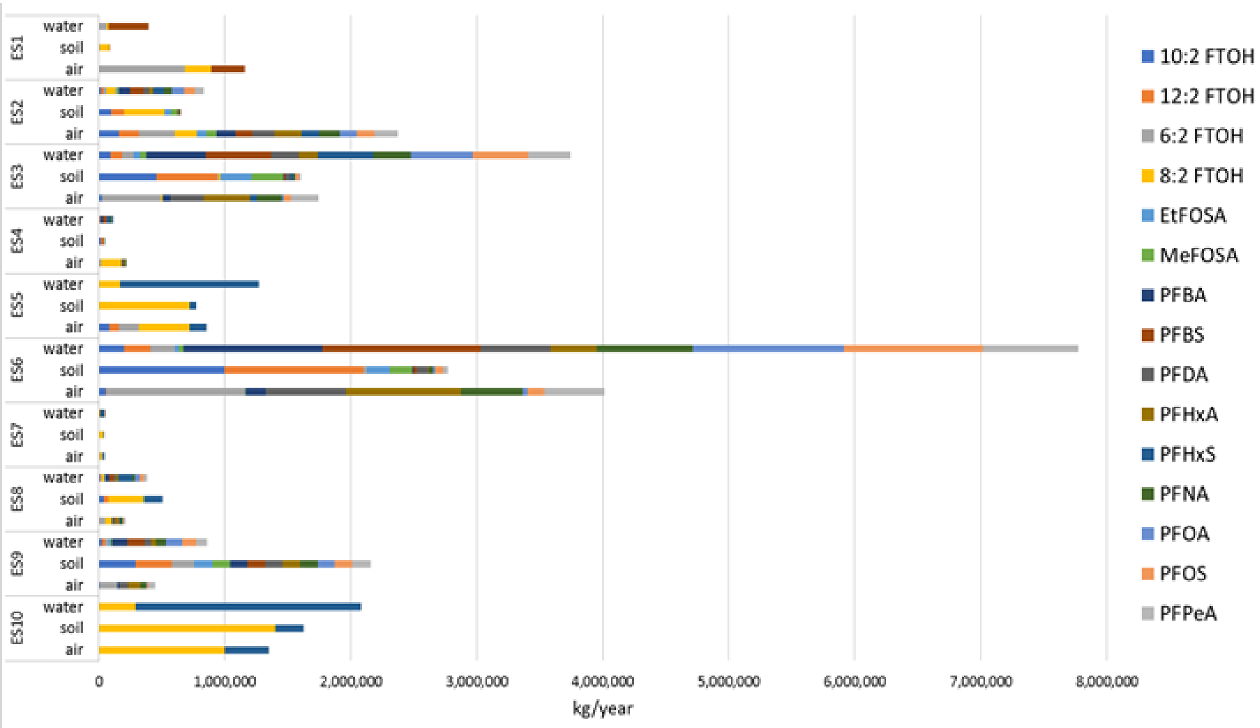


Figure 10: PFAS Releases by Pathway and Life Cycle Stages

Data source: Amec Foster Wheeler Environment & Infrastructure GmbH (now part of Wood), The Use of PFAS and Fluorine-Free Alternatives in Textiles, Upholstery, Carpets, Leather and Apparel, October 2020, https://echa.europa.eu/documents/10162/13641/pfas_in_textiles_final_report_en.pdf/0a3b1c60-3427-5327-4a19-4d98ee06f041.Data source: Amec Foster Wheeler Environment & Infrastructure GmbH (now part of Wood), The Use of PFAS and Fluorine-Free Alternatives in Textiles, Upholstery, Carpets, Leather and Apparel, October 2020, https://echa.europa.eu/documents/10162/13641/pfas_in_textiles_final_report_en.pdf/0a3b1c60-3427-5327-4a19-4d98ee06f041.

Most PFAS used during textile manufacturing end up either in the final products or in waste streams. PFAS in textile products can be released into domestic wastewater treatment plants through laundry, while a significant portion of PFAS in manufacturing waste streams are released into industrial wastewater treatment plants. Typical domestic and industrial wastewater treatment systems, including those for textile manufacturers, do not have the capacity to adequately capture PFAS; this results in PFAS released into the ambient environment via treated and discharged water streams, wastewater sludge, and possibly emitted air.[26] It can further pose risks to communities by impacting their drinking water and food sources.

Once PFAS chemicals are released into the environment, they are difficult and expensive to remediate. For example, 3M agreed to pay a $850 million settlement to Minnesota in 2018, after the state sued the company in 2010 for drinking water pollution and damages to natural resources caused by PFAS production.[27]

Existing Regulations and Limitations in Eliminating PFAS Chemicals

The regulatory landscape for PFAS is rapidly changing. Therefore, any description of its current state is likely to be outdated within a short period of time. However, the PFAS regulatory efforts to date have been generally limited, either in the scope of PFAS covered, the uses of PFAS covered, or both.

For example, at the global level, action has been taken under the Stockholm Convention to limit the production and use of PFOA and PFOS (and related compounds) under actions that began in 2009[iii] and were subsequently strengthened in 2019.[28] In addition, PFHxS and its related compounds are now proposed for listing and controls.[29]

Challenges remain in implementing what has already been adopted. Not all countries with large manufacturing capacity are Parties to the Stockholm Convention, and as of November 2019, only 86 of 183 Parties have incorporated PFAS into their Convention implementation plans some 10 years later. Information gaps and limited technical capacity are among the possible causes of this delay. There are also issues associated with the number and timing of exemptions. However, most importantly, even when fully implemented, the Stockholm Convention currently targets some long-chain PFAS but leaves most PFAS completely uncontrolled.

The EU has taken action to restrict PFOA and PFOS, consistent with the Stockholm Convention.[30] In addition, restriction processes are underway for other long-chain PFAS (C9-C14 PFCAs) and some short-chain PFAS, such as Gen-X (HFPO-DA), PFBS, and PFHxA.[31] Additional chemical evaluations under the EU's Registration, Evaluation, Authorisation, and Restriction of Chemicals (REACH), or as a consequence of listing PFBS and HFPO-DA as Substances of Very High Concern (SVHC) may also result in further regulatory action. Denmark banned the use of all PFAS in paper and cardboard food-contact materials as of July 2020.[32]

In the United States, the US EPA recently issued a "significant new use rule" (SNUR), requiring companies seeking to use certain long-chain PFAS in new ways to notify the Agency at least 90 days before engaging in the new use.[33] This 90-day notice enables the EPA to review and determine whether the new use should be allowed. The SNUR particularly affects imports, and it applies to consumer products that may have PFAS on them as surface coatings, such as apparel, carpets, and furniture.

States have been more active in restricting the use of PFAS as a class. Specifically, California[34], New Hampshire[35], New York[36], and Washington[37] have banned the sale and, in the case of California, the use of PFAS-containing firefighting foam. New York[38] and Washington[39] have banned the sale of food packaging that contains PFAS, and California is in the process of regulating PFAS in carpets, rugs, and after-market textile treatments.[40]

China has issued restrictions consistent with Stockholm Convention requirements and adopted a few voluntary initiatives that limit PFAS chemicals in textile products.[41] One such initiative is known as the "Technical Requirement for Environmental Labeling Products: Textile Products."[42] This voluntary initiative aimed at environmental labeling was implemented in 2017 and only covers two individual PFAS

[iii] In that same year, PFAS were identified as an issue of concern under SAICM, and in 2015 stakeholders were invited to consider stewardship programs and regulatory approaches to address PFAS.

substances: PFOA and PFOS. Recently, the guidelines for another similar initiative, the "Guidelines for the Use and Control of Key Chemical Substances in Consumer Products", were published and are expected to be implemented on June 1, 2021. More long-chain PFAS chemicals are included in this new voluntary initiative, which applies to a wider range of products.

Information on existing PFAS restrictions in other countries can be difficult to obtain. The OECD provides information on 14 countries, including six within the European Union.[43] A recent survey of 12 Middle Eastern and Asian countries indicated that, at best, some countries had partial restrictions consistent with the Stockholm Convention, but in other countries PFAS were largely unregulated.[44] In Africa, many countries are among the 86 Parties which have not updated their Convention Implementation Plans to include PFAS.[45]

While these initiatives certainly represent progress in addressing the risks posed by PFAS to human health and the environment, this piecemeal approach to PFAS control—either chemical-by-chemical or by use—is not effective or sustainable given the number of chemicals and uses involved. As the European Commission recently observed:

1. Action on long-chain PFAS led to the regrettable substitution of short-chain PFAS, which also pose significant risks to human health and the environment.
2. Short-chain PFAS may not perform as well as long-chain PFAS for the same applications, resulting in higher quantities used and higher environmental releases.
3. Long-chain PFAS can be produced as by-products during the manufacture of short-chain PFAS, thereby undercutting the effectiveness of long-chain production and use restrictions.
4. The costs to society related to PFAS, including health and remediation costs, are substantial.
5. The high number of PFAS and the variety of uses make it impossible to obtain detailed volume, toxicity, exposure, and other relevant data on all chemicals and associated uses.[46]

Accordingly, in the recently announced EU Chemical Strategy, the Commission proposed a series of actions aimed at phasing out all non-essential uses of PFAS as a class. Specifically, the European Commission will:

- Ban all PFAS as a group in fire-fighting foams and textiles;[47]
- Address PFAS with a group approach under relevant legislation covering, products, food, water, emissions, and waste;
- Address PFAS concerns on a global scale through international forums and bilaterally; and
- Promote research and innovation for chemical substitution and remediation.[48]

It is reasonable to anticipate that this class approach for regulating PFAS could expand within and beyond the EU. Under the EU strategy, addressing PFAS as a class is part of a broader strategy to develop a general approach to risk management, particularly for consumer products, in lieu of the chemical-by-chemical approach. And it is reasonable to anticipate textiles will be among the first sectors where the approach is applied on a broader scale, particularly in areas where much of the groundwork for essential use determinations has already been conducted.

Managing and Eliminating PFAS as a Chemical Class

While the PFAS terminology encompasses thousands of different chemicals, the cornerstone chemical structure for the entire class is the carbon-fluorine bond (see Figure 11).[49] This common structural relationship forms the underlying foundation for addressing PFAS as a class, in conjunction with related technical and policy bases described below.

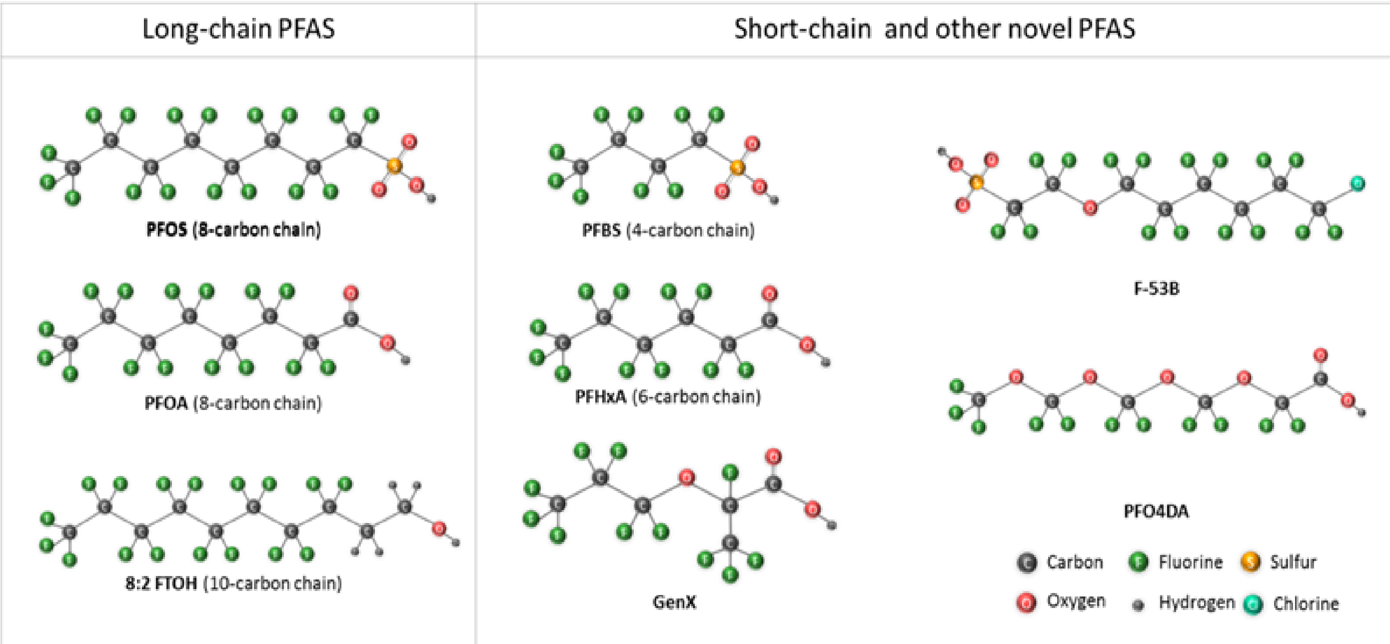


Figure 11: Examples of Chemical Structures in the PFAS Family

Source: XiaoZhi Lim, "Tainted Water: The Scientists Tracing Thousands of Fluorinated Chemicals in Our Environment," Nature 566, no. 7742 (February 6, 2019): 26-29, https://doi.org/10.1038/d41586-019-00441-1. Some structures were derived from this article and others were created using structure given in PubChem (https://pubchem.ncbi.nlm.nih.gov/) with style modifications.

First, it is the strength of the carbon-fluorine bond () that leads to the persistence and accumulation potential of the entire PFAS class. The thousands of PFAS variations, achieved through changes in chain length or active groups, all share this high persistence property due to their carbon-fluorine bonds.[50] Thus, the production of any PFAS will lead to long-term accumulation in the environment and living organisms, increasing the exposure and associated risks, both known and potential.[51] Scientists have therefore proposed that the high persistence of PFAS alone is sufficient reason for their management as a class.[52]

Second, toxicity data on well-studied PFAS suggest a high potential for the toxicity of other PFAS in the class, both in the wide array of health harms they are linked to and in their potency—that is, their ability to cause effects at very low doses. PFAS are chemically similar, and the health risks associated with one PFAS often overlap with other PFAS.[53] Figure 12 summarizes the health effects that the U.S. Centers for

Disease Control and Prevention's Agency for Toxic Substances and Disease Registry (ATSDR) found to be associated with various PFAS.[54] The figure demonstrates the wide array of health effects linked to PFAS exposure and the similar toxicological profiles of PFAS studied to date. While there is limited toxicity data on short-chain and other, newer PFAS, there is a growing body of evidence indicating that they have similar toxicologic effects as the long-chain legacy PFAS they have replaced (see PFHxA, PFBS, PFBA in Figure 12). Further, because people are often exposed to many of these chemicals at the same time, there is concern that a combination of different PFAS will target the same biological systems and cause greater effects than any single PFAS on its own.

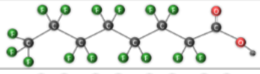
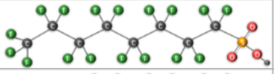
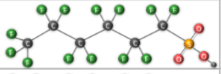
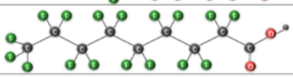
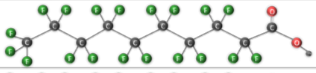
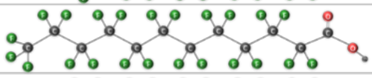
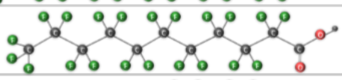
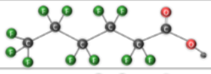
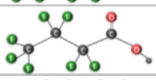
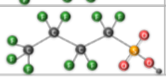
		Immune	Developmental & Reproductive	Lipids	Liver	Endocrine	Body Weight	Blood
PFOA		×	×	×	×	×	×	×
PFOS		×	×	×	×	×	×	×
PFHxS		×	×		×	×		×
PFNA		×	×	×	×	×	×	
PFDA		×	×	×	×	×	×	
PFDoDA		×	×		×		×	
PFUnDA		×	×		×		×	×
PFHxA			×		×			×
PFBA			×		×	×		×
PFBS					×			×

Figure 12: Findings on the Associations Between PFAS Exposure and Health Outcomes in Human and Animal Studies. (Note that this is not an exhaustive list of health outcomes and it includes both "serious" and "less serious" effects, as defined by ATSDR. Xs in blue represent PFAS for which ATSDR considers their liver effects to be specific to animals).
Data source: Agency for Toxic Substances and Disease Registry, Toxicological Profile for Perfluoroalkyls: Draft for Public Comment, June 2018, https://www.atsdr.cdc.gov/ToxProfiles/tp200-c2.pdf. Chemical structure created according to structures given in PubChem (https://pubchem.ncbi.nlm.nih.gov/), with style modifications.

It is also noteworthy that women make up the majority of the workforce within the textile industry in many countries, including Bangladesh, Cambodia, and Mexico.[55] This may be especially true in the cut and sew facilities, where workers directly handle fabrics that are treated with various chemicals of concern. PFAS chemicals can harm reproductive health, and exposure during pregnancy can cause adverse health effects on fetuses and offspring.[56] This critical exposure scenario suggests that the use of PFAS in textiles puts the health of women workers and their children at increased risk.

Third, the process and chemistry of PFAS production and transformation in the environment defies subcategorization, such as separating out polymers from monomers. This is because industrial processes and molecular changes in the environment can result in the release of single-molecule PFAS, even where they are not intentionally manufactured or used. For example, fluoropolymers such as polytetrafluoroethylene, also known as Teflon, require the use of single-molecule PFAS, such as PFOA and GenX, in their manufacture, which has resulted in severe environmental contamination from industrial waste.[57] In another example, Figure 13 shows how a fluorinated side-chain polymer used on clothing can release single-molecule PFAS during use and disposal. Thus, use of PFAS subclasses such as polymers and precursors can contribute to the accumulation of and exposure to monomer PFAS of concern.[58]

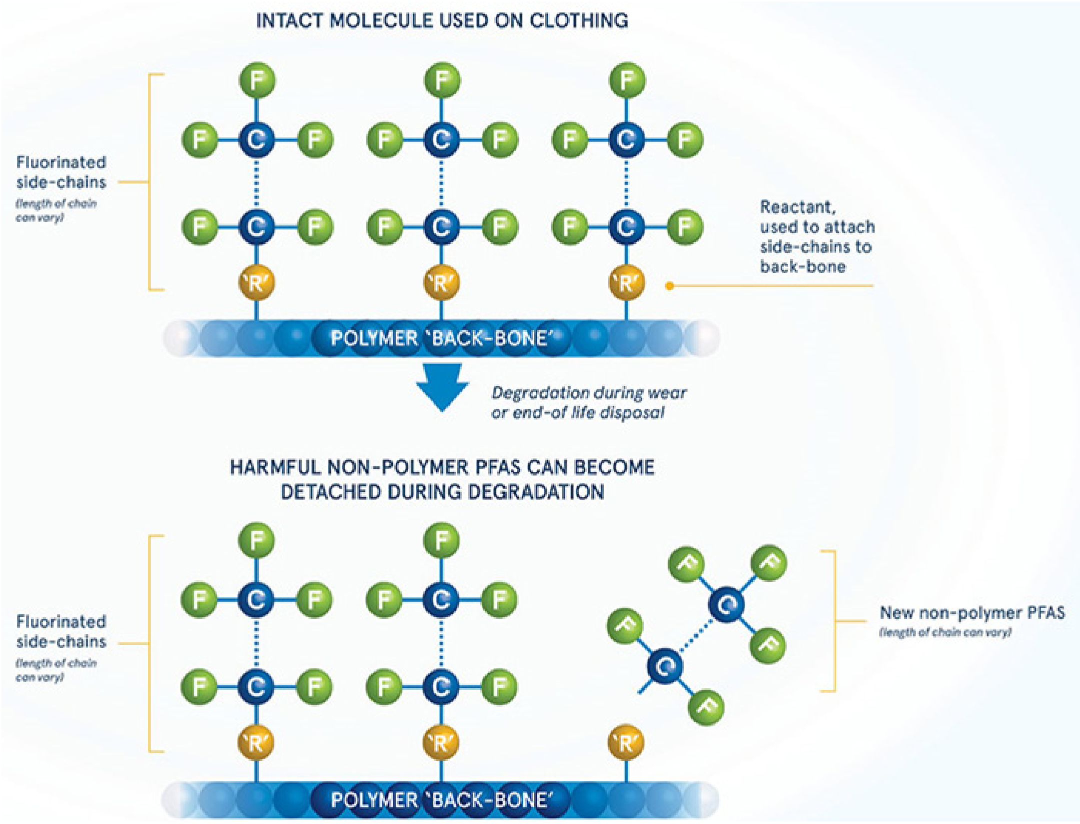


Figure 13: How a PFAS Polymer Used on Clothing Can Change to Non-polymer PFAS
Source: PFAS Free, "The Science," accessed Feb 2, 2021. https://www.pfasfree.org.uk/about-pfas/pfas-science-the-basics.

Fourth, commercially available laboratory methods can only detect the presence of less than 100 specific PFAS. Due to the complexity of the chemical formulations used in the textile sector, especially in the Asia-Pacific region, and poor tracking systems, it is very import to conduct quality assurance testing to ensure the avoidance of chemicals of concern. However, with the increasing number of PFAS variants added to the many existing ones, it is becoming more and more challenging and expensive for textile brands and suppliers to monitor specific PFAS. Emerging and cheaper laboratory methods for detecting PFAS measure total or extractable fluorine, thus providing an estimate of total PFAS, may present a more practical inventory mechanism for the private sector going forward.

Fifth, some of the newer PFAS are even more mobile (water soluble) and harder to remediate than the PFAS already targeted for action, further supporting the case for preventing additional releases where possible to do so. For example, a study that investigated PFAS in leachate from landfills in Norway found higher levels of legacy, long-chain PFAS (such as PFOS and PFOA) in the sediment phase of the leachate, but higher levels of short-chain PFAS (such as PFBS, PFPeA, and PFHxA) in the more mobile, liquid phase of the leachate.[59] Additionally, studies have found that widely used treatment technologies for the removal of PFOA and PFOS from water, such as granulated activated carbon, become progressively less effective for removing shorter chain PFAS as the chain length diminishes.[60]

Finally, given the number of structurally similar chemicals with known or potential hazards in this chemical class, there is no practical alternative to class management. It would be impossible to collect data on toxicity, production, use, and exposure for every PFAS chemical within a reasonable time frame to protect public health. In the absence of a class approach, the already experienced regrettable substitutions of one toxic PFAS for another will be with us for generations to come.

Box 1 presents a list of key statements and articles that provide scientific justification for why a class-based approach is appropriate and necessary for managing PFAS.

Box 1 Chronology of Scientific Statements for Managing PFAS as a Class

With concerns over the possible toxicity of PFAS, their similar environmental mobility and persistence, and their widespread human and environmental exposure, scientists and other health professionals have expressed concern about the continued and increasing production and releases of PFAS chemicals, especially in the past a few years. Here is a list of key statements and articles that provide scientific justification for why a class-based approach is appropriate and necessary for managing PFAS.

Helsingor Statement (2014)[61]

- expresses concerns about the potential impacts of fluorinated alternatives on human health and the environment

Madrid Statement (2015)[62]

- expresses concern over the persistence and potential for harm of PFAS and calls on the international community to "cooperate in limiting the production and use of PFAS and in developing safer non-fluorinated alternatives"

Zurich Statement (2018)[63]

- provides an action plan for the assessment and management of PFAS
  - a grouping approach to addressing PFAS
  - a phaseout of non-essential uses
  - the development of safer alternatives

The Concept of Essential Use for Determining When Uses of PFAS Can Be Phased Out (2019)[64]

- builds on the Madrid Statement and the Montreal Protocol to chart a path forward to phase out all non-essential uses of PFAS

Strategies for Grouping Per- and Polyfluoroalkyl Substances (PFAS) to Protect Human and Environmental Health (2020)[65]

- examines nine different approaches for grouping PFAS based either on their intrinsic properties or those that estimate cumulative exposure and/or health effects

The High Persistence of PFAS Is Sufficient for Their Management as a Chemical Class (2020)[66]

- argues that the continual release of highly persistent PFAS will result in both increasing concentrations and risk of known and unknown adverse health and environmental impacts of PFAS

Scientific Basis for Managing PFAS as a Chemical Class (2020)[67]

- presents the scientific justification for managing PFAS as a class and suggests ways in which government and industry can reduce PFAS-associated risks in a class-based manner

Overview of Corporate Commitments and Policies

Regulation of chemicals of concern is often slow and difficult. Voluntary industry and procurement measures can encourage substitution and reduce chemical emissions, especially for large classes of chemicals like PFAS, before legally binding restrictions are in place. Corporate leaders can also inform and shape the regulatory frameworks based on their collective transformation experiences.

Commitments

To exhibit corporate leadership, meaningful and transparent commitments are key, especially those made by textile brands and retailers. Some textile brands have already committed to and reached the goal of being 100 percent PFAS-free and others are in progress. See Figure 14 for a list of textile brands' commitments on PFAS elimination.

Current commitments are dominated by fashion and apparel brands, including C&A, Esprit, H&M, G-Star RAW, and Inditex from Europe; Uniqlo (of Fast Retailing) from Japan; and Levi's from the United States. It is likely that fashion brands are leading these efforts because the functionalities provided by PFAS are not necessary for their products. Given the success of these many fashion brands, there are substantial PFAS phaseout opportunities for the laggards in this market.

Sports and outdoor brands face more challenges to phase out PFAS while keeping the same level of product functionality. However, a considerable number of outdoor brands have been able to become 100 percent PFAS free, including Páramo, Rotauf, Jack Wolfskin, Deuter, and Didrikson from Europe and North Face and Nau from the United States. Although sportswear may require similar functionality with outdoor clothing, the number of PFAS-free commitments in that market are comparatively low.

Home textiles is another category where companies are making significant progress toward eliminating all PFAS, especially in carpets and rugs. Brands and retailers are leading the effort, including IKEA, Crate and Barrel, Room & Board, Engineered Floors, Lowe's, and Home Depot. Many carpet manufacturers are also producing products without PFAS, including Interface, Shaw, and Tarkett.

	Brand Name	Textile Sub-Category
Consumer Apparel & Accessories	Benetton[68]	fashion wear
	Burberry[69]	fashion wear
	C&A[70]	fashion wear
	Fast Retailing (Uniqlo, GU, Theory, Helmut Lang, PLST, Comptoir des Cotonniers, Princesse tam.am, and J Brand)[71]	fashion wear
	G-Star RAW[72]	fashion wear
	H&M[73]	fashion wear
	L Brands (Bath & Body Works, Victoria's Secret, Pink)[74]	fashion wear
	Lindex[75]	fashion wear
	Mango[76]	fashion wear
	Miroglio Fashion[77]	fashion wear
	Primark[78]	fashion wear
	Valentino[79]	fashion wear
	Inditex (Zara, Pull&Bear, Massimo Dutti, Bershka, Stradivarius, and Oysho)[80]	fashion wear and footwear
	Levi Strauss & Co.[81]	fashion wear and footwear
	Marks & Spencer[82]	fashion wear and footwear
	KEEN[83]	footwear
	Deuter[84]	outdoor wear
	Didriksons[85]	outdoor wear
	Nau[86]	outdoor wear
	Páramo[87]	outdoor wear
	Puma[88]	sportswear and footwear
Home Textile	Engineered Floors[89]	carpets and rugs
	Interface[90]	carpets and rugs
	Shaw[91]	carpets and rugs
	Tarkett[92]	carpets and rugs
	Inditex (Zara Home)[93]	home textile
	Naturepedic[94]	upholstery
	IKEA (all textile products)[95]	carpets and rugs, upholstery
Technical Textile	The TentLab[96]	tents
Other	Hawk Tools[97]	fabric and leather care product
	Nikwax[98]	fabric and leather care product
	Otter Wax[99]	fabric and leather care products
	DetraPel[100]	fabric treatment product

Figure 14 Brands That Have Achieved or Committed to Achieve 100 Percent PFAS Elimination from All Textile Products by 2020

Management Policies and Tools

In the textile industry, chemicals are generally controlled and managed through three main mechanisms: (1) limiting chemicals of concern attached to textile products through a restricted substances list (RSL); (2) controlling chemicals used in production through a manufacturing restricted substances list (MRSL); and (3) reducing chemicals released into the environment through emission and monitoring controls, including wastewater testing.

Many companies choose to be part of an industry collaboration and commit to RSLs shared by a membership group, including the Apparel and Footwear International RSL Management Group and the American Apparel & Footwear Association RSL.[101] In addition to the voluntary standards proposed by coalitions, many brands have developed and are following their own RSL to manage their supply chain.

While an RSL focuses on products and their impact on consumers' health and safety, MRSLs concentrate on controlling where chemicals are first used. The Zero Discharge of Hazardous Chemicals (ZDHC) Roadmap to Zero program is an industry collaboration formed after Greenpeace's Detox My Fashion campaign. It has published an MRSL to help corporations better manage the chemicals used in their productions.[102] However, current version of ZDHC's MRSL only restricts the use of two types of long-chain PFAS chemicals: PFOA and related substances and PFOS and related substances. Brands that aim to be 100 percent PFAS-free, such as Inditex, are following their own MRSL.

In addition to the MRSL, ZDHC also provides the most widely accepted guidance on wastewater treatment in the textile industry, but this guidance, too, only requires monitoring a few PFAS.[103]

Case Studies

IKEA and Inditex are among the corporations that are leading efforts to phase out PFAS chemicals in the textile industry. In this section, we discuss the chemical policy and supply chain management they have applied to accomplish a PFAS phaseout.[iv]

Inditex

INDITEX

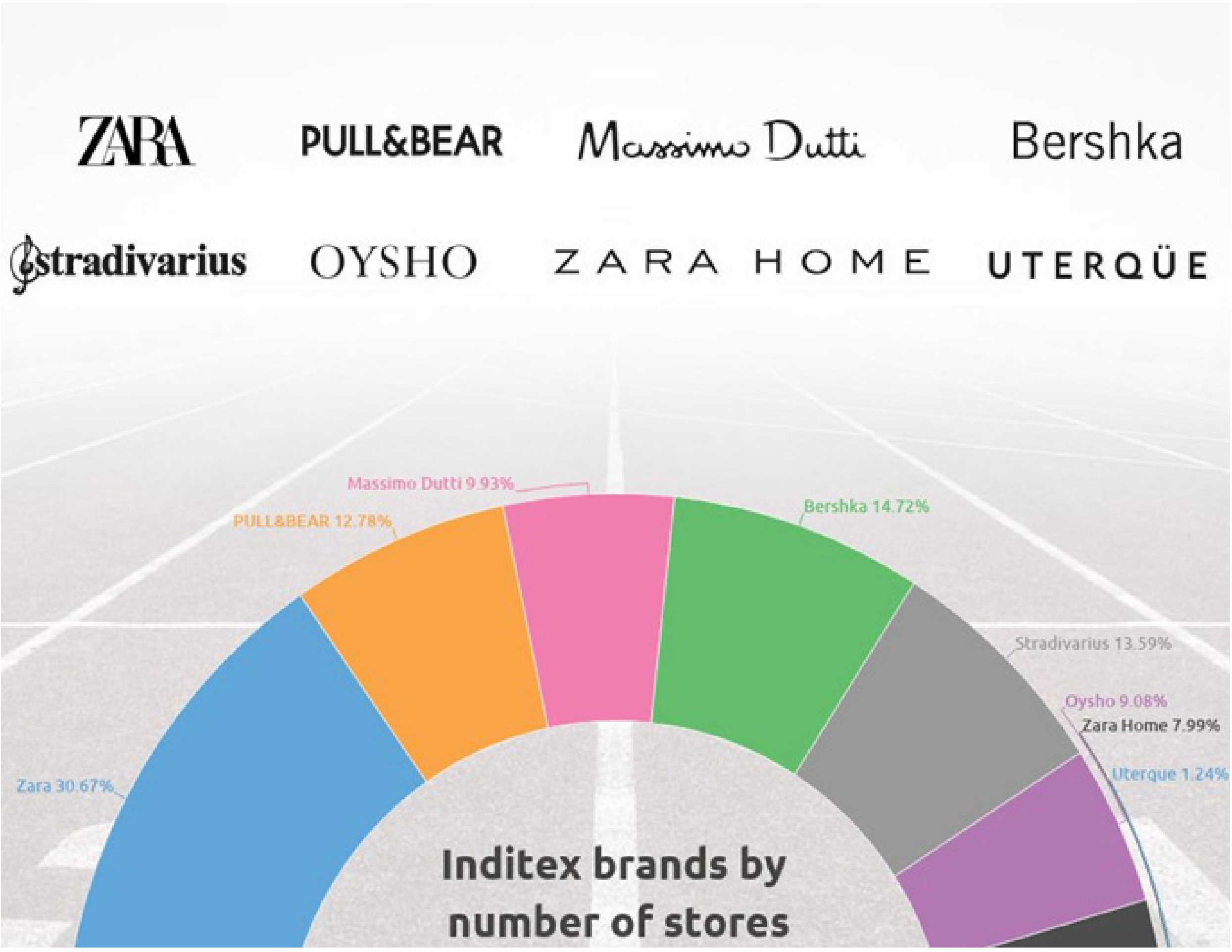


Figure 15: Inditex Brands by Number of Stores

Data source: Inditex, Annual Report 2019, 2019, https://static.inditex.com/annual_report_2019/pdfs/en/memoria/2019-Inditex-Annual-Report.pdf.

[iv] Other environmental or social aspects of these companies are outside the scope of this report.

Background

Inditex is one of the largest retail companies, and it consists of eight brands—Zara, Pull&Bear, Massimo Dutti, Bershka, Stradivarius, Oysho, Zara Home, and Uterqüe—with over 7,000 stores in 96 markets and a growing e-commerce business in 202 markets globally (see Figure 15).[104]

With billions of items sold around the world each year, Inditex works directly with about 2,000 suppliers who connect the company with thousands of factories. Most of these manufacturers are located in key supplier "clusters," which encompass 96 percent of Inditex's total production. The number of suppliers and factories are shown in Figure 16.[105]

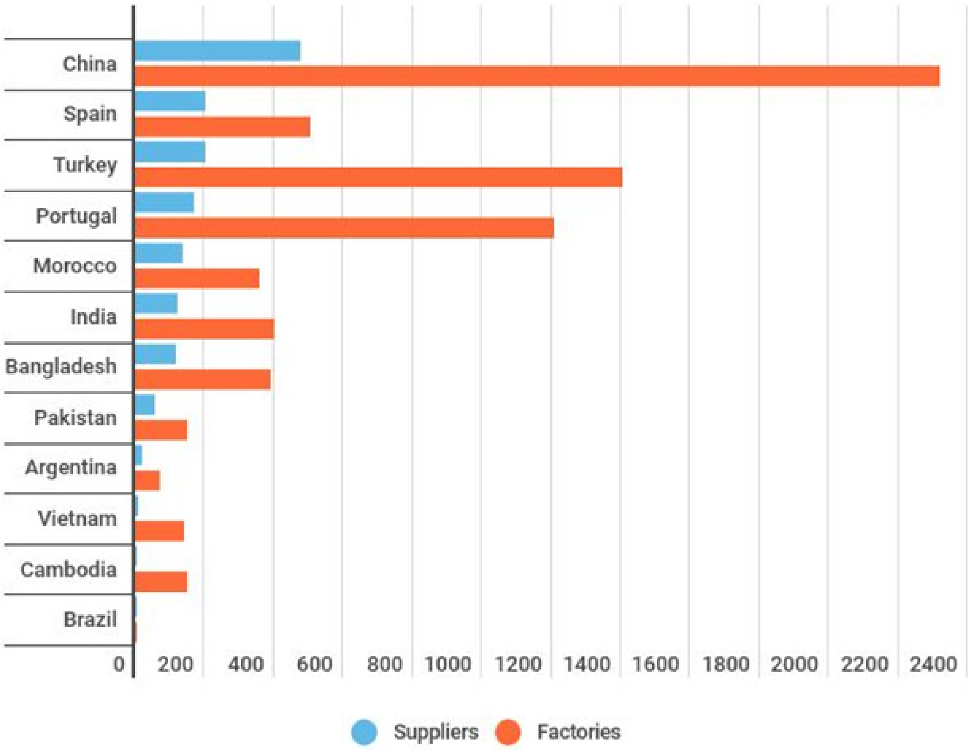


Figure 16: Number of Suppliers and Factories in Inditex's 12 Manufacturing Clusters
source: Inditex, "Commitment to the Excellence of Our Products: 3. Sustainable Management," accessed December 25, 2020, http://static.inditex.com/annual_report_2016/en/our-priorities/commitment-to-the-excellence-of-our-products/sustainable-management.php.

PFAS-free Commitment

Inditex's commitment to and success in phasing out PFAS did not come easy. According to Greenpeace, after the organization launched the Detox campaign in 2011, it took over a year of discussion and a widespread public action against Zara—Inditex's largest, most famous, and most profitable brand—to obtain Inditex's commitment to PFAS elimination.[106] In this "detox Zara" campaign, over 7,000 people in 80 cities in 20 countries around the world protested outside Zara stores and headquarters demanding toxic-free fashion.[107] In response, the company promised to eliminate releases of all hazardous chemicals from its life cycle and production procedures by January 1, 2020. The company also committed to investing in technology development. The PFAS (addressed as "perfluorocarbon" or "PFC") elimination element was included as a short-term action plan, together with supply-chain disclosure and some other priority chemical eliminations. See Figure 17 for key milestones of Inditex's PFAS elimination journey.

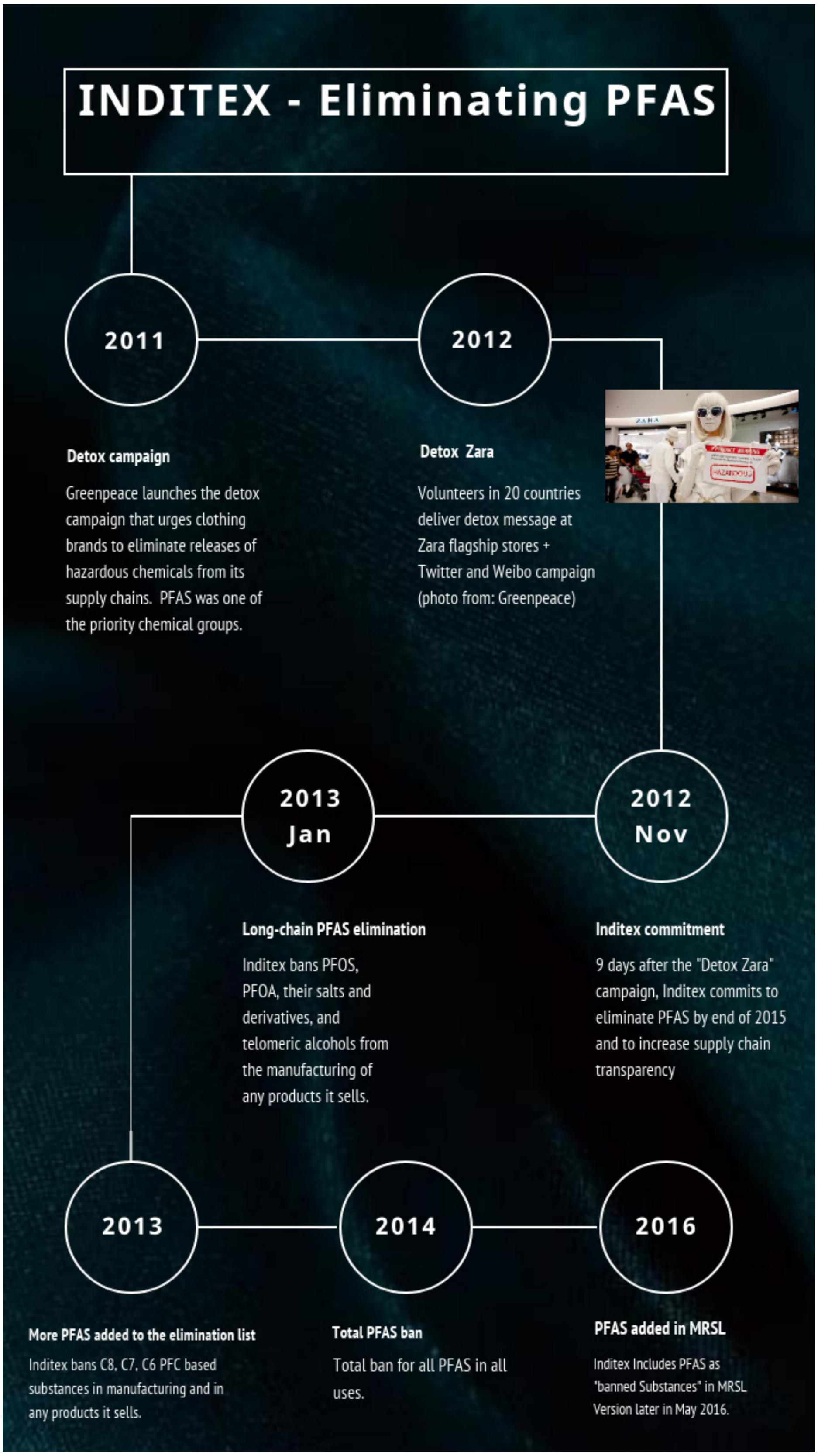


Figure 17 PFAS eliminaFigure 17: PFAS Elimination Roadmap: Inditex

Modified from: Greenpeace, "Detox My Fashion," accessed December 20, 2020, https://www.greenpeace.org/international/act/detox; Inditex, "Inditex Progress Report on the Detox Commitment 2020," April 2018, https://www.wateractionplan.com/documents/177327/558146/Inditex+Progress+Report+on+the+DETOX+Commitment+for+2020.+June+2018.pdf/1efb0cd7-2c76-04bc-f123-78d6fdd67c65; Inditex, "Inditex Commitment to Zero Discharge," November 27, 2012, https://www.wateractionplan.com/documents/177327/558146/Inditex+Commitment+to+Zero+Discharge.pdf/2d8a3c38-215e-a76c-00ed-0292eb137b9a.tion roadmap - Inditex

Under the PFAS elimination action element, Inditex planned to apply "the precautionary principle, recognizing that enough scientific evidence is available pointing towards a recognizable hazard posed by PFCs" and committed to "the total elimination of all PFC use in manufacturing and in products," which "includes the manufacturing of any products Inditex sells." The policy also requires "a review of all products it produces to ensure there are no PFCs in the products and a rigorous system of control to ensure that no traces of PFCs find their way into this supply chain in line with above."[108] Since then, a series of actions and improvements have been made in establishing a comprehensive system that Inditex uses today to ensure PFAS elimination and control. In 2016, the company received the "Avant-Garde" level from Greenpeace and was described as "on the cutting edge of the textile industry", with the company's PFAS elimination progress highlighted as one of its key accomplishments.

Approach to Chemicals Management

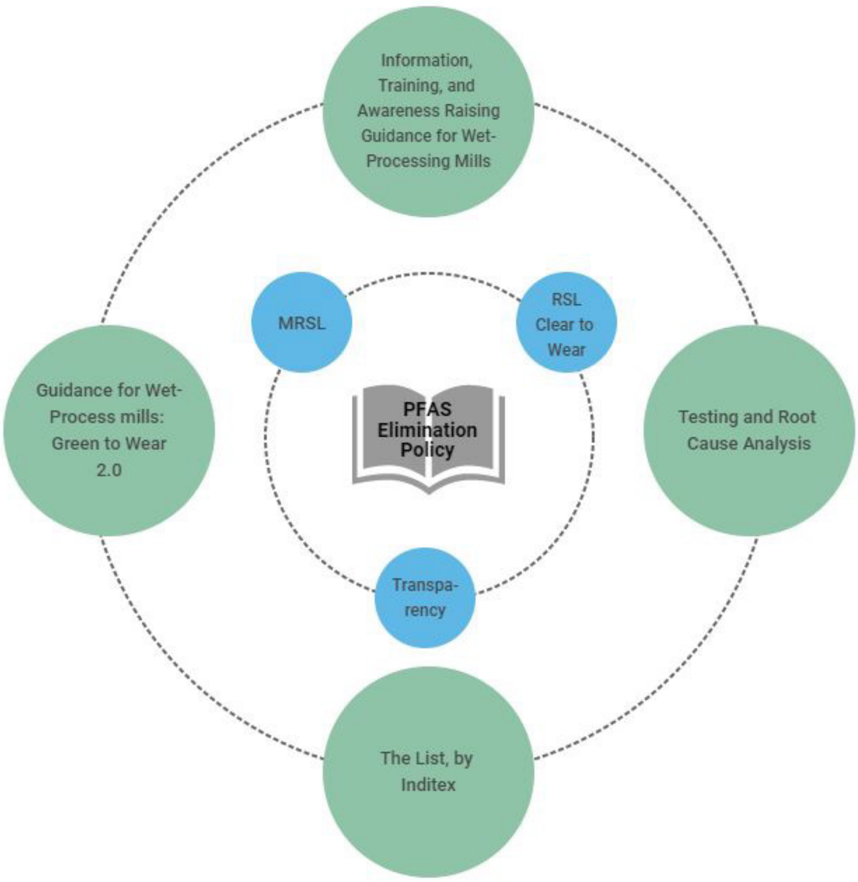


Figure 18 Inditex management and control structure for PFAS elimination

With PFAS elimination the central goal, a management and control system that covers both products and production was developed, with supporting instruments for implementation (see Figure 18). Three main tools were developed to ensure implementation of the PFAS elimination policy, along with several supporting instruments.

Clear to Wear

Clear to Wear is an RSL to safeguard consumer health and make sure no PFAS chemicals are contained in the company's final products.[109] This is a mandatory list that applies to all products aimed at uses younger than three years old (babies), clothing, footwear with direct and prolonged contact with the skin, accessories, and home textiles.

In the Clear to Wear standard, PFAS are defined as "a group of chemical substances derived from hydrocarbons where the hydrogen atoms have been replaced by fluorine atoms." Although Inditex prohibits the use of the whole PFAS chemical class, the company uses an individual substances list to manage and control PFAS use. The list is compiled based on PFAS applications in the textile industry. It is expected to include all PFAS chemicals that are used in the industry, which are, according to the current Clear to Wear standard, C4, C6, and C8 PFAS chemicals and the telomeric alcohols. All these chemicals are regularly tested for in final products. The standard also states that the lists are reviewed and revised annually to ensure all related chemicals are captured.

MRSL

The Inditex MRSL prohibits PFAS use in all manufacturing processes. PFAS fall under a usage ban in Inditex's MRSL, which indicates that the listed PFAS chemicals "may not be used to achieve a desired function or effect during production of the raw materials or product." Like the Clear to Wear standard, Inditex's MRSL is reviewed and revised annually. See Annex 1 of this report for the list of individual PFAS chemicals that are currently listed in Inditex's MRSL.

Traceability and Transparency

These appear to be among Inditex's priorities in managing its supply chain. All requirement and guidance materials are easily accessible on the company's website. Compiled supply chain and auditing results are also periodically reported. In China particularly, Inditex is part of the Green Supply Chain Map, which is developed by the Institute of Public & Environmental Affairs (IPE). In this map, Inditex is directly linked with its factories, many of which disclose their real-time discharge data, emission data, and compliance history (see Figure 19).

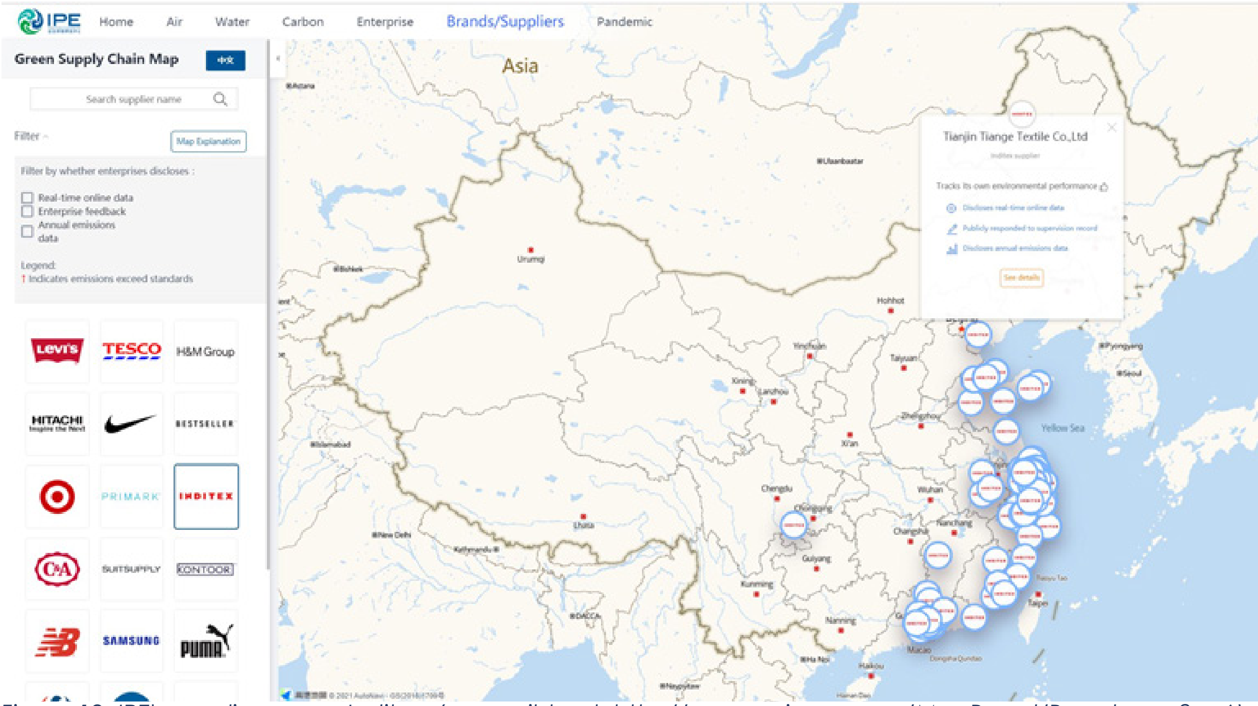


Figure 19 IPE's supplier map – Inditex (accessible at: http://wwwen.ipe.org.cn/MapBrand/Brand.aspx?q=6)

Supporting Instruments and Tools

While many brands and retailers set high standards for their suppliers, few help manufacturers fulfill these requirements. To support suppliers in complying with RSL and MRSL requirements, Inditex has developed a series of instruments and tools that manufacturing suppliers can use directly. Below are the tools most related to PFAS management.

Green to Wear 2.0

Wet-processing mills are the most resource intensive manufacturers in the textile industry. The two main production processes that occur at these facilities using PFAS are printing and finishing, where PFAS is used in water- and oil-repellency coating. Inditex developed several manufacturing guidance and standards specifically for wet-processing mills, which were recently merged into one document, Green to Wear 2.0.[110]

In the Green to Wear standard, wet-processing mills are categorized into four different levels:

- A ranking: best in class
- B ranking: facilities approved for Inditex productions
- C ranking: facilities approved for Inditex productions with a corrective action plan
- D ranking: facilities not approved for Inditex productions

Ranking is given to a mill based on its performance in emissions control, water and energy consumption, energy efficiency, wastewater discharge and testing, solid waste management, chemical management, and other operational requirements. Mills are asked to complete a questionnaire followed by an expert audit. It is worth pointing out that in this categorization, Inditex is linking its purchasing decisions directly to suppliers' environmental performance, as defined by clear standards. This linkage makes the sustainability requirements much more powerful than those where sustainability teams are working independently from the purchasing teams.

The List, by Inditex

Additional tools and guidance documents have been developed to further support the Green to Wear 2.0 standard. The List, by Inditex is a key document of Inditex's chemical strategy that was developed to help suppliers select chemicals that comply with the Clear to Wear RSL and MRSL requirements.[111]

Chemicals in this list are graded into three different categories: A, as chemicals that can be used without any restriction; B, as chemicals that may lead to non-compliance in the finished item due to manufacturing processes (thus, mills have to strictly follow the chemical technical data sheet and test more regularly); and C, as chemicals that cannot be used in any Inditex productions.

The fourth edition of The List, which was published in 2019, has a total of 23,373 chemicals from 24 manufacturers with classifications.

With respect to PFAS management, there are two key points:

There are around 180 chemicals from 16 manufacturers that Inditex approves for use as water or oil repellents. These chemicals generally provide water repellency but not oil repellency. This indicates that PFAS-free alternatives are widely available for water-repellent applications but not for oil repellency. However, with fashion clothing as the main product, oil-repellency is not a key function that Inditex needs to maintain.

There are more than 300 chemical mixes classified as C due to their PFAS content. While most of these chemicals are finishing auxiliaries—which include chemicals used as water- and oil-repellent coatings—some are dyes and printing pigments. This suggests that water-, oil-, and stain-repellency are not the only PFAS applications in the industry. A broader and more thorough screening is needed to avoid non-compliance in RSL and MRSL requirements.

Like other guiding documents, The List is updated regularly. The number of chemicals on the fourth edition of The List is five times greater than in the first edition from 2013. Mills may use chemicals that are not on The List but must follow a clear process detailed in a supporting document of Green to Wear 2.0.

Testing and Root Cause Analysis

At Inditex, testing is regularly performed on products for RSL requirements and in mills for MRSL requirements. RSL testing is conducted based on the Clear to Wear standard, and the ZDHC Wastewater Guidelines are often used for MRSL testing. The relevant section of the ZDHC Guidelines, which sets the limits of PFAS chemicals, is shown in Figure 20.

When issues arise from testing, Inditex sends designated expert teams to conduct root cause analysis and provide technical support to help mills cope with challenges.

Table 2K:

Perfluorinated and Polyfluorinated Chemicals (PFCs)

Substance or Substance Group	CAS	Reporting Limit (µg/L)	Standard Method for Analysis/ Testing
PFOS	1763-23-1	0.01	DIN 38407-42 (modified) Ionic PFC: Concentration or direct injection, LC/MS(-MS); Non-ionic PFC (FTOH): derivatisation with acetic anhydride followed by GC/MS
PFOA	335-67-1		
PFBS	375-73-5 29420-49-3 29420-43-3		
PFHxA	307-24-4		
8:2 FTOH	678-39-7	1	
6:2 FTOH	647-42-7		

Figure 20: PFAS Section of the ZDHC Wastewater Guidelines
Source: Roadmap to Zero Programme, ZDHC Wastewater Guidelines Version 1.1, ZDHC, July 2019, https://uploads-ssl.webflow.com/5c4065f2d6b53e08a1b03de7/5db70334bd2f007e2fbc8577_ZDHC_WastewaterGuidelines_V1.1_JUL19_compressed%20(1).pdf.

Information, Training and Awareness Raising

Inditex also invested in research and development to support its PFAS elimination efforts. For example, the company investigated PFAS alternatives, including assessing technical performance and potential toxicity.[112] It also developed and provided materials and training for direct suppliers and internal staff. Generally, Inditex developed a comprehensive chemical management system that led to success in eliminating PFAS use. The guiding documents and research results, which are shared publicly on Inditex's website, can play an important role for others working toward eliminating PFAS use.

Lessons Learned: Key Considerations

Keeping up with science is key to successful and efficient chemical management. For example, more comprehensive PFAS testing methods, such as total organic fluorine assays, have been developed recently. By adopting new testing methods for monitoring and quality assurances, brands, including Inditex, may be able to lower testing costs while capturing a broader variety of individual PFAS chemicals.

Inditex's market size and financial capacity is also an important element of its effective chemical management system. Suppliers and manufacturers are willing to comply with the company's requirements because the order sizes are significant. Inditex's ability to provide resources to facilitate supplier performance is another factor in this successful case study.

IKEA

Background

IKEA is a furniture retailer that has 445 stores in 60 markets around the world. IKEA's annual retail sales total around €40 billion, and its top five selling countries are Germany, the United States, France, the United Kingdom, and China.[113] IKEA's catalogue covers a wide variety of furniture and home products, including many textile articles such as upholstery, carpets and rugs, bedding, towels, and tablecloths. It is reported that textiles represent between 15 and 20 percent of IKEA's entire product range.[114] To ensure supply for this enormous number of products, IKEA works with 1,600 suppliers located in more than 50 countries.[115] Its top purchasing countries include China, Poland, Italy and Sweden.

IKEA is often seen as a front runner in eliminating and managing chemicals of concern, especially in furniture and textile products. IKEA's approach to its environmental and sustainability policies originated in the 1980s and 1990s, when the media started to report on toxic chemicals in the furniture giant's products and the environmental pollution caused by its production practices. The Danish government was the first to fine IKEA for formaldehyde exceeding the then newly legalized standard in the mid-1980s. When IKEA was able to track down the contamination source, a formaldehyde-containing glue, the furniture maker addressed the issue by working with chemical companies to eliminate formaldehyde from the glue. Ten years later, a second unexpected formaldehyde crisis occurred in IKEA's largest market, Germany. This time, formaldehyde was found in the BILLY bookshelf—one of IKEA's best sellers, both then and now—which resulted in a worldwide production pause and severe financial loss.[116] This appears to have been a turning point for IKEA's environmental and sustainability policies. These two formaldehyde crises stressed the importance of accounting for products' full life cycle. In both incidents, the production processes that led to formaldehyde contamination occurred in the upstream supply chain, which, at the time, usually did not have a close or direct working relationship with the ultimate brand and retail customers.[117]

IKEA has now developed a comprehensive environmental and chemical strategy and chemical-management system. Its chemical strategy, developed as a subcategory of its 2016 sustainability strategy, states, "All people have the right to safe and healthy products that are free from harmful chemicals."

Approach to Chemicals Management

There are a few highlights that contribute to IKEA's success in phasing out chemicals of concern.

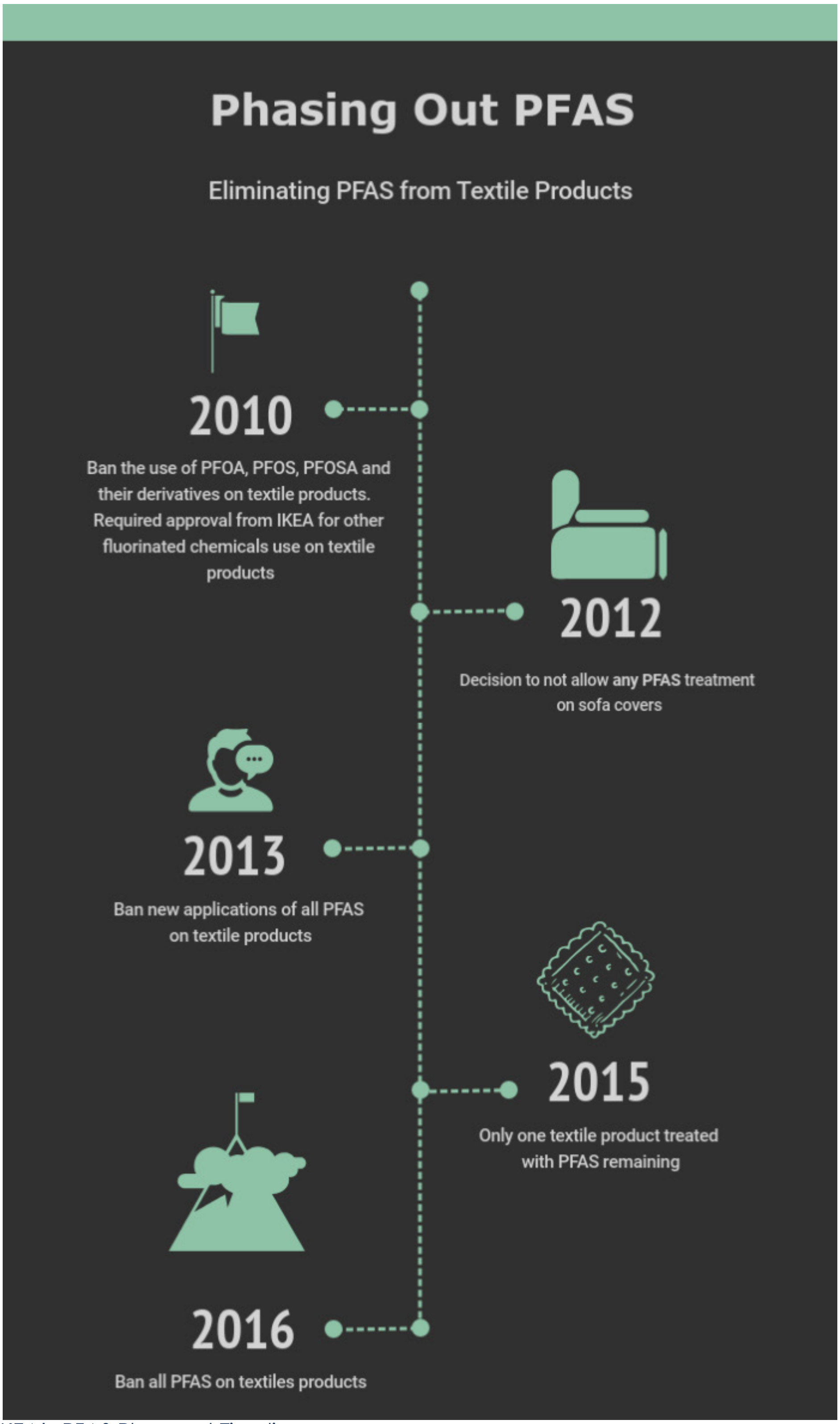


Figure 21: IKEA's PFAS Phaseout Timeline

Modified from: Therese Lilliebladh, "How IKEA Phases Out and Substitutes Chemicals of Concern," IKEA, June 2020, https://echa.europa.eu/documents/10162/29558259/05_therese_lillieblad h_scc2020_en.pdf/9569ec94-8b39-8a79-94cb-0b3b4bd8a2ca.

First, the class approach is applied to chemical management, where whole groups of chemicals of concern are banned. IKEA has also suggested that policy makers use the class approach to avoid regrettable substitutions. This is especially important in ensuring an efficient and effective PFAS elimination for the reasons discussed in previous sections.

Second, the strictest relevant regulations and policies are applied to all markets and suppliers across the board. IKEA requires that all articles comply with the strictest health, safety, and environmental requirements that exist within its sales markets. In some cases, IKEA requirements are stricter than all existing regulations. According to IKEA, the company's requirements are not only based on legislation, regulation, and standards, but also on current scientific knowledge. Customer expectations, nongovernmental organizations, and the media also play a very important role in decision-making. IKEA's ban on PFAS chemicals from all textile products is a good example. As we discussed in previous sections, this policy is more proactive than existing regulations for managing PFAS chemicals in the textile sector. Figure 21 shows the timeline of IKEA's phaseout of PFAS from its textile products.[118]

Third, a product's whole life cycle is accounted for. IKEA's chemical strategy states that all harmful effects to human health and the environment should be avoided throughout a product's life cycle, which includes raw material and final product manufacture, transport and distribution, product use, and end-of-life treatment. IKEA also tends to keep a longer than average relationship with its suppliers, with the current cooperation time averaging at 11 years.[119]

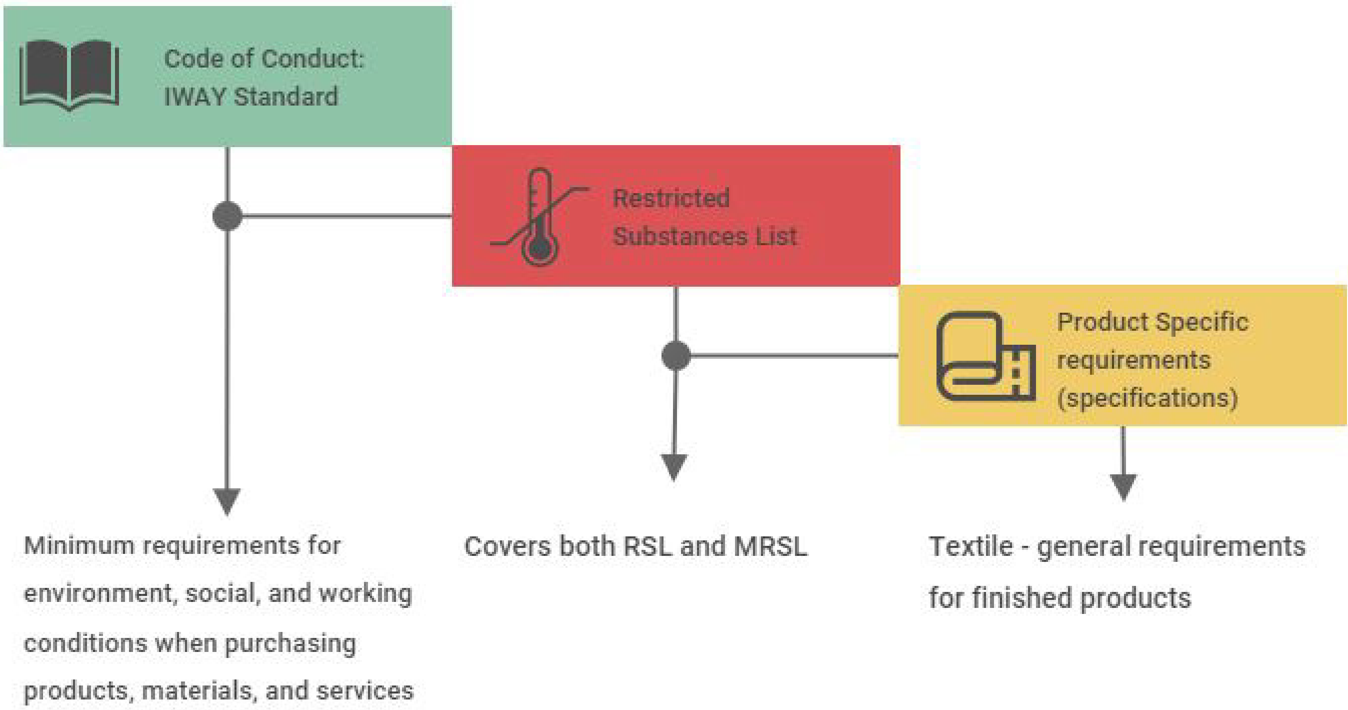


Figure 22: IKEA Specifications Related to Textile Products and PFAS

Fourth, IKEA's restricted substances list works as both an RSL and an MRSL. By having a restricted substance list that controls chemicals both contained in products and used in the manufacturing process, the health and safety of IKEA's customers and workers, as well as impacts on the environment, are accounted for when establishing chemical requirements.

Fifth, IKEA's chemical requirements are legally binding. IKEA uses a series of documents called specifications (see Figure 22 and Figure 23) to convey requirements to their suppliers. These specifications serve as legally binding contracts, which means IKEA has the right to terminate the purchasing agreement if the requirements are not fulfilled.[120]

Spec. no: IOS-MAT-0010
Date: 2019-12-20
Version no: AA-10911-15

Specification
Chemical compounds and substances

IKEA

Appendix J: List of common per- and polyfluoroalkyl substances (PFAS)

Note: this is an example list and is not a complete list of all PFAS

Table J: List of PFAS

Compound name	Acronym	CAS RN
PFSA-related substances		
Perfluoroctane sulfonate	PFOS	1763-23-1
Perfluoroctanesulfonamide	PFOSA	754-91-6
N-Methyl-Perfluoroctanesulfonamide	N-Me FOSA	31506-32-8
N-Ethyl-Perfluoroctanesulfonamide	N-Et_FOSA	4151-50-2
N-Methyl-Perfluoroctanesulfonamidoethanol	N-Me FOSE	24448-09-7
N-Ethyl-Perfluoroctanesulfonamidoethanol	N-Et FOSE	1691-99-2
Perfluorohexane sulfonate	PFHxS	355-46-4
PFCA-related substances		
Perfluoroctane acid	PFOA	335-67-1
Perfluorobutanoic acid	PFBA	375-22-4
Perfluoropentanoic acid	PFPeA	2706-90-3
Perfluorohexanoic acid	PFHxA	307-24-4
Perfluoroheptanoic acid	PFHpA	375-85-9
Perfluorononanoic acid	PFNA	375-95-1
Perfluorononanoic acid and its sodium and ammonium salts	NaPFN/APFN	21049-39-8, 4149-60-4
Perfluorodecanoic acid	PFDA	335-76-2
Perfluorodecanoic acid and its sodium and ammonium salts	NaPFD/APFD	3108-42-7, 3830-45-3
Perfluoroundecanoic acid	PFUnA	2058-94-8
Heptacosafluorotetradecanoic acid	PFTA	376-06-7
Tricosafluorododecanoic acid	PFDoA	307-55-1
Pentacosafluorotridecanoic acid	PFTrDA	72629-94-8
Ammonium pentadecafluorooctanoate	APFO	3825-26-1
Sodium perfluorooctanoate	NaPFO	335- 95-5
Potassium perfluorooctanoate	CaPFO	2395-00-8
Silver perfluorooctanoate	AgPFO	335-93-3
Perfluorooctanoyl fluoride	FPFO	335-66-0
Methyl pentadecafluorooctanoate	MePFO	376-27-2
Ethyl perfluorooctanonate	EtPFO	3108-24-5
Fluorotelomers		
Fluorotelomer sulfonate	FTS	757124-72-4
Fluorotelomer sulfonate	FTS	27619-97-2
Fluorotelomer sulfonate	FTS	678-39-7
1H,1H,2H,2H-Perfluorohexanol	FTOH	2043-47-2
1H,1H,2H,2H-Perfluoro-1-octanol	FTOH	647-42-7
1H,1H,2H,2H-Perfluoro-1-decanol	FTOH	678-39-7
1H,1H,2H,2H- Perfluorododecane-1-ol	FTOH	865-86-1
1H,1H,2H,2H-Perfluorooctylacrylat	FTA	17527-29-6
1H,1H,2H,2H-Perfluorodecylacrylat	FTA	27905-45-9
1H,1H,2H,2H-Perfluorododecylacrylat	FTA	17741-60-5
Tridecafluorooctyl methacrylate	FTMA	2144-53-8

Figure 23: Example List of Common PFAS

Source: IKEA's chemical compounds and substances specification document, spec. No: IOS-MAT-0010, version no: AA-10911-15.

Finally, IKEA applies an evaluation process for phaseout considerations. In this process, a series of stepwise questions are asked to evaluate the necessity of a chemical (see Figure 24).[121] This process was applied when considering PFAS elimination. According to IKEA, among the textile products in its catalog range, home and outdoor textiles were the key products being treated with PFAS for water and stain repellency. Using this evaluation process, IKEA was able to eliminate PFAS in products that only required water repellency, like shower curtains and rain gear, by finding available safer alternatives.

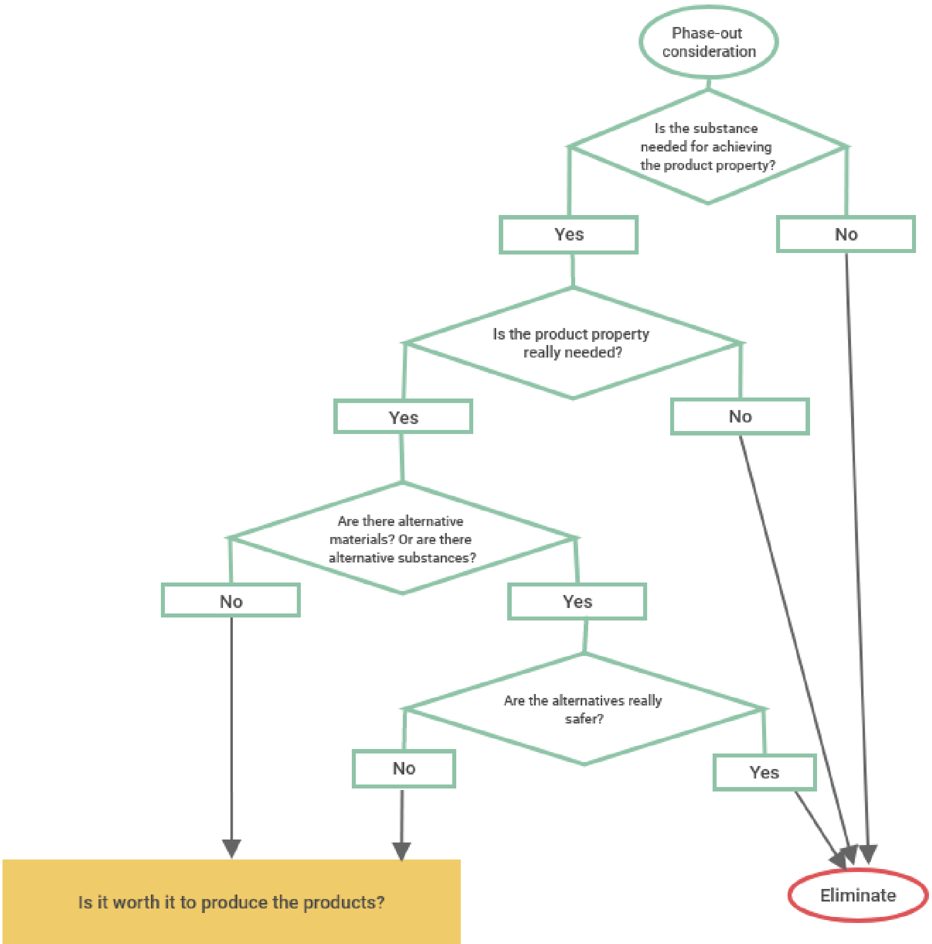


Figure 24: IKEA Phaseout Consideration Evaluation Process
Data source: Therese Lilliebladh, "How IKEA Phases Out and Substitutes Chemicals of Concern," IKEA, June 2020, https://echa.europa.eu/documents/10162/29558259/05_therese_lilliebladh_scc2020_en.pdf/9569ec94-8b39-8a79-94cb-0b3b4bd8a2ca.

However, this was not the case for a meter fabric sold on rolls. Most customers bought it to make tablecloths that had stain- and oil-resistant functionalities. When IKEA failed to find safe substitution to achieve this expected product property, the company was faced with the final question: "Is it worth it to produce the product?" IKEA decided it was not and took that meter fabric out of its product range.

Lessons Learned: Key Considerations

As IKEA stated during its presentation at the EU's Safer Chemicals Conference in 2020, "Most things still remain to be done."[122]

Keeping Up with the Science

When this report was drafted, IKEA was still using an earlier definition of PFAS:

> *"Substances which in their molecule contain a perfluorinated carbon chain with at least two carbon atoms (–CnF2n–, where n ≥ 2) and bonding to optional atoms or groups of atoms. Note: includes polymers/co-polymers, e.g. PTFE and fluoroalkyl acrylate co-polymers."*

The company should update its definition of PFAS to be consistent with scientific new developments, such as the definition provided by the OECD Global PFC Group on their website[123].

Increased Transparency

Details of IKEA's experiences eliminating PFAS are not readily accessible on the company's website. Increased transparency is beneficial for customers and other companies working to eliminate PFAS from their products.

Expand PFAS Policy to All Uses

One of IKEA's strategic objectives in chemical management is to conduct chemical risk assessments on all materials. Although IKEA has made the decision to phase out all PFAS use in textiles, as well as for paper and paperboard materials, IKEA is still using PTFE, also known as Teflon, in all its nonstick cookware.

Further, IKEA states under the sustainability section of these products: "No PFOA (perfluorooctanoic acid) is used to create the non-stick surface of this product." PFOA is only one of thousands of chemicals within the PFAS class. PFOA replacements used in the manufacture of PTFE, such as GenX, have also been found in the environment and to be associated with health harms similar to PFOA.[124] This language could mislead customers into thinking they are buying PFAS-free cookware.

Many cookware manufacturers have successfully phased out PFAS from their production, which makes it possible for IKEA to eliminate this harmful class of chemicals from their cookware products as well, utilizing the knowledge already gathered on PFAS. To make sure PFAS are not used anywhere else in IKEA's catalog, a thorough investigation across the whole product range should be conducted.

The Way Forward

Applying the Essential Use Framework for Assessing PFAS Use in the Textile Sector

As discussed previously, managing PFAS as a chemical class, especially in the textile sector, could be a more efficient and effective approach to reducing their harm to human health and the environment.[125] This approach is relevant for both the public and private sectors when developing policies and regulations and taking actions to eliminate PFAS chemicals.

As a result of the extreme persistence and associated risks of PFAS, it is critical to take action. While not all PFAS uses in the textile sector have safe alternatives, immediate reductions can still be achieved by phasing out all uses of PFAS where alternatives are available or when the functionality provided by PFAS is not necessary.

Whether or not PFAS are currently essential for a particular use and product will depend on the nature of the product, the functions for which PFAS are used, and whether safer alternatives are available to perform the functions deemed critical.[126] An alternative can either be a chemical substitution or a functional alternative, which refers to achieving the same functional objectives using a different material or technology. For example, materials or weaves can be changed to achieve water repellency instead of applying a chemical treatment.

If a certain PFAS use is determined to be non-essential, it should be eliminated. In the textile sector, for example, it is not essential for everyday-use fashion apparel and backpacks to be water- and/or stain-resistant.

For those PFAS uses that are considered currently essential but don't have a safer replacement chemical or technology, a temporary exemption can be applied. However, these exemptions should not be considered permanent. Instead, they should be treated as a temporary solution while efforts are made to develop a safe replacement, since PFAS-free alternatives are increasingly available in the market.[127]

The discussion of eliminating the PFAS chemical class is an example of managing chemicals of concern in the textile industry. A phaseout can be achieved for other chemical classes when similar effective policies are implemented in both the public and private sectors and when supporting guidance and tools are available.

Public-Sector Actions

Government stakeholders should provide strong governance, comprehensive policy frameworks, and support in capacity building as follows.

1. Eliminate non-essential PFAS productions/uses and prohibit analogous exports to the developing world.

   More comprehensive government actions and policy frameworks are needed to eliminate non-essential PFAS production and uses as soon as possible. These actions should also not allow prohibited PFAS or products to be exported from countries where there are restrictions to countries where there are no restrictions, to prevent disproportionate harm to vulnerable populations.

2. Promote research and development on safe alternatives for identified currently essential uses.

   Some critical PFAS uses, such as certain medical applications, may currently lack a safe alternative that provides the necessary level of performance. The public sector can provide the policy framework, strategic investments, and other support for research and development on identifying safe alternatives, particularly those uses related to societal well-being.

3. Periodically review uses deemed essential to account for development of alternatives development.

   The essential use decision making process should include a rigorous review mechanism for periodically revisiting uses deemed essential. The promotion of research and development will bring results. Accordingly, if during the review process a new, safe alternative is identified, the reviewed PFAS use may be considered substitutable and thus a candidate for phaseout. In this manner, continuous PFAS reductions can be achieved as alternatives become available.

4. Improve and expand global access to testing methods.

   To make sure that all PFAS are eliminated from non-essential products, regular and reliable testing is key. However, available testing methods for identifying the total amount of all PFAS chemicals in textile products are limited. There is a need for accessible, comprehensive PFAS testing technology to be expanded globally. The public sector can play a supporting role through capacity-building activities such as education, training, and targeted financial and technical assistance.

5. Facilitate data gathering, and international cooperation/capacity building

   The global trade of chemicals and products containing PFAS necessitates global cooperation in collecting the data for decision-making and for establishing the necessary policy frameworks, facilitating private-sector activities, and monitoring compliance. Legal frameworks and databases will be needed to obtain, compile, and utilize these data effectively. The public sector must exercise leadership in making this happen. Action areas may include facilitating information exchange for national, regional, or international regulatory frameworks and creating voluntary initiatives addressing PFAS, such as the OECD PFAS Portal. Particular attention may be devoted to data gathering and capacity building in the developing world through, for example, sharing data and experiences on industry PFAS use reporting and alternatives assessments. Regional data infrastructures may be promoted in the developing world to create efficiencies in data collection and to make maximum use of donor resources.

6. Facilitate private sector initiatives through purchasing decisions and awareness raising.

   Multiple examples have proven that companies can be front-runners in taking action, such as the efforts made by Inditex and IKEA. The public sector can be supportive of these efforts through procurement policies, education and outreach activities, and capacity-building opportunities that expand awareness of success stories and lessons learned.

7. Strengthen collaboration between all actors in the textiles value chain.

   SAICM's efforts in the textiles sector extend across the textiles life cycle, including the production of ingredients, chemical-critical stages of garment manufacturing, retail, consumption, and waste management. SAICM, with its multi-sectoral focus and platform for engagement with industry players, is well positioned to work across the value chain and provide a continued space for dialogue and action.

Private-Sector Actions

Companies in the private sector should adopt elimination policies and implement value-chain management that covers products' whole life cycle, as follows.

1. Adopt PFAS elimination policy at highest corporate levels.

   Senior management leadership and support will be needed to drive the necessary changes in manufacturing and supply chain managements. Only senior management can ensure cooperation throughout the company, including the purchasing divisions, and back up the commitment with the necessary resources.

2. Understand the supply chain and provide educational materials/training to suppliers to facilitate PFAS identification.

   With most manufacturing suppliers located all around the world, it is challenging for textile brands and retailers to conduct thorough chemical management on their supply chains. As a first step, brands and retailers must understand their supply chain well. That includes knowing who makes up the supply chain, mapping where they are located, drawing how they are connected, and identifying what chemicals are used for what purposes. Brands can use this learning process to provide training to their suppliers, especially on new and complicated topics such as PFAS. Such programs have seen many success stories when training, specifications, and guidance are provided by the brands.[128]

3. Inventory known and potential PFAS sources and uses – establish a baseline.

   One of the challenges of eliminating PFAS chemicals is identifying all of them. Using a class approach and new laboratory methods, companies may find it easier to inventory the presence of any PFAS and then focus their efforts on essential use determinations. Establishing a baseline inventory in the textile sector can be challenging—thus, companies are urged to be transparent in these efforts and share their experiences and success stories. Once the baseline is established, a clear goal and plan for PFAS elimination and reduction can be developed and implemented.

4. Assess essentiality of PFAS uses and alternatives, and make results known while protecting proprietary information.

   Textile brands and retailers should apply the essential use framework when taking action to eliminate PFAS use. While technical patents and intellectual property should be respected and protected, corporations should communicate to the public and other stakeholders the outcome of these decisions, so that Small and Medium Enterprises (SMEs) and others can follow to expedite PFAS eliminations globally and policy makers can be informed.

5. Conduct research and development on safe alternatives for identified essential uses.

   For certain PFAS uses that are currently deemed essential without available safe alternatives, textile brands and retailers, as well as technical experts, should take the initiative to conduct research and development on identifying safe alternatives for their products and supply chain.

6. Improve and expand global access to testing methods.

   Companies should exercise leadership and participate in capacity building where their supply chains are located. This includes creating and expanding testing capacity for PFAS measurement through their own activities and through their various trade associations and related entities. Without this capacity, companies will find it challenging to conduct the quality assurance needed to implement PFAS elimination policies.

7. Implement policy and monitor progress.

   Once a policy is developed and initiated, it may take years to accomplish all the desired results. A transparent process for obtaining data and reporting on results will be needed, both for stakeholders and policy makers.

8. Report policy implementation results transparently and confirm through a third-party audit.

   Companies will experience both successes and failures when implementing their PFAS elimination policies. Both are important to communicate widely, as lessons learned are digested and accumulated globally. Reporting accuracy and corporate credibility can be enhanced through a third-party audit conducted by an industrial expert.

Annex 1

list of individual PFAS chemicals that are currently listed in Inditex's MRSL.

7. PFCs		
Perfluorooctanoic acid (PFOA)	335-67-1	Usage Ban
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	Usage Ban
Perfluorooctanesulfonic acid potassium salt	2795-39-3	Usage Ban
Perfluorooctanesulfonamide	754-91-6	Usage Ban
Perfluorohexanoic acid (PFHxA)	307-24-4	Usage Ban
Perfluorohexanosulfonic acid (PFHxS)	355-46-4	Usage Ban
Perfluorobutanoic acid (PFBA)	375-22-4	Usage Ban
Perfluorobutanesulfonic acid (PFBS)	375-73-5	Usage Ban
2-(Perfluorooctyl)-ethanol (8:2 FTOH)	678-39-7	Usage Ban
2-(Perfluorohexyl)-ethanol (6:2 FTOH)	647-42-7	Usage Ban
2-(Perfluorobutyl)-ethanol (4:2 FTOH)	2043-47-2	Usage Ban
PFPeA	2706-90-3	Usage Ban
PFHpA	375-85-9	Usage Ban
PFNA	375-95-1	Usage Ban
PFDA	335-76-2	Usage Ban
PFUnA *(PFUnDA)*	2058-94-8	Usage Ban
PFDoA *(PFDoDA)*	307-55-1	Usage Ban
PFTrA *(PFTrDA)*	72629-94-8	Usage Ban
PFteA *(PFTeDA)*	376-06-7	Usage Ban
PFDS	335-77-3	Usage Ban
10:2 FTOH	865-86-1	Usage Ban
6:2 FTA	17527-29-6	Usage Ban
8:2 FTA	27905-45-9	Usage Ban
10:2 FTA	17741-60-5	Usage Ban
POSF	307-35-7	Usage Ban
N-Me-FOSA	31506-32-8	Usage Ban
N-Et-FOSA	4151-50-2	Usage Ban
N-Me-FOSE alcohol	24448-09-7	Usage Ban
N-Et-FOSE alcohol	1691-99-2	Usage Ban
PF-3,7-DMOA	172155-07-6	Usage Ban
HPFHpA	1546-95-8	Usage Ban
4HPFUnA	34598-33-9	Usage Ban
1H, 1H, S2, 2H-PFOS	27619-97-2	Usage Ban

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