



Toxics Link  
for a toxics-free world

# PFAS

## A Chemical of Concern

2026

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# Abbreviations

AFFF	Aqueous Film-Forming Foam
BIS	Bureau of Indian Standards
CAGR	Compound Annual Growth Rate
CPCB	Central Pollution Control Board
ECHA	European Chemicals Agency
EPA / USEPA	United States Environmental Protection Agency
F3 / SFFF	Fluorine-Free Foam / Synthetic Fluorine-Free Foam
FPM	Food Packaging Materials
FSSAI	Food Safety and Standards Authority of India
FTOH	Fluorotelomer Alcohol
ISO	International Organization for Standardization
MoEFCC	Ministry of Environment, Forest and Climate Change
ng/L	Nanograms per Liter
OECD	Organisation for Economic Co-operation and Development
PAPs	Polyfluoroalkyl Phosphates
PFAS	Per- and Polyfluoroalkyl Substances
PFBA	Perfluorobutanoic Acid
PFBS	Perfluorobutane Sulfonate
PFCA <sub>s</sub>	Perfluorocarboxylic Acids

# Abbreviations

PFHxA	Perfluorohexanoic Acid
PFHxS	Perfluorohexane Sulfonate
PFOS	Perfluorooctane Sulfonate
PFPE	Perfluoropolyethers
PFOA	Perfluorooctanoic Acid
PFSAs	Perfluorosulfonic Acids
POPs	Persistent Organic Pollutants
PPB	Parts per Billion
PPT	Parts per Trillion
PTFE	Polytetrafluoroethylene
PVDF	Polyvinylidene Fluoride
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
SIN List	Substitute It Now List
SVHC	Substances of Very High Concern
TSCA	Toxic Substances Control Act
TWI	Tolerable Weekly Intake
UNEP	United Nations Environment Programme
µg/kg	Micrograms per Kilogram

## Executive Summary

Per- and polyfluoroalkyl substances (PFAS) comprise a large group of synthetic chemicals that have been extensively used since the 1950s in a wide range of consumer and industrial products, including food packaging, textiles, firefighting foams, cosmetics, and paints. Their unique water-, oil-, and heat-resistant properties have contributed to their widespread application across sectors.

However, growing scientific evidence has brought to light significant concerns regarding their persistence, toxicity, and environmental mobility. Due to their extremely long half-lives and resistance to degradation, PFAS are commonly referred to as “forever chemicals.” These characteristics enable them to accumulate in the environment and living organisms, posing long-term risks to human health and ecosystems.

Recognising these risks, global regulatory efforts have been mooted. Under the Stockholm Convention on Persistent Organic Pollutants, several PFAS compounds—such as perfluorooctanoic acid (PFOA), perfluorooctane sulfonate (PFOS), and perfluorohexane sulfonate (PFHxS)—have been listed for restriction or elimination due to their persistence, bioaccumulation potential, toxicity, and ability for long-range environmental transport. In addition, the European Union and other countries, including China, Thailand, and Vietnam, have introduced regulatory measures to control PFAS use at both product and industrial levels as well as the in the environmental matrix.

In India, research on the occurrence and fate of PFAS in environmental matrices remains limited. Nevertheless, there is increasing recognition of their potential adverse impacts. Recent notifications by the Food Safety and Standards Authority of India and the Ministry of Environment, Forest and Climate Change indicate a growing policy focus on addressing PFAS-related risks.

Given the evolving global regulatory landscape and increasing trade implications, India needs to develop a comprehensive policy framework for PFAS management. Such a framework should address the entire lifecycle of these chemicals—from production and use to disposal—while aligning with international obligations and market requirements. This will not only help minimise environmental and health risks but also enhance the competitiveness of Indian products in the global market.

This document has therefore been prepared to assess the Indian scenario vis-à-vis global developments and to recommend appropriate policy actions for effective PFAS management, while ensuring minimal economic disruption.

# I. Introduction

Per- and polyfluoroalkyl substances (PFAS) are a family of man-made high-volume chemicals that are found in an extensive range of products. There are nearly 12,000 of chemicals included under PFAS out of which 5,000 types of PFAS are used commercially.

According to OECD/UNEP Global PFCI Group, PFAS are aliphatic organic compounds that share the feature of linked carbon atoms with complete (perfluorinated) or partial (polyfluorinated) replacement of hydrogen atoms by fluorine atoms.<sup>1,2</sup> These

chemicals are having diverse terminal functional groups of different length such as sulfonate, carboxylate, sulphonamide, alcohols, and phosphonate which can change the toxicity of the chemicals.<sup>3,4</sup>

This group of chemicals is known to be extremely persistent in the environment and within the human body, and is therefore widely referred to as “forever chemicals.” Their long-term persistence can pose significant risks to human health and wildlife.<sup>5,6</sup>

## FOUR MAIN INDUSTRIAL USES:

- Surfactant - Extremely low surface-tension
- Emulsifier
- Low friction
- Water, oil, grease, solvent repellent

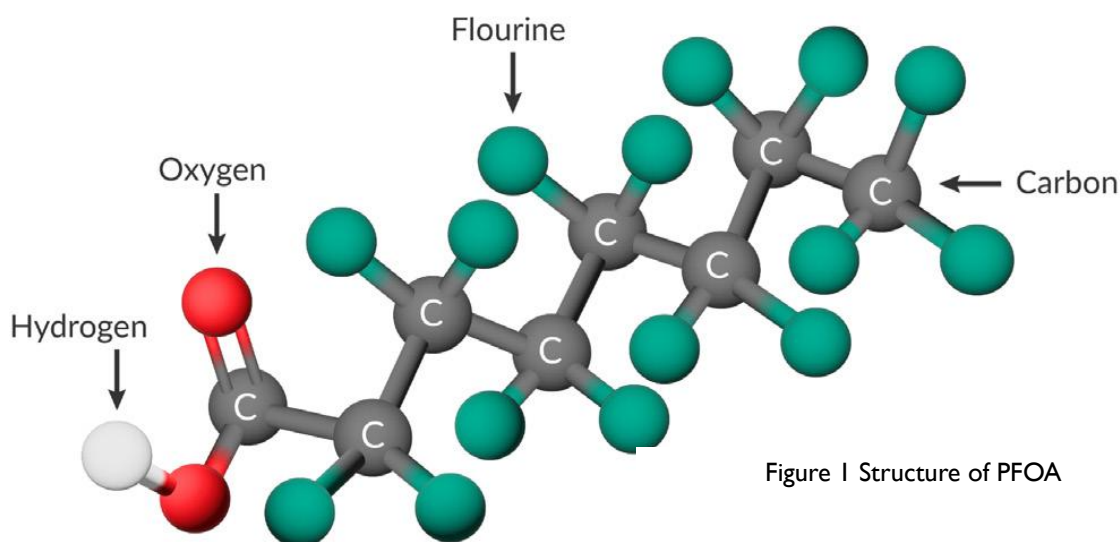


Figure 1 Structure of PFOA

## 2. Types of PFAS

### Classification of PFAS

The general classification of per- and polyfluoroalkyl substances (PFASs) is based on commonly agreed terminology for the nomenclature of PFASs. This classification is produced by the Organization for Economic Cooperation and Development (OECD) based on their chemical structure and number of fluorine atoms. PFAS can be sorted in many ways based on their structure. PFAS are described as long-chain or short-chain. Perfluoroalkyl sulfonates with five or fewer carbons, and perfluoroalkyl carboxylates with seven carbons or less are considered as **short-chain PFAS**. While Perfluoroalkyl sulfonic acids with 6 or more C atoms and perfluoroalkyl carboxylic acids with 7 or additional C atoms are considered **long-chain PFAS** and are sometimes known as legacy PFAS.<sup>7</sup>

PFAS are classified as either *non-polymer* or *polymer*.

- I. **Non-Polymers:** Non-polymer PFAS are small, discrete non-repeating molecules with low-molecular weight. They contain at least one fully fluorinated carbon group ( $-\text{CF}_2-$  or  $-\text{CF}_3$ ) and are characterised by strong carbon-fluorine bonds, which make them thermally stable, chemically resistant, and environmentally persistent<sup>8</sup>.

The two most widely studied subclasses are perfluorooctanoic acid (PFOA), perfluorooctane sulfonate (PFOS), perfluorohexane sulfonate (PFHxS), and shorter-chain analogues<sup>9</sup>. PFOA and PFOS, for example, have been used historically in a wide range of industrial and consumer products, including aqueous film-forming foams (AFFF) for firefighting, stain-resistant carpets, greaseproof food packaging, water-repellent textiles, chrome-plating operations, and numerous specialty chemical applications.

Non-polymer PFAS also include precursor compounds, such as **fluorotelomer alcohols (FTOHs)** and **polyfluoroalkyl phosphates (PAPs)**, are used as building blocks for certain polymer and non-polymer PFAS-based products.

A number of PFAS are on the REACH Candidate List of substances of very high concern (SVHC). In **Jan 2025, the European Chemicals Agency (ECHA) has proposed to ban 12000 substances of this group under REACH.**<sup>10, 11</sup>

2. **Polymers:** They are high-molecular-weight large molecules formed by combining many identical smaller per- and polyfluoroalkyl molecules. They are generally categorised into fluoropolymers (e.g., polytetrafluoroethylene, PTFE), perfluoropolyethers (PFPEs), and side-chain fluorinated polymers. These compounds are highly stable with low volatility, low solubility, and limited direct bioaccumulation in living organisms. However, their production processes can release non-polymer PFAS as by-products, and incineration or environmental degradation may generate harmful compounds.

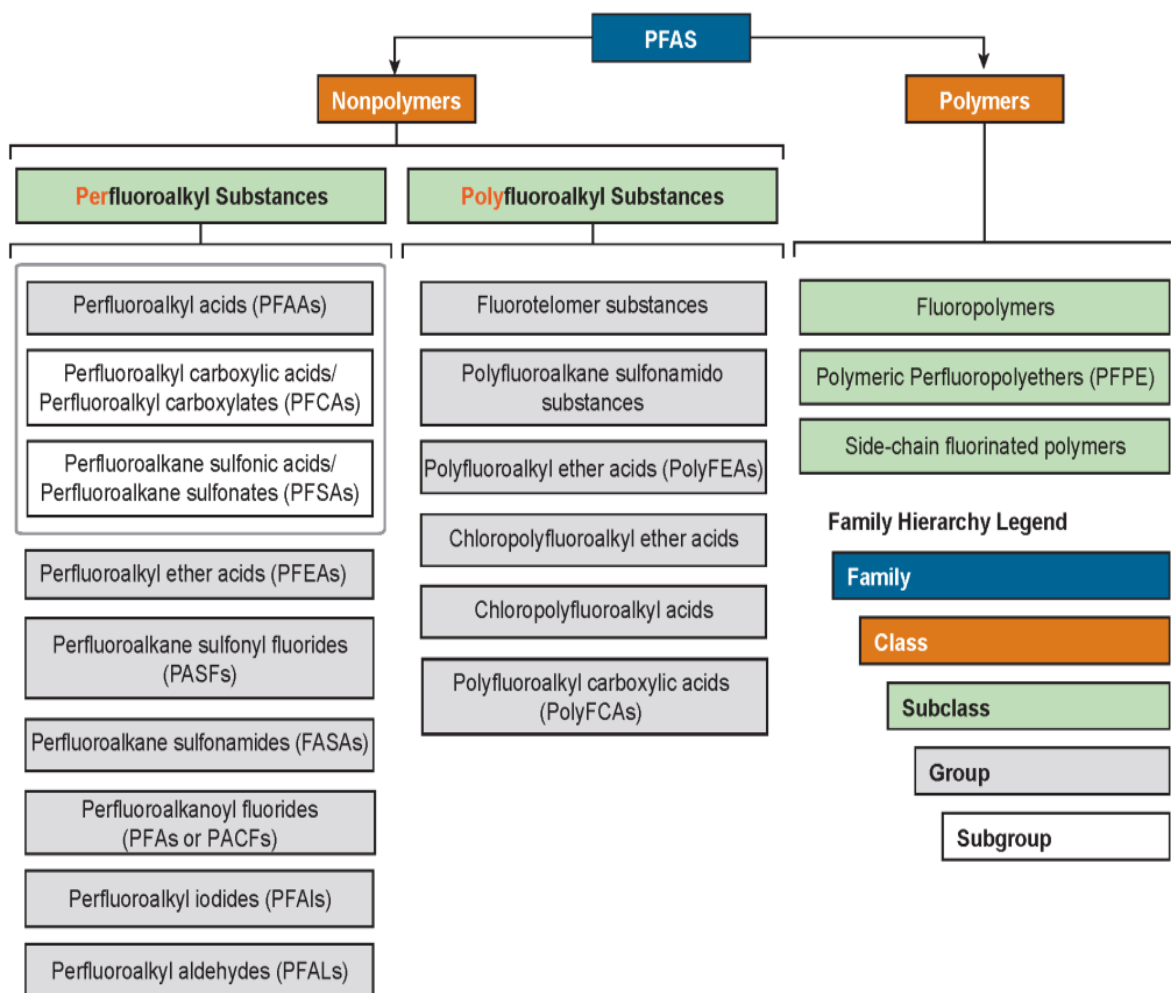


Figure 2. The PFAS Family. Source: <https://pfas-1.itrcweb.org/2-2-chemistry-terminology-and-acronyms/>

### 3. Industrial Application

PFAS have been produced on a commercial scale since the 1950s. PFAS generally reduce surface tension, foaming, lubrication, water/oil repellency, and coatings. A 2021 inventory of PFAS identified more than 4,700 PFAS with Chemical Abstracts Service (CAS) Registry Numbers that could have been, or may be, on the global market.<sup>12</sup>



Figure 3. Usages of PFAs. Source: <https://watermanaustralia.com/pfas-contaminated-water-treatment-techniques/>

Industry/Application	PFAs Type	Uses
Aviation and Aerospace	Polymer	Mechanical components (PFA tubing, piping, seals, cables and insulators)
	Nonpolymer	Hydraulic fluid additives to prevent evaporation, fires and corrosion
Automobile	Polymer	Mechanical components (wiring, cable, bearing, lubricants, polymer coating on carpets)
	Nonpolymer	Surface treatment for carpets, leather and exterior surfaces
Herbicides and Pesticides	Polymer	Not reported
	Nonpolymer	Active ingredients such as short-chain sulfonamides in plant growth regulators and sulfluramid in ant and termite baits
Building and construction	Polymer	Fluoropolymer membranes and coatings on roofing, stones, concretes; adhesives and additives in paints
	Nonpolymer	Additives in paints, coatings and surface treatments
Cosmetics and Personal care products	Polymer	Dental floss and micro powders in creams and lotions
	Nonpolymer	Shampoo, nail polish, eye makeup and dental cleaners
Electronics	Polymer	Insulators, solder sleeves, printed circuit boards, transducers
	Nonpolymer	Flame retardants for polycarbonate resin
Food Processing	Polymer	Fluoropolymer fabrication materials
	Nonpolymer	Coatings on food packaging
Metal Plating	Polymer	Not reported
	Nonpolymer	Wetting agent, mist suppression for harmful vapours
Mining	Polymer	Not reported
	Nonpolymer	Surfactants used in oil mining flotation
Textiles (upholstery, leather and apparel)	Polymer	Fluoropolymers used in outdoor gear, clothing and housewares, stain release finishing
	Nonpolymer	Chromium treatment for leather, coatings for oil and water repellent and stain release finishes
Household products	Polymer	Nonstick coatings on utensils
	Nonpolymer	Floor finishes and polishes, cleaning agents

## 4. Market Overview of PFAS

The Global PFAS Chemicals Market was valued at USD 3.5 billion in 2024 and is expected to reach USD 5.2 billion by 2030 with a CAGR of 5.8% from 2025 to 2030. Despite increasing regulatory restrictions on long-chain PFAS compounds worldwide, the market continues to expand as many industries transition toward short-chain PFAS alternatives. Incidentally the growth is largely supported by rising demand in emerging markets, particularly in the Asia–Pacific region, driven by expanding the applications in the textile, packaging, automotive, and electronics sectors.

In India PFAS chemicals market is projected to reach USD 51,727.5 million by 2034 from USD 29,500.0 million in 2023, growing at a CAGR of 5.19% during the forecast period 2024-2034<sup>13</sup>. Specifically, the fluoropolymers are valued at USD 817.7 million in 2023 and is projected to grow at a CAGR of 10.5% from 2024 to 2030. The fluoropolymers include Polytetrafluoroethylene (PTFE), Polyvinylidene Fluoride (PVDF), Fluorinated Ethylene Propylene (FEP), Fluoro-elastomers etc. Key India Fluoropolymer Companies are: <sup>14</sup>

- Gujarat Fluorochemicals Limited
- GMM Pfaudler
- Nishigandha Polymers
- Isha Fluoropolymer Co.
- NexGen
- Scorpion Industrial Polymers Private Limited
- Anhui Sinograce Chemical Co., Ltd.
- Dhvani Polymer

The growing market of the PFAS in India also need to be assessed critically.

## 5. Regulated PFAS

The decades of the studies have established that some of PFAs congeners are highly toxic and persistent for longer period. Therefore, considering these health and environmental impacts with the growing evidence of persistence, toxicity, and widespread environmental occurrence, the Stockholm Convention have listed some of these chemicals as persistent organic pollutants (POPs). Further the European chemicals legislation REACH (REACH 2006), have included many of the congeners of PFAs

as the chemicals of concern and has included in SIN list.

Notably, **Perfluorooctane sulfonate (PFOS)**, **Perfluorooctanoic acid (PFOA)**, and **Perfluorohexane sulfonate (PFHxS)**, along with their related compounds, have been listed as POPs under the Stockholm Convention. Several countries that have ratified the Convention regulate their use through measures such as exposure limits, product controls, and drinking water standards [**Annex I & II**].

### 5.1. Perfluorooctane Sulfonate (PFOS)

Perfluorooctane sulfonate (PFOS: C<sub>8</sub>F<sub>17</sub>) was added to Annex B of the Stockholm Convention on POPs in May 2009, with specific exemptions. According to a 2002 study by the Environmental Directorate of the OECD "PFOS is persistent, bio accumulative, and toxic to mammalian species<sup>15</sup>. It has a capacity to undergo long-range transport and also fulfills the toxicity criteria of the Stockholm Convention.<sup>16</sup>

Several countries have ratified this chemical ranges from strict no-zero limits in products and developed standards in drinking water to safeguard public health. For instance, China has established the drinking water standard of 40 ng/L for PFOS while EU has 0.1 ppb limit for the sum of 20 individual PFAS compounds

#### List of Acceptable Purposes and Specific Exemptions For Production And Use of PFOs, Its Salts & PFOs-F

##### Acceptable purposes:

Insect baits with sulfluramid (CAS No. 4151-50-2) as an active ingredient for control of leaf-cutting ants from *Atta* spp. and *Acromyrmex* spp. for agricultural use only.

##### Specific exemptions:

Metal plating (hard-metal plating) only in closed-loop systems; fire-fighting foam for liquid fuel vapour suppression and liquid fuel fires (Class B fires) in installed systems, including both mobile and fixed systems.

including PFOS. Denmark has also introduced a soil quality standard of 0.4 µg/kg for PFOS. In 2020, EU has also established a group tolerable weekly intake (TWI) threshold of 4.4 nanograms per kilogram of body weight per week. Additionally, PFOS has been banned in aqueous film-forming foams (AFFF) in the EU since 2011. More recently, in 2025, the European Chemicals Agency has restricted its application in technical textile, printing, sealing, excipients for pharmaceuticals, explosives etc. reflecting an increasingly comprehensive regulatory approach.

Similarly, countries such as Australia, Singapore, and Japan, along with a few US States such as Illinois, Washington, New Jersey, Massachusetts and Connecticut have banned PFOS in AFFF. In addition, China, in Dec 2023, has enlisted 10 PFOS congeners in List of New Pollutants for Priority Control (2023 Edition) that prohibit its manufacture, processing, use, import, or export. In India there is no regulation in place to restrict use of the chemical in the product and studies have found the contamination of these chemicals in the water .

## 5.2. Perfluorooctanoic Acid (PFOA)

PFOA, its salts and PFOA-related compounds were added to **Annex -A** in Stockholm Convention in COP-9 held in Geneva in May 2019 with specific exemptions for metal plating (hard-metal plating; only in closed-loop systems), fire-fighting foam for liquid fuel vapour suppression and liquid fuel fires (Class B fires) in installed systems.

Several countries have ratified PFOA and imposed restriction on its production, import and export. EU has restricted PFOA in AFFF in 2017 and further expanded restrictions in 2025 in technical textile, printing, sealing, excipients for pharmaceuticals, explosives etc. Countries such as Japan (since 2024) and Taiwan (since 2025) have implemented comprehensive bans across all sectors. Many US States have restricted its application in firefighting foam, cosmetics, textiles and food packaging materials. Canada has announced to completely banned PFOA in firefighting foam since 2027. Similarly, Singapore has also restricted PFOS in firefighting foams.

In contrast, India currently does not have specific regulations restricting the use of PFOA in consumer products, although “PFOA-free” labelled products, particularly utensils, are available in the market.

### 5.3. Perfluorohexanesulfonic Acid (PFHxS)

Perfluorohexanesulfonic acid (C<sub>6</sub>F<sub>13</sub>SO<sub>2</sub>, PFHxS) is a chemical compound from the group of short-chain perfluorosurfactants. It is a perfluoro-alkane-sulfonic acid in which all thirteen hydrogen atoms attached to carbons have been replaced by fluorine.<sup>17</sup> OECD has identified 72 PFHxS-related/precursor/polymer substances including PFHxS which contain the fluorinated alkyl moiety C<sub>6</sub>F<sub>13</sub>SO<sub>2</sub>. PFHxS was introduced as an alternative to PFOS. PFHxS has also been unintentionally produced during the electrochemical fluorination (ECF) processes of some other PFSA.

However, due to its negative health & environment impact, PFHxS was added to Annex A in Stockholm Convention in COP-10 held in Geneva in June 2022 without any exemption. Countries those have ratified and banned PFOS and PFOA have also banned PFHxS.

## 6. Alternatives

PFAS are used in a wide range of different industrial and consumer applications. However, due to their extreme environmental persistence and their impacts on human and ecosystem health, PFAS have been subject to many regulatory activities leading industries turning to alternatives. For instance, Fluorine-free foams (F3) are being adopted across the globe.<sup>18</sup> Many MNCs are phasing out PFAS from their products such as H&M (2013 in clothing & 2018 in cosmetics)<sup>19</sup>, Benetton (since 2013 in phase manner; 99% shifted by 2024)<sup>20</sup>, UNIQLO (2017)<sup>21</sup>, Home Depot (2019)<sup>22</sup> etc. Many other industries have announced to phase out in near future, for instance, 3M announced to phased out by 2025-26, EcoLab by 2026, BYK additives by 2026, Solvay by 2026, BASF by 2028, etc.<sup>23,24,25</sup>

These alternatives are either short-chain substitution for long-chain or multi-fluoro substitution for per-fluoro to reduce the proportion of fluorine atoms. There are thousands of PFAS-derived alternatives are being used or will be used in global production and commercialisation. The USEPA had review hundreds of “shorter chain-length PFAS telomeric” substitutes which is available under the TSCA New Chemicals Program<sup>26</sup>, and other documentation regarding replacement PFAS chemistries is available from the Performance Fluoropolymer Partnership<sup>27</sup> (2021) and American Chemistry Council<sup>28</sup> (2021).

Some fluorine containing alternatives are<sup>29</sup>:

- Short chain homologues of the long-chain PFAAs, including PBSF-based derivatives
- Perfluorohexane sulfonyl fluoride (PH<sub>x</sub>SF) as an alternative to PFH<sub>x</sub>S and PFOS
- Fluorotelomer-based products
- per- and poly-fluoroalkyl ether acids used as polymerisation aids in manufacture of fluoropolymers
- 6:2 fluorotelomer-based compounds

However, concerns have also been raised regarding these alternatives. Scientific studies indicate that that commonly used short-chain alternatives such as Perfluorohexanoic acid (PFH<sub>x</sub>A), perfluorobutanoic acid (PFBA), Sodium p-Perfluorooctanesulfonate (OBS) and 6:2 Fluorotelomer sulfonate etc. can cause deleterious effects such as oxidative stress, hepatotoxicity, neurotoxicity, histopathological alterations, behavioural and growth abnormalities, reproductive toxicity and metabolism defects in freshwater and marine species etc.<sup>30, 31,32 33</sup>.

PFAS-free alternatives, substance that does not contain fluorine, are also available in the market. Figuière et al (2025) have developed alternative assessment frameworks and identified 530 PFAS-free alternatives that are suitable to replace PFAS from 40 different applications.<sup>34</sup>

The four main families of alternative substances are:

1. Paraffin waxes
2. Hydrocarbon chains/branched
3. Silicones
4. Nanomaterials

Further, OECD/UNEP Global PFC Group had released report on the commercial availability and current uses of non-PFAs alternatives in food packaging materials<sup>35</sup> (2020) and coatings, paints and varnishes<sup>36</sup> (2022).

The Washington State Department of Ecology<sup>37</sup> also came up with safer alternatives in food packaging. The PFAS-free alternatives mentioned in these reports includes:

- Polyurethane (PU), polyethylene, polyvinylchloride, silicone, nano ceramic and nano aluminium oxide in coatings
- Glass, polyester, polyamides and polyethylene terephthalate for solar panels
- Polyurethane for paints
- Silicone, water-based synthetic biopolymers, vegetable-oil based bio-waxes, polylactic acid foam, starch, clay, chitosan or water soluble hydroxyethylcellulose, glass, aluminium, and reusable options for food packaging

## 7. Regulation in India

The Government of India has accepted the listing of these chemicals as Persistent Organic Pollutants (POPs) under the Stockholm Convention on Persistent Organic Pollutants. However, it has not yet ratified PFOS, PFOA or PFHxS that are enlisted as POPs in the Stockholm Convention and there is no national level regulation to address PFAS in products or environmental matrices.

The Government of India has released a Draft Chemical Management Rule 2020 that recognises PFOS and PFOA and their congeners as hazardous chemicals and gave a major thrust to manage these toxic chemicals. However, the draft is not yet notified.

Similarly, India has no established enforceable limits for PFAS in drinking water. Though the Bureau of Indian Standards (BIS) announced on 28 September, 2020 to adopt the PFOS and PFOA International Standards Organization (ISO) benchmarks as Indian Standards (IS) in water that includes ISO 3696:1987 water for analytical laboratory use – specification and test methods; ISO 5667-1 water quality – sampling – part 1: guidance on the design of sampling programmes and sampling techniques; and ISO 8466-1:1990 water quality – calibration and evaluation of analytical methods and estimation of performance characteristics – part 1: statistical evaluation of the linear calibration function. However, this has not been notified yet.

In October 2025, the Food Safety and Standards Authority of India (FSSAI) has released a draft amendment to the *Food Safety and Standards (Packaging) Regulations, 2018*, termed the *Food Safety and Standards (Packaging) Amendment Regulations, 2025* that proposes complete ban on use of PFAs in the manufacturing of food contact materials<sup>38</sup>.

Regrettably, considering the lack of regulation in India and increasingly stringent regulatory controls in many developed countries have led PFAS-related manufacturing and processing units to relocate and/ or expand in India, hence raising concerns about potential future environmental releases and exposure risks in the country.

The recent regulation on contaminated sites released by the Ministry of Environment Forest and Climate change under the Environment Protection (Management of Contaminated Sites) Rules, 2025 has restricted the presence of the PFOs, PFOAs and PFHx in the ground water. This regulatory development reflects the growing recognition of the risks and hazards associated with these chemicals.

## 8. Actions Needed

There are recent research studies that have reported presence of PFAS in Indian environmental matrices (Annex III). Given that India is a significant producer and user of PFAS substances, there is need of the regulation on restricting the use of the PFAS in the products where the economically viable alternatives are available.

Priority sectors for such regulation include food packaging and other food contact materials, textiles, firefighting foams, cosmetics, and paints—where safer substitutes already exist. Strengthening regulatory action in these areas would help reduce environmental contamination and limit human exposure, while also aligning with global efforts under frameworks such as the Stockholm Convention on Persistent Organic Pollutants.

Industrial Sector	Types of PFAS	Global Regulation	Alternatives	Alternatives Market share	Cost
Food packaging materials and food contact materials	PFOA, PFOS, fluorotelomer phosphate esters (PAPs), perfluorocarboxylic acids (PFCAs), and perfluorosulfonic acids (PFSA), such as 6:2 FTS, PFHxA, PFBS, and GenX etc.	Japan, Canada, Philippines, EU, US	Bio-based coatings (waxes, starches, proteins), silicones, talc-filled water-based polyacrylate, clay-based coatings (bentonite, halloysite), and engineered materials like graphene oxide or cellulose nanofibrils	Market share is growing	<ul style="list-style-type: none"> <li>• Talc-filled water-based polyacrylate ₹48 to ₹125 per kilogram</li> <li>• Food grade halloysite- ₹4,999 and ₹6,500 per kilogram</li> <li>• Food grade bentonite- ₹25 to ₹80 per kg</li> </ul>
Firefighting foams	Long-chain substances like PFOS and PFOA, Short-chain: C6-based fluorosurfactants	Australia, Canada, Japan, EU, Singapore, US	Alcohol Resistant-Synthetic Fluorine Free Foam (sulfuric acid derivative- mono-octyl-decyl-alkyl esters, sodium salts; D-Glucopyranose, oligomers, decyl octyl	Market share is growing	<ul style="list-style-type: none"> <li>• Mono-octyl-decyl-alkyl esters- Rs 250- 350/ kg</li> <li>• D-Glucopyranose- ₹40 to over ₹3,000 per kg depending upon</li> </ul>

			glycosides; 2-Butoxyethanol); Synthetic Fluorine-Free Foams (SFFF/F3)( hydrocarbon surfactants, polymers, solvents, and stabilisers); SoyFoam TF-1122; High-Expansion Foam (Hi-Ex)		<p>purity &amp; grade</p> <ul style="list-style-type: none"> <li>• 2-Butoxyethanol- ₹100 to ₹500 per kg depending upon purity &amp; grade</li> <li>• SoyFoam- imported from US; ₹16,000– ₹20,000 per 5 gallons (~19L)</li> </ul>
Textiles	<p>Long-chain: PFOS, PFOA</p> <p>Short-chain: PFHxS, PFHxA, Perfluorobutane sulfonic acid (PFBS), 6:2 Fluorotelomer alcohol (6:2 FTOH) etc.</p>	<p>Australia, Canada, France, Japan, EU</p>	Paraffin waxes <sup>39</sup>	USD 646.1 million by 2033	Textile use Semi Refined Paraffin Wax: 135/kg
			Hydrocarbons: Long-Chain such as stearyl acrylate; polyurethanes	USD 209.97 Million by 2034	<ul style="list-style-type: none"> <li>• Stearyl acrylate ₹650 to ₹5,800/kg</li> <li>• Polyurethanes ₹150–₹300/kg</li> </ul>
			Silicones <sup>40</sup>	USD 1,438.9 million by 2033	150-900/kg depending upon grade or purity
Cosmetics	<p>polytetrafluoroethylene (PTFE), perfluorononyl dimethicone, trifluoroacetyl tripeptide-2, tetradecyl aminobutyrolyvalylaminobutyric urea</p>	<p>Canada, Japan, France, California, Colorado, Maryland, Florida, Hawaii, Iowa, New York and Oregon</p>	<p>Fatty acid salts like magnesium stearate, sodium myristate; silicon-based compounds, bio-alkane solutions, natural waxes, and mineral powders like zinc oxide<sup>42</sup></p>	Market share is growing	<ul style="list-style-type: none"> <li>• Magnesium stearate- ₹85 to ₹200/kg</li> <li>• Zinc oxide- ₹150 and ₹300/kg</li> <li>• Bees wax- ₹250 to ₹500/kg</li> </ul>

	trifluoroacetate, perfluorohexylethyl triethoxysilane, methyl perfluorobutyl ether, and methyl perfluoroisobutyl ether etc. <sup>41</sup>	and Minnesota.			
Paints	PFOS, PFOA, PFHxS, fluoropolymers like PTFE and FEVE, along with fluorosurfactants such as 6:2 fluorotelomer alcohol (6:2 FTOH) and 6:2 fluorotelomer phosphate diester (6:2 diPAP)	Australia, Canada, Japan	<ul style="list-style-type: none"> <li>• Binders: acrylics, alkyds, and epoxies</li> <li>• Deaerators: polyacrylates, polyethers, and polysiloxanes</li> <li>• Viscosity: low aromatic mineral spirits and aromatic petroleum distillates</li> </ul>	Market share of all chemicals is growing	<ul style="list-style-type: none"> <li>• Polyacrylates- ₹100 and ₹300/kg</li> <li>• Polysiloxanes- ₹150 to ₹1,500/kg</li> <li>• Alkyds- ₹50 to ₹200/kg</li> </ul>

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## Annex I: Global Regulation in Products

Countries	Products	Regulations
EU	<b>General</b>	<p>August 2025 ECHA<sup>43</sup> had proposed the updated lists of 10,000 PFAS to be restricted in the sectors</p> <ul style="list-style-type: none"> <li>▪ printing applications</li> <li>▪ sealing applications</li> <li>▪ machinery applications</li> <li>▪ other medical applications, such as immediate packaging and excipients for pharmaceuticals</li> <li>▪ military applications</li> <li>▪ explosives</li> <li>▪ technical textiles</li> <li>▪ broader industrial uses, such as solvents and catalysts</li> </ul>
	<b>Food</b>	<p>On Sep 2020, EFSA established a group tolerable weekly intake (TWI) threshold of 4.4 nanograms per kilogram of body weight per week<sup>44</sup></p>
	<b>Food Packaging Materials</b>	<p><a href="#">Regulation (EU) 2025/40</a><sup>45</sup>, Packaging and Packaging Waste Regulation, restricted the PFAS in any FPM to 25ppb which is effective by August 12, 2026</p>
	<b>AFFF</b>	<ul style="list-style-type: none"> <li>• PFOS banned since 2011</li> <li>• PFOA restricted since 2017</li> <li>• ECHA's Committee for Socio-Economic Analysis (SEAC) adopted to phase-out entire PFAS since June 2023<sup>46</sup></li> </ul>
US	<b>Food Packaging Materials (FPM)</b>	<ul style="list-style-type: none"> <li>• <a href="#">H.R. 9864</a><sup>47</sup> under the Federal Food, Drug, and Cosmetic Act, PFAS is prohibited in FPM which is effective from January 2025.<sup>48</sup> Many states such as California, Colorado, Connecticut, Maine, Minnesota, Vermont, Washington etc. prohibited</li> </ul>
	<b>Textiles</b>	<ul style="list-style-type: none"> <li>• California <sup>49</sup>Assembly Bill No. 1817 on January 2025 prohibits the manufacture, distribution, sale or offer for sale of any new textile article containing a regulated PFAS.</li> <li>• New York<sup>50</sup> on January 2025 bans PFAS in apparels and indoor textiles under Section 37-0121 of the Environmental Conservation</li> </ul>

		<p>Law</p> <ul style="list-style-type: none"> <li>• Colorado prohibited PFAS chemicals in fabric treatments since January 2024 and indoor textile furnishings since January 2025.</li> </ul>
	<b>AFFF</b>	<ul style="list-style-type: none"> <li>• Several states have prohibited. Washington has banned manufacture, sale, import and export in 2018.<sup>51</sup></li> <li>• Illinois has prohibited in 2022.</li> <li>• Massachusetts and Connecticut has banned in foam as well as Firefighting protecting gear<sup>52</sup></li> <li>• New Jersey signed <a href="#">AB 4125</a> into law to prohibit the sale, manufacture, distribution and use of PFAs containing firefighting foams (FFF) from January 2026<sup>53</sup>.</li> </ul>
	<b>Cosmetics</b>	<ul style="list-style-type: none"> <li>• Illinois signed HB 2516 (<a href="#">PA 104-0231</a>, the Act) in August 2025 to prohibit PFAs in cosmetics and other personal care products; however, the Act will be effective from January 2032<sup>54</sup>.</li> <li>• Since January 1, 2025, the sale of cosmetic products containing intentionally added PFAS substances is banned in California, Colorado, Maryland, Florida, Hawaii, Iowa, New York and Oregon and Minnesota.</li> </ul>
<b>France<sup>55</sup></b>	<b>Clothing, Cosmetics, and Ski Waxes</b>	France has passed the law in February 2025 to prohibits the manufacture, import, export, and sale of PFAS-containing clothing, cosmetics, and ski waxes by 2026.
<b>Denmark</b>	<b>Pesticides<sup>56</sup></b>	The Danish Environmental Protection Agency restricted sale of 23 pesticides that contain Trifluoroacetic acid (TFA), a short-chain PFAS compound.
<b>Canada<sup>57</sup></b>		Environment and Climate Change Canada (“ECCC”) and Health Canada proposed to list PFAS chemicals — as a class — as toxic substances under the Canadian Environmental Protection Act, 1999 (“CEPA”) and prohibit its use in phase manner. In Phase-I AFFF will be prohibited completely by 2027. The timeline of phase-2 is not yet decided but it will prohibit PFAS usages in Cosmetics, textiles, ski waxes, building materials (Paint and coating, adhesive and sealant, cleaning products, waxes and polishes etc.), food packaging materials, food additives, and non-industrial food contact products etc.
<b>Australia<sup>58</sup></b>	AFFF, textiles, surface coatings, cleaning agents,	<ul style="list-style-type: none"> <li>• Since June 2025 Australia under <b>Schedule 7</b> of the <b>Industrial Chemicals Environmental Management Standard</b>, had ratified and banned PFOS, PFOA and PFHxS that are enlisted as POPs in the Stockholm Convention.</li> </ul>

	industrial surfactants and imported articles	<ul style="list-style-type: none"> <li>The unintentional trace contamination limit is set to 25 ppb</li> </ul>
<b>Philippines</b>	Food packaging materials	Philippines has banned in baby food packaging containers and other child care products <sup>59</sup>
<b>Japan<sup>60</sup></b>		Since Nov 2024, under the Chemical Substances Control Law (CSCL) the manufacture, import, and use of 138 PFAS (Per- and Polyfluoroalkyl Substances) are completely banned.
<b>China</b>		In Dec 2023, enlisted 10 PFOS congeners in List of New Pollutants for Priority Control (2023 Edition) that prohibit manufacture, processing, use, import, or export.
<b>Taiwan<sup>61</sup></b>		On August 2025, proposed draft to restrict 269 PFAS. For manufacturing, importing, selling, using, or storing PFAS at concentrations of 0.1% or above, approval documents must be obtained.
<b>Singapore</b>	AFFF <sup>62</sup>	National Environment Agency (NEA) phase out the import and use of PFAS (PFOA, PFOS & PFHxS) containing firefighting foams since January 1, 2026. Sets the threshold limit of 25 ppb for PFOA, and 10,000 ppb for PFOS
		National Environment Agency, August 2025 enlisted Long-chain perfluorocarboxylic acids (chain lengths at least C9 but not exceeding C21), their salts and related compounds enlisted as hazardous substances that need a Hazardous Substances Licence (HS Licence) to import, export, manufacture, or sale

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# Annex II: Global Regulation in Environment

## Matrices

Country	Legal instrument	Medium	Regulations
EU	Directive (EU) 2020/2184 of the European Parliament and of the Council <sup>63</sup>	Drinking water	<ul style="list-style-type: none"> <li>• 0.1 ppb limit for the sum of 20 individual PFAS compounds</li> <li>• 0.5 µg/L (0.5 ppb) limit for "Total PFAS"</li> </ul>
Denmark	Soil Quality Standard, 2021	Soil	<ul style="list-style-type: none"> <li>• 0.4 µg/kg for PFOS</li> </ul>
USA	EPA National Primary Drinking Water Regulations (NPDWR), 2024 <sup>64</sup>	Drinking water	<ul style="list-style-type: none"> <li>• 4.0 parts per trillion (ppt) for PFOA and PFOS,</li> <li>• 10 ppt for PFHxS, PFNA, and HFPO-DA (GenX)</li> </ul>
	US EPA Regional Screening Advisory Levels <sup>65</sup>	Soil	<ul style="list-style-type: none"> <li>• PFOA <ul style="list-style-type: none"> <li>▪ 19 ppt for residential soil level</li> <li>▪ 78 ppt for Industrial soil level</li> </ul> </li> <li>• PFOS <ul style="list-style-type: none"> <li>▪ 6.3 ppb for residential soil level</li> <li>▪ 58 ppb for Industrial soil level</li> </ul> </li> <li>PFHxS <ul style="list-style-type: none"> <li>▪ 1.3 ppm for residential soil level</li> <li>▪ 16 ppm for Industrial soil level</li> </ul> </li> </ul>
Japan	Water Supply Act No. 177 of 1957 <sup>66</sup>	Drinking water	50 ng/L
Canada	Health Canada <sup>67</sup>	Drinking water	30 ng/L for a sum of 25 specific PFAS
	Canadian Soil and Groundwater Quality Guidelines <sup>68</sup>	Imported Bio-solids/ fertilisers	50ppb for PFOS

Australia	Australian Drinking Water Guidelines (ADWG), 2025 <sup>69</sup>	Drinking water	8 ng/L for PFOS, 200 ng/L for PFOA, 30 ng/L for PFHxS, 1000 ng/L for PFBS
	PFAS National Environmental Management Plan (NEMP 3.0), 2024 <sup>70</sup>	Soil	3 ppb for PFOS/PFHxS in residential gardens
New Zealand	Drinking Water Standards, 2022 <sup>71</sup>	Drinking water	70ng/L for PFOS and PFHxS 560ng/L for PFOA
China	Standards for Drinking Water Quality (GB5749-2022) <sup>72</sup>	Drinking water	80 ng/L for PFOA 40 ng/L for PFOS
South Korea	POPs Act <sup>73</sup>	Drinking water	70ng/L for PFOA and PFOS 480ng/L for PFHxS

## Annex-III- Recent Research Studies in India

Year	Author	Matrix/location	Title	Findings
2024	G.V. Koulini & Indumathi M. Nambi <sup>74</sup>	surface and groundwater, Chennai, Tamil Nadu	Occurrence of forever chemicals in Chennai waters, India	PFAS found in all samples ranging from 0.10 ng/L to 136.27 ng/L
2024	Sharma et al <sup>75</sup>	Groundwater, Kamrup, assam	Comprehensive assessment of per and polyfluoroalkyl substances (PFAS) contamination in groundwater of Kamrup, Assam, India: occurrence, health risks, and metabolomic insights	detected 12 PFAS in groundwater samples from both the Kamrup Metro and Rural regions
2026	Tatavarthi et al <sup>76</sup>	12 PFAS in water and sediments samples, Godavari region between Polavaram and Dowleswaram	Distribution and source analysis of per and polyfluoroalkyl substances in water and sediment from Polavaram to Dowleswaram in the Godavari River Basin	PFAS concentration in water samples ranged between 29.06 – 70.81 ng/L, and 31.57 – 113.32 ng/kg in sediments
2026	Muller et al <sup>77</sup>	40 PFAS in sediments,	PFAS Contamination and Fluorine Mass Balance in Sediments of the Upper Ganges River and Ganges Canal.	individual PFAS ranged from 0.02 to 5.3 ng g <sup>-1</sup> , while $\Sigma$ Target PFAS concentrations ranged from 3.4 to 8.6 ng g <sup>-1</sup>
2026	Khalid, N. K. K <sup>78</sup>	River water, Kerala	Per- and polyfluoroalkyl substances (PFAS) in five major rivers in Kerala, India: A growing threat to water quality.	43 PFAS compounds in five major rivers in Kerala with highest concentration of 558 ng/L

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