

Research Article

How the European Union & the United States Tackle the Regulatory Challenges of PFAS - A Push for International Cooperation

Jessica Lee Williams , Chris Wold*

School of Environmental Law, Lewis & Clark Law School, Portland, United States

Abstract

This research explores the latest approaches to regulating per- and polyfluoroalkyl substances (PFAS) domestically in the United States and compares these methods to those utilized internationally, particularly in Europe. PFAS, often referred to as "forever chemicals" due to their persistence in the environment, have become a significant concern due to their adverse effects on human health and the environment. These substances are found in a wide range of consumer products and industrial processes, leading to widespread contamination of water, soil, and wildlife. In the U.S., regulations surrounding PFAS have been slow to evolve, with patchwork state-level efforts and federal inaction creating gaps in enforcement and protection. In a comparative approach, this research seeks to provide insights into the effectiveness of the various regulatory frameworks in place internationally. Europe, particularly the European Union, has taken more proactive steps in regulating PFAS, with stricter limits on the substances, ongoing research into their effects, and initiatives to promote cleaner alternatives. By examining the successes and challenges faced by these international efforts, readers will gain a clearer understanding of what might be the most promising path forward for the United States. One key takeaway from this comparison is the potential for international cooperation to address environmental issues that transcend national borders. This paper suggests that the U.S. could benefit significantly from adopting a similar approach to the European Union, aligning its policies with international standards to prevent further environmental and public health degradation. One of the most significant barriers to comprehensive environmental policy in the U.S. is often economic. Thus, the central question explored in this research is: Can a nation be held liable for long-persisting pollutants like PFAS, and what steps should be taken to ensure accountability in addressing these contaminants?

Keywords

Per- and Polyfluoroalkyl Substances (PFAS), PFAS Regulation, Environmental Policy, International Cooperation, Public Health, European Union, Remediation Efforts, U.S. Environmental Law, Environmental Justice

1. Introduction

Often referred to as "forever chemicals," per and polyfluoroalkyl compounds are anthropogenic poisons that have infiltrated every industrialized region, posing a significant threat to human health and the environment [1]. The

*Corresponding author: wold@lclark.edu (Chris Wold)

Received: 19 March 2025; **Accepted:** 15 April 2025; **Published:** 18 October 2025



Copyright: © The Author(s), 2025. Published by Science Publishing Group. This is an **Open Access** article, distributed under the terms of the Creative Commons Attribution 4.0 License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution and reproduction in any medium, provided the original work is properly cited.

jarring term refers to the persistence of the compound in the environment and human body, taking years or even decades to break down PFAS was first utilized in the U.S. during the 1940s and was manufactured by corporate giants like 3M and DuPont for their water- and grease-repellent properties. These materials were soon widely incorporated into consumer goods such as military-grade firefighting foams and non-stick cookware. Today, more than 14,000 PFAS are used in thousands of products, with an estimated 3,000 tons discharged into U.S. soils and landfills in 2020 [2]. These chemicals have become a part of daily life because of their endurance and resistance to breakdown, gradually building up in soil, water, and living organisms, outlasting even microplastics [3].

The first form of PFAS, polychlorotrifluoroethylene (PCTFE), was discovered by Fritz Schloffer and Otto Scherer in 1934 at the former German chemical conglomerate IG Farben. The company 3M invested in this formula when buying out IG Farben and would later derive from it PFOA (perfluorooctanoic acid) in the mid-20th century, which eventually led to the creation of Teflon amongst other international trade products [4]. This series of business exchanges led to widespread contamination before regulatory responses began to take shape in the late 20th and early 21st centuries [5]. With an emphasis on the textile, food packaging, and firefighting industries, the commercial incentive to produce PFAS variants spurred the extensive manufacturing and usage of PFAS around the world [5].

By the 2000s, there was increased scrutiny of PFAS in the U.S. and Europe due to a rising understanding of the health and environmental hazards linked to PFAS contamination [6]. PFAS exposure has been connected to severe health issues, including various cancers, obesity, liver damage, and developmental harm [7]. The European Chemicals Agency (ECHA) introduced measures, such as the Registration, Evaluation, Authorization, and Restriction of Chemicals (REACH) regulation aimed at better managing the risks associated with chemical substances, including PFAS [8]. Comparatively, the U.S. Environmental Protection Agency (EPA) did not explicitly address PFAS until 2009.¹ Presently, various forms of PFAS are regulated primarily by states, with the exception of recent federal drinking water regulations [2].

The regulatory challenge surrounding PFAS is grounded in its variety. With more than 14,000 PFAS in use today, uncertainty prevails about which PFAS are causing which adverse health effects [9]. However, we know that certain groups of people, such as those living near manufacturing sites, are particularly vulnerable. Manufacturing sites, wastewater treatment facilities, and military posts in the United States are presently the main point-source contributors to PFAS contamination [10]. The state with the highest concentrations is, by far, the Great Lakes state of Michigan,

a legacy of the carcinogen's manufacturing origins [11]. Additionally, disparities such as age and gender exemplify that select populations and regions bear a disproportionate burden of PFAS exposure [12].

Recent regulatory efforts in the U.S., such as the EPA's revised PFAS Action Act of 2021, have begun to address the chemical crisis [13]. This federal law aims to accelerate the identification and regulation of PFAS by requiring the EPA to establish drinking water standards and assess the health impacts of various PFAS compounds. However, conservative factions continue to oppose these initiatives, and until the Biden Administration, efforts relied on voluntary measures, constrained by limited state resources [14]. Despite these new federal actions, there is no comprehensive federal ban on PFAS, and much of the responsibility for PFAS regulation still falls to individual states. A dozen states have taken action, prohibiting PFAS in a range of consumer products such as apparel, cleaning products, cookware, cosmetics, and menstrual products [15]. This decentralized and fragmented approach to regulation introduces significant concerns regarding the efficacy of the United States' existing policy.

By contrast, the European Union (EU) has taken a more proactive and cohesive stance on PFAS regulation. The EU is pursuing a widespread recast of their Drinking Water Directive that prioritizes public health advocacy based on precautionary principles to remove PFAS from drinking water across its member nations [16]. Additionally, the EU's REACH regulation proposes outright bans and tighter restrictions on several PFAS compounds in multiple industries [17]. The EU employs a precautionary principle in environmental policy, which places the burden of proof on industries to demonstrate the safety of a substance before it can be approved, a stark contrast to the U.S. system, where regulators must prove a chemical is harmful before restricting it—often only after damage has occurred [18].

EU members have voted to include PFOA, its salts, and PFOA-related compounds on the Stockholm Convention's list of Persistent Organic Pollutants (Stockholm Convention), furthering international cooperation [19]. Upon approval, these specific PFAS compounds will be included in Annex A, meaning their production, consumption, import, and export will be banned [20]. While the EPA has conducted several risk assessments regarding various PFAS, these actions only came recently as public awareness has elevated the issue [21]. Notably, the EU is a party to the Stockholm Convention, but the United States is not.

As a technologically, scientifically, medically, and economically developed global superpower with the capability and resources to face this challenge head-on, the United States must adopt an international regulatory framework to address the PFAS crisis and protect public health. If the regulation of PFAS in the U.S. continues to rely on the limited resources and low-cost solutions presented by its member states, the phase-out of this toxin will require more time than the EU's centralized initiatives. Once leading the way in

¹ U.S. Env't Prot. Agenc, Provisional Health Advisories for Perfluorooctanoic Acid (PFOA) and Perfluorooctane Sulfonate (PFOS), EPA PFAS PORTAL (2009, Jan 8).

the environmental movement, the U.S. now trails behind global leaders in this field; its political division and preference for profit over sustainability obstruct the efficient control of harmful carcinogens like PFAS. The consequences of the United States' environmental degradation may outlive the nation, leaving a troubled legacy for future generations.

This paper examines the regulation of PFAS in the United States and European Union, highlighting each country's approach, relative successes, and shortcomings. Section II will review the uses and economic value of PFAS to demonstrate just how complex regulating its removal will prove to be, as the chemical family has become so deeply rooted in industry and everyday consumer products. Section III explores the ever-expanding environmental and human health impacts of PFAS to prove why something so useful must be foregone despite its global market value and industrial appeal. Sections IV and V delve into the current legislative initiatives governing PFAS in the US and the EU, respectively. Section VI recommends an international framework development or adoption and a brief overview of the challenges in pursuing these recommendations. Lastly, Section VII presents a conclusion summarizing the legal research presented.

2. Uses and Economic Value of PFAS

PFAS chemicals have superior resistance to heat, water, and oil; hence, their early adoption in consumer goods and manufacturing industries [22]. PFAS are a family of synthetic chemicals with a vast variety of applications due to their unique characteristics. Here, we will explore the diverse uses of PFAS and their economic significance.

2.1. PFAS in Consumer Products

PFAS are commonly found in consumer products like non-stick cookware, where they provide durability and convenience but, now that we know better, also raise environmental and health concerns. PFAS-coated non-stick cookware became a kitchen staple by offering consumers an easy-to-clean and durable product. According to Grand View Research, the North American non-stick cookware industry was valued at over \$2.8 billion in 2019, few of these market reports, however, disclose any data on what percentage of these products contain PFAS [23]. These specially manufactured pots and pans can shed particles of their coating after just a handful of cycles through the dishwasher, subsequently entering public drainage systems and eventually passing through wastewater treatment [24].

PFAS extends beyond our kitchens into many rooms of the typical household and when discarded find its way into landfills. For example, Perfluorooctanoic Acid (PFOA) and Perfluorooctanesulfonic Acid (PFOS) are specific PFAS compounds used primarily to make fabrics resistant to stains, water, and dirt in textiles. Items such as carpets, upholstery,

jackets, and shoes were often treated with these chemicals to increase their longevity and ease of maintenance [25]. The global textile market, valued at over \$920 billion in 2020, involves many products treated with PFAS. For example, water- and stain-resistant outdoor gear, such as tents, boots, and raincoats. Many of these products eventually find themselves in our washing machines and, like Teflon dishware, after many washes, shed microscopic particulates into our drains that flow undetected through thousands of wastewater treatment plants.

Not only do we cook with and wear PFAS, but we also buy it at grocery stores and restaurants. PFAS provides resistance against grease and oil for pizza boxes, sandwich wrappings, and microwave popcorn bags. These chemicals play a key role in maintaining package integrity and preventing contamination of the food inside but, ironically, may pose a greater risk than any outside contaminant [26]. Further, the toxic long-chain fluoropolymer family is not where you might think in the bathroom.

PFAS, however, are also used in cosmetics for their water and smudge resistance. Such products include foundation, mascara, and lip gloss by brands like Maybelline, L'Oreal, and CoverGirl [19]. The cosmetics industry, projected at over \$500 billion worldwide, uses PFAS extensively in long-lasting products and has yet to be regulated due to the need for further research [32]. Because these chemicals enhance beauty products' performance and consumer appeal, they have become a major driver in market growth [27]. Companies in the United States tend not to list PFAS on their product labels because they aren't required to, making it hard for consumers to avoid them.

In lieu of federal regulation, companies in states not regulating cosmetic PFAS are permitted to classify its presence in their formulas as a trade secret, meaning the consumer cannot tell based on labeling whether the product or packaging contains PFAS. To further complicate the concern, whether the supply chain knowingly adds these toxic chemicals to their formulations is still being determined via litigation [28]. Recognizing the threats posed by PFAS, laws and regulations to address it in cosmetics are currently pending. The Modernization of Cosmetics Regulation Act (MoCRA) requires the Food & Drug Administration (FDA) to assess the safety of PFAS in cosmetics and publish its results by the end of 2025 [29]. MoCRA also requires manufacturers, packagers, and distributors to submit lists of ingredients to the FDA [30]. Additionally, many states have enacted laws that ban or restrict the use of PFAS in cosmetics. For example, California's PFAS-Free Beauty Act of 2022 bans PFAS in cosmetics sold in the state.

Much like their presence in consumer products, PFAS are ubiquitous in industrial applications as well. Aqueous Film-Forming Foam (AFFF) contains PFAS and has been popularly used to extinguish fuel-based and electric fires in the United States since the 1960s [31]. The foam has been so vital in preventing fire spread at airports, military bases, and indus-

trial facilities that the Department of Defense (DOD) still uses AFFF in 1,500 facilities and more than 6,500 mobile sources worldwide, according to the U.S. Government Accountability Office. The Office further confirms PFAS detections in drinking water and groundwater in and around DOD installations [32]. Global sales of AFFF are estimated at \$390 million in 2022 [24]. Continued reliance on these foams still exists today with a projected 3-4% increase in global demand increase projected for 2032 [38]. The environmental and health concerns stemming from PFAS contamination in federally distributed firefighting foams have led to a surge in research for alternatives, as well as legal repercussions [33]. New data is rapidly informing local suits consolidated into major settlements against corporate producers 3M and DuPont, settling for more than \$10 billion, a small fraction of the product's profit margin [34]. Notably, 3M announced the initial phase-out of AFFF in their sale products by 2000 after becoming aware of their environmental bioaccumulation effects following advanced industry studies in the 1990s [35]. This demonstrates that even 20 years later, the PFAS problem is only beginning to unravel.

2.2. Global Economic Significance and Treatment Strategies

The total economic impact of the PFAS chemical family is impossible to quantify due to the vast array of industries and applications that use them. However, we can see that even a handful of vital industries reliant on PFAS, including cookware, textiles, and firefighting, are worth billions of dollars annually [43]. These industrial sectors create significant employment opportunities that stimulate economic growth and drive technological innovation. While PFAS offer significant economic benefits, the growing recognition of their long-term environmental and human health harm increasingly prompts industry and consumers to seek alternatives, with lawsuits garnering billions for the victims of PFAS contamination [36]. Still, billions are only a small part of total damages, with little in the way of systematic justice. If the U.S. wishes to overcome industry dependence on these formulas, then employment creation efforts should focus on industry phase-out and replacement initiatives. The production, use, and disposal of PFAS-related products supports millions of jobs worldwide. Manufacturing plants, research institutions, and retail operations benefit from PFAS use, making these chemicals economically valuable. The shift toward PFAS-free products could challenge businesses built around these substances' widespread use but have the potential to open safer profit revenues. Beyond replacement, global leaders like the U.S. and EU are rapidly developing advanced treatment technologies.

The primary disposal methods for PFAS internationally include landfilling, incineration, and wastewater treatment [37]. While incineration is being considered seriously as a potential method for PFAS disposal of terrestrial matter such

as soils and sediments, there are concerns about incomplete destruction of PFAS at typical incineration temperatures, potentially leading to harmful emissions [48]. Multiple states and the Department of Defense (DOD) have even implemented bans on incinerating PFAS-containing materials, making landfilling and advanced wastewater treatment more economically viable options [38]. Research shows that facilities reaching temperatures of 1,500 degrees Celsius (2,730 degrees Fahrenheit) can effectively break down PFAS compounds, eliminating their harmful environmental qualities [39]. However, the limited availability of such high-temperature facilities and the risks posed by leachate from landfills make these methods less ideal for long-term environmental health [40]. Reactive methods like landfilling and incineration only address contamination after it has entered the environment or water supply, leaving future risks largely unaddressed. Long-term solutions to PFAS cleanup are being seen in biological research aiming to utilize methods like bioremediation, which uses microorganisms to break down contaminants, and phytoremediation, where selected plant species are engineered to absorb and degrade target pollutants [50]. Both approaches are in their infancy but hold promise as potential methods for treating PFAS in soils and groundwater [27]. For now, the most fleshed out approach in the U.S. and EU focuses on water treatment which will be further reviewed in Section III Subsection C.

3. Environmental and Human Health Impacts of PFAS

The widespread use of PFAS has resulted in significant environmental and human health concerns. These chemicals are persistent in the environment and have been shown to bioaccumulate in living things, presenting a complex and alarming puzzle concerning their long-term effects on ecosystems and human populations [47]. The unique properties and environmental behaviors of different PFAS compounds are determined by variations in their chemical structures. For example, the strong carbon-fluorine bonds make many PFAS resistant to degradation, leading to their nickname "forever chemicals." Additionally, the chain length and functional groups can affect their solubility, bioaccumulation potential, and toxicity [9].

3.1. Environmental Impact

PFAS are called "forever chemicals" because once released into water, soil, and air, they can persist for decades [41]. This persistence has led to widespread contamination of natural ecosystems, especially water sources. PFAS accumulates in surface waters primarily through industrial discharges and firefighting foams [31]. The most serious threat to wildlife, especially aquatic species, is due to bioaccumulation, in which chemical compounds like PFAS build up in

the food chain, thus affecting biodiversity and ecosystem health [12]. Bioaccumulation concerns have spread to humans after industrial farming practices introduced PFAS to crops via treated wastewater for irrigation. PFAS can persist in fields like legumes and root crops for decades, contaminating fields treated many years ago [42]. PFAS concentrations in water sources have led to health advisories, bottled water provisions, and intensive clean-up efforts in communities near industrial sites, military bases, and airports. While the EPA has issued strict limits for PFOA, PFOS, GenX, and Perfluorobutanesulfonic Acid (PFBS) these advisories are guidance values and are not federally enforceable across the board [43].

The persistence of PFAS in ecosystems disrupts wildlife populations, which in turn exacerbates the impact on public health. Studies have shown that PFAS can impair the health of fish and other aquatic species by affecting their reproductive systems, growth rates, and immune functions [44]. Ecological disruption and human health go hand-in-hand when evaluating the health implications of PFAS. This is seen in the effect of bioaccumulation of PFAS to native tribes who are culturally more reliant on fish consumption, a 2021 study published in the National Library of Medicine asserting that “diet is the major human exposure pathway for some PFAS but there is large variability across populations and PFAS compounds” [45]. Animal toxicity studies have been used to study how the body handles PFAS following oral exposures [46].

Animal testing is an unavoidable part of biological research on PFAS in both The States and the EU. REACH prioritizes avoiding animal testing, requiring it only as a last resort when no alternative methods are available [47]. This proactive stance ensures that non-animal testing methods are prioritized, reinforcing a strong commitment to reducing animal use and supporting the development of alternative testing methods.

In contrast, under the TSCA, the EPA is directed to reduce and replace animal testing “to the extent practicable and scientifically justified” [48]. Unlike REACH, which requires formal approval for individual animal tests and prioritizes non-animal alternatives, TSCA does not mandate approval for animal tests nor explicitly require the prioritization of non-animal alternatives. However, this does not imply that no alternative methods are available.

3.2. Human Health Impacts

Many scientific studies have linked PFAS exposure to a variety of health conditions to date, including cancer (especially kidney and liver cancer), developmental problems, immune system dysfunction, and liver damage [49]. Among the most abundant PFAS in environmental media are some of the oldest; PFOA and PFOS have been linked to adverse health outcomes for decades. A population-based cohort study published by the Environmental Health Perspectives

Journal in June 2022 found that exposure to PFAS variants, particularly PFOS, was significantly associated with an increased risk of all-cause mortality, heart disease, and cancer. The study showed that higher levels of PFOS exposure were linked to a 70% higher risk of cancer mortality and a 58% higher risk of heart disease mortality. Notably, the study estimated that reducing PFOS levels in the U.S. population could prevent approximately 382,000 deaths annually from 1999 to 2015, with this number decreasing to around 69,000 annually from 2015 to 2018 due to a decline in PFOS exposure [50]. These findings underscore the significant public health risks associated with PFOS exposure and the need for continued action to reduce PFAS contamination, particularly as PFOS remains a major contributor to mortality risks in the U.S. population.

Environmentally marginalized groups, including low-income communities, communities of color, and women, are disproportionately impacted by PFAS contamination, and the longer it takes to phase out these harmful chemicals, the greater the environmental injustice they face [51]. Communities near industrial sites or military bases, where PFAS exposure is more prevalent, have fewer resources to mitigate or address the effects of contamination [52]. Women, in particular, face unique risks due to biological factors and targeted product consumption [68]. Additionally, individuals with kidney disease may struggle to excrete PFAS through urine, leading to higher internal accumulation. The slow pace of action in phasing out PFAS by a global superpower like the U.S. perpetuates systemic inequalities as these vulnerable populations bear the brunt of prolonged exposure, with serious health consequences [69, 70]. As PFAS persists in the environment, the gap in exposure between marginalized groups and more affluent populations widens, exacerbating both environmental and gender-based injustices [53].

Responding clinically to PFAS contamination is an issue of environmental justice in medical care [54]. As the extent of contamination becomes known, housing values have been shown to decrease, and those with the means to move are more likely to do so, leaving behind those with the fewest resources and options. For the United States to pursue international cooperation on PFAS expands the nation's resources. In many regions where there are vulnerable populations, such as the Great Lakes States, this may prove urgent to ensure equal public access to PFAS screenings that might not otherwise be independently affordable for the nation [55].

3.3. Responding to The Human Health Impacts of PFAS

Safety concerns over PFAS have lingered since the American environmental movement of the 1970s, with state-level advocacy under the Biden Administration reigniting public awareness. Just before the federal 2021 PFAS Action Act was published, New Jersey became the first state in the union to establish a maximum contamination level (MCL) for any

type of PFAS [56]. Since 2007, thirty out of fifty states have approved 155 PFAS laws and regulations, the majority of which have been in the past five years [76]. These state-level initiatives cover cookware, cosmetics, cleaning products, and more [57]. States at the forefront of PFAS legislation like Colorado, Maine, Vermont, and Connecticut are presently working toward blanket bans for PFAS-containing products like these [20]. Many of these initiatives include mandates for labeling and reporting, in an attempt to make transboundary trade between states transparent [20]. For example, Colorado's initial PFAS restrictions from 2022 targeted specific products like carpets, food packaging, and children's toys [9]. The law was expanded in 2024 under Senate Bill 24-081, to include cleaning products, such as floor maintenance products used in hospitals, cookware, dental floss, and menstrual products containing PFAS, with deadlines for compliance starting as early as 2026. Specific brands or examples of products affected are not mentioned and this is purposeful, not disclosing name-brand producers in these policies protects industry. These have been significant regulatory moves stemming from the advancement of ideas and research following EPA's first PFAS provisional health advisory, published over ten years earlier [18].

The revised PFAS Action Act, released two years after its original 2019 publication, covers more bases across industries, taking advantage of the latest research [18]. New provisions were added that were not present before, but some key concerns have yet to be addressed. The original publication of the PFAS Action Act aimed to designate specific PFAS chemicals as hazardous substances under the Superfund Law [58]. This designation enables the cleanup of highly contaminated sites to be funded by the polluters responsible [18]. The Act also assigned the task of setting drinking water standards for PFAS to the EPA and required the agency to increase its risk assessments of these compounds under the TSCA [59]. Funding for research into the health effects of PFAS was provided to the Centers for Disease Control and Prevention (CDC) and the Agency for Toxic Substances and Disease Registry (ATSDR) to support epidemiological studies in communities with known PFAS contamination [86]. These studies focused on populations exposed to elevated levels of PFAS, often from drinking water or other sources such as military bases and industrial sites [86].

As a priority, these agencies directed federal funding to support biomonitoring efforts, which track the presence of PFAS chemicals in people's blood and urine [86]. This method helps researchers gauge the extent of exposure in different communities and correlate PFAS levels in the body to specific health outcomes [86]. In addition to biomonitoring, innovative filtration technologies, such as granular activated carbon (GAC) and ion exchange resins, received significant support following the passage of the legislative initiative [86]. States with high levels of PFAS contamination, such as Michigan, New Jersey, and California, have used federal support to monitor PFAS levels in local water sup-

plies and implement cleanup strategies [60].

The original 2019 version of the Act focused on a few of the most well-known and widespread PFAS chemicals, including PFOA, PFOS, PFNA, and PFHxS [61]. By 2022, the scope of the Act was expanded to include additional PFAS chemicals such as PFBS, GenX, PFDA, PFUnDA, and short-chain PFAS [62]. This was done to ensure more comprehensive regulation and cleanup of PFAS contamination.

In 2019, there was no federally enforceable drinking water standard for PFAS. The EPA had set non-enforceable health advisory levels of 70 parts per trillion (ppt) for both PFOA and PFOS [63]. Notably, it was the PFOA Stewardship Program that launched in the U.S. before the compound could be listed under the Stockholm Convention on Persistent Organic Pollutants. The EPA's *voluntary* program began in 2006, while PFOA was officially added to the Stockholm Convention's Annex A (for elimination) in 2019. The Stewardship Program set a path for the global recognition of PFOA as a persistent, bioaccumulative, and toxic substance, influencing more substantial international regulatory actions [64]. While the United States's scientific knowledge of PFAS is progressive it has taken until 2024 to establish enforceable drinking water standards with much stricter limits: 0.004 ppt for PFOA, 0.02 ppt for PFOS, and 0.04 ppt combined for other PFAS [65]. These 2024 standards are now federally enforceable, meaning public water systems must comply or face penalties [66].

Following the passage of the Act, the EPA and state agencies launched biomonitoring programs to track human exposure to PFAS in specific areas, particularly in communities adjacent to military bases and those with high levels of PFAS detected in drinking water [67]. Notable locations included Pease International Tradeport in New Hampshire, Wurtsmith Air Force Base in Michigan, Travis Air Force Base in California, and St. Lawrence County, New York [68].

While federal and state sites, such as military bases and Superfund sites, have received significant funding for PFAS cleanup, progress at industrial sites has been slower for several reasons [69]. The major challenge is the regulatory and liability landscape: PFAS contamination is widespread, and the industrial sites involved in producing or using PFAS chemicals have often been impossible to effectively regulate or hold liable because there were few consistent national standards [70]. Private industrial sites, unlike federal or military sites, often do not receive the same level of direct funding or oversight from the federal government for cleanup efforts. The EPA's approach to managing PFAS has evolved over time, and several factors contribute to the delay in enacting federal laws, even though stewardship programs were offered as early as 2010 [71]. While federal agencies like the EPA have significant authority and funding to oversee and enforce cleanups at Superfund sites and federal facilities, private industrial sites typically fall under the (at times contradictory) requirements of state and federal regulations [103]. These sites may be subject to state and federal over-

sight, but their cleanup process can be slower, limited by complex liability issues [101].

Industrial sites often face extensive contamination with multiple PFAS compounds, making cleanup more complicated and expensive [72]. Remediating soil, groundwater, and air contamination can be prohibitively costly for private companies [104]. Many industrial facilities have discharged PFAS into nearby water bodies or soils, complicating cleanup efforts [101]. These sites require long-term monitoring and significant investment to track and address contamination [101].

Another reason for the slow progress at industrial sites is the focus of federal funding on more immediate public health risks, such as the contamination of drinking water supplies and federal properties [73]. These concerns are considered higher priorities because they impact larger populations, leaving industrial sites with less attention and support [74]. Finally, identifying responsible parties at private industrial sites has been complex and time-consuming [43]. In multiple instances, more than one company may have polluted PFAS at a single location, further complicating efforts to assign liability [19].

In wake of these battles posed by the PFAS epidemic, states are taking matters into their own hands, in some instances this includes covering the costs to update federally regulated Wastewater Treatment Plants (WWTPs) [19]. Yorba Linda, California, built the nation's largest PFAS water treatment plant to tackle contamination from "forever chemicals." The treatment plant, using resin-filled tanks to filter PFAS from groundwater, serves 80,000 people and was constructed after all 10 of Yorba Linda's wells exceeded state PFAS limits in 2020 [19]. These limits were stricter than federal standards at the time and required water providers to stop using contaminated wells or notify the public [19]. Switching to imported water initially doubled costs, prompting cities like Yorba Linda and Anaheim to fast-track filtration plants [19]. Anaheim, serving 500,000 people, now plans to expand its treatment to meet the EPA's even stricter 2029 standards, at an estimated \$200 million cost [45]. Orange County's contamination largely stems from the Santa Ana River, runoff, sewage treatment plants, and industrial legacy pollution. Treating more than 100 contaminated wells across the county is projected to cost \$1.8 billion over 30 years [75]. The region's efforts serve as a model for addressing PFAS nationwide, though the problem may grow with stricter standards and spreading contamination. Given the massive price tag, there is growing recognition that addressing these issues is not solely a local responsibility. Federal funding is essential to help communities across the country meet new EPA standards, particularly as PFAS contamination often originates from industrial, military, and other federally regulated sources.

It is crucial to note that a total ban on the fluoropolymer chemical family that yields PFAS would cripple vital industries everywhere, including advanced medical care. Hospitals

and doctors rely on medical devices and equipment containing PFAS, such as catheters, stents, surgical meshes, needles for biopsies, ventilators, and diagnostic devices like X-ray films and endoscopes, which have been the norm for decades. PFAS's unique properties, including its durability and nonreactivity, make it essential for preventing infections, friction, and clotting in medical devices, as well as ensuring high-frequency performance in pacemakers and MRI devices [76]. Nonetheless, this progression raises a regulatory dilemma. A patchwork of state legislation, absent an established and comprehensive federal oversight, has led to uncertainty and inconsistencies in the management of PFAS nationwide [77]. The divergence between the public's expectations and the EPA's capabilities demonstrates that increased transparency and collaboration are necessary changes needed to protect public health sustainably [21].

3.4. Regulatory Challenges and Options

Some of the most pressing issues with PFAS regulation involve their persistence in the environment and the limitations of current technologies to remediate existing PFAS pollution. This makes it difficult to address the widespread contamination caused by these chemicals effectively. Conventional drinking water treatment processes, like coagulation, flocculation, and chlorination, are ineffective at removing PFAS [48]. With respect to other treatment processes, incineration can create new PFAS that may or may not be detectable [28]. The effectiveness of incineration in destroying PFAS is not yet well understood [26]. The inherent concern is that incinerating PFAS-containing waste may potentially produce harmful air pollutants, such as fluorinated greenhouse gases and products of incomplete combustion [78]. PFAS requires higher temperatures and extended reaction times, which can be expensive. The carbon-fluorine bond in PFAS chemicals is particularly resistant to combustion, making PFAS difficult to incinerate.

Environmentally progressive nations and states have moved toward banning specific PFAS compounds or entire classes of PFAS chemicals. Bans may include consumer products, like non-stick cookware, clothing, and food packaging, where safer alternatives exist. While banning all forms of PFAS would be impossible, it is important to target those most known to be associated with adverse effects on human health and the environment. While short-chain PFAS are less bioaccumulative, their safety and environmental impact remain under scrutiny.

One of the most recent examples of strides in international PFAS regulation is seen in Germany. Germany has taken the international lead in its submission of proposals for restriction on specific forms of PFAS to the European Chemicals Agency for pre-approval to the European Commission (executive branch of the EU) as well as the Stockholm Convention. This proposal was submitted during Germany's presidency of the European Union in 2020. By June 2022,

parties to the Stockholm Convention decided to include PFHxS, its salts, and related compounds in its treaty per Germany's proposal [79]. Now in 2024, the European Union has adopted the opinion in favor of Germany's proposal and restricted a new subgroup of PFAS, PFHxA and its related substances, for some uses, including food packaging, cosmetics, and consumer textiles [21, 60, 100]. This is not the first PFAS addressed in an MEA; PFOS (perfluorooctane sulfonic acid) has been included in the international Stockholm Convention since 2009 to eliminate its use. However, Germany's initiatives have been among the most significant steps in PFAS regulation since then.

One crucial regulatory strategy is setting safe levels of PFAS in drinking water. Numerous states in the United States and countries in Europe have either set or are setting limits on the concentration level of PFAS in water supplies [80]. These water quality standards are the most direct solution to reducing exposure to harmful levels of these chemicals and protecting public health.

The U.S. is at the forefront of scientific research into PFAS treatment technologies, utilizing methods such as granular activated carbon (GAC), ion exchange, high-pressure membranes like reverse osmosis, and hydrothermal processing [100]. The EPA has identified these as the Best Available Technologies (BAT) for removing PFAS from drinking water [96]. The EPA has for the first time in the year 2024 established legally enforceable Maximum Contaminant Levels (MCLs) for six PFAS in drinking water. Two common contaminants, PFOA and PFOS, are limited to 4 ppt, while PFHxS, PFNA, and HFPO-DA are limited to 10 ppt [50]. Additionally, the EPA set a Hazard Index MCL for PFAS mixtures containing at least two or more of PFHxS, PFNA, HFPO-DA, and PFBS to account for the fact that low levels of individual PFAS would not likely result in adverse health effects but may pose health concerns when combined [81]. These new standards are considerably more stringent than the initial advisory of 70 ppt set back in 2016 and exceed any limit that states had individually set. The EPA has also published health-based, non-enforceable Maximum Contaminant Level Goals (MCLGs) of zero for PFAS with PFOA, reflecting the latest science that shows no level of exposure is without health risks.

Even equipped with advanced treatment methods, the U.S. faces challenges in consistent implementation. On a small scale, this is because of the costs associated with technological distribution, but on the macro level, it is the result of the country's roots in federalism, where each state has begun adopting its policies ahead of federal initiatives, creating variability in the effectiveness of treatment across the nation [82]. Hopefully, with the EPA's most recent work, an effective federal scheme will emerge. Moreover, there are unresolved concerns about managing the PFAS waste resulting from these treatment processes and the cost of implementing filtration and removal technologies. Whether the federal government will take further steps to harmonize PFAS regu-

lation within the new administration is unclear; in either case states will soon be facing the impact of patchwork regulation on interstate commerce which shall be further discussed in Section IV Subsection A.

The European Union's approach to PFAS contamination is scientifically similar, turning to treatment technologies like GAC and reverse osmosis [56]. However, the EU's strategy extends beyond treatment. Their technology, though essentially equal to the U.S., will work better in cooperation with its more established and regionally consistent policies on consumer products. The EU has established enforceable limits for PFAS in drinking water that apply to all members, ensuring that treatment technologies are applied effectively across the nations [83]. This regulatory framework reduces the incidence of costly cleanup efforts later on by preventing further PFAS contamination at its source—restricting these chemicals in industrial and consumer products before they can enter water supplies. While the U.S. excels in scientific innovation for PFAS treatment, its lack of cohesive national policies to eliminate instead of substitute forms of PFAS undermines the full potential of these technologies, preventing a lasting solution to the issue [84]. By comparison, Europe's collaborative multi-national regulations and treatment efforts show a more sustainable response, promising long-term protection against PFAS exposure.

4. U.S. Regulation of PFAS

4.1. Regulation Under State Law

Various states in the United States have taken proactive steps to regulate PFAS, often implementing stricter standards than those at the federal level, in areas outside of the latest federal drinking water standards. For example, California and Connecticut have set some of the most stringent limits on PFAS in consumer products. Many states have also sued companies responsible for PFAS formulation, seeking to hold them accountable for the environmental and collective medical damages caused by their products. It will be the continuation of these suits that pushes the federal government to require agencies to amend regulations outside of the Clean Water Act.

It is alarming to think that menstrual products may contain harmful chemicals that uniquely and adversely affect women's biological health. In California, women and their supporters have been vocal about this issue, channeling their frustrations through legal action. A pending lawsuit alleges that Edgewell's Carefree panty liners contain PFOA, a PFAS chemical linked to reproductive harm, and that the company failed to warn consumers about this risk, violating California's Proposition 65 [85]. Proposition 65, also known as the Safe Drinking Water and Toxic Enforcement Act of 1986, requires businesses to provide warnings if their products or operations expose individuals to chemicals known to cause

cancer, birth defects, or other reproductive harm [82]. The law applies to any business with ten or more employees that manufactures, distributes, or sells products in California, as well as those that have operations in the state [86]. In this case, the lawsuit claims that Edgewell failed to provide the required warning to consumers about the potential risks associated with PFOA in its products.

Similarly, Connecticut residents are pursuing legal action against Kimberly-Clark for using PFAS in the manufacture of tissues at its New Milford plant, claiming the company's actions have led to contamination of local water supplies and properties [78]. These cases highlight the broader concern of PFAS contamination across consumer products and the environment, with lawsuits being filed consistently and involving individuals as well as class actions. The outcomes of these cases will undoubtedly influence future legal frameworks, shaping how laws, businesses, and consumers approach the environmental and health consequences of PFAS.

The patchwork of state regulations regarding PFAS contamination further complicates matters for businesses, especially those that manufacture products linked to PFAS pollution. Companies face significant challenges in navigating these varying regulations, which can create logistical and legal hurdles. For instance, manufacturers of consumer goods, such as non-stick cookware and outdoor gear, may be confronted with restrictions on selling their products in certain states due to contamination issues or may face the costly process of reformulating their products to address environmental concerns [87].

For instance, Vermont's approach to PFAS regulation contrasts with Texas's due to differences in geography and local industry priorities. Vermont, concerned about the contamination of the Great Lakes—a key drinking water source—has been more proactive in controlling PFAS in consumer goods. As of May 2024, Vermont will ban intentionally added PFAS in items like cookware, cosmetics, food packaging, ski wax, textiles, and menstrual products by 2026. The state's definition of "regulated PFAS" includes chemicals added intentionally or those that serve a functional purpose in products. This comprehensive regulatory stance reflects Vermont's strong environmental ethic and its commitment to protecting public health through clean water, aligning with its agricultural and tourism-based economy, which is less dependent on PFAS-producing industries.

In contrast, Texas, home to a significant oil and gas industry, has taken a more cautious approach to PFAS regulation. While Texas is not as impacted by PFAS contamination in water as Vermont, its economy heavily relies on sectors like petroleum, chemicals, and manufacturing, industries that have historically downplayed the risks associated with PFAS. Texas has primarily focused on PFAS in drinking water rather than implementing broader bans on consumer products. The state's industrial base has influenced this approach, as stricter regulations could increase operational costs and affect economic competitiveness. This dilemma is a small re-

flection of similar difficulties that may be faced when trading PFAS-containing products internationally.

4.2. Federal Regulation Under TSCA

U.S. efforts to regulate PFAS have largely been prescriptive rather than preventative, focusing on determining which specific PFAS are acceptable for continued use in industry rather than focusing research efforts on developing alternatives. At the federal level, there has been a reluctance to fully embrace the development and adoption of safer alternatives, as policymakers are often more concerned with maintaining the current profit structures of industries that rely heavily on PFAS. Instead of pushing for a broad shift away from PFAS, the U.S. regulatory approach has been primarily focused on drawing lines between different classes of PFAS and deciding which ones should remain in use. The U.S. takes PFAS most seriously regarding water as direct consumption poses the greatest adverse health effects [88]. This piecemeal approach is trying to avoid what would no doubt be major disruptions to industry practices and profits, even at the expense of exposure to the evolving risks associated with these carcinogens.

The Toxic Substances Control Act is the primary federal statute regulating chemicals in the United States, originally passed in 1976. Under TSCA, the EPA is responsible for evaluating and managing the risks posed by chemicals, including those like PFAS, which are persistent and pose significant public health risks. The Act allows the EPA to assess and regulate chemicals already in commerce.

In one of its recent efforts, the EPA designated certain PFAS variations as "inactive" on the TSCA inventory, meaning that these chemicals cannot be manufactured, imported, or processed without first notifying the agency [61]. This mechanism helps prevent unintended introduction of harmful chemicals into the marketplace. Additionally, the EPA has implemented a Significant New Use Rule (SNUR) for inactive PFAS on the TSCA inventory, requiring companies to notify the agency at least 90 days before engaging in any significant new use of these chemicals [89]. However, despite these measures, TSCA's structure presents limitations in comprehensively addressing PFAS contamination. The Act relies on the EPA's capacity to evaluate each substance individually, and while it can restrict or ban specific chemicals, it does not provide a proactive, overarching framework like REACH or global treaties such as the Stockholm Convention, which are more suited to handling persistent chemicals on a broader scale.

As of January 6, 2025, the EPA has further expanded the scope of PFAS regulated under the TSCA and the Toxics Release Inventory (TRI) [70]. In accordance with the 2020 National Defense Authorization Act (NDAA), the EPA has automatically added nine PFAS to the TRI list for Reporting Year 2025. This action follows the finalization of toxicity values for these substances in 2024. As a result, facilities in

TRI-covered industry sectors are now required to track and collect data on these chemicals throughout 2025, with reporting forms due by July 1, 2026 [90]. This addition brings the total number of PFAS subject to TRI reporting to 205. The nine PFAS added to the list are: Ammonium perfluorodecanoate (PFDA NH_4), Sodium perfluorodecanoate (PFDA-Na), Perfluoro-3-methoxypropanoic acid, and several variants of 6:2 Fluorotelomer sulfonate (including the ammonium, potassium, and sodium salts, and the anion form).

In October 2024, the EPA proposed a rule to further expand PFAS reporting requirements. This proposal includes adding 16 individual PFAS and 15 PFAS categories, representing over 100 individual PFAS, to the TRI. These substances would be designated as chemicals of special concern and subject to a lower reporting threshold of 100 pounds. The proposal also seeks to reclassify certain PFAS previously listed individually into the new categories and clarify the criteria for automatic addition of PFAS to the TRI under the NDAA.

Facilities that manufacture, process, or use these PFAS in quantities exceeding the reporting thresholds must report their environmental releases and waste management quantities to the TRI. This information is made publicly available to inform communities and policymakers about potential chemical exposures. The EPA continues to evaluate and regulate PFAS under TSCA to mitigate potential risks associated with these substances. Facilities are encouraged to stay informed about regulatory developments to ensure compliance with reporting and safety requirements. For more detailed information, please refer to the EPA's official announcements and Federal Register notices.

While there is undoubtedly a need for swift regulatory action, deciphering which forms are the most harmful versus most essential requires continued research. The TSCA update is a good step forward that will limit the use of listed PFAS, but the Agency's reliance on congressional budget approvals hinders its effectiveness. While the Agency wields the expertise and technology to tackle PFAS issues, its decisiveness often faces constraints such as political disagreements, budget limitations, and industry opposition. This has led to criticisms that the nation has strayed from the progressive environmental leadership it once exemplified, looking back to the 1970s [100].

5. EU Regulation of PFAS

In contrast to the U.S., where power is concentrated in a single nation, the twenty-seven countries of the European Union (EU) collaborate to regulate PFAS through comprehensive legal frameworks. The EU member states include countries such as Germany, France, and Italy, among others. When the EU passes legislation, it may take the form of a regulation or a directive. A regulation is directly applicable in all EU countries, meaning member states must implement

it without further legislation. In contrast, a directive requires member states to adopt their own national laws to achieve the directive's goals. For example, REACH (Registration, Evaluation, Authorization, and Restriction of Chemicals) is a regulation, which means its provisions apply directly to all EU member states. On the other hand, the Drinking Water Directive is a directive, so each member state must implement it in line with the directive's requirements, though the specific implementation can vary [91].

Other members of the EU have also implemented significant regulatory steps in alignment with the recast Drinking Water Directive, which sets stringent limits on PFAS in drinking water (0.5 $\mu\text{g/l}$ or 500 ppt) [91]. Specific limits require that twenty of the most widespread and dangerous forms of PFAS must each be below 0.1 $\mu\text{g/L}$ or 100 ppt. Member nations must comply with these standards by 2026. Notably, in the U.S. and the EU, environmental justice considerations related to PFAS (per- and polyfluoroalkyl substances) are approached differently, reflecting distinct regulatory frameworks and policy priorities. The amended drinking water directive dedicates a complete section of the statute to outlining greater protection measures for vulnerable groups [17]. It focuses on better advocating for the health of vulnerable populations, such as children and pregnant women, by regulating contaminants that pose a higher risk to these groups [92].

Comparatively, the EU has adopted proactive and preventative measures, focusing its multi-national research power on developing PFAS alternatives. Rather than sifting through the thousands of individual PFAS compounds to decide which might still be deemed "safe," the EU has prioritized finding safer, fluorine-free chemicals to replace PFAS in relevant industries [93]. Focusing on alternatives enables a more timely and decisive reduction in the environmental footprint of PFAS. On the other hand, the U.S. remains divided in debates over which substances must remain in use for the sake of industry, leading to research gaps, and leaving structures like the TSCA an unfinished puzzle. Consequently, while the U.S. and EU are advancing research into PFAS alternatives, the EU's forward-thinking strategy enables them to remove PFAS from the environment faster than the U.S.

Countries like Sweden, Denmark, and Germany, major manufacturers in sectors historically reliant on PFAS (such as textiles, firefighting foams, and chemicals), have implemented proactive measures to address the risks associated with "forever chemicals." These nations have pioneered regulatory frameworks that limit the use of PFAS, like AFFF, and incentivize the development of safer alternatives. For example, Sweden has banned the use of PFAS in firefighting foams. It is investing heavily in research to replace these chemicals in industrial applications [94]. Similarly, Denmark has adopted strict regulations that mandate the phasing out of PFAS in consumer products [95]. Germany, with its robust industrial background, has enforced the inclusion of PFAS in its national environmental monitoring programs to better

track and mitigate contamination [96]. These regulations are backed by intense scientific research, which informs both policy and public health strategies.

In contrast, the U.S. regulation of AFFF containing PFAS varies significantly by state. While some states, such as New York [97], have enacted bans on the sale and use of PFAS-containing AFFF, others, like California [98], have imposed restrictions on its use, particularly in non-essential applications like training exercises. However, there is no comprehensive federal ban on AFFF containing PFAS in The States.

Regarding developing alternatives to PFAS, the EU has proactively incentivized research and innovation. For example, the EU-funded ZeroF project aims to create substitutes for PFAS in food packaging and textiles, involving 12 research and industry partners from nine countries [99]. Meanwhile, the U.S. Department of Defense has mandated the transition from using firefighting foam containing PFAS; however, this decision was made internally and was not backed by Congress [100]. The U.S. EPA has also been working on PFAS-related regulations, but the pace and scope of these efforts vary significantly compared to the EU's more centralized and proactive approach.

The European Chemicals Agency plays a crucial role in this regulatory landscape by assessing the risks posed by chemical substances, including PFAS, and promoting a harmonized approach across the EU nations [81]. PFAS litigation in the European Union has been relatively limited compared to the United States, mainly because EU regulations are more focused on preventative measures, including the restriction of PFAS in products and the regulation of water quality, rather than on the types of mass tort or environmental lawsuits common in the U.S. However, some key legal and regulatory developments have demonstrated the EU's efforts to address PFAS contamination through legal channels, best demonstrated through the REACH program.

The EU's process for regulating PFAS is more structured, proactive, and scientifically rigorous than the US system. It begins with a collaborative proposal from multiple members and a scientific evaluation by the agency. A six-month public consultation gathers stakeholder input, and expert committees like the Risk Assessment Committee (RAC) provide opinions. The European Commission then proposes restrictions, which the REACH Committee of all member nations votes on. This ensures restrictions are based on robust science, involve public considerations, and apply uniformly across the EU [38].

Let us briefly compare REACH to the U.S. system under the Toxic Substances Control Act. The EPA also reviews chemicals but lacks the same comprehensive scientific evaluation resources as the expansive EU alliance. While public comment is part of the U.S. process, it is conducted in a limited 60-day window from a mixed bag of laymen and experts. Additionally, the agency must show proof of harm before acting, making the process slower. This contrasts with the EU's precautionary principle, which allows action even

without full scientific certainty, prioritizing public health. It is important to remember that the legislative processes taken on by each entity are done so on vastly different scales and apply to various governmental schemes, meaning the greatest practical divergences to be expected are in manpower, timeline, and functionality as opposed to content and methodology.

5.1. Regulatory Framework Under REACH

Adopted in 2007, REACH (Registration, Evaluation, Authorization, and Restriction of Chemicals) is a broad and robust EU regulation that aims to safeguard human health and the environment from the risks posed by chemicals like PFAS, while maintaining and promoting competition in the EU chemicals industry [38]. REACH covers all chemical substances used in industrial processes or everyday products, including cleaning agents, paints, clothing, furniture, and electrical appliances [38]. This broad scope means that REACH applies to a wide range of industries throughout the EU, even those not directly involved in chemical production.

Under REACH, the responsibility lies with companies to determine and manage the risks associated with chemicals they produce or market within the EU. To comply, companies must register their chemicals with the European Chemicals Agency (ECHA) and demonstrate how they can be used safely, outlining the necessary risk management measures for consumers [22]. If ECHA concludes that a substance poses an unacceptable risk, its production can be restricted, banned, or made subject to prior authorization [101]. REACH's long-term goal in addressing PFAS is to stimulate the substitution of the most hazardous variants with safer alternatives, helping to mitigate the environmental and health impacts of these persistent chemicals [102].

Given the developing concern surrounding the environmental persistence and adverse health effects associated with PFAS, REACH has proven to be an essential vehicle for its regulation in the European Union. For example, long-chain perfluorocarboxylic acids found across the cosmetics industry have been deemed "substances of very high concern" and are subsequently highly restricted [38].

Beyond the approaches previously discussed in Section V by EU members like Sweden, Denmark, and Germany, several other members have adopted additional measures on top of REACH to regulate PFAS, including limits on its use in consumer products in trade [103]. We have also seen this on a smaller scale in the United States. Current advisories under the TSCA create a non-enforceable PFAS baseline as a guide to which individual states can adopt stricter standards.

5.2. The EU's Approach Compared to the U.S.

Both REACH and the TSCA have the same core objectives, REACH has the advantage of the collective scientific resources of the EU. Both REACH and the TSCA offer op-

portunities for public interaction and input, but they differ in their processes, levels of accessibility, and scope of engagement. The EU has been more aggressive in its PFAS regulation than the United States. The EU has restricted certain PFAS chemicals more quickly, and multiple EU countries have imposed stringent limits on the use of these substances in consumer products, where the US has no federal ban on any form of PFAS across the board. However, critics argue that the EU has not fully addressed the scope of PFAS contamination and is still struggling to find comprehensive solutions. The main obstacles faced even in these developing nations are the need for further research and vetted treatment processes. The most apparent divergence between these two powers can be measured in scale, as the U.S. is only one nation, albeit the most powerful in the world today.

Public involvement through the TSCA in the U.S. is confined to a 60-day comment period, and the EPA has to prove harm before it can take action on chemicals. In comparison, when ECHA proposes restrictions or authorizations for chemicals, the public can participate through a public consultation process, typically lasting around 6 to 12 weeks [104]. Both regimes allow stakeholders (including citizens, NGOs, industries, and public health organizations) to submit comments on the proposed actions. These comments are considered by both agencies in the final decision-making process, with a notable difference in time allotment.

Divergence in governmental structure, scale, and approach reflect the broader legislative, institutional, and procedural disparities between the two regulatory systems. REACH's comprehensive scope and emphasis on precaution enable quicker and more proactive responses to chemical risks, such as PFAS, while TSCA's more reactive nature may result in slower regulatory processes. Both frameworks aim to minimize the risks posed by dangerous chemicals, but REACH offers a more coordinated and evidence-driven approach to managing ubiquitous hazards. In terms of impact, the REACH regulations oversee a population of approximately 450 million people across the European Union, and the TSCA covers a population of about 330 million people. This means that 28 of the most powerful countries on the planet are regulating PFAS, but, in their combined efforts, are only protecting less than 10% of the global population.

6. A Path Forward for Regulation

Regulating PFAS under the current structures of TSCA and REACH is limited. International conventions provide a better path toward controlling chemicals contaminating the entire planet, as can be seen in the success of the Stockholm Convention. Incorporating PFAS into existing multilateral environmental agreements (MEAs) could lead to a more systematic and globally coordinated phaseout from its products and the environment. While PFAS are certainly unique and abundant enough to make up their own convention, for the

sake of vital time, it would be wiser to incorporate PFAS into an existing convention as is being pursued by the EU. The ultimate recommendation made by the findings of this research is that the United States follow the lead of the European Union and seek international support.

It is better to pursue global action through the Stockholm Convention rather than unilateral action for various reasons, most notably the impact of global coordination versus the limitations of a single-nation approach. PFAS are ubiquitous, widely used across industries worldwide, and have spread through air, water, soil, and food. Phasing out PFAS on a national level would have limited effectiveness if other countries continue to produce and use them, further complicating international trade relations. The Stockholm Convention is a global treaty designed to protect human health and the environment from persistent organic pollutants (POPs)—chemicals that remain in the environment for long periods, become widely distributed, and accumulate in the fatty tissue of humans and wildlife, having harmful impacts on both health and the environment [105]. The Convention requires parties to prohibit and eliminate the production, use, and trade of POPs listed in Annex A. It also mandates restrictions on the production and use, as well as import and export, of POPs listed in Annex B, and requires parties to reduce or eliminate the release of POPs listed in Annex C [103]. Once PFAS are added to the list of POPs, this treaty will compel participating countries to take coordinated actions to restrict, reduce, and eliminate the most dangerous forms of PFAS, ensuring a global response and reducing the risk of continued cross-border contamination and production.

Multilateral collaboration creates a shared responsibility among signatories and opens doors to the resources of the Global Environmental Facility, the interim financial mechanism for the convention, and the United Nations Industrial Development Organization, supporting developing countries in implementing the convention. Not only does PFAS pose environmental justice concerns domestically but globally as well. Bringing PFAS to the Stockholm Convention prevents global policy imbalances, which have been seen on a smaller scale in the federalist structure of the United States. Variance across nations in their PFAS restrictions make developing nations vulnerable to toxic waste dumping by developed consumers like the U.S. and EU. The danger PFAS poses to the people of the world may additionally call for inclusion in the Basel Convention, an international treaty designed to regulate the transboundary movement of hazardous waste, aiming to mitigate the issue of waste colonialism [103].

Perhaps the most persuasive way to implore the US to seek international support in PFAS regulation is to highlight its economic feasibility. Addressing PFAS globally through the Stockholm Convention would facilitate the development of standardized technologies and processes for treating contaminated water, cleaning up polluted sites, and replacing PFAS with safer alternatives. These economies of scale can lead to more affordable solutions, which might be difficult to

achieve through isolated national efforts. Moreover, this could be an excellent opportunity in terms of trade. Countries that sign the Stockholm Convention are less likely to face trade barriers related to chemicals or environmental standards. By working within the Stockholm Convention framework, the U.S. can help shape global chemical policy and push for more stringent global standards on PFAS. This provides leverage to create stronger regulations and commitments from other countries.

The United States can regain its status as a leader in the global environmental movement by submitting PFAS to MEAs like the Stockholm Convention. In doing so, a uniform approach to phasing out this harmful family of carcinogens can ensure the best available means for protecting the public health and restoring the environment for all people from every corner of the globe.

7. Conclusion

While progress has been made in the U.S. and the EU, significant hurdles still remain in managing PFAS and effectively phasing them out of widespread use. The continuous introduction of PFAS into the global environment, despite growing awareness of its adverse health impacts, creates high stakes for more effective and consistent regulatory measures. Whether through federal or international efforts, the time for decisive action is now. To protect public health and restore the environment for all, it is critical for nations, especially the U.S., to embrace coordinated global action. By doing so, we can ensure that the best available means for addressing the PFAS crisis are put into place, safeguarding future generations from its devastating effects.

Abbreviations

AFFF	Aqueous Film-Forming Foam
ATSDR	Agency for Toxic Substances & Disease Registry
BAT	Best Available Technologies
BMI	Body Mass Index
CDC	Centers for Disease Control & Prevention
DOD	Department of Defense
ECHA	European Chemicals Agency
EPA	Environmental Protection Agency
EU/E.U.	European Union
EWG	Environmental Working Group
FDA	Food & Drug Administration
GAC	Granular Activated Carbon
GenX	The Manufacturing Process Combines Two Molecules of Hexafluoropropylene Oxide (HFPO) to form HFPO-DA. HFPO-DA Is Converted into Its Ammonium Salt That Is the Official GenX Compound
MCLGs	Maximum Contaminant Level Goals

MCLs	Maximum Contaminant Levels
MEAs	Multilateral Environmental Agreements
MoCRA	Modernization of Cosmetics Regulation Act
NDAA	National Defense Authorization Act
PFAS	Polyfluoroalkyl Substances
PFBS	Perfluorobutanesulfonic Acid
PFDA	Perfluorodecanoic Acid
PCTFE	Polychlorotrifluoroethylene
PFHxS	Perfluorohexane Sulfonic Acid
PFNA	Perfluorononanoic Acid
PFOA	Perfluorooctanoic Acid
PFOS	Perfluorooctanesulfonic Acid
PFUnDA	Perfluoroundecanoic Acid
POPs	Persistent Organic Pollutants
RAC	Risk Assessment Committee
REACH	Registration, Evaluation, Authorization, & Restriction of Chemicals
SNUR	Significant New Use Rules
TRI	Toxic Report Inventory
TSCA	Toxic Substances Control Act
US/U.S.	United States (The States)
WHO	World Health Organization
WOTUS	Waters of the United States
WWTPs	Wastewater Treatment Plants

Conflicts of Interest

The authors declare no conflicts of interest.

References

- [1] Fenton, et al. Per- and Polyfluoroalkyl Substance Toxicity and Human Health Review: Current State of Knowledge and Strategies for Informing Future Research. *Environmental Toxicology and Chemistry*, vol. 40, no. 3, pp. 545-567 (2021).
- [2] Thabet et al., A critical review of perfluoroalkyl and polyfluoroalkyl substances (PFAS) landfill disposal in the United States, *Science of the Total Environment*. Volume 905, Page 1 (2023).
- [3] McGreal, C. PFAS: Toxic 'forever chemicals' found in food and water. *The Guardian*, Page 2 (2024, February 19).
- [4] Samora & Lucas, The history of PFAS: From World War II to your Teflon pan, *Manufacturing Deep Dive*, the Genesis of Forever Chemicals, Page 3 (2023).
- [5] U.S. Env't Prot. Agency, Our current understanding of human health and environmental risks of PFAS, U.S. EPA (2023).
- [6] Jones et al. PFAS: What we study. Division of Cancer Epidemiology and Genetics, National Cancer Institute, PFAS Information Page (n.d.).
- [7] European Chemicals Agency. ECHA receives a PFAS restriction proposal from five national authorities, *Latest News Dropdown* (2023).

- [8] U.S. Env't Prot. Agenc, Provisional Health Advisories for Perfluorooctanoic Acid (PFOA) and Perfluorooctane Sulfonate (PFOS), EPA PFAS Portal (2009, Jan 8).
- [9] Chen, A., PFAS 'forever chemicals' maps show water contamination hotspots worldwide, CBS News (2023, March 24).
- [10] ELG Law, Most PFAS-contaminated states, Environmental Litigation Group (n.d.).
- [11] See *infra* Section III - Discussing the environmental effects of PFAS variants.
- [12] H. R. 2467, 117th Cong. (1st Sess. 2021).
- [13] Pien Huang, States are covering the costs to update WWTPs: How a California county got PFAS out of its drinking water, health news from national public radio (2024, Sept).
- [14] James B. Pollack & Zack J. Zahner, State Action on PFAS Expands with Bans, Labeling, and Reporting Requirements, marten law, news & insights, Colorado expands product bans and introduces labeling Requirements for Outdoor Apparel (2024, June).
- [15] European Environment Agency, Treatment of drinking water to remove PFAS, European Zero Pollution Dashboards (2024, Oct).
- [16] Peter Simpson, Restriction of per- and polyfluoroalkyl substances (PFAS) under REACH, European Chemicals Agency, Slides 40-43 (202, Oct).
- [17] Widener, A., The Battle Over PFAS Regulation in Europe, Chemical & Engineering News (2023, Aug).
- [18] Stockholm Convention on Persistent Organic Pollutants, Decision SC-9/14, Perfluorooctanoic Acid (PFOA), its Salts and PFOA-related Compounds (2019).
- [19] Stockholm Convention on Persistent Organic Pollutants, Website for The Stockholm Convention on Persistent Organic Pollutants, the Convention/Overview/Main Provisions, Paragraph 2.
- [20] Kraft, A., EPA Office of Research and Development Human Health Toxicity Assessment Products on PFAS, Remplex Virtual Summit, Washington, D.C. (2021, Nov).
- [21] Bahareh Karimi Douna & Hossein Yousefi, Removal of PFAS by Biological Methods, Asian Pacific Journal of Environment and Cancer, Vol. 6, PFAS Biological Treatment, Introduction section, Paragraph 1. (2023, March).
- [22] Grand View Reporting, Nonstick Cookware Market Size, Share & Trends Analysis Report By Raw Material (Teflon Coated, Ceramic Coating), By Distribution Channel (Supermarkets & Hypermarkets, Online), By Region, And Segment Forecasts, Home «Homecare & Decor» Nonstick Cookware Market Size Report, 2021-2028, Figure 1 (2024).
- [23] Karen B. Gibbs, 21 things you should never put in the dishwasher, TODAY NEWS, Page 1, Section 3: Nonstick Pots & Pans (2020, Oct).
- [24] European Environment Agency, PFAS in textiles in Europe's circular economy, How PFAS Are Used in Textiles, Page 1 (2024, Sept).
- [25] Food & Drug Administration, Industry Actions End Sales of PFAS Used in US Food Packaging, Home/News & Events/FDA Newsroom/Press Announcements, Paragraphs 1-3 (2024, Feb).
- [26] Tom Perkins for The Guardian, Toxic 'forever chemicals' widespread in top makeup brands, study finds, Lifestyle menu, Makeup, Paragraph 8 (2021, June).
- [27] Weitz & Luxenberg Law Firm, PFAS in Cosmetics, consumer protection/product liability/ PFAS in Mascara Lawsuits (2022).
- [28] Modernization of Cosmetics Regulation Act of 2022, Pub. L. No. 117-328, § 604, 136 Stat. 4459 (2022).
- [29] U.S. Food & Drug Admin., Per and Polyfluoroalkyl Substances (PFAS) in Cosmetics, The Modernization of Cosmetics Regulation Act of 2022 (2024, Jan).
- [30] Keefe Law Firm, AFFF Firefighting Foam: History, Usage, and Ever-Present Public Health Risks, AFFF Firefighting Foam Development, Paragraph 2 (n.d.).
- [31] U.S. Government Accountability Office, Firefighting Foam: DOD is Working to Address Challenges to Transitioning to PFAS-Free Alternatives, Why GAO Did This Study, Page 2 (2024, July).
- [32] Global Market Insights, Firefighting Foam Market - By Type (Aqueous Film Forming Foam (AFFF), Alcohol-Resistant Aqueous Film Forming Foam (AR-AFFF), Protein Foam, Synthetic Detergent Foam), By End-Use, By Fire Class & Forecast, 2023 - 2032, Summary tab, Firefighting Foam Market Analysis, Page 2 (2023, Dec).
- [33] U.S. Env't Prot. Agency, DuPont and Chemours Company PFOA Settlements, U.S. EPA (2022, February 22).
- [34] 3M Corp. Website, View 3M's position on recent news relating to fluorocchemistry regulation and stewardship, PFAS statements page, 3M's Phase-out of PFOS and PFOA, Page 3 (2024).
- [35] ChemSec Reports, The Top 12 PFAS Producers in the World and the Staggering Societal Costs of PFAS Pollution, International Chemical Secretariat (2023, May).
- [36] Stoiber T., Evans S., Naidenko O., Disposal of products and materials containing per- and polyfluoroalkyl substances (PFAS): A cyclical problem, Chemosphere (2020, Dec).
- [37] U.S. Secretary of Defense for Energy, Installations, and Environment, Department of Defense Incineration Moratorium Report to Congress, (2024, Feb).
- [38] Mills et al. Typical Conditions for Incineration of Municipal Waste and Fluoropolymers. Battelle Memorial Institute, U.S. Env'tl. Prot. Agency (2019).
- [39] U.S. Env't Prot. Agency, PFAS Explained, section 2 (2024).

- [40] SeJiuyi Li a, Jing Sun a, Pengyang Li, Exposure routes, bio-accumulation and toxic effects of per- and polyfluoroalkyl substances (PFASs) on plants: A critical review, *Science Direct Scholarly Journal*, ELSEVIER Publishing, Vol. 158, Section 2.2 Bioaccumulation (2022, Jan).
- [41] Minnesota Dept. of Health, PFAS and Homegrown Garden Produce, Page 1 Introduction (2022, Jan).
- [42] U.S. Env't Prot. Agency, Per- and Polyfluoroalkyl Substances (PFAS): Final PFAS National Primary Drinking Water Regulation Summary, (2023).
- [43] Nayak S, Sahoo G, Das II, Mohanty AK, Kumar R, Sahoo L, Sundaray JK, Poly- and Perfluoroalkyl Substances (PFAS): Do They Matter to Aquatic Ecosystems?, *National Library of Medicine* (2023, June).
- [44] J. M. Armitage et al., PFAS Exposure Pathways for Humans and Wildlife: A Synthesis of Current Knowledge and Key Gaps in Understanding, *Environ. Toxicol. Chem.* (2021, March).
- [45] Chester Rodriguez, What do laboratory animal studies tell us about the toxicity of PFAS?, *Water & Health Advisory Council, Toxicity Findings from Laboratory Animal Studies*, Pages 4-5 (2021).
- [46] European Animal Research Association, REACH Testing for Cosmetic Ingredients, What Is REACH testing? Page 1 Section 1 (2023).
- [47] U.S. Env't Prot. Agency, Alternative Test Methods and Strategies to Reduce Vertebrate Animal Testing, *Assessing and Managing Chemicals under TSCA* (2024).
- [48] See *supra* note 7, Discussion Section, Paragraph 2.
- [49] Wen, Xue, Mei Wang, Xuewen Xu & Tao Li, Exposure to Per- and Polyfluoroalkyl Substances and Mortality in U.S. Adults: A Population-Based Cohort Study, 130 ENV'T HEALTH PERSPECTIVES 027014 (2022).
- [50] Backhaus & Hayes, Environmental injustice: Passing on the costs of 'forever chemicals' cleanup, *Environmental Working Group* (2022, May 26).
- [51] Schaidt et al. Communities of color disproportionately exposed to PFAS pollution in drinking water, *Harvard T. H. Chan School of Public Health* (2023, May 15).
- [52] Rickard et al., Per- and poly-fluoroalkyl substances (PFAS) and female reproductive outcomes: PFAS elimination, endocrine-mediated effects, and disease, page 2 (2022, Jan 15).
- [53] U.S. National Library of Med. Guidance on PFAS Exposure, Testing, and Clinical Follow-Up.. national capital bookshelf, Page 2, section 2, environmental justice (2024).
- [54] Isabella Raponi, Phil Brown, and Alissa Cordner, Improved medical screening in PFAS-impacted communities to identify early disease, *Environmental Health News, Home/Originals/Toxics, PFAS testing, The importance of medical screening for PFAS*, Page 2 (2021, June).
- [55] New Jersey Dept. of Environmental Protection, Affirming National Leadership Role, NJ Publishes Formal Stringent Drinking Water Standards for PFOA & PFOS, (20/P025) Trenton (2020).
- [56] Safer States Environmental Policy Organizations Network, PFAS, All Safer Solutions, All States, Bill tracking - Search Results (2025).
- [57] Thomas S. Lee, Bryan E. Keyt, Merrit M. Jones, John R. Kindschuh, PFAS in consumer products: state-by-state regulations, BCLP - bryan cave Leighton Paisner Global Law Firm, Enacted & Proposed PFAS Consumer Product Laws (2024, July).
- [58] U.S. Congress. Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. § 9601 et seq., TITLE 42 — THE PUBLIC HEALTH AND WELFARE (2021).
- [59] PFAS Action Act of 2021, H. R. 2467, § 6, 117th Cong. (2021).
- [60] PFAS Action Act of 2019, H. R. 535, 116th Cong. (2019).
- [61] U.S. Env'tl. Prot. Agency, Health Advisory for PFOA and PFOS (2016).
- [62] U.S. Env'tl. Prot. Agency, PFOA Stewardship Program, 71 Fed. Reg. 10441 (Mar. 1, 2006).
- [63] U.S. Env't Prot. Agency, Per- and Polyfluoroalkyl Substances (PFAS) - Final PFAS National Primary Drinking Water Regulation, source date from Summary, Supporting Materials, and Background menus, (2024).
- [64] Section 1414 of the Safe Drinking Water Act (SDWA) 42 U.S.C. § 300g-3 (2021).
- [65] Agency for Toxic Substances and Disease Registry, PFAS Exposure Assessment Final Report - Findings Across Ten Exposure Assessment Sites, Center for Disease Control & Prevention (2022, Sept).
- [66] Senate Committee on Environment and Public Works, Superfund Sites Identified by the Environmental Protection Agency to Have PFAS Contamination, 117th Congress (2021).
- [67] David Vergun, DOD Officials Testify on Defense Environmental Restoration Program, Dept. of Defense News, Paragraph 10 (2021, June).
- [68] Nicole Marie Brennan, Abigail Teresa Evans, Meredith Kate Fritz, Stephanie Allison Peak & Haley Elizabeth von Holst, Trends in the Regulation of Per- and Polyfluoroalkyl Substances (PFAS): A Scoping Review, *International Journal Environmental Research & Public Health* (2021).
- [69] U.S. Env'tl. Prot. Agency, EPA's Summary Tables for 2014 Company Progress Reports, 2020/2015 pfoa stewardship program hello (2025).
- [70] *Atlantic Richfield Co. v. Christian*, 140 S. Ct. 1335 (2020). - Standards of clean up differed between the State and the Federal EPA.

- [71] Alison L. Ling, Estimated Scale of Costs to Remove PFAS from the Environment at Current Emission Rates, science of the total environment (2024).
- [72] Interstate Tech. & Regulatory Council, Per- and Polyfluoroalkyl Substances (PFAS), section 2.3.1 awareness of potential health impacts (2023).
- [73] Violet v. Picillo, 648 F. Supp. 1283 (D.R.I. 1986). - Case alleges 35 PRPs.
- [74] American Chemistry Council, Overly Broad PFAS Restrictions Could Endanger Healthcare Quality and Cost, (2023, July).
- [75] Bureau Veritas North America, PFAS replacement compounds, BVNA (2018, Oct 12).
- [76] Illinois Dept. of Environmental Protection, PFAS: Water quality, IL EPA (2024).
- [77] European Commission Published Initiatives, Persistent Organic Pollutants: Perfluorohexane Sulfonic Acid (PFHxS), Regulation (EU) 2019/1021 - Commission adoption 30 May 2023.
- [78] Betty Hakkert, Committee for Risk Assessment, Opinion Proposing Harmonised Classification and Labelling at EU Level of Undecafluorohexanoic Acid, PFHxA, Sodium Undecafluorohexanoate, NaPFHx, Ammonium Undecafluorohexanoate, APFHx, Other Inorganic Salts of Undecafluorohexanoic Acid, echa (2024, March 14).
- [79] U.S. Env't Prot. Agency, Treatment Options for Removing PFAS from Drinking Water, national primary drinking water regulations, fact sheet (2024, Apr).
- [80] Global Affairs, PFAS (forever chemicals): Countries and regulations (2024).
- [81] Eurofins, PFAS restriction proposal (2023, February 7).
- [82] Lautanen et al., PFAS in wastewater biosolids are coming under scrutiny, regulation, Marten LAW (2024, Sept 10).
- [83] Alex Arger, Lawsuit claims menstrual product contains forever chemical known to cause reproductive issues, Scripps News Health Page (2024, Nov).
- [84] Safe Drinking Water and Toxic Enforcement Act of 1986 (Cal. Health & Safety Code § 25249.5 et seq.).
- [85] Clark Mindock, Kimberly-Clark factory where Kleenex made pollutes town with PFAS, lawsuit says, Reuters International News (2024, Feb).
- [86] Avinash Kar, Dr. Anna Reade, Susan Lee, Dirty Water: Toxic "Forever" PFAS Chemicals Are Prevalent in the Drinking Water of Environmental Justice Communities, National Resources Defense Council (2024, Feb).
- [87] U.S. Env't Prot. Agency, Toxic Chemical Release Reporting; Community Right-to-Know, 89 Federal Register 81776, 40 CFR Part 372 (2024).
- [88] U.S. Env't Prot. Agency, EPA Adds Nine Additional PFAS to the Toxics Release Inventory, (2025, Jan).
- [89] U.S. Env't Prot. Agency, Per- and poly-fluoroalkyl chemical substances designated as inactive on the TSCA inventory, Federal Register (2024, January 11).
- [90] Official Journal of the EU, ...of the European Parliament and of the Council of 16 December 2020 on the quality of water intended for human consumption, Drinking Water Directive 2020/2184, Legislation Series 435 (2020).
- [91] European Chemicals Agency, Per- and Polyfluoroalkyl Substances (PFAS), ECHA Home Page/News/Hot topics/Per- and polyfluoroalkyl substances (2025).
- [92] Elise D. Solberg, Denmark to Map PFAS Emissions from Industrial Smoke, awe international environment impact magazine (2025, Feb).
- [93] European Chemicals Agency, ECHA and Five European Countries Issue Progress Update on PFAS Restriction, ECHA/NR/24/31 (2024).
- [94] New York State Department of Environmental Conservation, New York State's Ban on PFAS in Firefighting Foam, Home Page/Regulations and Enforcement/Proposed Regulations Available for Public Comment/Storage And Use Of Fire Fighting Foams - Fact Sheet (2024).
- [95] Cal. Code Regs. Tit. 19, § 2540 (2023).
- [96] The ZeroF European Union Project, Project Page (2023).
- [97] John Swanson, U.S. Department of Defense to Phase Out PFAS in Firefighting Foam, national fire sprinkler association (2024, June).
- [98] European Chemicals Agency, Perfluoroalkyl chemicals (PFAS), ECHA PFAS Database (2024).
- [99] European Chemicals Agency, Understanding REACH, Legislative Portal (2024).
- [100] Persistent Organic Pollutants Review Committee, Long-chain perfluorocarboxylic acids (PFCAs, C9–C21), their salts and related compounds Draft risk management evaluation Page 7, Section 1.5 Subsection 27 (2023, March).
- [101] Stephanie Amaru & Reza Zarghamee, French Parliament Unanimously Approves a Bill Banning Certain PFAS Pillsbury Law PFAS Observer, Paragraph 2 (2024, Apr).
- [102] Stockholm Convention, at art. 1.
- [103] United Nations. (2001). *Stockholm Convention on Persistent Organic Pollutants*. 2256 U.N.T.S. 119. Articles III & V.
- [104] Maggie Clark, The (PFAS)T and the Furious: Applying Hazardous Waste Management Frameworks to the Global Presence of PFAS, Vol. 87, ISSUE 3, ARTICLE 7. JOURNAL OF AIR LAW & COMMERCE (2022).
- [105] United Nations Environment Programme. Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal. unep, Sections 1-26 (1989).