PFAS and the Pollution Trap:
Contested knowledge in environmental justice struggles

Layla Lomé van der Donk[1], Marcel Llavero-Pasquina[1]

[1]*Institut de Ciència i Tecnologia Ambiental, Universitat Autònoma de Barcelona*

Abstract

Emerging evidence on per- and polyfluoroalkyl substances (PFAS) contamination hotspots has put these persistent chemicals under growing scrutiny. However, chemical corporations' deliberate efforts at veiling risks associated with PFAS have led regulatory bodies to give a slow response to this ominous environmental and public health threat. This article analyses 25 environmental conflicts over PFAS contamination using the Global Atlas of Environmental Justice, paying particular attention to the contestation of knowledge and the roles of PFAS' chemical properties in shaping these conflicts. In doing so, it situates environmental justice struggles in the arena of post-normal science and adds to the empirical demonstration of manufactured uncertainty by PFAS-emitting industries. It highlights how the invisible nature of PFAS allows those responsible for contamination to keep the environmental threat under the radar, which supports the case for treating embodied experiences of people in affected communities as valuable sources of data informing timely policy interventions. The analysis contributes to environmental justice literature by pointing at the emergence of new environmental justice communities and sacrifice zones through what we liken to a "pollution trap" created by invisible yet persistent toxics. Our findings call for urgent preventive action, research, dissemination, and regulation, particularly out of concern over the expansion of toxic frontiers to the Global South.

Keywords: PFAS, forever chemicals, environmental justice, EJAtlas, post-normal science, manufactured uncertainty

1. Introduction

Less than a century since they were invented, Per- and Fluoroalkyl Substances (PFAS) have become virtually ubiquitous in the environment, having penetrated the most remote corners of the Earth (Andrews et al., 2023; Cordner et al., 2021; Renfrew & Pearson, 2021). They are present in nearly the entire American population (Calafat et al., 2019), and wildlife worldwide (Andrews et al., 2023). The Forever Pollution Map (Forever Pollution Project, 2023) reveals the extent of PFAS contamination across Europe, with over 23,000 contaminated sites and more than 2,300 PFAS contamination

hotspots. Pesticide Action Network Europe (2024) detected PFAS in mineral waters from several European countries, indicating that contamination goes beyond surface and tap water, reaching into groundwater and deep aquifers previously thought to remain free from such pollutants. According to the Forever Lobbying Project (2024), the cleanup costs of all PFAS in Europe amount to €2 trillion. Cleanup of PFAS contamination sites is highly challenging given the limited effectiveness of traditional environmental remediation technologies and the high costs of sophisticated removal methods (Tapa et al., 2024).

PFAS pose a significant threat to public health and non-human life (Cordner et al., 2021). Human exposure occurs through ingestion (food, water, dust), inhalation, skin contact, and in utero exposure (De Silva et al., 2020; Hyötyläinen et al., 2024; Sunderland et al., 2018), with dietary exposure constituting the primary route (Sunderland et al., 2018). Prolonged exposure to certain types of PFAS can impair immune system functioning and can lead to cancer, particularly kidney, liver, and testicular cancer (Agency for Toxic Substances and Disease Registry, 2021; Sunderland et al., 2018). Even at low concentrations, PFAS can damage the thyroid and cause developmental issues (Brunn et al., 2023). Children are especially vulnerable (Blake & Fenton, 2020; Chohen et al., 2020). Although people worldwide interact with PFAS through countless everyday objects, exposure is most severe near chemical manufacturing sites (Onencan, Bisschop, & Hendlin, 2024). As a result, these contaminants have been the source of various environmental justice (EJ) conflicts featuring health impacts, which Navas and colleagues (2022) particularly call Environmental Health Conflicts (EHCs).

PFAS' chemical structure is characterised by carbon-fluoride bonds, providing the basis of their characteristic recalcitrance (Sinclair, Long, & Jones, 2020). Their durability makes them attractive to a wide range of industrial uses, including non-stick coatings, food packaging, firefighting foams, and textile treatments (EJAtlas, 2022; Glüge et al., 2020; Sinclair, Long, & Jones, 2020). The persistence that forms the basis of PFAS' industrial value is simultaneously the foundation of the environmental problems they create. PFAS are notoriously hard to destroy, to which they owe their nickname "forever chemicals' (U.S. House Committee on Oversight and Reform, 2019). PFAS are bioaccumulative, building up in organisms and magnifying as they move up the food chain, leading to gradual accumulation in ecosystems (Brunn et al., 2023; Onencan, Bisschop, & Hendlin, 2024).

Research on the perspectives of those fighting PFAS contamination is limited. As Onencan, Bisschop, and Hendlin (2024) note, insufficient attention has been given to the views and actions of affected communities. And yet, PFAS continue to be produced and released into the environment, where they remain for centuries to come. More than 10,000 types of PFAS are currently on the market (Forever Pollution Project, 2025), and new variants continue to emerge. Hence, from a political ecology and a planetary health perspective, it is crucial to examine *who* benefits from their production, *who* suffers

from their impacts, and *how* affected communities seek justice. With the aim to inform policy regulations and call the attention of the academic community to this widespread yet understudied environmental issue, we particularly ask: 1. how is knowledge contested between companies seeking profit and environmental justice communities defending life, and 2. how do the unique chemical properties of PFAS shape the strategies of companies and the reaction of affected communities in environmental conflicts?

Theoretically, this work frames forever chemical contamination within post-normal science (PNS) and conceptualises the PFAS industry's manipulative tactics as manufacturing of uncertainty. Empirically, we analyze 25 PFAS contamination cases documented in the Environmental Justice Atlas (EJAtlas) using a mixed-methods approach, combining case studies with quantitative analysis. The EJAtlas allows for a systematic and transnational comparative analysis of resistance strategies, mobilization patterns, and outcomes, highlighting the protagonism of communities mobilizing and emphasizing the human aspect of these struggles while illuminating global patterns of PFAS contamination and resistance. We contribute to the literature by bringing attention to the environmental justice struggles around PFAS, a rapidly emerging yet understudied environmental challenge. We do so by linking socio-political patterns of conflict to PFAS' invisibility, persistence, and chemical diversity, while particularly considering how knowledge is contested in high stakes environmental questions. Through our analysis, we introduce the concept of the pollution trap, which advances the understanding of environmental justice conflicts linked to emerging contaminants and has broad relevance for other environmental challenges like air pollution, pesticides, or microplastics.

2. Literature review

2.1 The corrupted conversation

Industries have long employed the tactic of manufacturing uncertainty to hijack the discourse around various environmental and public health issues. By amplifying gaps in evidence and casting doubt on the legitimacy of scientific findings, they have been able to delay regulations and maintain favorable conditions for their operations (Michaels & Monforton, 2005; Oreskes, 2015). Vested interests often dismiss evidence as "junk science" unable to justify public health and environmental regulations (Michaels & Monforton, 2005). This manipulative strategy prioritises market interests over public safety, hindering precautionary measures and perpetuating a "laissez-faire" governance approach that permits harmful practices to continue.

One prominent example is the tobacco industry's decades-long effort to discredit evidence linking smoking to cancer (Saloojee & Dagli, 2000). Despite scientific consensus, Big Tobacco went through great lengths to protect its interests by funding studies designed to sow doubt and labeling legitimate research as junk science (ibid.). Similar manipulative tactics geared at creating artificial scientific

controversy have been used by the lead (Nriagu, 1998; Rosner & Markowitz, 2007), asbestos (Egilman, Bird, & Lee, 2014; Zulkarnain, Pradnyaparamitha, & Basrowi, 2023; Shearer, 2015), petrochemical (Tilsted et al., 2022), and glyphosate-based herbicides (GBHs) industries (Myers et al., 2016).

2.2 Manufacturing of uncertainty by the PFAS industry

The dynamics of manufactured uncertainty are also evident in the case of forever chemicals (Gaber, Bero, & Woodruff, 2022). For decades, chemical industries suppressed evidence of the environmental and health risks associated with PFAS contamination (Bilott, 2019; Gaber, Bero, & Woodruff, 2022). Internal documents from the 1960s and 1970s reveal that PFAS manufacturers knew of the toxicity of forever chemicals long before the wider scientific community and regulatory bodies were notified (Gaber, Bero, & Woodruff, 2022). In-house animal studies by DuPont hinted at a range of potential health impacts, but findings were hidden from the public (Gaber, Bero, & Woodruff, 2022). A 1976 workplace exposure study by chemical manufacturer 3M found extremely elevated blood levels of fluorochemicals among employees at one of the company's manufacturing sites (Lerner, 2018), yet manufacturers suppressed the evidence and continued production (Cordner et al., 2021).

The PFAS industry's extensive efforts to obscure the truth about its operations are exemplified by the 20-year legal battle between environmental attorney Robert Bilott and DuPont (now Chemours) over PFAS contamination in Parkersburg, Virginia (EJAtlas, 2022; Renfrew & Pearson, 2021). This landmark case, which inspired the film *Dark Waters* (2019), exposed decades of suppressed evidence by DuPont, which had known about the harmful impacts of operations at the Washington Works plant since the 1970s (EJAtlas, 2022). Instead of reporting the alarming findings from its internal studies, DuPont continued producing PFOA (also known as C8), knowingly endangering its employees and public health. Such actions fall under what Wickham and Shriver (2021) call "coerced ignorance", where the public remains uninformed about the risks of PFAS due to the industry's efforts to control the narrative by persistently presenting PFAS as harmless and casting doubt on studies linking exposure to health impacts (Renfrew & Pearson, 2021).

The PFAS industry's manipulative tactics not only kept the public in the dark regarding the toxic contamination of their bodies and environments, but they also fostered a laissez-faire approach to forever chemical governance. In the United States, forever chemicals were grandfathered in under the Toxic Substances and Control Act (1976), exempting thousands of in-use chemicals from regulation under the unverified premise they were non-hazardous (Gross & Birnbaum, 2017; Richter, Corner, and Brown, 2020). Both the US Environmental Protection Agency (EPA) and the European Commission's Registration, Evaluation, Authorisation, and Restriction of Chemicals (REACH) framework rely on voluntary reporting of concerns by the chemical industry (ECHA, n.d.; Renfrew &

Pearson, 2021). Manufacturers who introduce new types of PFAS often use confidential business information (CBI) to keep details about compounds private, which, as Sheriff and colleagues (2020) explain, hinders regulatory action and risk management. Richter, Corner, and Brown (2020) further argue that such CBI claims obstruct independent research and monitoring efforts, ultimately facilitating manufactured ignorance.

By this point, evidence of PFAS toxicity has finally prompted some regulatory action. The two most widely applied and investigated types, PFOS and PFOA, are now phased out in the United States (Renfrew & Pearson, 2021; Sinclair, Long, & Jones, 2020). In 2017, Europe passed a ban on PFOA, enacted in 2020 (Tudela & Delgado; 2025). However, manufacturers have conveniently replaced banned compounds with novel short-chain PFAS. In 2009, DuPont replaced PFOA with perfluoro-2-propoxypropoanoic acid, known by its trade name 'GenX' (Lapado, Mohammed, & Nwosu, 2019). Although DuPont introduced GenX as an allegedly less persistent alternative to its precursors, recent studies show the compound to be equally, if not more, persistent and toxic (Gomis et al., 2018; Yang et al., 2022; Zhang et al., 2021).

With PFAS having infiltrated every nook and cranny of modern consumer societies and the environment, it can be difficult to envision a way out of the socio-environmental crisis they pose. However, there are ways to phase them out of production chains (Glüge et al., 2020), though challenging (Hansen et al, 2024). Efforts to identify alternatives for transitioning away from PFAS are ongoing (Lennquist et al., 2024). In early 2023, Denmark, Germany, the Netherlands, Norway, and Sweden submitted a collective proposal to the European Chemicals Agency (ECHA) for a universal restriction on PFAS (uPFAS) under the REACH regulation (Forever Pollution Project, 2025). Unlike previous bans, this groundbreaking regulation targets PFAS as a class, including yet-to-be-developed chemicals with similar structural characteristics (Forever Pollution Project, 2025; Gleiss Lutz, 2024). The proposal aligns with Cousins and colleagues' (2020) precautionary argument that "the high persistence of PFAS is sufficient cause of concern for all "non-essential" uses of PFAS to be phased out". The Forever Lobbying Project revealed extensive lobbying by the plastics industry to exempt fluoropolymers from the restriction, finding misleading arguments lacking scientific support, and finding parallels with the manipulative tactics used by the tobacco and fossil fuel industries (Forever Pollution Project, 2025).

3. Theoretical framework: Post-Normal Science (PNS) in the context of manufactured uncertainty

The recurring patterns of manufactured uncertainty across industries underscore the inadequacy of traditional scientific approaches in addressing complex environmental challenges (Funtowicz & Ravetz, 1997). As Funtowicz and Ravetz (1993, p. 744) argue, conventional "normal science" - with

its linear notion of progress and arguably reductionist methods, falls short when "facts are uncertain, values in dispute, stakes high and decisions urgent". Traditional scientific approaches are inadequate when handling the urgency and diverse values inherent in such issues.

Post-normal science (PNS) emerged in the early 1990s as a framework better suited to navigate complex issues such as environmental contaminants (Funtowicz, Ravetz, 1993; Ravetz, 2004). It emphasises a more reflective, nuanced approach to scientific praxis (ibid.), coming to terms with the profound complexity, unpredictability, and inherent uncertainty of many natural processes (Westra, 1997). PNS advocates for including a diverse range of stakeholders - a so-called "extended peer community" - to democratise scientific discourse and ensure decision-making is informed by a plurality of perspectives (Funtowicz, Ravetz, 1993). By extending the peer community, PNS diversifies problem-solving processes by incorporating local knowledge from "those whose lives and livelihood depend on the solution of the problems" (Funtowicz, Ravetz, 1997, p. 174).

Manufactured uncertainty contrasts sharply with Funtowicz and Ravetz's conception of PNS. Instead of promoting epistemic diversity and inclusivity, such efforts foster epistemic monopoly. Due to the political and financial power in the hands of large corporations, conversations tend to be dominated by their voices, sidelining those who challenge the social and environmental impacts of industrial activities. While PNS seeks to address uncertainty constructively and inclusively, manufactured uncertainty deliberately undermines this approach.

PFAS, like many toxic contaminants, are characterised by their invisibility, making it difficult to trace their impacts. Coupled with their cumulative, gradual effects on health and the environment, such contaminants are emblematic of Nixon's (2011) concept of "slow violence" - a form of harm easily overlooked but real for those directly affected (Davies, 2022). The challenge of linking substances to their impacts paves the way for the PFAS industry to manipulate the conversation by manufacturing uncertainty. However, the concealment of toxic contamination arises not solely from its intangibility but also from the systemic disregard for embodied experiences of harm. As Davies (2022) argues, slow violence persists not due to a lack of detailed accounts from those impacted, but rather because these testimonies do not 'count', echoing Spivak's (1988) concept of epistemic violence. Without 'hard' evidence directly linking contamination to health and environmental impacts, affected communities continue enduring the gradual accumulation of toxins, irreversibly wounding their bodies and environments despite early warnings.

4. Methods

To investigate the experiences of communities affected by PFAS contamination, this article draws from the Environmental Justice Atlas (EJAtlas), the largest global database of environmental conflicts (Temper et al., 2018), featuring over 4,250 cases by February 2025. The EJAtlas combines categorical data with rich textual data, hence useful for both quantitative and qualitative analyses. By bridging local conflicts worldwide, the EJAtlas demonstrates that environmental conflicts are systemic, not anecdotal (Martinez-Alier, 2023). It constitutes a useful tool for conducting comparative political ecology and serves as a testament to what Martinez–Alier and colleagues (2016) refer to as the global movement for environmental justice.

This article continues a broader effort to apply a commodity-based approach to the EJAtlas. Prior work in this tradition has focused on oil and gas (Llavero-Pasquina et al., 2024), sand mining (Bisht & Martinez Alier, 2022), iron ore (Saes & Bisht, 2020), coal (Roy & Schaffartzik, 2021), dams (Del Bene, Scheidel, & Temper, 2018), and critical metals and minerals (Walter, Deniau, & Vargas, 2024). A commodity-focused lens may reveal patterns unique to particular industries. In this context, we contribute to the literature on PFAS by analysing conflicts across diverse settings, moving beyond isolated case studies to develop a political ecology of PFAS contamination. This study is the outcome of an effort at expanding coverage on PFAS-related conflicts in the EJAtlas, as they were seriously underrepresented up until recently. Over a year and a half, we documented 18 PFAS contamination cases in the database.

This article presents two types of analysis: a qualitative case-based examination of a selection of cases in the EJAtlas and a quantitative analysis of 25 PFAS-related conflicts. Through a mixed-methods approach, we combined case studies with quantitative statistical analysis. Data was drawn from the EJAtlas and supplementary academic and gray literature, including reports, legal documents, and policy briefs. For the qualitative analysis, purposeful sampling was used with the ambition of representing diverse geographical contexts, different types of perpetrators, and actor groups. Case studies are discussed first to provide rich, contextual examples before turning to statistical analysis.

Table 1 presents the 25 PFAS cases included in the quantitative analysis, with their respective country, settings, responsible parties, and environmental justice outcomes. Cases were selected based on the inclusion of “PFAS”, “PFOA” and/or “PFOS” in their title or case description. From this selection, one case was excluded as an outlier, as it is the only case in the Global South. The quantitative analysis tested the frequency of the EJAtlas variables (i.e. conflict type, impacts, mobilisation forms, and outcomes) in the 25 PFAS cases against a baseline of all other conflicts in the United States, the European Union, and Australia (n = 841) using a Pearson’s Chi-squared test. The baseline was selected on the basis that all documented PFAS cases took place in these jurisdictions, chosen to avoid potential biases related to comparing cases outside these geographies. Variables definitions are

provided in the EJAtlas[1]. The analysis was performed using RStudio 2023.03.0 and R 4.3.1. The script is provided as supplementary material and data can be requested from the EJAtlas.

Table 1

5. Results

5.1 Case studies

PFAS pollution by Chemours/Dupont, Dordrecht, the Netherlands

Since the 1960s, manufacturing at Chemours' (formerly DuPont) chemical facility in Dordrecht has contaminated the surrounding area with PFAS, including PFOA purchased from 3M and used for Teflon production (EJAtlas, 2023). Despite being aware of the health risks of PFAS exposure since the 1960s, DuPont continued to release these chemicals into the air, sewage, and the local river (Dordrecht, n.d.). By 1981, birth defects among employees' children raised concerns (Tudela & Delgado, 2025), leading the company to prohibit pregnant and fertile female employees from performing tasks that might expose them to PFOA.

In 1993, DuPont discovered high concentrations of PFAS in the groundwater beneath its Dordrecht facility, likely due to leaks from damaged pipes (EJAtlas, 2023). Instead of addressing the contamination, the company concealed the discovery to avoid legal and financial consequences. By 2008, internal tests revealed higher PFOA blood levels in workers at the Dordrecht site compared to other DuPont facilities. DuPont had phased out PFOA by 2012 in response to stricter regulations. To continue producing Teflon, the company replaced PFOA with GenX. In 2015, DuPont's chemical division became Chemours, complicating efforts at holding the company accountable for the contamination (EJAtlas, 2023).

In 2015, a television report triggered parliamentary concern, leading to a large-scale investigation into the contamination at the Dordrecht facility (EJAtlas, 2023). By 2016, blood tests confirmed extremely elevated PFAS levels in local residents' bloodstreams. The following year, local residents and governments formed *Burenraad DuPont Chemours* [Neighborhood Council DuPont Chemours] to strengthen communication with the company. In February 2018, municipalities filed a liability claim against DuPont and Chemours, accusing them of failing to warn the public and taking precautions despite knowing the environmental and health risks associated with PFOA and GenX. That same year, the Ministry of Health, Welfare, and Sport advised against consuming vegetables grown within 1 kilometer of the plant. Tests later revealed serious PFAS contamination of eggs from nearby poultry and water bodies within a 15-kilometer radius of the site. The environmental contamination affected

1 https://ejatlas.org/backoffice/cms/en/definitions/

an estimated 750,000 residents (HEAL, 2023). A 2023 documentary highlighted health issues, such as nerve pain and prostate cancer, affecting (former) workers and local residents (Bosma, 2023). Following this revelation, local residents formed the weekly protest group *Gezondheid Voor Alles* [Health First].

In 2019, the European Chemicals Agency (ECHA) added GenX to the list of Substances of Very High Concern (EJAtlas, 2023). Chemours appealed this decision to the EU Court of Justice, but the appeal was rejected. In 2023, a class-action lawsuit was filed on behalf of approximately 3,000 affected residents, many reporting severe health impacts allegedly linked to PFAS exposure. A crowdfunding campaign supported the legal action. In September 2023, an independent commission recommended suspending Chemours' operations until PFAS emissions were reduced to zero. However, the plant remained operational as of January 2025, since closure was found to have financial consequences, and because the court was not fully convinced of the health risks of PFAS exposure due to a lack of hard evidence (Bormans, 2023; DCMR, 2025).

The company's deliberate concealment of environmental contamination and health risks is illustrative of manufactured uncertainty. Obscuring the toxic legacy behind a new name made it even more difficult to hold the company accountable. The burden of proof fell onto affected residents, who were left to fill the gaps caused by governmental inaction and corporate deception.

Figure 1

PFAS-polluted water in Hoosick Falls, NY

Drinking water contamination in Rensselaer County, New York, exposed thousands of residents in Hoosick Falls, Petersburgh, and Bennington to PFAS (EJAtlas, 2024c). The pollution originated from a Saint-Gobain Performance Plastics manufacturing plant located along the Hoosick River, near the village's water treatment plant. The plant, known as the McCaffrey Street site, active since the 1960s and previously operated by Allied Signal (now Honeywell) (EPA, n.d.), was used to manufacture circuit board laminates and products containing polytetrafluoroethylene (PTFE), a PFAS compound (EJAtlas, 2024c). Saint-Gobain used PFOA until it was phased out in 2015. Decades of industrial activity resulted in widespread contamination of groundwater, surface water, soil, and air, affecting both the municipal water supply and private wells.

Saint Gobain became the largest employer in Hoosick Falls (EJAtlas, 2024c), making the village somewhat resemble a "company town" (Crawford, 1995, p.2). Workers, reliant on the plant for employment, faced a difficult tension between disclosing knowledge of the contamination and risking their jobs with few chances for alternative employment. This tension is also discussed by Onencan,

Bisschop, & Hendlin, 2024, who found that harm created by PFAS contamination is often downplayed or denied due to the deep-rooted dependence on chemical industries.

In 2014, local resident Michael Hickey, whose father had recently died of cancer, tested the village's water and found extremely high levels of PFOA (EJAtlas, 2024c). At the time, alarming rates of serious illnesses created concerns within the community (Lyons, 2015). Hickey reported his findings to the EPA, but local officials withheld the information for 18 months, assuring residents that the water was perfectly safe to drink. In December 2015, the public was finally informed about the contamination (EJAtlas, 2024c). Despite growing evidence, New York State officials downplayed health risks (Rabinow, 2019). In January 2016, however, the federal EPA issued an advisory against drinking water with PFOA levels above 100 parts per trillion (ppt) (EJAtlas, 2024c). On February 11, 2016, New York State's Department of Environmental Conservation (DEC) found Saint-Gobain and Honeywell responsible for the contamination. The McCaffrey Street site was classified as a Class 2 State Superfund Site.

Alarming levels of PFAS were detected in residents' bloodstreams, especially children's (EJAtlas, 2024c). A 2018 health survey revealed elevated illness rates in Hoosick Falls, Petersburgh, and Bennington. Property values in the area also collapsed, making it difficult for residents to sell their homes and relocate. As such, residents found themselves in what we like to call a 'pollution trap', unable to escape their sickening environment.

In early 2016, more than 2,500 affected residents filed a class-action lawsuit against the companies responsible, including DuPont and 3M due to their roles in the PFOA's discovery, processing, and distribution (EJAtlas, 2024c). Residents also took direct action at the State Capitol, displaying their PFAS blood levels on signs, posters, and their bodies (see figure 2). Community groups emerged, such as the Water Angels, whose volunteers delivered bottled water to residents unable to access distribution points. The New York Water Project (NYWP) pushed for state intervention and advocated for funding to address the crisis. The social media campaign PFOA Project NY raised awareness about the impacts of PFAS contamination by sharing pictures of affected residents displaying their PFAS blood levels. In 2022, the class-action lawsuit settled for $65 million. Additionally, Saint-Gobain and Honeywell contributed $5.5 million for water infrastructure. While these wins provided some relief, they could not compensate for the irreversible health effects, deaths, and environmental damage caused by the contamination.

Figure 2

PFAS contamination class action by Wreck Bay community, NSW, Australia

Although PFAS have never been produced in Australia, they are still widely present in consumer products, as well as Aqueous Film Forming Foam (AFFF), a type of firefighting foam commonly used at military sites and air bases (EJAtlas, 2024b). Starting in the 1970s, the Australian Defense Force (ADF) applied AFFFs containing PFAS produced by 3M at its facilities, including the HMAS Creswell and the Jervis Bay Range Facility near Wreck Bay, South East Wales. By 1981, the department had been alerted to the environmental contamination caused by the use of these firefighting foams and was advised to take action to prevent the contamination from spreading further. By the late 1990s, the ADF took steps to protect employees from drinking contaminated water but failed to address the source of pollution, allowing PFAS to continue contaminating the surrounding environment, including the community's sacred water bodies.

In 2016, a nationwide study detected alarming levels of PFAS, leading to the closure of a creek, which had long been an important source of fish for the local community (EJAtlas, 2024b). The following year, an extensive investigation by the ADF confirmed PFAS contamination of surface waters, groundwater, and sediments near the HMAS Creswell and Jervis Bay sites. Seafood in Booderee National Park also contained PFAS. Amidst growing concerns over environmental contamination, local residents began suspecting a cluster of illnesses, such as cancer, heart disease, and kidney disease. As elder Uncle Fino expressed, the community is left constantly wondering, "*Who's going to die next?*" (Fellner, 2023). In 2018, they demanded blood tests to assess chemical exposure. It took until 2020 for the ADF to officially confirm the contamination. The chemical contamination marks a significant rupture between the Wreck Bay community and their ancestral lands, severely impacting their cultural heritage and sense of belonging (EJAtlas, 2024b).

In 2021, the Wreck Bay Aboriginal Community Council filed a class action lawsuit against the Commonwealth of Australia, seeking compensation for the loss of access to land and waterways (EJAtlas, 2024b). The case resulted in a 22 million AUD settlement, part of a broader 132.7 million AUD agreement between the Australian Commonwealth and seven communities affected by PFAS contamination from the ADF's use of AFFFs. However, the settlement did not cover potential personal injuries, and hence many community members felt unsatisfied with the outcome. As one lawyer representing the community stated, "*Monetary compensation will never be adequate to repair that kind of loss*" (Australian Associated Press, 2023). Some community members appealed the settlement, but the initial settlement remained unchanged (EJAtlas, 2024b). Despite the litigation, the Department of Defence has yet to accept liability for the contamination.

Figure 3

5.2 Statistical overview of PFAS conflicts

The case studies presented above are a useful representation of the local particular dynamics of environmental conflicts involving PFAS. To provide a complementary overview that captures the systemic environmental justice dynamics of PFAS conflicts, this section presents a statistical characterisation of the 25 PFAS cases included in this study (Table 1). To identify the environmental justice specificities of the 25 conflicts involving PFAS, a battery of coded categories is compared against a baseline of all other conflicts in the US, the EU, and Australia (n = 841) with a chi-squared test. The results are presented in full in Table S1 and summarised in Figures 4 and 5.

Figure 4

The facilities sparking conflicts over PFAS are related to chemical industries, water and waste treatment, and military installations (p-value <0.001). The environmental and health impacts are clearly related to contamination and toxicity. Ground and surface water pollution impacts, and exposure to unknown health risks are overrepresented in PFAS cases (p-value <0.001). Affected communities are exposed to unknown or uncertain risks much more often than in the rest of environmental conflicts (p-value <0.001). Health impacts affect women disproportionately, and explain an overrepresentation of violations of human rights (p-value <0.05). In contrast, loss of landscape, deforestation, and displacement were underrepresented impacts (p-value <0.05).

In contrast to the baseline, mobilisation against PFAS contamination is significantly overrepresented to demand compensation and remediation once impacts have already occurred (p-value <0.001). Conversely, no preventive resistance is recorded for any of the PFAS cases compared to nearly half of the cases in the baseline. Local governments are overrepresented actors (p-value <0.05) while social movements are underrepresented (p-value <0.01) (Figure 5). International EJOS and racially discriminated groups are more than two-fold underrepresented (p-value >0.05). Trade unions are not involved in any of the PFAS-related conflicts, and industrial workers are 20% underrepresented compared to all industrial conflicts in the EJAtlas (p-value >0.05).

The strategies used by resistance groups are marked by their lack of violence and physical disruption. Street protests are significantly underrepresented (p-value <0.001), there are no reports involving sabotage, property damage, strikes, or threats to use arms, only one instance of occupations or boycotts, and two blockades. In contrast, non-disruptive strategies such as lawsuits and epidemiological studies are significantly overrepresented (p-value < 0.01).

PFAS conflicts are overrepresented in remediative outcomes such as court victories, environmental rehabilitation, and compensation (p-value < 0.001). Despite this, the facilities driving the impacts tend to remain in operation compared to the baseline sample (p-value <0.05), and the perceived

environmental justice attainment is underrepresented by 60%, and the EJAtlas contributors report to be unsure over the attainment of environmental justice 40% more often (p-value >0.05).

Figure 5

6. Discussion

Human societies shape their material environment based on ideas and ideals. In turn, power struggles over knowledge, discourses, and beliefs are anchored in the chemical properties of the material realities that serve as their battleground. Conflict must be understood in both ideological and material terms. In the case of PFAS, their particular chemical characteristics influence how related environmental conflicts unfold. These conflicts revolve around contested knowledge between profit-driven companies and EJ communities, involving lasting harm to conditions of life and rendering bodies and environments permanently toxic. These issues are inextricable from PFAS' intangibility, persistence, and chemical diversity, which we will now discuss in turn. Our analysis weaves together qualitative insights with quantitative data to understand the complex dynamics of PFAS-related conflicts.

6.1 Contested knowledge

PFAS' intangibility sets them apart from the many other sources of environmental conflict. A copper mine, a real estate development, or a wind farm all represent clear and visible threats to surrounding communities, and their impacts are hard to contest. In contrast, the invisibility of PFAS allows companies to "socialise the costs of contamination" through what D'Alisa and Demaria (2024, p. 5) call "accumulation by contamination". Invisibility enables companies to evade accountability, discredit evidence, dispute the causal links between their toxic releases and the resulting harm to people and the environment, and delay meaningful action, protecting their relentless accumulation of wealth.

Communities first encounter PFAS through health impacts. This explains why mobilizations only emerge to demand reparations once impacts have been felt, at which point it is already too late to prevent lasting harm. For example, DuPont's PFAS contamination in Dordrecht, which dates back to 1967 but took until the 2010s for conclusive evidence to surface and for action to be taken, illustrates such delays in action (EJAtlas, 2023). Industry denial of the links between contamination and health damage constitutes another layer of violence, as communities face both harm and dismissal of their suffering. In Parkersburg, West Virginia, residents suspected DuPont's role in unexplainable cattle deaths but lacked proof (EJAtlas, 2022), illustrating the limits of traditional science in the early stages of contamination.

PFAS' intangibility makes it difficult for affected communities carrying the burden of proof to meet the evidentiary standards of "hard" data. However, through community-based participatory research, they generate their own forms of knowledge, challenging industry-driven narratives and exposing the links between public health deterioration and PFAS contamination. This demonstrates the unfolding of post-normal science, embodied harm is considered a legitimate source of knowledge. Funtowicz and Ravetz' (1993) argue that popular epidemiology constitutes one of the ways in which extended peer communities can improve the understanding and management of environmental issues. Genuinely including affected communities bridges the gap between scientific knowledge and the complex realities in which contamination unfolds.

PFAS disputes reflect how a commodity's intangibility shapes the contest over established knowledge and socio-ecological cost-shifting in environmental conflicts, mirroring patterns in disputes such as over climate change and the impacts of atmospheric CO_2 accumulation (Oreskes & Conway, 2011). A central tenet of corporate accumulation and cost-shifting arguably relies on rendering tangible commodities invisible to hide their impacts. A clear example is oil, the substance that powers the world economy - ubiquitous yet rarely seen. Disconnecting consumption from its impacts breaks the moral connection between those benefiting from extractivism and those suffering its consequences. A PNS approach to environmental conflict calls for a different way of understanding truth, where lived experiences are revalued and legitimised. PFAS contamination conflicts demonstrate the importance of harnessing the potential of embodied experiences of harm to expose the links between consumption and impact, benefits and burdens, and the materiality of the commodities driving the economy.

6.2 The pollution trap

The challenges posed by the intangibility of PFAS are compounded by their persistence. Because of their intangibility, they were not perceived as dangerous for decades, and because of their persistence, they created irremediable sacrifice zones and compromised bodies. Once released into the environment, PFAS are there to stay: health is permanently damaged and environmental remediation is a complicated and expensive undertaking. This combination of PFAS' characteristics creates a " pollution trap" where property values plummet by the time definite evidence emerges, locking residents in toxic landscapes, as in Hoosick Falls. Environmental justice literature has previously discussed the links between hazardous facilities and property values (Affuso et al., 2010; Smolen et al., 1992; Taylor, 2014).

PFAS also creates new environmental justice communities. In the EJAtlas, communities affected by PFAS contamination do not resemble 'traditional' environmental justice groups, such as racialised groups, informal workers, landless peasants, and social movements (Bullard, 2018). While

marginalised communities typically bear the brunt of environmental harm (Banzhaf, Ma, & Timmins, 2019; Collins et al, 2016; Taylor, 2014), PFAS-emitting industries such as manufacturing plants and military sites do not fit this pattern. One possible explanation for this observation could be that, until recently, PFAS were considered harmless - "safe until proven dangerous" (Ravetz, 2004) - and were thus not placed through racial or class zoning. Generally, environmental injustice arises from the displacement of polluting activities to areas inhabited by marginalised communities (Bullard, 2018). In the case of PFAS, a plausible concern is that environmental injustice will unfold the other way around, as marginalised communities could be displaced to these new sacrifice zones by disinvestment, gentrification, and the real estate market.

Our analysis shows that the emerging EJ communities affected by PFAS contamination resist differently than traditional environmental justice groups. As speaks from our quantitative analysis, those mobilizing against PFAS contamination tend to pursue the institutionalised way, opting for litigation, local consultations, complaint letters, and petitions, rather than subversive mobilization forms such as property damage, sabotage, and boycotts. This choice of tactics suggests a belief that environmental injustices can be solved through the same system that created them, possibly due to these communities' (perceived) social privileges. Indeed, in PFAS conflicts we see a greater level of court victories than in other conflicts. However, ultimately, they often fail to stop harmful projects and deliver a sense of justice, highlighting these communities' enduring sacrifice.

The role of workers in PFAS conflicts is particularly noteworthy, as they face a dilemma between jobs that sustain their livelihoods and chemicals that harm their health. Companies exploit this tension by inverting the logic of dependence: from industry relying on labour to workers relying on wages, creating an "economised life" where workers' lives are reduced to their economic roles serving accumulation. As such, the fate of workers has been tied to the fate of the industry, condemning them to either economic or organic death. Notably, no trade unions are involved in the 25 cases analysed, suggesting that workers prioritize economic survival over health concerns, falling into a "labour pollution trap".

Despite severe contamination of soils, air, and water, few displacements, land dispossessions, or loss of traditional practices have occurred in PFAS conflicts. This reflects how industrial communities in the Global North are increasingly detached from their local environments and instead rely largely on global commodity chains. This issue is particularly concerning given the potential shift of PFAS manufacturing to the Global South, where local populations depend more on their immediate environment for sustenance. In light of this observation, it is hopeful to echo Renfrew and Pearson's claim that "*Toxic events entail transformative processes that bring into being novel understandings of self and community, of place and environment, of local history and industrial legacy"* (2021, p. 148).

As communities' surroundings are contaminated with toxic chemicals, they face a profound reckoning with their ecological interdependence. As such, toxic events confront affected communities with their boundedness in collective life-defending struggles and their embeddedness in ecological systems. At the end of the day, the "economised life" is a corporate construct that cannot escape the organic foundations of life. True liberation of workers and communities lies in fighting accumulation while reclaiming ecological life-sustaining functions based on interdependence and autonomy - a struggle unfolding on a global scale documented across thousands of environmental conflicts in the EJAtlas.

6.3 Expanding toxic frontiers

The perverse reality of PFAS contamination complicates efforts to reclaim the most basic living conditions, such as soil and water. In Dordrecht, PFAS have contaminated home-grown food, while in Wreck Bay, they have rendered fishing unsafe. The chemical diversity of PFAS complicates identification and remediation. In Dordrecht, DuPont replaced PFOA with GenX when faced with regulations. Regulators often lag behind, needing to prove the toxicity of chemicals once they are already in use. The industry's use of confidentiality further hinders investigations into novel types of PFAS, leaving scientists to play catch-up in identifying contamination.

As with many extractive industrial industries, stronger regulations in the Global North can push production and its socio-ecological costs to the Global South (Brunnermeier & Levinson, 2004; Lucas et al., 1992), where research on PFAS is limited (see exception in Bangladesh, EJAtlas, 2024a). The chemical industry has used PFAS' intangibility to delay regulation and exploits PFAS' chemical diversity to manufacture uncertainty and find loopholes to avoid bans and sanctions. However, thanks to the efforts of mobilised communities, journalists, scientists, and lawyers, public awareness of PFAS' far-reaching and persistent impacts is growing. This exemplifies how PNS is a powerful force driving policy changes, as stricter regulations are being adopted in high-income countries. Still, these regulatory wins risk pushing PFAS manufacturing to regions with looser laws, such as parts of Eastern Asia (Podder et al., 2021). Alarmingly, high PFAS levels have already been detected in countries like China, Japan, and South Korea, where protections against these chemicals are minimal (Baluyot, Reyes, & Velarde, 2021).

Environmental justice advocates and environmental decision-makers should remain vigilant of the unchecked expansion of the PFAS toxic frontier into the Global South. PFAS is now recognized as an issue in the Global North, where available technical capabilities have been able to link the sources of contamination with their impacts. PFAS' chemical diversity makes it difficult to understand the full scale of impacts and take meaningful action to address this class of chemicals as a whole. The lack of information and detection capabilities in the Global South should be a major concern, requiring better waste management, chemical industry oversight, and monitoring of military sites in these regions. As

our study forcefully demonstrates, the ability to anticipate impacts and lead preventive action shifts power dynamics in environmental conflicts, offering environmental defenders greater chances to protect their communities and environments from the relentless expansion of toxic contamination.

7. Conclusion

PFAS have left a lasting imprint on the global environment and public health. While these chemicals are now omnipresent, their burdens are concentrated in specific localities. Scientific research and community activism have brought the issue to public attention, the judicial terrain, and regulatory spheres, although often too late. Hence, taking stock of the experiences of environmental justice defenders mobilizing against PFAS contamination is crucial to avoid repeating past mistakes. This article explored how knowledge is contested between profit-driven corporations and EJ communities, and how PFAS' intangibility, persistence, and chemical diversity shape both corporate strategies and community responses to contamination.

Data from 25 PFAS-related conflicts in the EJAtlas shows that PFAS' chemical properties play an important role both in the harm experienced by affected communities and in the unfolding of environmental conflicts. PFAS' intangibility provides fertile ground for industries to obscure harm and shift costs onto communities, benefitting from the fact that people's testimonies systematically carry little weight in the equation. Framing PFAS as a post-normal issue highlights the importance of taking people's embodied experiences of harm seriously to inform timely action. This is critical given PFAS' persistence, which transforms contaminated areas into new sacrifice zones. These landscapes are inhabited by emerging EJ communities, whose mobilization strategies reflect their status as newly affected groups. The chemical diversity of PFAS' chemical diversity further complicates regulatory responses as new chemicals continue to enter the market. Efforts at regulating them and controlling contamination are undermined by the industry's appeals to confidentiality and lobbying against regulating PFAS as a single class, leaving scientists and regulators to chase after the facts.

Breaking this pattern of injustice is crucial as we turn our attention to the Global South, where people depend more on their immediate environment. With attention to PFAS contamination severely biased towards the Global North, urgent attention is needed to address emerging and less-explored sites of contamination in the Global South. Additionally, looking forward, the gendered and racial impacts of PFAS exposure warrants further investigation, considering the particular health effects of PFAS exposure to women and children (Agency for Toxic Substances and Disease Registry, 2021; Blake & Fenton, 2020; Chohen et al., 2020; Ding et al., 2020).

Applying the EJAtlas to PFAS contamination demonstrates the flexibility of this tool in better understanding emerging environmental contaminants and informing appropriate responses. Putting PFAS in the spotlight provides an opportunity to reflect on the broader implications of intangible contaminants for environmental justice. The industrial apparatus with its systemic profit-over-people mentality continues to find ways to externalise costs, rendering affected communities and their environments disposable. However, new ways of knowing and resisting are emerging to challenge these mechanisms.

References

Affuso, E., De Parisot, C.V., Ho, C.S., & Hite, D. (2010). The impact of hazardous waste on property values: The effect of lead pollution. *Urbani Izziv, 21*(2), pp. 117-126. Doi: 10.5379/urbani-izziv-en-2010-21-02-005

Agency for Toxic Substances and Disease Registry. (2021). *Toxicological Profile for Perfluoroalkyls*. U.S. Department of Health and Human Services. https://www.atsdr.cdc.gov/toxprofiles/tp200.pdf

Andrews, D. Q., Stoiber, T., Temkin, A. M., & Naidenko, O. V. (2023). Discussion. Has the human population become a sentinel for the adverse effects of PFAS contamination on wildlife health and endangered species? *Science of The Total Environment*, *901*, 165939. https://doi.org/10.1016/j.scitotenv.2023.165939

Australian Associated Press. (2023, 25 May). Wreck Bay: NSW Indigenous community secures $22m Pfas contamination settlement. *The Guardian*. https://www.theguardian.com/australia-news/2023/may/25/wreck-bay-pfas-compensation-settlement-nsw-indigenous-community-forever-chemicals-leak

Baluyot, J.C., Reyes, E.M., & Velarde, M.C. (2021). Per- and polyfluoroalkyl substances (PFAS) as contaminants of emerging concern in Asia's freshwater resources. *Environmental Research, 197*. https://doi.org/10.1016/j.envres.2021.111122

Banzhaf, S., Ma, L., & Timmins, C. (2019). Environmental justice: The economics of race, place, and pollution. *Journal of Economic Perspectives, 33*(1), 185-208. https://doi.org/10.1257/jep.33.1.185

Bilott, R. (2019). *Exposure*. Atria Publishing Group

Bisht, A., & Martinez‐Alier, J. (2023). Coastal sand mining of heavy mineral sands: Contestations, resistance, and ecological distribution conflicts at HMS extraction frontiers across the world. *Journal of Industrial Ecology*, *27*(1), 238-253. https://doi.org/10.1111/jiec.13358

Blake, B.E., & Fenton, S.E. (2020). Early life exposure to per- and polyfluoroalkyl substances (PFAS)

and latent health outcomes: A review including the placenta as a target tissue and possible driver of peri- and postnatal effects. *Toxicology, 443*. https://doi.org/10.1016/j.tox.2020.152565

Brunnermeier, S.B., & Levinson, A. (2004). Brunnermeier, S. B., & Levinson, A. (2004). Examining the evidence on environmental regulations and industry location. *The Journal of Environment & Development, 13*(1), pp. 6-41. https://doi.org/10.1177/1070496503256500

Brunn, H., Arnold, G., Körner, W., Rippen, G., Steinhäuser, K. G., & Valentin, I. (2023). PFAS: forever chemicals—persistent, bioaccumulative and mobile. Reviewing the status and the need for their phase out and remediation of contaminated sites. *Environmental Sciences Europe, 35*(1), pp. 1-50. https://doi.org/10.1186/s12302-023-00721-8

Bormans, A. (2023, September 20). Sluiting Chemours-fabriek is 'juridisch onhaalbaar'. *De Volkskrant.* https://www.volkskrant.nl/nieuws-achtergrond/sluiting-chemours-fabriek-is-juridisch-onhaalbaar~b03733a9/

Bullard, R. D. (2018). *Dumping in Dixie: Race, class, and environmental quality*. Third Edition. Routledge.

Calafat, A. M., Kato, K., Hubbard, K., Jia, T., Botelho, J. C., & Wong, L. Y. (2019). Legacy and alternative per-and polyfluoroalkyl substances in the US general population: Paired serum-urine data from the 2013–2014 National Health and Nutrition Examination Survey. *Environment International*, *131*, 105048. https://doi.org/10.1016/j.envint.2019.105048

Chohen, A., Petaway, H., Riviera-Diaz, V., Day, A., Colaianni, O., & Keramati, M. (2020). Per and polyfluoroalkyl substances scientific literature review: water exposure, impact on human health, and implications for regulatory reform. *Reviews on Environmental Health, 36*(2), pp. 235-259. https://doi.org/10.1515/reveh-2020-0049

Collins, M. B., Munoz, I., & JaJa, J. (2016). Linking 'toxic outliers' to environmental justice communities. *Environmental Research Letters, 11*(1), 015004. doi: 10.1088/1748-9326/11/1/015004

Cordner, A., Goldenman, G., Birnbaum, L.S., Brown, P., Miller, M.F., Mueller, R., Patton, S., Salvatore, D.H., & Trasande, L. (2021). The True Cost of PFAS and the Benefits of Acting Now. *Environmental Science & Technology, 55*(14), pp. 9630-9633. https://doi.org/10.1021/acs.est.1c03565

Cousins, I.T., DeWitt, J.C., Glüge, J., Goldenman, G., Herzke, D., Lohmann, R., Ng, C.A., Scheringer, N., Wang, Z. (2020). The high persistence of PFAS is sufficient for their management as a chemical class. *Environmental Science: Processes & Impacts, 22*(12), pp. 2307-2312. https://doi.org/10.1039/D0EM00355G

Crawford, M. (1995). *Building the Workingman's Paradise: The Design of American Company Towns*. Verso.

Davies, T. (2022). Slow violence and toxic geographies: 'Out of sight' to whom? (2022). *Environment and Planning C: Politics and Space, 40*(2), pp. 409-427. https://doi.org/10.1177/2399654419841063

D'Alisa, G., & Demaria, F. (2024). Accumulation by contamination: Worldwide cost-shifting strategies of capital in waste management. *World development, 184*, 106725. https://doi.org/10.1016/j.worlddev.2024.106725

DCMR. (2025, February 4). DCMR legt sanctie op aan Chemours voor lozing van PFAS-soort. https://www.dcmr.nl/actueel/nieuws/dcmr-legt-sanctie-op-aan-chemours-voor-lozing-van-pfas-soort

Del Bene, D., Scheidel, A., & Temper, L. (2018). More dams, more violence? A global analysis on resistances and repression around conflictive dams through co-produced knowledge. *Sustainability Science, 13,* pp. 617-633. https://doi.org/10.1007/s11625-018-0558-1

De Silva, A.O., Armitage, J.M., Bruton, T.A., Dassuncao, C., Heiger-Bernays, W., Hu, X.C., Kärrman, A., Kelly, B., Ng, C., Rubock, A., Sun, M., Webster, T.F., Sunderland, E.M. (2020). PFAS Exposure Pathways for Humans and Wildlife: A Synthesis of Current Knowledge and Key Gaps in Understanding. *Environmental Toxicology and Chemistry, 40*(3), pp. 631-657. https://doi.org/10.1002/etc.4935

Ding, N., Harlow, S.D., Randolph Jr, J.F., Loch-Caruso, R., & Park, S.K. (2020). Perfluoroalkyl and polyfluoroalkyl substances (PFAS) and their effects on the ovary. *Human Reproduction Update,26*(5), pp. 724-752. https://doi.org/10.1093/humupd/dmaa018

Dordrecht. (n.d.). Gezondheid. https://cms.dordrecht.nl/Inwoners/Overzicht_Inwoners/PFAS_en_Dossier_Chemours/Gezondheid

ECHA. (n.d.). *Understanding reach*. European Chemicals Agency. https://echa.europa.eu/regulations/reach/understanding-reach

Egilman, D., Bird, T., & Lee, C. (2014). Dust diseases and the legacy of corporate manipulation of science and law. *International Journal of Occupational and Environmental Law, 20*(2), pp. 115-125. https://doi.org/10.1179/1077352514Z.000000000104

Environmental Protection Agency. (n.d.). Saint-Gobain Performance Plastics Village of Hoosick Falls, NY. https://cumulis.epa.gov/supercpad/SiteProfiles/index.cfm?fuseaction=second.cleanup&id=0202702

Felner, C. (2023, May 22). Paradise Poisoned: How the idyllic town of Wreck Bay was left asking 'Who's going to die next?'. *The Sydney Morning Herald*. https://www.smh.com.au/national/nsw/paradise-poisoned-how-the-idyllic-town-of-wreck-bay-was-left-asking-who-s-going-to-die-next-20230519-p5d9pb.html

Forever Pollution Project. (2023). *The Forever Pollution Project.* https://foreverpollution.eu/

Forever Pollution Project (2025). *Unaffordable*. Retrieved January 14, 2025, from https://foreverpollution.eu/lobbying/the-cost-of-remediation/

Funtowicz, S.O., & Ravetz, J.R. (1993). Science for the post-normal age. *Futures, 25*(7), pp. 739-755. https://doi.org/10.1016/0016-3287(93)90022-L

Funtowicz, S.O., & Ravetz, J.R. (1997). Environmental problems, post-normal science, and extended peer communities. Études et Recherches sur les Systèmes Agraires et le Développement, pp.169-175. https://www.researchgate.net/profile/Jerome-Ravetz/publication/284905619_Environmental_problems_post-normal_science_and_extended_peer_communities/links/56aa606f08ae8f386566326a/Environmental-problems-post-normal-science-and-extended-peer-communities.pdf

Gaber, N., Bero, L., & Woodruff, T. (2022). The Devil they Knew: Chemical Documents Analysis of Industry Influence on PFAS Science. *Annals of Global Health, 89*(1). https://doi.org/10.5334/aogh.4013

Gleis Lutz. (2024). *PFAS restriction proposal on the EU level*. https://www.gleisslutz.com/en/news-events/know-how/pfas-restriction-proposal-eu-level

Glüge, J., Scheringer, M., Cousins, I. T., DeWitt, J. C., Goldenman, G., Herzke, D., Lohmann, R., Ng, C.A., Trier, X., & Wang, Z. (2020). An overview of the uses of per-and polyfluoroalkyl substances (PFAS). *Environmental Science: Processes & Impacts*, *22*(12), 2345-2373. doi: 10.1039/d0em00291g

Gomis, M. I., Vestergren, R., Borg, D., & Cousins, I. T. (2018). Comparing the toxic potency in vivo of long-chain perfluoroalkyl acids and fluorinated alternatives. *Environment International, 113*, 1-9. https://doi.org/10.1016/j.envint.2018.01.011

Gross, L., & Birnbaum, L. (2017). Regulating toxic chemicals for public and environmental health. *PLoS Biology, 15*(12). https://doi.org/10.1371/journal.pbio.2004814

Hansen, S.F., Bunde, C.T.H, Roy, M.A., Tickner, J.A, & Baun, A. (2024). Late lessons from early warnings on PFAS. *Nature Water, 2*(12), pp. 1157, 1165. https://doi.org/10.1038/s44221-023-00168-4

Health and Environmental Alliance (HEAL). (2023). The real-life impact of PFAS pollution on communities – examples from Veneto, Antwerp, Dordrecht, Ronneby and Korsør and how to take action. HEAL. https://www.env-health.org/the-real-life-impact-of-pfas-pollution-on-communities-examples-from-veneto-antwerp-dordrecht-ronneby-and-korsor-and-how-to-take-action/

Hyötyläinen, T., McGlinchey, A., Salihovic, S., Schubert, A., Douglas, A., Hay, D. C. (2024). In utero exposures to perfluoroalkyl substances and the human fetal liver metabolome in Scotland: a cross-sectional study. *The Lancet, 8*(1), pp. e5-e17. https://doi.org/10.1016/S2542-5196(23)00257-7

Ladapo, J. A., Mohammed, A. K., & Nwosu, V. C. (2019). Review of GenX Pollution: GenX

Pollution of the Cape Fear River in North Carolina, USA. *WSEAS Transactions on Environment and Development, 15*, 144-152. https://wseas.com/journals/ead/2019/a285115-089.pdf

Lennquist, A., Kleimark, J., Arp, H.P.H., & Hale, S.E. (2024). Facilitating the market transition away from persistent and mobile substances: a report on tools developed by ChemSec in the ZeroPM project: SIN list, Marketplace and the PFAS guide. *Environmental Sciences Europe, 36*(2). https://doi.org/10.1186/s12302-023-00829-x

Lerner, S. (2018, July 31). *3M knew about the dangers of PFOA and PFOS decades ago, internal documents show*. The Intercept. https://theintercept.com/2018/07/31/3m-pfas-minnesota-pfoa-pfos/

Llavero-Pasquina, M., Navas, G., Cantoni, R., & Martínez-Alier, J. (2024). The political ecology of oil and gas corporations: TotalEnergies and post-colonial exploitation to concentrate energy in industrial economies. *Energy Research & Social Science*, *109*, 103434. https://doi.org/10.1016/j.erss.2024.103434

Lucas, R.E., Wheeler, D., & Hettige, H. (1992). Economic development, environmental regulation, and the international migration of toxic industrial pollution, 1960-88 (Vol. 1062). World Bank Publications. https://core.ac.uk/download/pdf/6616217.pdf

Lyons, B.J. (2015, December 14). A danger that lurks below. *Times Union*. https://www.timesunion.com/local/article/A-danger-that-lurks-below-6694498.php

Martinez-Alier, J., Temper, L., Del Bene, D., & Scheidel, A. (2016). Is there a global environmental justice movement? *The Journal of Peasant Studies, 43*(3), pp. 731-755. http://dx.doi.org/10.1080/03066150.2016.1141198

Martinez-Alier, J. (2023). *Land, Water, Air and Freedom.* Edward Elgar Publishing.

McKinley, J. (2016, June 15). Hoosick Falls Residents Take Anger Over Tainted Water to New York's Capitol. *The New York Times*. https://www.nytimes.com/2016/06/16/nyregion/hoosick-falls-residents-take-anger-over-tainted-water-to-new-yorks-capitol.html

Michaels, D., & Monforton, C. (2005). Manufacturing uncertainty: contested science and the protection of the public's health and environment. *American Journal of Public Health, 95*, pp. S39-S48. https://doi.org/10.2105/AJPH.2004.043059

Myers, J.P., Antoniou, M.N., Blumberg, B., Carroll, L., Colborn, T., Everett, L.G., Hansen, M., Landrigan, P.J., Lanphear, B.P., Mesnage, R., Vandenberg, L.N., vom Saal, F.S., Welshons, W.V., & Benbrook, C.M. (2016). Concerns over use of glyphosate-based herbicides and risks associated with exposures: a consensus statement. *Environmental Health, 15*(19). https://doi.org/10.1186/s12940-016-0117-0

Navas, G., D'Alisa, Q, & Martinez-Alier, J. (2022). The role of working-class communities and the

slow violence of toxic pollution in environmental health conflicts: A global perspective. *Global Environmental Change*, 73. https://doi.org/10.1016/j.gloenvcha.2022.102474

Nixon, R. (2011). *Slow Violence and the Environmentalism of the Poor*. Harvard University Press. https://doi.org/10.4159/harvard.9780674061194

Nriagu, J.O. (1998). Clair Patterson and Robert Kehoe's Paradigm of ''Show Me the Data'' on Environmental Lead Poisoning. *Environmental Research, 78*(2), pp. 71-78. https://doi.org/10.1006/enrs.1997.3808

Onencan, A. M., Bisschop, L., & Hendlin, Y. (2024). Experiences of living within PFAS-polluted environs: a systematic review. *Crime, Law and Social Change*, pp. 1-27. https://doi.org/10.1007/s10611-024-10173-7

Oreskes, N., & Conway, E. M. (2011). *Merchants of doubt: How a handful of scientists obscured the truth on issues from tobacco smoke to global warming*. Bloomsbury Publishing USA.

Oreskes, N. (2015). The fact of uncertainty, the uncertainty of facts and the cultural resonance of doubt. *Philosophical Transactions of the Royal Society Series A,* 373, 20140455. http://dx.doi.org/10.1098/rsta.2014.0455

Pesticide Action Network Europe (2024, December). *TFA: The 'Forever Chemical' in European Mineral Waters.* https://www.pan-europe.info/resources/briefings/2024/12/tfa-%E2%80%98forever-chemical%E2%80%99-european-mineral-waters?utm_source=Laposta&utm_campaign=Press+Release+32&utm_medium=email

Podder, A., Sadmani, A.H.M.A., Reinhart, D., Chang, N., & Goel, R. (2021). Per and poly-fluoroalkyl substances (PFAS) as a contaminant of emerging concern in surface water: A transboundary review of their occurrences and toxicity effects. *Journal of Hazardous Materials, 419*. https://doi.org/10.1016/j.jhazmat.2021.126361

Rabinow, L. (2019). *Persistent: Why New York State and the United States still don't regulate PFOA in drinking water* [Doctoral thesis, Rensselaer Polytechnic Institute]. https://media.proquest.com/media/hms/PFT/2/a9LeC?_s=cbLaAWA3TcqnZNB3gu4cArpi0BY%3D

Ravetz, J. (2004). The post-normal science of precaution. *Futures, 36*(3), pp. 347-357. https://doi.org/10.1016/S0016-3287(03)00160-5

Renfrew, D., & Pearson, T. W. (2021). The social life of the "forever chemical": PFAS pollution legacies and toxic events. *Environment and Society*, *12*(1), 146-163. https://doi.org/10.3167/ares.2021.120109

Richter, L., Cordner, A., & Brown, P. (2020). Producing Ignorance Through Regulatory Structure: The Case of Per- and Polyfluoroalkyl Substances (PFAS). *Sociological Perspectives, 64*(4), pp. 631-656. https://doi.org/10.1177/0731121420964827

Rosner, D., & Markowitz, G. (2007). The Politics of Lead Toxicology and theDevastating

Consequences for Children. *American Journal of Industrial Medicine.* pp. 740-756. https://doi.org/10.1002/ajim.20435

Roy, B., & Schaffartzik, A. (2021). Talk renewables, walk coal: The paradox of India's energy transition. Ecological Economics, 180, 106871. https://doi.org/10.1016/j.ecolecon.2020.106871

Saes, B. M., & Bisht, A. (2020). Iron ore peripheries in the extractive boom: A comparison between mining conflicts in India and Brazil. *The Extractive Industries and Society*, *7*(4), 1567-1578. https://doi.org/10.1016/j.exis.2020.09.010

Salvidge, R., & Hosea, L. (2025, January 14). Industry using 'tobacco playbook' to fend off 'forever chemicals' regulation. *The Guardian*. https://www.theguardian.com/environment/2025/jan/14/industry-using-tobacco-playbook-to-fend-off-forever-chemicals-regulation

Saloojee, Y., & Dagli, E. (2000). Tobacco industry tactics for resisting public policy on health. *Bulletin of the World Health Organization, 78*, 902-910. https://pubmed.ncbi.nlm.nih.gov/10994263/

Shearer, C. (2015). On Corporate Accountability: Lead, Asbestos, and Fossil Fuel Lawsuits. *NEW SOLUTIONS: A Journal of Environmental and Occupational Health Policy, 25*(2), pp. 172-188. https://doi.org/10.1177/1048291115583306

Sheriff, I., Debela, S.A., Kabia, O.A., Ntoutoume, C.E., & Turay, M.J. (2020). The phase out of and restrictions on per-and polyfluoroalkyl substances: Time for a rethink. *Chemosphere, 251*, 126313. https://doi.org/10.1016/j.chemosphere.2020.126313

Sinclair, G.M., Long, S.M., & Jones, O.A.H. (2020). What are the effects of PFAS exposure at environmentally relevant concentrations? *Chemosphere, 258.* https://doi.org/10.1016/j.chemosphere.2020.127340

Smolen, G., Moore, G., & Conway, L. (1992). Economic Effects of Hazardous Chemical and Proposed Radioactive Waste Landfills on Surrounding Real Estate Values. *Journal of Real Estate Research, 7*(3), pp. 283-295. https://doi.org/10.1080/10835547.1992.12090681

Spivak, G.C. (1988). Can the Subaltern Speak? In Nelson, C., & Grossberg, L. (Eds.), *Marxism and the Interpretation of Culture* (pp. 271-316). London: Macmillan.

Sunderland, E.M., Hu, X.C., Dassuncao, C., Tokranov, A.K., Wagner, C.C., & Allen, J.G. (2018). A review of the pathways of human exposure to poly- and perfluoroalkyl substances (PFASs) and present understanding of health effects. *Journal of Exposure Science & Environmental Epidemiology, 29*(2), pp. 131-147. https://doi.org/10.1038/s41370-018-0094-1

Tapa, B.S., Pandit, S., Mishra, R.K., Joshi, S., Idris, A.M., & Tusher, T.R. (2024). Emergence of per- and poly-fluoroalkyl substances (PFAS) and advances in the remediation strategies. *Science of The Total Environment, 916.* DOI: https://doi.org/10.1016/j.scitotenv.2024.170142

Taylor, D. (2014). *Toxic Communities: Environmental Racism, Industrial Pollution, and Residential*

Mobility. New York University Press.

Temper, L., Demaria, F., Scheidel, A., Del Bene, D., Martinez-Alier, J., (2018). The Global Environmental Justice Atlas (EJAtlas): ecological distribution conflicts as forces for sustainability. *Sustainability Science, 13*, pp. 573–584. https://doi.org/10.1007/s11625-018-0563-4

Tilsted, J.P., Mah, A., Nielsen, T.D., Finkill, G., & Bauer, F. (2022). Petrochemical transition narratives: Selling fossil fuel solutions in a decarbonizing world. *Energy Research & Social Science, 94.* https://doi.org/10.1016/j.erss.2022.102880

Tudela, A., & Delgado, A. (2025). Alerta PFAS: 70 años de engaños de la industria química que ya han llegado al grifo y a tu sangre [PFAS Alert: 70 Years of Chemical Industry Deception Now in Your Taps and Blood]. El Diario. https://especiales.eldiario.es/alerta-pfas-papeles-secretos-contaminacion-quimica/

U.S. House Committee on Oversight and Reform (2019). *The Devil They Knew – PFAS Contamination and the Need for Corporate Accountability*. U.S. Government Publishing Office. https://www.congress.gov/116/chrg/CHRG-116hhrg37586/CHRG-116hhrg37586.pdf

Walter, M., Deniau, Y., & Vargas, V.H. (2024). The Politics of 'Green' Extraction Frontiers: Mapping Metals and Mineral Mining Conflicts Related to the Energy Transition in the Americas. *Critical Sociology*. https://doi.org/10.1177/08969205241305963

Westra, L. (1997). Post-Normal Science, the Precautionary Principle and the Ethics of Integrity. *Foundations of Science,* 2, pp. 237-262. https://doi.org/10.1023/A:1009667603750

Wickham, G.M., & Shriver, T.E. (2021). Emerging contaminants, coerced ignorance and environmental health concerns: The case of per- and polyfluoroalkyl substances (PFAS). *Sociology of Health and Illness. 43*(3), pp. 764-778. https://doi.org/10.1111/1467-9566.13253

Yang, L. H., Yang, W. J., Lv, S. H., Zhu, T. T., Sharif, H. M. A., Yang, C., Du, J., & Lin, H. (2022). Is HFPO-DA (GenX) a suitable substitute for PFOA? A comprehensive degradation comparison of PFOA and GenX via electrooxidation. *Environmental Research, 204*, 111995. https://doi.org/10.1016/j.envres.2021.111995

Bosma, B. (2023). *De PFAS-doofpot* [Film]. Zembla. https://www.bnnvara.nl/zembla/artikelen/de-pfas-doofpot

Zhang, S., Chen, K., Li, W., Chai, Y., Zhu, J., Chu, B., Li, N., Yan, J., Zhang, S., & Yang, Y. (2021). Varied thyroid disrupting effects of perfluorooctanoic acid (PFOA) and its novel alternatives hexafluoropropylene-oxide-dimer-acid (GenX) and ammonium 4, 8-dioxa-3H-perfluorononanoate (ADONA) in vitro. *Environment International, 156*, 106745. https://doi.org/10.1016/j.envint.2021.106745

Zulkarnain, H.S., Pradnyaparamitha, D.A., & Basrowi, R.W. (2023). Scientific Misconduct in

Asbestos-related Occupational Health Studies: A Literature Review on the Impact of Intellectual Dishonesty to Scientific Research. *The Indonesian Journal of Community and Occupational Medicine, 2*(3), pp. 143-149. https://doi.org/10.53773/ijcom.v2i3.73.143-9

EJAtlas sources

EJAtlas. (2022). DuPont C8 Contamination in Parkersburg, West Virginia and Ohio, USA. https://ejatlas.org/conflict/hollie

EJAtlas. (2023). PFAS pollution by Chemours/Dupont, Dordrecht, The Netherlands. https://ejatlas.org/conflict/pfas-pollution-by-chemours-dupont-the-netherlands

EJAtlas (2024a). Hazardous working conditions in the Bangladeshi textile industry, including forever chemical contamination, Bangladesh. https://ejatlas.org/conflict/pfas-pollution-by-the-textile-industry-bangladesh/

EJAtlas. (2024b). PFAS contamination class action by Wreck Bay community, NSW, Australia. https://ejatlas.org/conflict/pfas-contamination-class-action-by-wreck-bay-community-nsw-australia

EJAtlas (2024c). PFAS-polluted water in Hoosick Falls, NY, USA. https://ejatlas.org/conflict/pfas-polluted-water-in-hoosick-falls-ny-usa