PFAS IN KALE PILOT STUDY

PFAS “forever chemicals” found in conventionally and organically farmed kale samples nationwide

BAN PFAS

Report by

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Introduction

Human-made "forever chemicals," more correctly known as poly- and per-fluoroalkyl substances (or PFAS), have recently been found to permeate almost all parts of our environment, including our drinking water and food supply.

They are increasingly recognized as a significant threat both to planetary and human health.[1]

PFAS are a class of over 12,000 discrete chemicals used in an incredibly wide range of consumer and industrial applications[2] with histories of use in the aerospace, automotive, construction, and electronics industries going back to the 1940s.[3] They are now commonly used in some varieties of non-stick cookware, plastic packaging, cosmetics, stain-resistant carpeting, waterproof clothing, fire-fighting foams, lubricants, and were recently found in dental flosses[4] and tampons.[5] The property that make them so popular is their ability to resist both grease and water.

What unites these chemicals is the presence of a carbon-fluorine bond which is one of the strongest in chemistry. This strength is also the source of these chemicals' hazard: PFAS chemicals are highly persistent in the environment and have been accumulating in soils, waterways, and oceans over decades. Only recently have the human health effects been recognized, and there is now evidence that once they have been released, their removal from surface water, groundwater, sediment, or soil is extremely difficult and expensive, if it is possible at all.[6] Monitoring studies of PFAS have demonstrated ubiquitous distribution in the environment, including humans, animals, drinking water, food crops, as well as remote areas of the Earth.[7, 8] PFAS accumulate in human tissue and organs, have the potential to travel over great distances, and have toxic effects on the environment and human health.[9]

Of the thousands of PFAS chemicals that are known, only two have been studied intensively for their toxicological effects and persistence, namely perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS). Studies have shown these chemicals can cause reproductive and developmental problems, liver and kidney issues, and immunological effects in laboratory animals.[10] Both chemicals have caused tumors in animal studies.[11]

Yet, for more than 99 percent of PFAS chemicals, no data on repeated-dose toxicity, carcinogenicity, or reproductive toxicity is available. Nor is there an understanding of the cumulative effects of being exposed to multiple PFAS compounds at the same time.

This is a ticking time bomb for both human health and environmental impacts. Thousands of PFAS chemicals have become ubiquitous in the environment, where they persist for an incredibly long time; they are highly mobile, capable of traveling tremendous distances from where they were released; they seep into the ground where they accumulate in the plants that we eat or make their way into our drinking water; we add them unwittingly to our foods when we cook using certain saucepans; we cover or wrap foods with PFAS-containing materials, and; they get into the air and are in the dust that we breathe in. More than that, once we are exposed to these ubiquitous chemicals, they accumulate in our bodies and appear likely to cause a rash of negative health effects we are only just beginning to relate to life-long exposure.

US regulatory agencies have proven themselves incapable or unwilling to meaningfully address the extensive contamination of our world and bodies with PFAS. The EPA's approach to PFAS has largely been to monitor and report.[12] The few actions that have been taken have mostly been limited to PFOA and PFOS, which have been voluntarily phased out of production in the US. This is in deep contrast to the approach being taken in Europe, where there is a concerted effort being taken by regulators, environmental scientists, and industry stakeholders to phase out PFAS of all kinds. Moreover, the FDA has been monitoring PFAS in the food supply and its own data suggests contamination is limited to certain seafoods and meat products.[13]

The American people deserve more. To help understand more about the pervasive nature of PFAS contamination in the food supply, this pilot study by the Alliance for Natural Health (ANH) USA involved the collection and analysis of PFAS in vegetable (kale) samples from four different states of the United States. This builds on other testing that has revealed concerning levels of PFAS in fish[14], peanut butter[15], pasta sauces, ketchup, cooking oils, and more.

METHODS

In order to test the validity of the FDA results from the Total Diet Study (TDS) which have yet to find evidence of PFAS contamination in vegetables[16], samples of curly kale (*Brassica oleracea* [Acephama Group]) were collected by ANH team members at a selected retail outlet in each of four states, namely: Stop & Shop, New York; Publix, Georgia; Weis, Pennsylvania, and; Wholefoods, Arizona.

Two kale samples (conventionally grown, and organically certified) were purchased from each store, and the instructions for dispatch provided by the analytical laboratory (Eurofins Lancaster Laboratories Environment Testing, LLC; Lancaster, PA, USA) were followed strictly. This included placement of samples directly into PFAS-free collection bags (supplied by Eurofins), placement in cool-bags with fresh ice, and immediate dispatch by courier for next day delivery to the laboratory.

Photographs of the samples are shown in Plates 1 to 8. Three samples (shown in Plates 1, 5 and 7) were loose at the point of sale, while the remainder were pre-packed in some form of plastic bag or container.

PLATE 1 (STOP+SHOP, NY): CONVENTIONAL KALE, LOOSE

PLATE 2 (STOP+SHOP, NY): ORGANIC KALE, FRONT OF PLASTIC PACKAGING

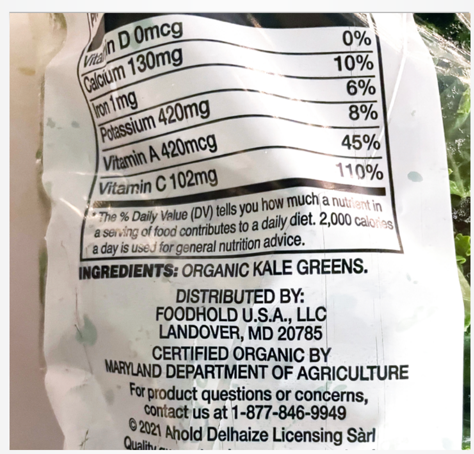

PLATE 2 (STOP+SHOP, NY): ORGANIC KALE, BACK OF PLASTIC PACKAGING

PLATE 3 (PUBLIX, GA): CONVENTIONAL KALE, FRONT OF PLASTIC PACKAGING

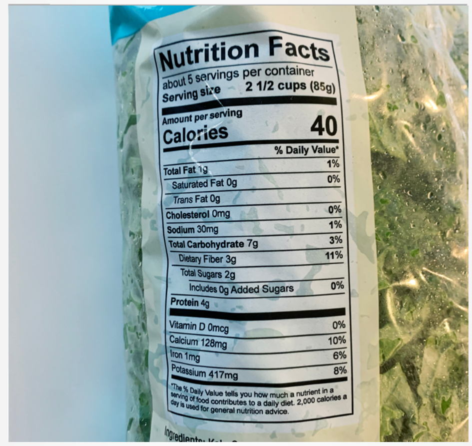

PLATE 3 (PUBLIX, GA): CONVENTIONAL KALE, REAR OF PLASTIC PACKAGING

PLATE 4 (PUBLIX, GA): ORGANIC KALE, FRONT OF PLASTIC PACKAGING

PLATE 4 (PUBLIX, GA): ORGANIC KALE, REAR OF PLASTIC PACKAGING

PLATE 5 (WEIS, PA): CONVENTIONAL KALE, LOOSE

PLATE 6 (WEIS, PA): BABY KALE, ORGANIC, PACKAGED IN PLASTIC BOX

PLATE 7 (WHOLEFOODS, AZ): ORGANIC RED KALE, LOOSE (PLACED WITHIN PFAS-FREE COLLECTION BAG SUPPLIED BY EUROFINS).

PLATE 8 (WHOLEFOODS, AZ): ORGANIC GREEN KALE, LOOSE

Sixteen PFAS compounds were analyzed in each sample, namely:

- Perfluorobutanoic acid (PFBA)
- Perfluoropentanoic acid (PFPA)
- Perfluorohexanoic acid (PFHxA)
- Perfluoroheptanoic acid (PFHpA)
- Perfluorooctanoic acid (PFOA)
- Perfluorononanoic acid (PFNA)
- Perfluorodecanoic acid (PFDA)
- Perfluorobutane sulfonic acid (PFBS)
- Perfluoropentane sulfonic acid (PFPS)
- Perfluorohexane sulfonic acid (PFHxS)
- Perfluoroheptane sulfonic acid (PFHS)
- Perfluorooctane sulfonic acid (PFOS)
- 4,8-Dioxa-3H-perfluorononanoic acid
- 9Cl-PF3ONS
- HFPODA
- 11Cl-PF3OUdS

Limits of detection (LOD) for all analytes were 20 ng/kg, with the exception of: PFBA, which was 80 ng/kg; HFPODA, which was 100 ng/kg, and; PFBS, which was 40 ng/kg.

RESULTS

The results for each of the two samples taken from the 4 stores, based on all analyzes above the laboratory LODs, are summarized in Figure 1.

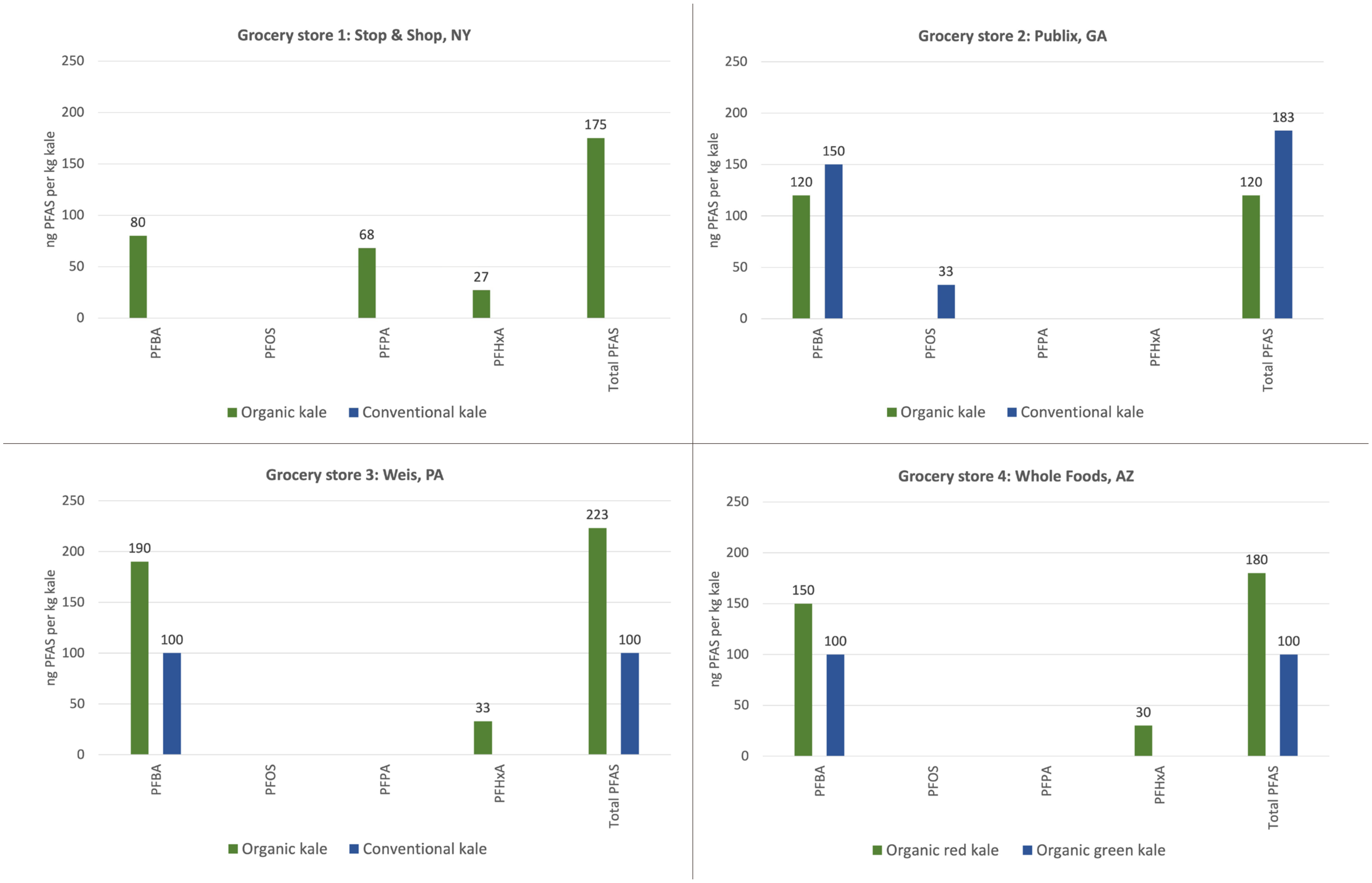

Figure 1. *Summary of analyzes for conventionally-grown and organically-grown samples taken from each of 4 stores, in New York, Georgia, Pennsylvania and Arizona, respectively. Unit of measurement = ng PFAS per kg = equivalent to parts per trillion (ppt). Note: Total PFAS levels are based on the assumption that the levels of all PFAS below the limit of detection were zero.*

While the highest level of total PFAS was found in one sample of conventional kale purchased at a Publix store in Georgia, total PFAS levels found were greater in organic versus conventional samples in the other three stores/ states.

Only one of 8 samples had no detectable levels, this being the conventional kale sample taken from Stop & Shop in New York.

PFBA was the PFAS form most widely distributed and abundant in the 8 samples. The total level of PFAS was likely to exceed the levels reflected in the total PFAS amounts (Fig. 1) which were based on the likely incorrect assumption that all PFAS below the level of detection were actually zero.

DISCUSSION

Interpreting the Pilot Study Findings

While the PFAS levels found in 7 of 8 kale samples may appear low, it was our expectation that they would be zero given that the US Total Diet Survey data (2019-21) had found no evidence of contamination in any plant foods, with the possible exception of a protein powder (the FDA does not clarify whether this was of animal or plant origin).[16]

Comparison of Levels Detected with ATDSR Proposed Minimal Risk Levels

This subsection aims to put the pilot study findings into context by comparing them with other available data. The Agency for Toxic Substances and Disease Registry (ATSDR) of the US Department of Health and Human Services (DHHS) published a report in May 2021 that issued estimated Minimal Risk Levels (MRLs) for 12 commonly found PFAS.[17] Given limited high quality data, uncertainties in the available data, the paucity of human studies, and extrapolations from limited animal studies, the MRLs were viewed by the ATSDR authors as being cautionary, although the authors stressed that the persistence, ubiquitous nature, and broad range of known toxicological (acute and chronic) effects, meant that even these figures may be subject to change as more data become available. The report cites extensive evidence, albeit a considerable amount associated rather than causal, of hepatic, cardiovascular, immune, reproductive and developmental effects. It proposes MRLs in the range of 2×10^{-6} to 2×10^{-5} (= 0.000002 and 0.00002) mg per kg body weight for specific PFAS, including PFOA and PFOS.

In the present pilot study, PFOS was only found in one of eight samples (conventional kale, Publix, GA) at a concentration of 33 ng/kg. What was more surprising was that it was found at all, given a voluntary phase out of PFOS and PFOA from food packaging and food contact materials agreed with the FDA prior to 2020.[18] Nevertheless, based on the one finding of PFOS, assuming an individual consumed 200 grams of kale (a large but achievable level in the normal diet if consumed as a vegetable and, for example, in smoothies), this would equate to around 7 ng (= 0.000007 mg) total intake. In a 60 kg individual, this would amount to about 0.00000012, which is about 6% of the proposed ATDSR MRL for PFOS.

More than this, of the PFAS detected in the 8 samples, the PFOS in the one store (Publix, GA) was among the lowest, with only two samples having slightly lower levels of individual PFAS. By contrast, total levels (the sum of all 16 PFAS determined by Eurofins) were often around 6 times greater than this, averaging 175 mg/kg for organic kale and 128 mg/kg for the 3 stores in which detectable levels were found in conventional kale.

A survey of international data and regulatory responses, especially in Europe, would suggest the ATDSR MRLs are out-of-date and appear likely to have been developed more for the practical benefit of the chemical and food industries, rather than any genuine concern for human health.

Comparison of Levels Detected with EPA Drinking Water Advisories

The Environmental Protection Agency (EPA) has issued updated health advisories for the presence of PFOA and PFOS in drinking water.[19] In that update, the EPA stated the newest data “indicate that some negative health effects may occur with concentrations of PFOA or PFOS in water that are near zero.” In other words, any exposure to PFOS and PFOA should be of concern.

We must also consider that eating kale tainted with PFAS is just one route of many routes of exposure in a given day—the diverse range of foods we eat, the water we drink, the air we breathe, the cookware we use, the lubricants we apply to our vehicles, and even the clothes we wear, are among the many possible points of exposure for one or more PFAS.

In a recent study, scientists at the Environmental Working Group (EWG) calculated eating one 8 ounce serving of fish at 20 ng/kg PFOS is equivalent to consuming one month of drinking water contaminated with PFOS at 0.1 parts per trillion (ppt), or 5.7 times the interim U.S. EPA health advisory.[12]

Using this model, eating one serving (67 g) of kale with 0.033 ng/g PFOS is equivalent to one month of drinking water at 0.05 ppt, which is 1.5 times higher than the EPA's interim health advisory for PFOS.

Other Perspectives from Further Afield

By contrast, the European Food Safety Authority (EFSA) has set a Tolerable Weekly Intake of 4.4 ng/kg bw.[20] Disturbingly, this is the equivalent of consuming two portions (67 g each) of kale with the same level as that found in the Publix store (GA) a week, implying any intake above this amount (from all sources) would equate to a potential health risk.

Indeed, as more scientific data are published about PFAS it seems apparent that these chemicals are dangerous even at extremely low levels. The German Federal Institute for Risk Assessment (BfR) argues that analytical methods (LODs) are currently not sufficiently sensitive.[21]

In the decades following the contamination of drinking water near a Teflon plant in Parkersburg, West Virginia that helped draw national attention to this issue, levels of PFAS considered "safe" have dropped precipitously: in 2010 the EPA's short term health advisory level for PFOA was 400 ppt; a few years later in 2016 that level dropped to 70 ppt combined for PFOS and PFOA; then in 2022, the EPA interim health advisory updated these levels yet again to 0.004 ppt for PFOA and 0.02 ppt for PFOS. For PFOA, this represents a 100 percent decrease in the level that is considered safe in just over 10 years.[22]

Human Health Concerns

Studies have demonstrated a wide range of negative health effects from exposure to PFAS including cancer,[23] weakened immune systems among children,[24] weight gain,[25] and liver, kidney, thyroid, and reproductive problems.[26] EFSA, the European equivalent of the FDA, concluded that increased levels of PFAS in blood were linked to reduction in vaccine antibody response, increased serum cholesterol, increased serum alanine transferase (a sign of liver disease), and reduced birth weight.[20]

These concerns are amplified by PFAS's ability to bioaccumulate.[27] PFAS are readily absorbed by the body and distributed through human tissue, where they can remain for a long time. Estimated human half-lives for different PFAS chemicals range from as little as a few days, to a month, to a couple of years, through to over ten years.[28] Some short-chain PFAS may be more readily excreted through urine than the longer-chain PFAS that they are replacing in commerce, but some animal research suggests that short-chain PFAS can bioaccumulate in excess of long-chain PFAS.[10] (Older "long-chain" PFAS like PFOS and PFOA are generally understood to have more than six carbons, "short-chain" PFAS have fewer than six.) Many PFAS chemicals bind to proteins and thus accumulate in protein-rich tissues in the liver, kidneys, and blood.[27]

With PFAS exposure, it's "death by a thousand cuts": small exposures from different foods and food packages, added to PFAS we inhale in dust,[29] added to the PFAS in our drinking water, added to the PFAS we get from consumer goods like sportswear, cosmetics, and personal care products, added to PFAS unintentionally added[30] to products during manufacturing, add up to a looming public health problem, as they are all accumulating in our body faster than we can get rid of them.

What We Don't Know Could Kill Us

One of the most alarming aspects of PFAS as it pertains to human health is the fact that what we don't know far outweighs what we do know. The human health effects and bioaccumulation information referenced above are in relation to a few of the well-studied PFAS chemicals, notably PFOS and PFOA, along with a handful of other compounds. But there are over 12,000 chemicals in this class and virtually no informative toxicological or environmental data on the vast majority of them. While the little data available for the less-studied PFAS indicate that they have similar effects as those that are better studied,[9] there is a high degree of uncertainty as to how these chemicals behave in the body, both individually and cumulatively. Risk assessors typically look at one chemical's toxicity to determine safe levels; but what if the presence of multiple PFAS in the body at once, which reflects real world conditions, antagonizes the effects and makes them even more dangerous?

Evidence also indicates that we are being exposed to more PFAS than previously estimated. One study of tap water in five US cities found that less than half of the total organic fluorine measured in the water was accounted for by the sum of the individually identified PFAS. This means that there were far more PFAS in the water than the analysis could even identify.[31]

As mentioned above, long-chain PFAS like PFOA and PFOS have been replaced by a newer generation of PFAS known as "short-chain" PFAS that chemical companies claim are safer. There is a startling lack of data on the safety of these chemicals, but the evidence so far shows[9] that they are just as, if not more, dangerous than older PFAS:

- The evidence indicates that short-chain PFAS can be equally persistent in the environment as long-chain PFAS. They are also more mobile in the environment and more difficult to remove from drinking water.
- Short-chain PFAS have been shown to be more effectively taken up by plants.
- Little is known about the long-term impacts of exposure to short-chain PFAS, but a growing body of evidence suggests they have similar adverse health effects as the chemicals they were made to replace, including immune problems, reproductive and developmental issues, damage to the liver and kidneys, and cancer.

There are thousands of these short-chain PFAS circulating in the environment and in our bodies, yet we know very little about their effects or long-term impacts. We don't know how many of them bioaccumulate, and at what rate. We don't know the human health effects that result from the presence of multiple PFAS in the body at a given time. This represents a massive dice roll with our health, not to mention the health of our environment.

REGULATORY STATUS

The current regulatory structure that exists to deal with the dangers of environmental toxins in the US is entirely inadequate to manage the risk posed by PFAS contamination. The main regulatory agency tasked with protecting Americans from unsafe environmental chemicals is the EPA. To regulate chemicals, the EPA's main tools come from the authority granted by the Toxic Substances Control Act (TSCA) which was passed in 1976.[32] At that time, over 62,000 chemicals on the market already, including some PFAS chemicals, were "grandfathered" in, meaning they were considered safe by default since they were already in use.

For "new" chemicals, the law calls for manufacturers to submit Pre-Manufacture Notices (PMNs) to the EPA 90 days prior to production. For most PMN submissions, data on chemical toxicity are not required. The law only requires companies to notify EPA of toxicity data that they have available, which of course disincentivizes companies from carrying out the tests in the first place. PMN submissions are shockingly lacking in data that help EPA risk assessors actually assess risk, so they are forced to make inferences and extrapolations based on compounds with similar chemical structures. One EPA scientist estimated that during a busy week he might have 30 minutes to review his portion of a PMN.[33] The EPA can only act to restrict or ban a chemical if it is found to present an "unreasonable risk of injury to health," a term which is not defined by the law. This standard was designed to limit action against harmful chemicals: the burden of proof was so difficult that the EPA couldn't ban asbestos, a known carcinogen that kills 15,000 people a year.

At best, the EPA can negotiate voluntary industry phase-outs as it did with PFOA and PFOS. As noted by one review of this topic:

> This set of conditions favors rapid approvals over basic testing of new chemicals, for example, to characterize their toxicity, environmental fate, and transport, or even assessing capacity of municipal drinking water facilities to remove new chemical compounds once they are released.[33]

If there's a startling lack of data on PFAS, we can thank the architects of the TSCA which, at least in part, happened to be the chemical industry.[34]

The EPA has other authorities to deal with PFAS contamination under the Clean Water Act (CWA), the Safe Drinking Water Act (SDWA), and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).[35] Under the SDWA, the EPA can promulgate national drinking water regulations for contaminants in water provided by public water systems. After issuing interim health advisories for PFOA and PFOS in 2022, the EPA issued a proposed rule to limit these chemicals in drinking water in 2023.[36] The CWA prohibits the discharge of pollutants to waters of the United States without a permit. CERCLA provides federal funds to clean up uncontrolled or abandoned hazardous waste sites. In 2022, the EPA issued a proposed rule to designate PFOA and PFOS as hazardous substances under CERCLA, which increases the liability of polluters to pay for environmental cleanup costs.

WHY A PFAS BAN CANNOT BE DELAYED!

For the reasons discussed above, scientists in the field have called for the EPA to regulate PFAS as a class rather than take the usual approach of dealing with each distinct chemical, one at a time, which clearly isn't practical when there are some 12,000 different PFAS. Less than 1 percent of all PFAS have been tested for their hazardous effects. It has taken the EPA decades to even start the process of setting enforceable drinking water standards for just two PFAS chemicals; the agency's current approach of assessing one chemical at a time is akin to doing nothing. Even if the EPA restricts or bans one chemical, industry can simply move on to the next one.

While the Biden-Harris Administration has established a White House Council on Environmental Quality specifically to deal with PFAS [37], the actions it proposes involve little more than monitoring and limited clean up efforts.

This approach is in stark contrast to the concerted actions being taken by European regulators that have already phased out PFOS in 2009 and PFOA in 2020. Under the REACH program, there is a major effort to phase out all PFAS identified as 'substances of very high concern' based on persistence, mobility and toxicity.[38]

All PFAS, whether short-chain or long-chain, are extremely persistent in the environment due to their molecular structure, with studies estimating that some PFAS have lifetimes in the thousands of years.[39] It is clear that their risk to human health and the environment has been greatly underestimated and US agencies are still trying to appease industry rather than protect the public and the environment, both of which are heavily threatened by 'forever chemicals.'

CONCLUSIONS

The present pilot likely shines a spotlight on the very tip of the PFAS iceberg and suggests we cannot trust what regulators like the FDA are telling us, specifically in this case: that plant foods are PFAS-free. It also demands that regulators, a broad range of industries, and citizens act rapidly to minimize ongoing exposures to 'forever chemicals'.

Given we have detected significant levels of PFOS (that was supposedly removed from the food supply), along with 3 other PFAS in a foodstuff (kale), widely regarded as among the most healthy in the human diet, what might be a realistic daily or weekly exposure to all PFAS for an average American? The only reasonable answer to this question is we do not know, especially taking into account the multiple routes and sources of exposure.

However, what the current pilot study suggests is:

- There is a much greater problem with PFAS contamination than the FDA would have us believe. Given we found PFAS levels in the 100-225 ppt (ng/kg) range in 7 out of 8 kale samples from 4 states, when the EPA tells us contamination is limited to seafood and meat, it seems likely that PFAS contamination of plant foods may be a very real problem,
- Almost every American will likely exceed the European Tolerable Weekly Intake from foods set by the European scientific institution, EFSA,
- The amounts in kale might frequently exceed the levels considered safe by the EPA for drinking water,
- Consuming organic foods (as found in the present pilot) won't necessarily reduce PFAS exposures,
- It makes no scientific sense to view each of 12,000 PFAS chemicals individually when assessing risk, and,
- Human safety assessment needs to be urgently undertaken to establish total exposures to PFAS via all routes (oral, dermal, and inhalation) and from multiple sources.

It is the unique strength of the carbon-fluorine bond in PFAS that contribute to their extreme persistence, and their accumulation in living and non-living systems, in the process creating a great risk of harm to both human health and the environment. Despite PFAS representing the most recently recognized group of persistent organic pollutants (POPs), we have enough evidence already to know that these 'forever chemicals' pose a very real threat to humanity and the wider environment on which we depend.

If we hope to stem the tide of contamination that threatens our health, the health of our children, and the health of the environment, we cannot play PFAS whack-a-mole. We must consider these chemicals as a class – and then ban them forever – as a class.

That process cannot be implemented just to make it convenient to industries that either produce PFAS or depend on these chemicals for their products. An outright regulatory ban must be prioritized in under 5 years, and immediate steps need to be taken to initiate industry phase outs.

BAN PFAS

PFAS FREE

As we have learned with the phasing out of other hazardous compounds in consumer products such as parabens and bisphenols, one of the most rapid ways of ensuring change would be by creating overwhelming demand for PFAS-free products.

However, this requires a concerted effort to raise public and industry awareness of the widespread distribution of these chemicals, as well as greater transparency of PFAS on ingredient listings on products or as contaminates on technical data sheets used by manufacturers or sellers. The checkered history of regulatory reform to eliminate toxic and hazardous chemicals tells us that regulatory change is often delayed, often following consumer and political pressure predicated on emerging yet unequivocal scientific evidence of grave concerns.

Alongside such efforts, much more research is needed to investigate the full extent of contamination of PFAS in the US food supply, and to identify ways in which citizens can choose foods, other products, and lifestyles that minimize their current exposures.

There is also an urgent need to prioritize research into: alternatives to PFAS across all current industrial applications; finding environmentally safe ways of decontaminating aquifers and ecosystems, and; safe ways of enhancing the safe biotransformation (detoxification) of PFAS in humans.

VISIT BanPFAS.org TO TAKE A STAND AGAINST PFAS

Please join ANH-USA in saying 'No to PFAS' and 'Yes to PFAS-free'. We will be pushing hard for both regulatory and industrial reform, while doing what we can to raise awareness of the dangers of PFAS.

Help us rid America of this dangerous and insidious group of synthetic compounds and donate to ANH-USA, by supporting our **lobbying efforts** and/or our **educational work**.

Thank you.

BAN PFAS .ORG

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