Persisting **perfluorinated compounds**

Led by **Professor Pim de Voogt** at the University of Amsterdam, the PERFOOD project hopes to identify the origin of per- and polyfluorinated alkylated substances in our diets and determine our exposure to them to improve their regulation and management

What are the principal aims and objectives of PERFluorinated Organic compounds in Our Diet (PERFOOD)?

The aims of PERFOOD are to assess the origin of per- and polyfluorinated alkylated substances (PFAS) in our diet and the diet's contribution to the total human exposure to PFAS. To that end, the project has developed robust and reliable analytical tools for the determination of PFAS, and uses these to: qualify and quantify PFAS in our diet; understand how PFAS are transferred from the environment into dietary items; and quantify the possible contribution of food/beverage contact materials and food and water processing to the overall PFAS levels in our diet.

For those who do not know, can you elucidate what PFAS are, and explain their socioeconomic and scientific importance?

We have recently pleaded for a new terminology of perfluoros: rather than using the acronym PFCs (used to abbreviate perfluorocarbons in official Kyoto Protocol documents since its adoption in 1997), we prefer using PFAS (perfluorinated and polyfluorinated alkylated substances). PFAS are highly fluorinated substances that contain a chain of linked carbon (C) atoms on which most, or all the hydrogen substituents have been replaced by fluorine (F) atoms, usually connected to some 'head group' (eg. sulphonate or carboxylate).

PFAS have been widely used in many industrial and commercial applications. They are very persistent and hardly degrade. PFAS have been detected in the environment, wildlife and humans. Scientific questions focus on how these substances are transported in the environment and to what extent and how humans and wildlife are exposed.

Can you describe some of the robust and reliable analytical tools and methods to analyse PFAS in food items that have been developed through PERFOOD?

One of the major challenges of PERFOOD's analytical work package was to develop methods that would allow us to determine PFAS at ultra-trace levels. To that end, a lot of effort was put into reducing blank levels, which is a real challenge due to the omnipresence of fluorinated polymers in analytical equipment and some solvents used for sample treatment and clean-up.

Have the results of PERFOOD investigations identified the mechanisms by which PFAS are transferred from the environment into dietary items?

PERFOOD has investigated and quantified several pathways that include: transfer of PFAS from soil and feed to meat and dairy products; transfer of PFAS from surface waters into drinking water; transfer of PFAS from water and pore water to vegetables (in greenhouse and field experiments); and migration of PFAS from food contact materials into food.

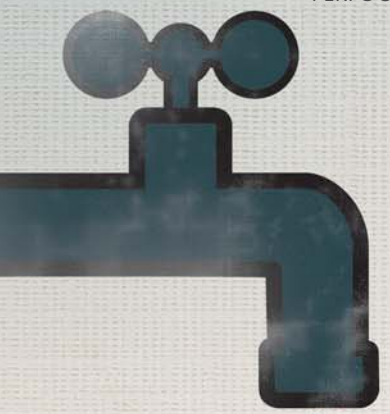
These experiments have shown that: PFAS are transferred along these pathways, albeit differentially; PFAS are accumulating in plant roots but poorly translocating to plant leaves; short-chain PFAS are poorly removed in drinking water treatment and end up in tap water and beverages; and some food contact materials can be a source of PFAS in food items.

PERFOOD is a major collaboration among diverse stakeholders and experts. Could you give an insight into the expertise that has been required in the project?

The expertise involved in the project includes analytical chemists, food chemists, environmental chemists, experts on water quality, measurement quality assurance (QA/QC) managers, specialists on food contact materials and migration, specialists on human food consumption and dietary habits, and risk assessors.

The outputs from PERFOOD build our knowledge of the relative importance of human exposure to PFAS, and how we are exposed. As these results could be considered a public health concern, is there a political advocacy element to the project? Do you expect the results to be translated into policy actions in Europe and beyond in the future?

The existing guidelines on tolerable daily intakes of two PFAS in the EU were published by the European Food Safety Authority (EFSA) in 2008. The EFSA document concluded that 'due to the substantial lack of suitable analytical data, many assumptions have been made in order to derive exposure estimates. Therefore, figures on levels in food and exposure provided in this opinion should be taken as indicative' and 'that further data on PFAS levels in food and in humans would be desirable'. PERFOOD members and groups of the European Committee for Standardisation (CEN) are drafting European guidelines for the analytical determination of PFAS in various media.



PERFOOD for thought

The **PERFOOD** project aims to detect per- and polyfluorinated organic compounds in our diets, as well as assessing their intake by the European population through food consumption and beverages

A SURPRISING RANGE of common household foods, beverages and packaging often contain a group of potentially toxic chemicals known as per- and polyfluorinated alkylated substances (PFAS). These humanmade substances are highly durable, water-and dirt-repellent, and heat resistant; properties that make PFAS ideal for use in food packaging, waterproofing, surfactants, floor polish and so on. Unfortunately, whilst the chemical and physical properties of PFAS are perfect for these applications, they subsequently allow the compounds to persist for very long periods of time in the environment, including the human body. Understanding the origins, transmission and risks associated with these chemicals is a considerable logistical and scientific challenge. It is this challenge that the PERFluorinated Organic compounds in Our Diet (PERFOOD) project, led by Professor Pim de Voogt, has taken on.

Members of the PFAS chemicals are similar in structure to hydrocarbon chains, but the hydrogen atoms are replaced by fluorine. The bonds between carbon (C) and flluorine (F) atoms are very strong. This high proportion of C-F bonds makes PFAS resistant to degradation by heat, stress or time. "The chemical and thermal stability of a perfluoroalkyl moiety, which is caused by the very strong C-F bond, in addition to its hydrophobic and lipophobic nature, leads to highly useful and enduring properties," explains de Voogt. The persistence of these compounds means that PFAS can stay in the human body for years.

Some forms of PFAS are known to cause liver damage and tumours in animals, and it is now known that PFAS can be detected in the blood of people across the globe, illustrating that the contamination of the environment by PFAS is a worldwide issue. The human response to the presence of these chemicals is so far comparatively unknown, making PFAS an unpredictable environmental contaminant.

Experts from a wide range of fields have come together under the PERFOOD umbrella to try and identify the origins of PFAS in our diets and assess to what extent this source is responsible for the presence of the contaminants in our bodies. This ambitious goal has been split into three holistic research aims: firstly, to identify which compounds are present in our diets and how numerous they are; secondly, to understand how these contaminants find their way into our dietary items; and finally, to elucidate the extent to which food and drink packaging alongside processing are responsible for the contamination of consumables by PFAS.

OVERCOMING CHALLENGES

Much of the previous work on PFAS was limited in its value as the methods of detection and analysis were crude. This made legislation and reduction difficult to justify. One of the first challenges addressed by PERFOOD was to develop better analytical techniques and methodologies, providing a truer estimate of the presence of PFAS in human bodies and consumables: "Four different specific methods for the determination of perfluorinated alkyl acids (sulphonates, carboxylates and phosphonates) have been developed and validated for different food items," de Voogt elaborates. This improvement

in detection was a crucial first step towards the project's goals and has provided the first genuine sets of data for the extent of PFAS contamination in humans and consumables.

Worryingly, little is known about how different types of PFAS affect the human body. This is perhaps surprising due to the global nature of the issue: "PFAS are present in human serum collected worldwide and have very long half-lives in human blood (years)," explains de Voogt. Although exposure is known to be widespread, the impact needs to be better understood: "The relevance of these findings for humans is a matter of research, since most of the laboratory tests have been conducted at levels of exposure beyond those experienced by humans," he elaborates.

THE EFFECTS OF PFAS

It is known that the sharing of maternal blood through the umbilical cord means newborn babies have levels of PFAS in their bodies similar to their mothers. This is further exacerbated by the transfer of PFAS in breast milk to young infants, however de Voogt suggests this may be a lesser concern: "Infants do receive additional exposure to PFAS through breastfeeding, but the specific concerns about exposure from breast milk are not as critical as for other persistent organic pollutants".

In order to estimate the exposure from our diets, the PERFOOD team conducted an analysis of the food we eat: "Prerequisites for our project were two sampling campaigns, designed to collect similar food items in a uniform procedure enabling direct comparison between different regions in Europe covering all major food items consumed by the European population," de Voogt elucidates. The PERFOOD methodologies and widespread sampling campaigns have produced encouraging results, demonstrating that human exposure to PFAS through the diet is less than was estimated five years ago.

While the impressive work of PERFOOD indicates that PFAS may be a less numerous environmental contaminant than previously thought, the participating scientists have been able to confirm the importance of diet as a source of these contaminants: "Despite the lower dietary exposure, this route is still the dominant one for human exposure to PFAS for the background human population, ie. the majority of people who are not exposed either occupationally or through living close to a hotspot of contamination," reflects de Voogt.

Crucially, the PERFOOD project has been able to identify the main sources of dietary contamination, thereby suggesting methods for reducing these sources. Since food contact materials can be a source of PFAS in food due to migration, it is necessary to develop alternatives for PFAS applied in such materials. Another major source is drinking water prepared from surface waters; however, in this case the contamination is at a level that poses no threat to human health. This improved understanding will hopefully lead to updated regulations regarding acceptable levels of PFAS in the environment and subsequently our diets. de Voogt and his PERFOOD collaborators hope such legislation will occur primarily in the EU, but also across other parts of the world thereafter.

FUTURE ENDEAVOURS

The work of PERFOOD has also attracted international attention leading to spin-off projects in Belgium and China – PERFOOD-Belgium and PFC-ChiNo, respectively. Although PERFOOD has been able to make a notable contribution to our knowledge, de Voogt is clear that more work needs to be done: "The results of PERFOOD and other scientific research have shown that we certainly need to know more about the environmental emissions and behaviour of precursors of the persistent PFAS".

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The PFAS group contains a wide range of chemical compounds of varying structure and composition; their relative risks are similarly varied. Short-chain molecules pose possible problems for the future, therefore further research on the toxicology of short-chain PFAS is necessary. The research community is now shifting its focus to create new forms of PFAS that meet commercial and industrial criteria but have no demonstrable environmental effects.

PERFOOD's research is critical to build on our understanding of PFAS. de Voogt's team has been able to clarify crucial questions including transmission, origin and environmental concentrations of the contaminants. By putting this knowledge into the context of European dietary habits, PERFOOD has created a set of holistic research data that can be used to better regulate the use of PFAS in the future.

INTELLIGENCE

PERFOOD

PERFLUORINATED ORGANIC COMPOUNDS IN OUR DIET

OBJECTIVES

Assessing the origin of per- and polufluorinated alkylated substances (PFAS) in diet and diet's contribution to total human exposure to PFAS through developing robust/reliable analytical tools to:

- Qualify and quantify PFAS in our diets
- Understand transfer from the environment into dietary items
- Quantify the contribution of food/beverage contact materials and food/water processing to overall PFAS levels in diets

KEY PARTNERS

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