SR5
A Systematic Review

MISTRA EviEM
EVIDENCE-BASED ENVIRONMENTAL MANAGEMENT

EviEM Fact Sheet 2018

# Temporal trends of perfluoroalkyl acids in humans and in the environment

*Several actions have been taken to reduce the use and emissions of per- and polyfluoroalkyl substances (PFASs). EviEM has investigated what effects the actions have had on concentrations of perfluoroalkyl acids (PFAAs) in humans and in the environment.*

## Many PFASs are toxic and widely distributed in the environment

Per- and polyfluoroalkyl substances (PFASs) are a broad class of man-made substances that have been produced and used in a wide variety of consumer products and in industrial processes for several decades. The properties of these substances may enhance the functionality of the products, but unfortunately the properties may be less favourable in other respects. Many perfluoroalkyl acids (PFAAs) are toxic and can potentially disturb the reproductive system of organisms or cause liver damage. When released to the environment they are also very persistent and occur in forms that are easily taken up by living organisms.

The PFAAs, as well as precursors that subsequently break down and form PFAAs, can be transported long distances both in the atmosphere and in rivers and ocean currents. Consequently, they have now been detected in the environment in most parts of the world, even in remote areas such as the Arctic.

As a response to concerns for both environmental and human health the industry started to phase out the manufacture of some types of PFASs in 2000, and further regulatory and voluntary actions have followed. However, these actions have not been implemented worldwide. In some regions, particularly in Asia, the production of some phased-out PFASs has on the contrary increased after 2000. There is also a concern that alternative PFASs, which may be equally problematic, have replaced phased-out PFASs in many products, and that precursors to phased-out PFASs still are produced.

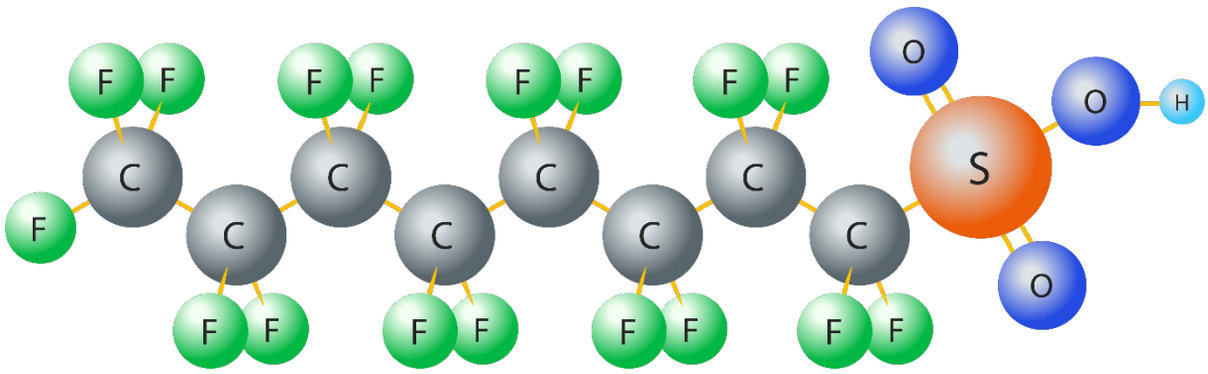
To investigate the effects of implemented phase-outs, EviEM conducted a systematic review (SR) of temporal trends of PFAS concentrations in the environment and in human samples. The SR focused on two groups of perfluoroalkyl acids and their precursors: perfluoroalkyl carboxylic acids (PFCAs) and perfluoroalkane sulfonic acids (PFSAs).

PFASs can now be found in the environment across the globe. Photo: Devra Cooper.

## Results are heterogeneous, but some patterns can be discerned

Owing to the diversity of PFASs (i.e. chain-length, molecular weight, degree and pattern of fluorination, presence of polar functional groups etc.), it is difficult to generalize their production histories, properties, and environmental fate. Different temporal trends between different PFASs are therefore expected, but the results show that the trends can vary also for individual PFASs, even within the same region or sample type. The results also show that many published datasets have low statistical power to detect any trend even if there would be one. Such datasets provide little information on changes in concentration with time. However, some fairly clear patterns can be discerned.

In regions where regulations and phase-outs have been implemented, human concentrations of perfluorooctane sulfonic acid (PFOS), perfluorodecane sulfonic acid (PFDS), and perfluorooctanoic acid (PFOA) are generally declining, while previously increasing concentrations of perfluorohexane sulfonic acid (PFHxS) have begun to level off. Rapid declines for some PFOS-precursors have also been consistently observed in human studies. In contrast, limited data indicate




Depiction of a PFOS molecule (not to scale). Illustration: Claes Bernes.

that concentrations of PFOS and PFOA in humans are increasing in China where the production of these substances has increased. Concentrations of longer-chained PFCAs (9-14 carbon atoms) in humans are generally increasing or show insignificant trends with low power to detect a trend.

For abiotic and biological environmental samples there are no clear patterns of declining trends. Most substances show mixed results, but a majority of the trends are based on datasets with low power to detect a trend and appear to be insignificant. The evidence base for environmental samples is thus relatively weak. Nevertheless, in environmental biological samples, increasing trends predominate for concentrations of PFCAs with 9-14 carbon atoms.

## Implications of the findings

Results suggest that declining PFOS, PFOS-precursor and PFOA concentrations in humans likely resulted from removal of certain PFASs from commercial products including paper and board used in food packaging. Increasing concentrations of long chain PFCAs in most sample types, and in most regions, is likely due to increased use of alternative PFASs. Continued temporal trend monitoring in the environment with well-designed studies are necessary to evaluate the effectiveness of past and continuing regulatory mitigation measures. The environmental persistence of many PFASs likely results in long environmental disappearance half-lives that will be difficult to detect in datasets without high statistical power. Also, to achieve a more rapid decline of PFAS concentrations in the environment, phase-outs and regulations will probably need to be implemented globally. For human samples, more temporal trend studies are needed in regions where manufacturing is most intense, as the one human study available in China is much different than in North America or Europe. Furthermore, temporal data for any PFAS in any sample type is practically non-existent from the Southern hemisphere.

### What is a systematic review?

A systematic review is characterized by meticulous planning, methodical procedures and a transparent, complete documentation of all assessments carried out in the course of the work. This approach is designed to avoid bias and increase reliability and repeatability.

### How this review was conducted

This systematic review was initiated and financed by the Mistra Council for Evidence-Based Environmental Management (EviEM). The review was conducted as a project by a specially appointed team of researchers chaired by Cynthia de Wit, professor at the Department of Environmental Science and Analytical Chemistry, Stockholm University, Sweden. The project was managed by Magnus Land, EviEM.

### EviEM

The Mistra Council for Evidence-Based Environmental Management (EviEM) strives to ensure that environmental management in Sweden is informed by the best possible scientific evidence. Through systematic reviews of relevant research, we aim to improve the basis for decisions in environmental policy. EviEM is funded by the Swedish Foundation for Strategic Environmental Research (Mistra) and hosted by Stockholm Environment Institute (SEI). It is financially and politically independent.

## Free access to full report

A more detailed summary of this review is available at the EviEM website (www.eviem.se/en). The full report on the review can also be downloaded there. The report has been published in the journal *Environmental Evidence* (www.environmentalevidencejournal.org).

MISTRA EviEM
EVIDENCE-BASED ENVIRONMENTAL MANAGEMENT

Mistra EviEM, Stockholm Environment Institute
Box 24218, SE-104 51 Stockholm, Sweden
info@eviem.se / www.eviem.se / @MistraEviEM