PFAS Exposure Pathway Factsheet

How can humans be exposed to PFAS?
There are multiple pathways by which individuals can be exposed to per- and polyfluoroalkyl substances (PFAS). Understanding these common pathways is important to put in context the extent and relative exposure to PFAS from its presence in numerous consumer products and environmental media. A pathway is defined as the route by which you come into contact with PFAS in your life. For PFAS, there are multiple ways in which individuals have been and continue to be exposed to PFAS. The primary pathways of exposure are inhalation and ingestion, and, less significantly, dermal absorption.

Inhalation
Inhaling PFAS in the air we breathe occurs if these compounds are present as a vapor, gas, mist, or in particulate (such as dust) form.

Ingestion
Ingesting PFAS could occur through the consumption of water, food, or other media which contain these compounds, or via incidental ingestion of small amounts of soil (for example, children playing outdoors).

Dermal
Products containing PFAS that come into contact or are applied to the skin have the potential to be absorbed through the skin.

PFAS Mass Flow in Society
In order to understand where PFAS exposure starts, it is important to understand how PFAS move through modern society. To date, it is estimated that over 9,000 chemicals meet the classification of PFAS. These substances provide consumer products with their anti-stick, stain-repellent, and water-proof properties. As a result, since first discovered in the 1930's, they have been widely used in the production of many everyday products. Some examples include food packaging, cosmetics, clothing, cookware, furniture, and carpeting. Viewing PFAS from a life-cycle lens helps to illustrate and identify primary pathways of exposure. There are four primary processes that go into the complete life cycle of a product: PFAS production, product manufacturing, product use, and waste management. While all of these processes can contribute to PFAS emissions, from a human exposure standpoint, the most significant process can be product use.

Baseline Concentrations of PFAS

Given the wide-spread use of PFAS world-wide, we are exposed to PFAS to some degree on a daily basis. The levels of PFAS in the environment has now contributed to detectable background levels in areas that are not close to specific releases like production facilities. Baseline levels are typically relatively low and result from PFAS becoming airborne and being transported beyond the initial point source, sometimes large distances. Some studies have tracked the mobility of PFAS and have identified impacts miles from a known source such as US Forest land and the arctic.

Concentration of PFAS in Everyday Items

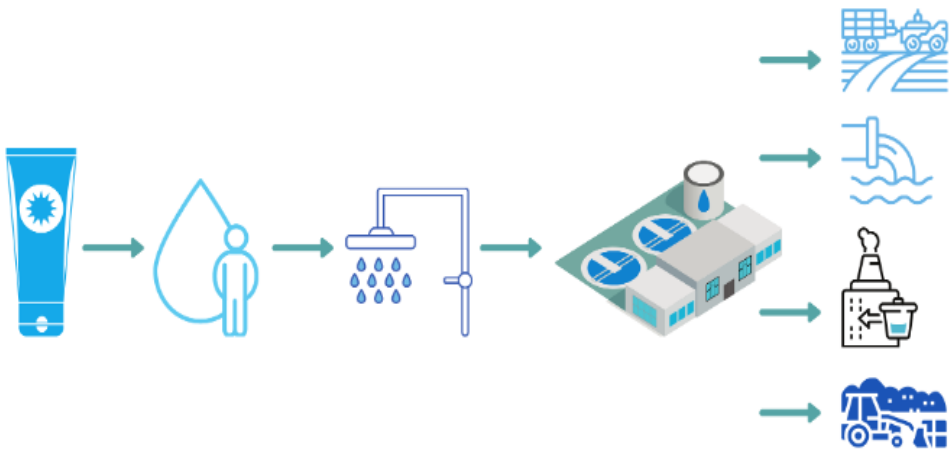
A majority of our daily exposure comes from the direct interaction with many consumer products and food-containing PFAS from packaging material. This exposure will vary from person to person and will depend on personal choices and daily habits. Indirect exposures can also play a role in daily exposure from consumer products such as carpeting treated with PFAS that can be released in our homes.

Breaking Down Daily PFAS Exposure

Direct exposure to PFAS has been identified through multiple media such as cosmetics, carpet, furniture, food, packaging, and indoor air (Sunderland et al., 2019). Although PFAS are in a wide range of consumer products, the quantification of exposure is not completely understood. Numerous studies have evaluated the available literature to understand individual exposure to PFAS through inhalation, dermal, and ingestion routes, and especially of food and drinking water ingestion. Most studies have concluded that food was the primary route of exposure rather than dermal and inhalation or even drinking water. Ingestion (dietary exposure) can account for upwards of 86% of total daily exposure to one of the PFAS of highest concern, PFOS, for adults (Sunderland et al., 2019). In USEPA risk assessment, it is conservatively assumed that drinking water accounts for 20% of daily human exposure. We spend approximately 90% of our time indoors and breath in air and dust. Concentrations of volatile PFAS from dust, air, and carpet have been identified to be major sources of fluorotelomer alcohols (FTOHs) in air in consumer households. Air has been demonstrated to pose the largest exposure risk, to date, of FTOHs and perfluorinated alkyl acids in young children (Morales-McDevitt et al., 2021).

The potential for indirect exposure can be challenging to track. This is because once a product is manufactured with PFAS, we do not have a complete understanding of what happens to PFAS once they enter the consumer market. For example, when a person enjoys a day at the beach, the PFAS laden sunscreen they apply can enter their bodies through dermal exposure and after showering the PFAS-containing sunscreen washes down the drain traveling to a wastewater treatment plant. After treatment, the effluent could be discharged to surface water or groundwater and the treated biosolids could be land applied on agricultural soil. While such beneficial uses could create remote opportunities for indirect exposure, they would likely be less significant than direct routes (see graphic).

The exact contribution of these indirect exposure pathways has not been studied so we have an incomplete understanding of human exposure. However, given the level of treatment and regulatory control measures at management facilities, such as wastewater treatment plants, drinking water treatment facilities, and solid waste management facilities, these processes add multiple degrees of separation that reduce the likelihood of exposure greater than direct exposure from PFAS-containing consumer products (e.g., household dust, carpet, cosmetics, food packaging, etc.).



Although there is a growing focus nationally to examine PFAS levels in certain settings such as drinking water, wastewater, and solid waste management facilities, these facilities manage or receive PFAS-containing materials from primary sources such as consumer products. Currently available data suggests that materials at these facilities represent a relatively minor exposure pathway to humans. In order to significantly reduce exposure potential in society via the more common daily pathways, the obvious solution is to reduce the broad use of PFAS in common consumer products and other materials. Fortunately, there is already a movement nationally to ban use of long-chain PFAS in products such as food packaging, fire-fighting foam, and consumer products. These bans have successfully resulted in the reduction of these specific compounds in our blood, breast milk, and the aquatic environment. Society must consider the continued use of PFAS in consumer products to successfully mitigate concerns.

References

Sunderland EM, Hu XC, Dassuncao C, Tokranov AK, Wagner CC, Allen JG. A review of the pathways of human exposure to poly- and perfluoroalkyl substances (PFASs) and present understanding of health effects. J Expo Sci Environ Epidemiol. 2019 Mar;29(2):131-147. doi: 10.1038/s41370-018-0094-1. Epub 2018 Nov 23. PMID: 30470793; PMCID: PMC6380916.

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