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Bees provide essential pollination services, thereby contributing to the preservation of biodiversity, ecosystem stability and food security. Bees, however, face numerous threats including loss of habitat and resources, climate change, natural disasters, predation, pests, diseases and exposure to crop protection products. Per- and polyfluoroalkyl substances (PFAS), a class of persistent organofluorine compounds, are now ubiquitous throughout the environment. Exposure to PFAS may present a particular threat to bees, but viable exposure routes and the resultant impacts of PFAS on this key pollinator species are poorly understood. In particular, plants readily take up PFAS but translocation to pollen and nectar, key components of the bee diet, is not yet confirmed. Active ingredients of numerous and commonly used pesticides such as Bifenthrin, Fipronil, and Fluvalinate include PFAS or are PFAS synergists. Bee exposure to these pesticides may occur through direct application or residue consumption. Some studies demonstrated that PFAS, in particular perfluorooctane sulfonate (PFOS), is toxic to bees and increases mortality at concentrations detected in contaminated environmental surface water. Sublethal PFOS exposure in insects (*Drosophila hydei*, *Enallagma cyathigerum*, *Bombus terrestris* L. and *Apis mellifera*) impairs developmental and reproductive function with the greatest effects observed on the larval life stage. This current work describes the first review of available literature on the risk that PFAS poses to bees, including potential exposure routes, behavioural responses, biological impacts and transfer to honey. Knowledge gaps include exposure routes in the field, the relative importance each exposure route, chronic sublethal exposure effects on bee health, and the risks to consumers of bee products. These knowledge gaps must be filled to allow development of protective reference thresholds that protect bee populations, food security and consumer safety.

Are PFAS yet another threat to bees?

A review of the evidence

Dr Carolyn Sonter

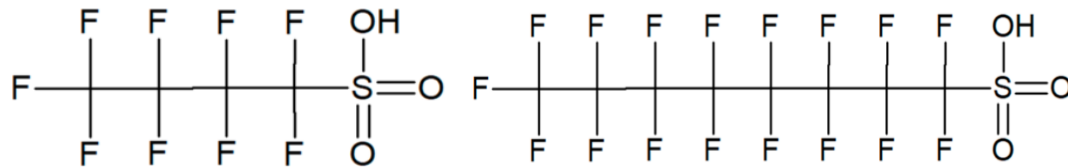
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The University of New England (Armidale campus) acknowledges that this research was conducted on the country of the Anaiwan people, who are the traditional custodians on whose land this University stands. We also pay our respect to their Elders past, present and emerging.

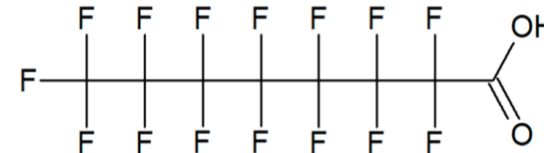
What are PFAS?

- Per- and polyfluoroalkyl substances
- A class of organofluorine compounds – thousands
- Used in protective coatings, reinforced fabrics, rubber piping, firefighting foams, surfactants and insecticides
- Range in chain length from 4 to 18 molecules
- Gen X created to replace PFOA

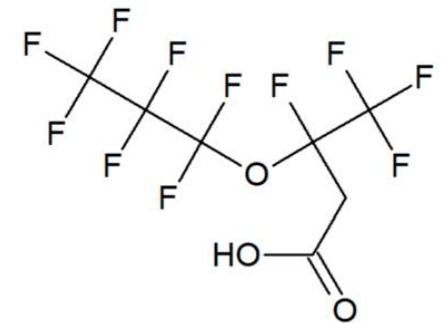


PFBS

PFOS



PFOA



GenX

What are PFAS a problem?

- Once in the environment PFAS adsorbs to soil particles and can be transported as dust and in water
- Persistent and resistant to environmental degradation - half life can range from several years in the human body (PFOS and PFOA) to >1000 years in soil (some PFAS polymers)
- PFAS can bioaccumulate and biomagnify up the food chain
- Detrimental impacts observed in all tested animal species, e.g. oxidative stress, DNA mutations, liver damage and blood cancers



What do we know about PFAS and bees?



- Very little!
- Bees do not appear to be attracted to or avoid the smell of PFOS (Sonter et al. 2024)
- PFAS have been detected in honey samples from Europe (Surma et al. 2016)
- PFAS has been detected on bees and in pollen (Muller et al., 2025; Wright et al., 2025)
- Main PFAS detected were PFOA, PFHpA, PFNA and PFHxS
- Investigations hindered by high limit of detection in most media - ppb

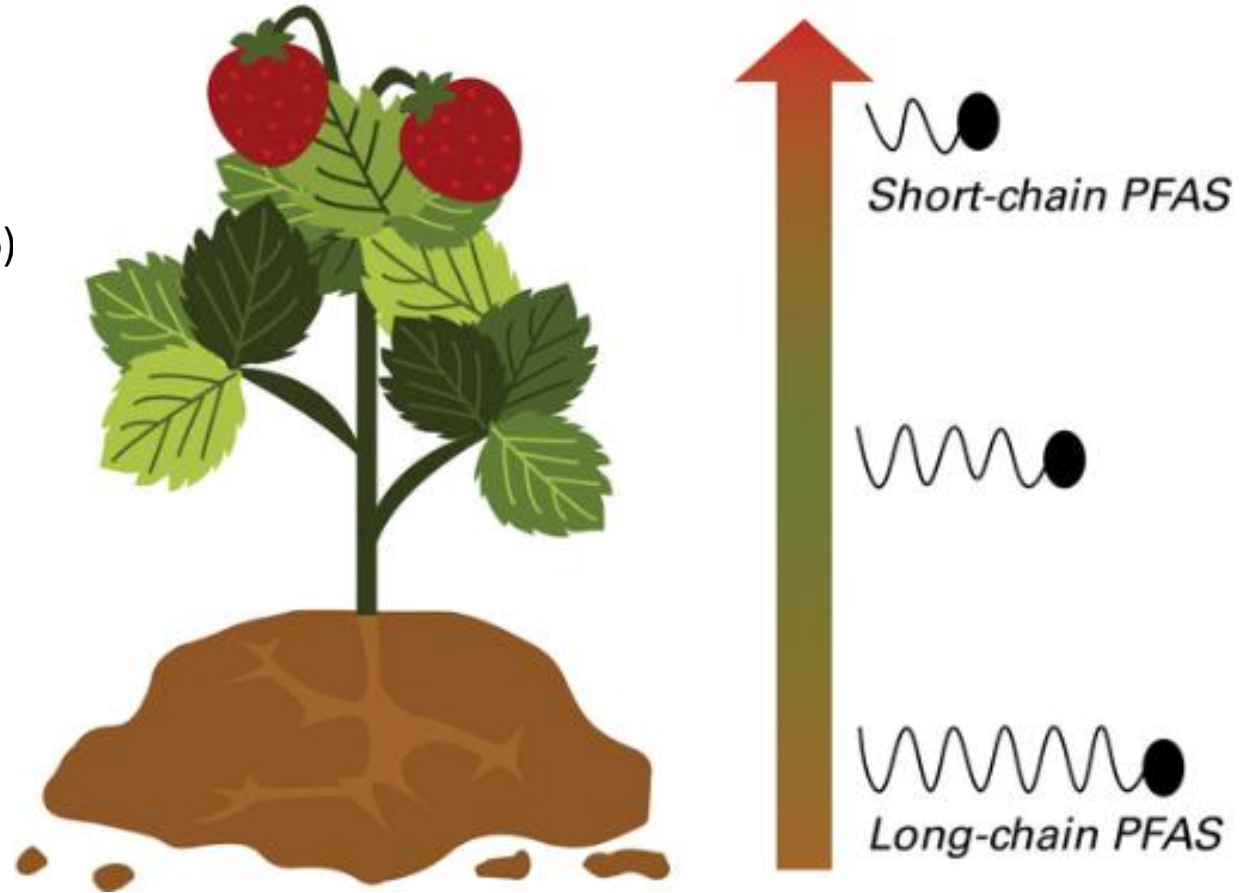
Potential exposure routes of PFAS to bees

Confirmed:

- Dust (Yamazaki et al., 2022)
- Pollen (Muller et al., 2025; Wright et al., 2025)
- Water (Dauchy, 2023)
- Paint (Cahuas, et al., 2022)
- Crop protection product residues (Sehgal et al., 2024)

Not confirmed:

- Flower nectar



North Carolina State Extension, (2024)

Toxicity of PFAS to bees?



- Lethal dose (LD50) for PFOS for *A. mellifera* at 0.40 µg/bee (at 72 hrs post exposure) (Wilkins 2001)
- *Bombus terrestris* exposure to PFOS:
 - increased mortality ($\geq 5 \text{ mg L}^{-1}$),
 - decreased reproductive potential and egg production ($\geq 1 \text{ mg L}^{-1}$),
 - decrease in mitochondrial electron transport system activity of 26%
 - Bioaccumulation Factor (BAF) of 27.9 for PFOS in bumble bees (Mommaerts et al., 2011)
- When *A. mellifera* exposed to PFOS, brood development ceased at 0.02 mg L⁻¹ and mortality increased at $\geq 0.8 \text{ mg L}^{-1}$ (Sonter et al., 2021)
- PFAS accumulates in *A. mellifera* tissue, is eliminated in faeces and transfers to honey (Sonter et al., 2021)



Table 1. PFOS detected in bee tissue, honey and faeces in bee colonies exposed to PFOS for a 4-week period (Sonter et al., 2021).

	Bee Tissue			Honey		Faeces
PFAS	Control	0.02 mg L ⁻¹	1.6 mg L ⁻¹	Control	0.02 mg L ⁻¹	1.6 mg L ⁻¹
PFHpA			0.0070±0.0030			0.0044
PFOA			0.0003±0			0.0017
PFNA						0.0044
PFDA						0.0014
PFPeS			0.0018±0.0007			
PFHxS		0.0122±0.0122	0.0425±0.0174		0.0072	0.0069
PFHpS		0.0049±0.0023	0.0146±0.0054		0.0013	0.0014
PFOS		0.0887±0.0887	0.3223±0.1130		0.033	0.013

- BAF of **0.3** (mean) in bee tissue
- Honey transfer factor of **0.4** (0.02 mg L⁻¹ exposure only)
- Faecal elimination of **0.013 mg kg⁻¹** (1.6 mg L⁻¹ exposure only)

Knowledge gaps

- Confirm all exposure routes of PFAS to bees, especially flower nectar
- Identify relative importance of field exposure routes
- Field-based evidence regarding chronic sublethal exposure on all bee species, native and introduced
- Understand impact of PFAS on whole bee colony
- Impact of PFAS on the bee proteome – impact at a cellular level
- Extent of honey contamination



Want to talk more about PFAS and bees?

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