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Perfluoroalkyl Substance (PFAS) and Microplastics Capability Statement

Environment Institute

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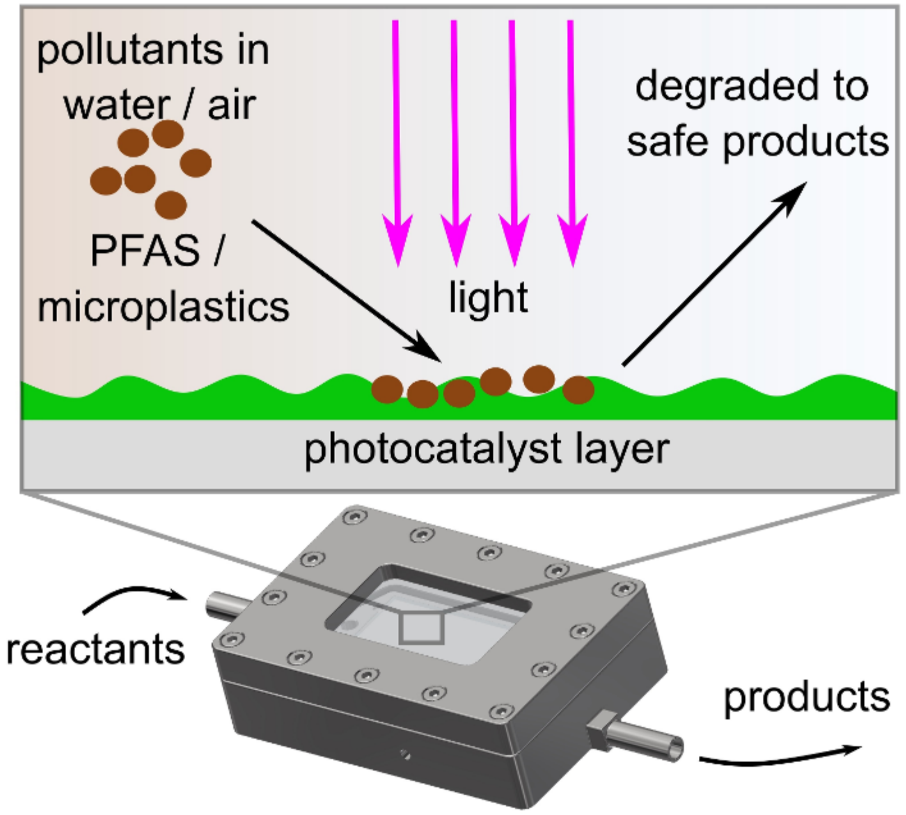
Perfluoroalkyl substance (PFAS) remediation strategies

Cameron Shearer, Department of Chemistry, The University of Adelaide

Perfluoroalkyl substances (PFAS)
PFAS are a family of prevalent man-made chemicals consisting of C-F bonds and widely used in industrial processes and household products; with contamination now pervasive Worldwide and within Australia (Green et. al. 2024). PFAS do not degrade in the environment and bio-accumulate within the food chain (hence called 'forever chemicals'). In humans, PFAS are routinely detected in blood and organs in people without industrial exposure. Developmental defects are documented in children of women exposed to high levels of PFAS; however, it is emerging that even low levels of PFAS, currently deemed safe, can exert toxicity (Wintanley et. al. 2024).

PFAS Identification and Quantification
The University of Adelaide hosts world-class analytical facilities which can be used for the identification and quantification of PFAS. NMR spectroscopy can be used to quantify PFAS in concentrated samples (>1 ppm). Liquid chromatography – mass spectrometry (LC-MS) is the US EPA approved method to quantify specific PFAS chemicals (>1 ug/L without pre-concentration). The University hosts multiple LC-MS systems. Within the Department of Chemistry, we have calibrated procedures for 32 specific PFAS compounds using a high-resolution LC-MS system which can be used for both targeted and untargeted analysis.



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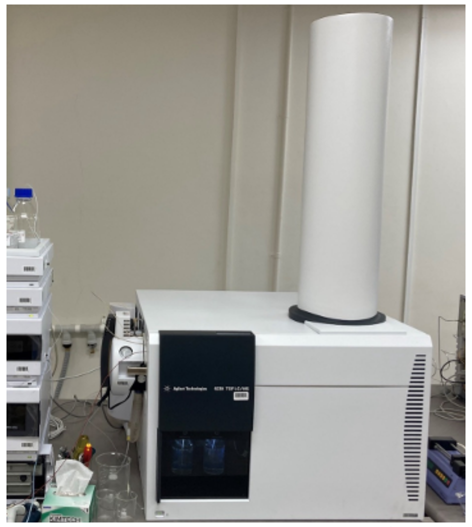
PFAS degradation technology
The chemical properties of PFAS which make them so beneficial in industry also make them recalcitrant to degradation in the natural environment and to common oxidising chemicals. Thermal incineration of hazardous waste is a rapid but difficult to control process and has been reported to release shorter chain PFAS. More controlled techniques which can mineralise PFAS are ultrasonic destruction, electrochemical oxidation or photocatalytic degradation.

Recently Dr. Cameron Shearer with Membrane Systems Australia (now owned by Enviropacific) patented a PFAS treatment chain consisting of PFAS capture, PFAS concentration and PFAS destruction (Shearer et. al. 2021).PFAS destruction if far more viable when highly concentrated and the treatment chain can be modified for a range of PFAS waste streams. Ultrasonic destruction was shown to completely breakdown the PFAS to safe products (fluoride, carbon dioxide).

In a recent breakthrough study (Hamza et. al. 2025), Dr. Shearer's team have developed a sunlight-activated material that can degrade PFAS in water. This approach uses visible light to drive chemical reactions that break down PFAS into harmless components including fluoride. This discovery offers a promising, low-energy solution for PFAS remediation, with potential applications in water treatment and environmental cleanup. As PFAS contamination continues to pose a global health risk, this research represents a critical step toward safer communities and cleaner ecosystems.

NMR Spectrometer



Liquid Chromatography - Mass Spectrometry (LC-MS)

Mahmoud Adel Hamza, PhD Candidate (ABC News, 2025)

PFAS and microplastic identification and quantification

Patrick Reis Santos, Nina Wootton, Bronwyn Gillanders,School of Biological Sciences, The University of Adelaide

PFAS contamination in marine environments comes from multiple sources, including firefighting foams, household plastics, and textiles treated for water and stain-repellent properties. At the same time as the use of PFAS continues to rise, global plastic production is soaring with large volumes of plastic ending up in land and aquatic environments through river runoff, wastewater outfalls, or via sludge and biosolids used in agriculture, forestry and land rehabilitation, among many other sources. Once in the environment, plastic debris break down and degrade into smaller pieces, known as microplastics (< 5mm). Due to their complex physicochemical properties, plastics and PFAS readily interact, with microplastics acting as potential transport vectors for chemical contamination. Adsorption and desorption processes influence how PFAS, but also a suite of other contaminants, bind to or release from plastic particles. Overall, factors such as polymer type, additives (including PFAS), and environmental weathering influence the chemical load and, ultimately, the risks associated with the presence of microplastics on ecosystems and organisms.

We have optimised methods to detect PFAS on microplastics collected from coastal and marine environments, as well as within tissues of fish and other organisms. These approaches allow us to quantify PFAS transport through marine environments and food webs, assess exposure mechanisms in keystone species, and evaluate the potential risks of PFAS exposure through seafood consumption. In collaboration with Dr Mike Williams at CSIRO, we have also developed multi-residue analysis capable of simultaneously analysing PFAS, plastic additives, and other emerging contaminants such as pharmaceuticals and pesticides, to deliver efficient, integrated assessments of contaminant interactions (Dolling *et. al.*2024). Using the same method to target multiple compounds, and applying it to both plastic and biological tissues, provides a robust pathway to explore the link and potential synergies between microplastics and other emerging contaminants in the environment. It also enhances our understanding of how the breakdown and environmental weathering of plastics influence the sorption and desorption of PFAS, which can inform the design of polymers for reduced contaminant binding or environmental impact. These are a key national and international priorities (Wootton *et. al.*2024).

Our research builds on the expertise of the Gillanders lab in microplastic identification and quantification in multiple environmental matrices, including coastal sediments, water, and biota (e.g., bivalve, crustacea, fish). Microplastic quantification follows international best practices, with Dr Patrick Reis-Santos and Dr Nina Wootton leading the development of national Standard Operating Procedures (SOPs) for microplastic analysis in collaboration with more than 40 researchers across Australia (Wootton *et. al.* 2025). Overall, determining the occurrence, magnitude, and polymer types of microplastic contamination is essential for identifying the main sources and drivers of contamination, providing the basis for assessing environmental risk. Likewise, understanding the combined effects of legacy contaminants, such as PFAS and microplastics, depends on clear information about their presence and interactions in the environment.

A person holding microplastics found at a beach

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Degradation of microplastics using light and catalysts

Tak W. Kee, Department of Chemistry, The University of Adelaide

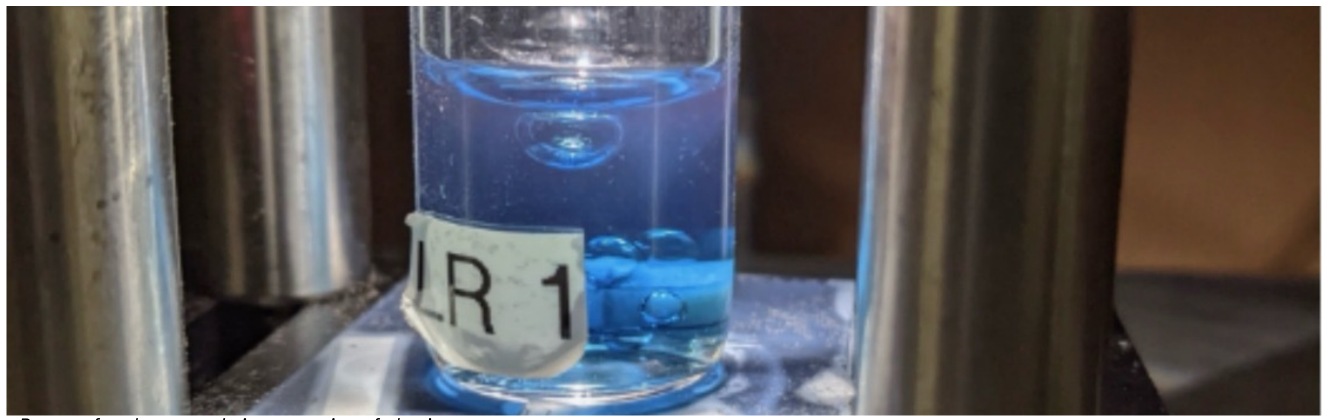
Microplastics are small plastic particles that measure less than 5 millimetres in size. They are found in the forms of microbeads, microfibres, and broken-down plastic products. They are found in water bodies, soil and in air, potentially resulting in severe impacts on human health because of their accumulation in the food chain. In the long term, reducing the use of single-use plastics and proper waste management will reduce the spread of microplastics. In the short to medium term, isolation and degradation of existing microplastics that is accumulated in the environment can limit the impact of these substances.

Disposal of the isolated microplastics is a current challenge. Plasma gasification, pyrolysis and incineration have been proposed but these methods are known to produce harmful and hazardous emissions. To overcome this significant challenge, we propose to use photo-catalytic degradation of microplastics. This process involves using light and light-absorbing chemical compounds to catalyse the conversion of microplastics to useful chemical building blocks in industry.

A recent study showed that a combination of blue light and the compound fluorenone in the presence of dissolved polystyrene (Styrofoam) degrades polystyrene in several hours to form smaller chemical compounds including benzoic acid as a major component. In particular, benzoic acid is a useful chemical building block in industry.

We are examining the photo-catalytic degradation of other components of microplastics including poly (methyl methacrylate) (Perspex), polyethylene terephthalate (PET) and polyesters using blue light and fluorenone as a catalyst. The aim is to generate methacrylic acid, terephthalic acid and ethylene glycol, which are useful compounds in industry.

The group of Assoc. Prof. Tak W. Kee at the University of Adelaide has expertise in photo-catalysis and advanced laser spectroscopy. His lab and facilities at the University are equipped with the reactors, light sources, liquid and gas chromatography, and mass spectrometry instrumentation that are necessary to study the degradation and conversion of microplastics to useful chemical building blocks. The objectives of this research are to degrade these potentially harmful plastic materials using an environmentally sustainable method and simultaneously generate useful chemical building blocks in industry.



Reactor for photo-catalytic conversion of plastics

Major funders and partners

- Australian Research Council
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- CSIRO Land and Water
- NESP Marine and Coastal Hub

Key Publications

PFAS

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Kaurna acknowledgement
We acknowledge and pay our respects to the Kaurna people, the original custodians of the Adelaide Plains and the land on which the University of Adelaide's campuses at North Terrace, Waite, and Roseworthy are built. We acknowledge the deep feelings of attachment and relationship of the Kaurna people to country and we respect and value their past, present and ongoing connection to the land and cultural beliefs. The University continues to develop respectful and reciprocal relationships with all Indigenous peoples in Australia, and with other Indigenous peoples throughout the world.