WYDZIAŁ CHEMICZNY

KATEDRA CHEMII NIEORGANICZNEJ, ANALITYCZNEJ I ELEKTROCHEMII

mgr inż. Magdalena Zarębska

ROZPRAWA DOKTORSKA

Opracowanie i zastosowanie nowych procedur analitycznych do oznaczania wybranych związków poli- i perfluoroalkilowych w próbach środowiskowych

Przewodnik po jednotematycznym cyklu publikacji

Development and application of new analytical procedures for the determination of selected poly- and perfluoroalkyl substances in environmental samples

Guide to a thematic series of publications

Promotor pracy: dr hab. inż. Sylwia Bajkacz, prof. PŚ

Opiekun ze strony przedsiębiorcy: dr hab. Zofia Hordyjewicz-Baran

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Abstract

Poly- and perfluoroalkyl substances (PFAS) are a large group of persistent chemical pollutants that pose a significant threat to human health and the environment due to their chemical stability, toxicity, and bioaccumulative properties. PFAS present a major challenge in environmental protection, and their analytical determination remains a key area of research. In accordance with Directive (EU) 2020/2184, which mandates the monitoring of selected PFAS compounds in drinking water by 2026, the development of sensitive and reliable analytical methods is essential for effective control of their presence.

The aim of this doctoral thesis was to develop and apply new analytical procedures for determination of 25 PFAS compounds in various environmental matrices, with a particular focus on water samples. The study targeted 20 compounds listed in the Directive and 5 emerging substitutes with potentially harmful effects. PFAS were isolated from liquid samples using solid-phase extraction (SPE), from sediments via a modified alkaline QuEChERS procedure, and from plant tissues through alkaline digestion (ADE) combined with solid–liquid extraction (SLE). Method optimization was carried out using both one-factor-at-a-time (OFAT) and design of experiments (DoE) approaches. Targeted analysis of PFAS was performed using high-performance liquid chromatography coupled with tandem mass spectrometry (LC-MS/MS) in scheduled multiple reaction monitoring (sMRM) mode, while the identification of transformation products was carried out using an integrated semi-targeted screening and confirmation approach, employing various mass spectrometric scanning modes. The methods were validated according to trace-level detection requirements, and the use of isotopically labeled internal PFAS standards ensured matrix effect compensation and high precision. The environmental profile of the developed methods was assessed as moderate. The developed **procedures were applied to monitor PFAS in waters and sediments** of the southern section of the Oder River. The results were used to assess PFAS occurrence, identify potential emission sources, and conduct ecological risk assessment. In addition, the **methods were used to evaluate PFAS removal efficiency using (i) domestic filters, (ii) photodegradation in the proposed advanced reduction process (ARP), and (iii) currently applied wastewater treatment technologies**, confirming their applicability for eliminating these contaminants. The research findings were published in a series of six scientific articles, one review and five presenting own original experimental work.

As part of the implementation doctoral program, four developed analytical procedures were implemented at the Łukasiewicz Research Network – ICSO "Blachownia" for the determination of PFAS in both liquid (water, wastewater) and solid (soil, plant tissue) samples, **enhancing the institute's analytical service portfolio.**