Non-Thermal Plasma Treatment for Safe Agricultural Reuse of Municipal Wastewater and Urine: Contaminant Removal and Resource Recovery

Summary

This PhD project aims to develop a sustainable, energy-efficient treatment process for removing contaminants of emerging concern (CECs) from municipal wastewater and urine for safe agricultural reuse. The research focuses on gas-phase pulsed corona discharge (PCD), a non-thermal plasma technology with superior energy efficiency compared to conventional advanced oxidation processes. Key objectives include optimizing selective CECs degradation, achieving effective bacterial control, and assessing the environmental and economic feasibility of the process. The position offers the opportunity to work on innovative plasma-based water treatment technologies within a wider initiative promoting sustainable water reuse and circular nutrient management in agriculture.

Research field:	Chemical, materials and energy technology
Supervisors:	Niina Dulova Sergei Preis
Availability:	This position is available.
Offered by:	School of Engineering Department of Materials and Environmental Technology
Application deadline:	Applications are accepted between June 01, 2025 00:00 and June 30, 2025 23:59 (Europe/Zurich)

Description

The research

The presence of contaminants of emerging concern (CECs) such as pharmaceuticals, personal care products, and pesticides in wastewater poses growing environmental and health risks. These compounds, often toxic, carcinogenic, and endocrine-disrupting, resist removal by conventional wastewater treatment methods. This issue obstructs safe reuse of nutrient-rich waste streams like municipal wastewater and source-separated urine in agriculture - a practice essential for advancing sustainable nutrient and water recycling. The European Commission highlights the dual challenges of water scarcity and priority pharmaceuticals control, calling for affordable, effective tertiary treatment solutions. Existing chemical, biological, and physical methods have yet to provide a practical answer, particularly regarding pharmaceutical residues and microbial safety in treated wastewaters intended for farmland application.

The doctoral project aims to develop an energy-efficient sustainable treatment process based on gas-phase pulsed corona discharge (PCD), a non-thermal plasma technology. The technology demonstrated superior energy efficiency among advanced oxidation processes (AOPs) through the generation of highly reactive short-living oxidants at the gas-liquid interface. The specific objectives include:

- achieving selective energy-efficient PCD-based degradation of priority pharmaceuticals in urine and municipal wastewater;
- ensuring bacterial inactivation with simultaneous removal of priority pharmaceuticals from municipal wastewater for safe agricultural reuse;
- environmental sustainability assessment of the proposed treatment process.

The doctoral research project will deliver a validated PCD treatment protocol capable of efficient removal of pharmaceuticals, CECs, and bacteria from complex aqueous matrices. The research will address key questions regarding the optimization of operational parameters for selective oxidation, the mechanisms of pollutant degradation via short-living oxidants, and the environmental sustainability of the technology at scale. The outcomes are expected to support the integration of sustainable, cost-effective treatment solutions into wastewater and nutrient management systems, promoting circular economy principles in the sector.

Responsibilities and (foreseen) tasks

- Planning and conducting treatment experiments with municipal wastewater and source-separated urine.

- Performing analytical characterization of wastewater and urine samples.
- Collecting foreground and background data for environmental sustainability assessments using the Life Cycle Assessment (LCA) approach.
- Analyzing experimental and assessment data, and preparing scientific publications independently and in collaboration with co-authors.

Applicants should fulfil the following requirements:

- A Master's degree (or equivalent) in a relevant field such as environmental engineering, chemical engineering, materials technology, or a related discipline.
- A strong interest in the application of advanced oxidation processes (AOPs) to the treatment of water-based matrices.
- Proven writing, analytical, and data interpretation skills.
- Very good/Excellent proficiency in spoken and written English.
- The ability to work both independently and collaboratively within a research team.

The following experience is beneficial:

- Prior experience in application of advanced oxidation processes (AOPs).
- Previous experience in environmental LCA (E-LCA) and carbon footprint calculations.
- Very good to excellent command of the Estonian language.

We offer:

- A fully funded 4-year PhD position focused on the application of advanced oxidation processes (AOPs) for municipal wastewater and source-separated urine treatment, with the aim of enabling reuse and nutrient recovery.
- The opportunity to work in an interdisciplinary research environment, integrating engineering, analytical chemistry, and environmental sustainability assessment.
- Opportunities to participate in conferences, undertake research internships and networking with partner universities and research centers in the field of environmental engineering and sustainable technology.

About the department

The Department of Materials and Environmental Technology is a national leader in high-level, internationally recognized teaching, research, and development in materials and environmental technology. Within the Department, the Laboratory of Environmental Technology (LET) focuses on applied sustainability and environmental research, addressing key topics such as:

- Water and wastewater treatment
- Contaminated soil remediation
- Air pollution abatement
- Degradation and removal of contaminants of emerging concern in aqueous matrices
- Valorization, processing, and recycling of solid waste
- Life cycle assessment and carbon footprint calculation

LET has extensive experience in managing and participating in national and international projects, including BSR/Central Baltic INTERREG, ERA-MIN, Erasmus+, and LIFE programs, with a strong emphasis on advanced treatment of environmental matrices, sustainable waste management, and circular economy.

Additional information

For further information, please contact: Dr. Niina Dulova (e-mail: niina.dulova@taltech.ee) and Prof. Sergei Preis (e-mail: sergei.preis@taltech.ee)

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