SPRING 2026

CEETLETTER

VSB TECHNICAL UNIVERSITY OF OSTRAVA | CENTRE FOR ENERGY AND ENVIRONMENTAL TECHNOLOGIES

FOREWORD BY THE DIRECTOR OF CEET

Each new edition of our newsletter once again confirms that CEET is not just a collection of projects, results, and publications. Above all, it is a space where people, expertise, and topics come together. Topics that have a real impact on today's energy sector, the environment, and modern technologies.

In this issue, we once again bring you stories of research that aim to go beyond the boundaries of laboratories. From energy recovery from waste and new approaches to water treatment to advanced biosensors and materials research, it is clear that today's challenges cannot be addressed in isolation.

They require interdisciplinary cooperation, openness to new approaches, and the ability to translate knowledge into practice.

I am pleased to see that CEET continues to foster an environment where, alongside excellent research, strong international partnerships are formed, new research opportunities emerge, and inspiring professional journeys take shape. It is this combination of expertise, cooperation, and practical relevance that gives our work its meaning.

This issue is also a reminder that behind every result, there are real people. They are the ones who give CEET its energy, direction, and credibility.

I wish you an inspiring read.

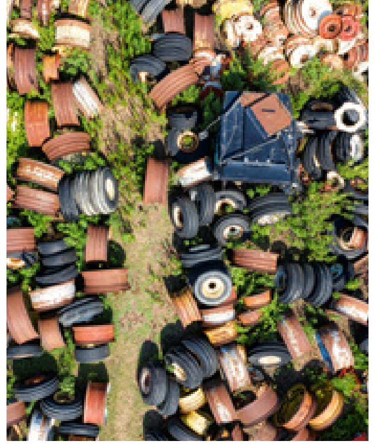
Stanislav Mišák
CEET Director

RESEARCH AND INNOVATION

AI IN WASTE-TO-ENERGY APPLICATIONS

AI-WASTE PROJECT

CEET researchers have achieved another success in the field of international grants. The supported project AI-WASTE (AI-supported optimization of thermochemical processes for resource recovery from waste) focuses on technologies for converting solid alternative fuels from waste (TAP) for energy production and the extraction of useful raw materials. Part of the solution also includes AI-assisted computational models aimed at optimizing operational conditions and enhancing the efficiency of these processes. This grant is being managed within the SIGMA program, pillar DC4 – Bilateral Cooperation, announced by the Technology Agency of the Czech Republic.



Waste Production Grows Faster Than Capacity

Global waste management has significantly changed in recent years. Thanks to legislative pressures, improved technology availability, and awareness efforts, recycling and waste-to-energy (WtE) rates have increased. However, newly installed capacities for recycling and WtE are not always keeping pace with the constantly growing waste production. According to the United Nations Environment Programme (UNEP), the global amount of municipal solid waste is expected to increase from about 2.1 billion tons in 2023 to 3.8 billion tons by 2050, a more than 50% increase.

It's not just about tons. UNEP estimates that by 2020, the direct costs of municipal waste globally amounted to around 252 billion USD (with health, pollution, and climate impacts raising it to about 361 billion USD), and without changes, annual costs could rise to 640.3 billion USD by 2050. Interestingly, UNEP's modeling also presents a „reverse" scenario. With a transition to a circular economy, the system could achieve a net annual economic benefit of 108.5 billion USD (instead of net costs). In such a situation, it becomes crucial not only what is done with the waste but also how exactly each technology is managed and optimized in practice.

More Efficient Management of Complex Processes

This is where the AI-WASTE project comes into play. Waste-to-energy (WtE) can be understood simply. A part of the waste that is no longer reasonably recyclable can be converted into fuel after appropriate treatment and then used for energy production and sometimes other useful outputs. However, waste is not a „standard raw material.“ Sometimes the fuel is high-calorific and stable, while at other times, its composition varies significantly. When the fuel changes, the process in the plant must also be adjusted, as efficiency may decrease or emissions worsen.

Jakub Čespiva

At the Energy Research Centre, Jakub has long focused on thermochemical processes, especially the gasification of biomass and solid alternative fuels from waste (TAP). As part of his doctoral studies, he expanded this focus to include catalytic synthesis of liquid hydrocarbons with potential for enhancing energy independence. He is currently a member of the Innovation and Safety research group, where he coordinates several national and international projects focused on alternative energy processes and related technologies. His work aims for practical outcomes while also contributing to scientific publications. In addition to these activities, he oversees teaching the Combustion Devices course in the follow-up master's program at the Department of Energy, Faculty of Mechanical Engineering, VSB-TUO, and is actively involved in organizing the International Energy and Environment Conference (IEEC).

AI-WASTE, therefore, aims to make the operation of these technologies smarter and more precise. In practice, this means collecting data from operations, understanding what is happening in the processes, and using computational models and AI to help the system propose optimal settings based on the specific „waste-derived fuel“ available at the time.

The project involves teams from CEET, specifically the Energy Research Centre and the Institute of Environmental Technology, as well as colleagues from the Department of Energy, Faculty of Mechanical Engineering, VSB-TUO, who have facilities for testing various fuel conversion methods, including a gasification reactor (200 kW), rotary combustion furnace (150 kW), fluidized bed boiler (12 kW), and domestic stationary heat sources (6 kW). This portfolio is expanded by an industrial retort pyrolysis unit (6 MW) owned by Henry Gas a.s., the project's main coordinator, which is also focused on preparing homogenized pellets from TAP fuel with consistent properties. The preparation and testing of these pellets also involve OZO Ostrava s.r.o. Thanks to this connection, the research is supported not only by experimental research but also by real-world experience.

Why Artificial Intelligence is Involved

Thermochemical conversion of waste fuels is a complex process that changes over time and reacts to various inputs. In practice, it is necessary to find a balance between the fuel's properties, air supply (or other oxidizing media), energy input, material flows, and other factors. Any change can affect efficiency, emissions quality, and the type of products the process generates.

This is where AI-WASTE helps. The goal is to develop predictive software that, based on experimental data, can suggest the optimal combination of input parameters based on the specific fuel being

IT IS NOT ENOUGH TO DECIDE WHAT TO DO WITH WASTE. WHAT TRULY MATTERS IS HOW PRECISELY WE CONTROL THE TECHNOLOGIES THAT PROCESS IT.

supplied. A well-optimized process can lead to lower harmful emissions in exhaust gases, higher productivity, better quality of synthesis gas in pyrolysis and gasification, and, most importantly, better utilization of the energy contained in the fuel.

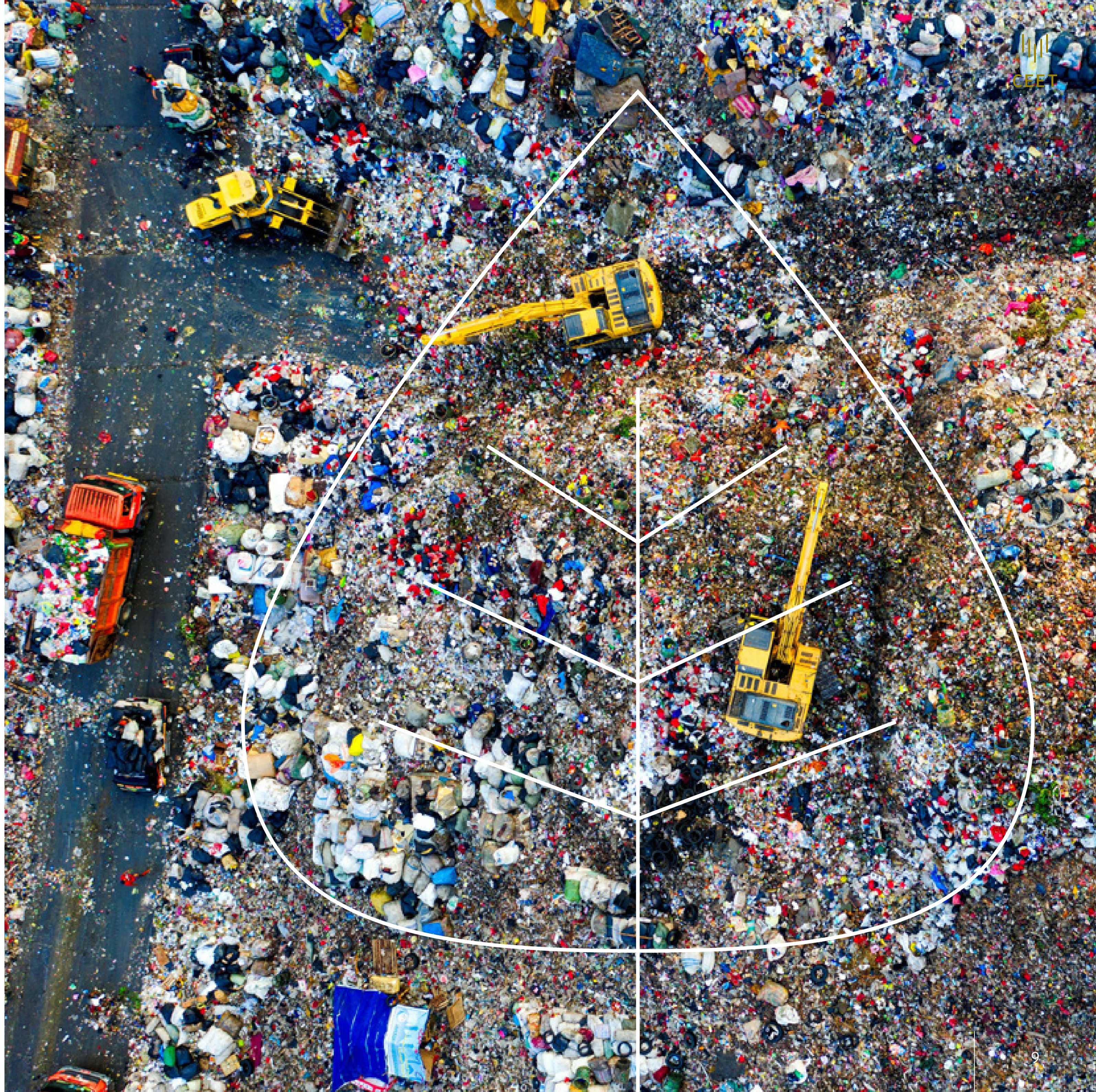
The software development, which is the main planned output of the project, will be carried out in close cooperation with project partners in Taiwan: National Cheng Kung University, Industrial Technology Research Institute, and Belltone Ltd. The Taiwanese part of the consortium brings expertise in predictive AI modeling of energy processes and will help enhance the research capacity at VSB-TUO, in line with current global trends.

In addition to AI-WASTE, CEET researchers have also succeeded in the SIGMA DC4 program with the HYCOBOX (ERC), TRANSHYLAB (ERC), and H2HUB (CENET/ERC) projects.

Practical Benefits

Better coordination of WtE technologies using TAP can support the increasing importance of waste-to-energy applications, especially due to stricter landfill conditions and the challenges of recycling certain energy-rich materials. If TAP's potential is well-utilized, WtE technologies could play a more significant role in transforming the energy sector in the Czech Republic.

As part of the AI-WASTE project, a thorough life-cycle assessment (LCA) of selected secondary raw materials, products, and technological processes will be conducted. This will allow for a better understanding and communication of environmental impacts and provide a basis for comparing these impacts with other approaches in waste management.



CZECH-PERUVIAN COOPERATION GIVING BIO-WASTE NEW PURPOSE

BEYOND THE BEATEN PATH

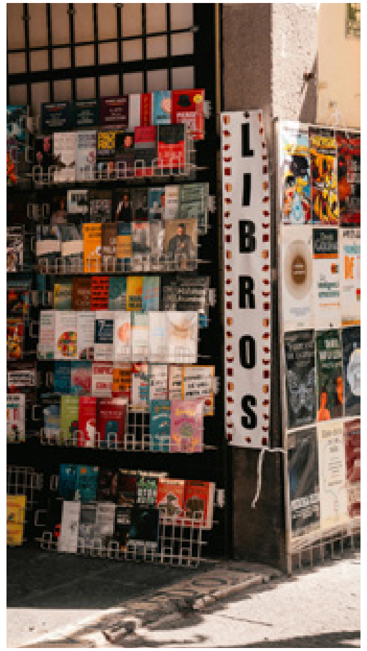
When modern facilities, bold scientists, and long-term trust between teams come together, a program with real impact is born. This is exactly what has been made possible by the long-standing partnership between the CEET Institute of Environmental Technology and Peruvian academics from the National University of Engineering. This unique program offers young scientists from Peru the opportunity to complete part of their studies at VSB – TUO. Thanks to this initiative, doctoral student José Antonio Moscol Ortiz has the opportunity to utilize CEET's equipment and infrastructure for his research, which focuses on transforming agricultural waste into functional materials capable of capturing harmful gases. Together with the program guarantor, Lenka Matějová, they demonstrate that sharing know-how and having the courage to cross borders brings new solutions in the fields of materials research, circular economy, and environmental protection. In this joint interview, they explain how the program originated, what it brings to both the university and the students, and what they are currently working on together.

Lenka Matějová

Lenka Matějová is the head of the Preparation of Materials and Waste Valorisation research group at CEET, Institute of Environmental Technology (IET). She graduated from the Faculty of Chemical Technology at the University of Chemistry and Technology in Prague, where she subsequently pursued her PhD at the Institute of Chemical Processes of the Czech Academy of Sciences. She spent eleven years at the Academy of Sciences as an active research scientist. Her work focuses on the research and development of various macroscopic forms of nanostructured materials for environmental protection. In particular, she specializes in catalysts for the oxidation of VOCs and chlorinated VOCs, sorbents for VOC and NH_3 capture, as well as photocatalysts and hybrid materials for CO_2 reduction and capture. She also explores the use of different types of waste as input materials for the preparation of functional materials, including processes such as pyrolysis and the application of supercritical fluids. In addition, she is interested in the ecotoxicity and genotoxicity of newly developed materials, as well as in the use of supercritical fluids for waste valorisation into value-added products and for the development of materials with novel properties. She also supports theoretical (computational) materials research as a complementary approach to the experimental work carried out within her research group. Lenka Matějová is actively involved in teaching, particularly through the supervision of student theses. She has experience with both national research projects funded by the Czech Science Foundation (GAČR) and international collaborations, including projects with partners from Finland, Peru, and France. She is a member of the High Pressure Working Party of the European Federation of Chemical Engineering and has authored or co-authored approximately one hundred peer-reviewed publications in international scientific journals.

Lenka Matějová

Lenka, let's pick up on the mentioned international cooperation. In your opinion, what is the biggest benefit of such projects?



For me, it's the people I get to work with. Each country has slightly different scientific procedures and work cultures. Thanks to cooperation, I have the opportunity to discover other approaches and get inspired by what works better elsewhere. If I see that some processes are more efficient, I try to bring them into our environment. At the same time, long-term partnerships are formed that often grow into friendships. And that is what makes me happiest, especially when cooperation continues and we function as a well-coordinated team across countries.

You are currently the program coordinator. Is its creation and operation also the result of long-term cooperation?

Yes, exactly. During my time at the Academy of Sciences, I established a scientific and research cooperation with Prof. J. Solís and Dr. M. Gómez. The cooperation worked very well, so it continued after I joined VSB-TUO. After ten years of working together, an opportunity arose to apply for funding for doctoral scholarships for students from Peru, which led to the current program. Our Peruvian colleagues had visited us several times in the past and were familiar with our facilities and research environment. The cooperation was a natural result of long-standing relationships and mutual trust.

Focusing on the doctoral program, how does it actually work, and how long do the students from Peru study with us? Are there any selection criteria?

This program was created by the National University of Engineering in Peru, in cooperation with the ProCiencia agency, which funds it. Doctoral students can spend one and a half years of their three-year studies at a foreign partner university, primarily for the scientific-research part of their studies. Partner universities announce dissertation topics, which are then offered to Peruvian students who have gone through a selection process. They then choose a topic according to their field of expertise and interest.

Peru is geographically quite distant. What do you think motivates doctoral students from Peru to complete part of their studies here with us?

They get to experience an entirely different infrastructure. Waste management in Peru, and generally in South America, is set up differently than in Europe, where stricter limits and regulations apply. They see different solutions and technologies here. These experiences can then be taken back home as inspiration for further development.

Beyond professional growth, it's also a significant personal experience. Meeting a different culture and mentality helps individuals sort out their own values. Such experiences are often as valuable as the scientific knowledge itself.

The last question will look a bit into the future. Are you currently planning any other international projects?

Yes, we are currently working with colleagues from France, from the University of Strasbourg, on a proposal for a Horizon project within the New CO2 Technologies call. The project involves partners from France, Norway, and Denmark, and we submitted the proposal on February 16th. We have already cooperated successfully with the University of Strasbourg in the past, so I'm happy that we are once again building on an existing partnership.

José Antonio Moscol Ortiz

Antonio, let's start with what brought you to research. How did it all begin?

I have always been interested in the environment and science. Gradually, I began to desire finding solutions to specific problems, a feeling that deepened during my university studies. My interest grew even further once I started teaching. Conducting my own research allows me to share my discoveries not only with colleagues but also with students, which motivates me to become a better educator. The research community is still a new and fascinating world to me, and I truly enjoy being a part of it.

You are spending part of your doctoral studies at our university. Why the Czech Republic, the CEET centre, and specifically the Institute of Environmental Technology?

The main reason was a recommendation from my supervisor, Gerardo Cruz, from my home university in Tumbes. He had previously collaborated with Dr. Lenka Matějová and recommended her research group because they have the right expertise and infrastructure to help move my research forward. Additionally, I wanted to study at an institution where English is spoken to improve my language skills. I originally planned to complete my master's degree abroad, but I became a father at that time. I decided to prioritize my family and stayed in Peru. In a sense, this opportunity fulfills a goal I had set for myself much earlier.

> *THE MOST VALUABLE ASPECT OF INTERNATIONAL COOPERATION IS NOT THE PROJECTS, BUT THE PEOPLE AND THE SHARED EXPERIENCES.*

Let's move on to the next question. What are you currently working on?

My research focuses on the utilization of agricultural bio-waste, which I would like to reprocess into a new functional material. I brought biomass from the Zarumilla region in Peru, where I live; in this region, we grow the red mombin (Spondias purpurea). This plant produces fruit with a very hard, woody seed, which I use to produce activated carbon materials based on biochar. My intention is to use this material to capture ammonia gas from the air. Ammonia is produced during the decomposition of organic matter, but also as a byproduct of various industrial processes. Capturing this gas is an important challenge, especially in the context of the circular economy. If ammonia could be captured effectively, it could be reused—for example, as fertilizer. We are currently in the material preparation phase. The next step will be testing its ability to capture ammonia and, of course, evaluating its efficiency.

That sounds very interesting. What are the potential benefits of this new material?

The main benefit is environmental: we are using a material that is currently considered waste and transforming it into a tool for solving pollution problems. At the same time, this could offer farmers a new income opportunity, as they could sell this raw material to companies. The industry, in turn, would gain a sustainable material for its further development. Besides ammonia adsorption, we are also testing this material for the removal of xylenes and comparing its performance with previous biomaterials to explore all possible applications.

You've been here for some time now, about a year and a quarter. How would you describe your experience so far?

It's the first time I've been outside my home country, and what's more, in Europe. I've met a lot of great people here who are not only professionals but also very friendly and helpful. Thanks to this friendly atmosphere, I've truly felt at home. The studies themselves are demanding because the structure of doctoral programs in Peru is quite different, but the experience with a different academic environment has greatly broadened my horizons. It has also allowed me to establish valuable contacts with researchers working in the same field. When I return to Peru, I will have an international research network at my disposal thanks to these contacts, which will help me in my future research.

You mentioned that the academic environment here is different. How does it differ from the one in Peru?

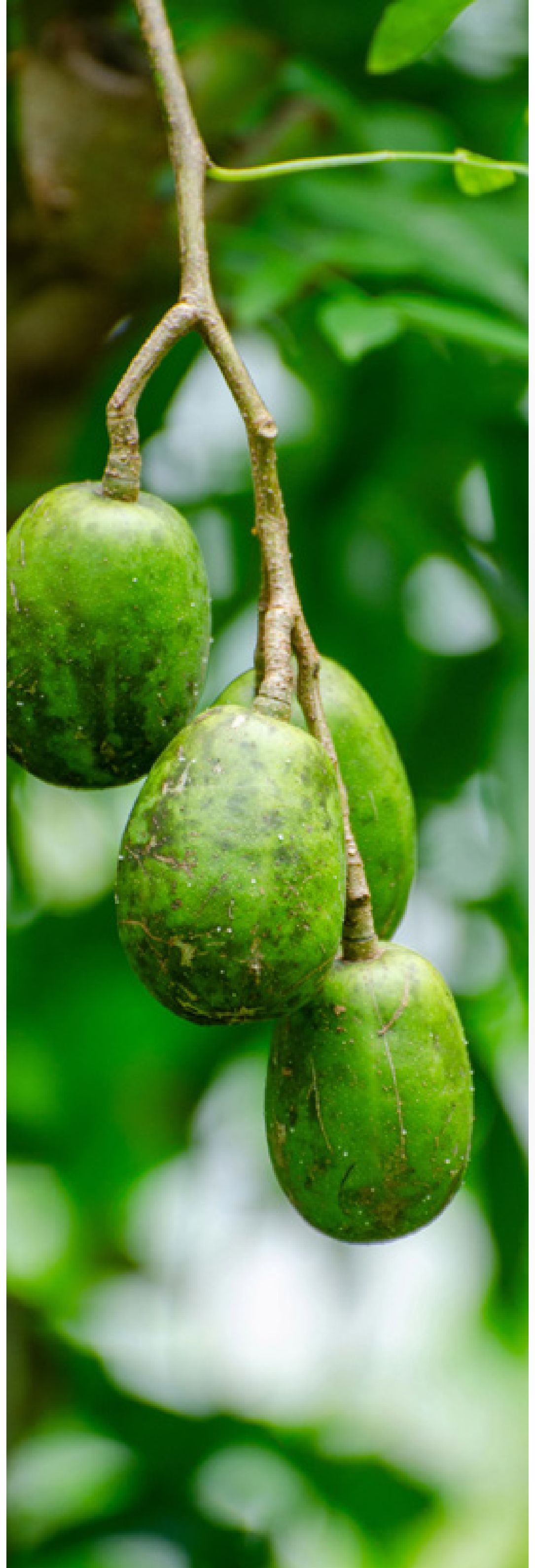
Research in Peru is still in the development stage. At our university, we only have a small research institute. We have basic infrastructure, but we often lack the advanced equipment and instruments needed for deeper research. We still have a long way to go. Here, on the contrary, the laboratories are very well-equipped, and the research environment is much more advanced. I also noticed that there are professionals here who dedicate themselves exclusively to research. That is not common in Peru; there, research is usually conducted by university professors alongside their teaching duties.

And what about everyday life? Is it fundamentally different from your homeland?

There are a lot of differences! Where I live in Peru, the temperature hardly changes—it's like your summer, but all year round. Here, the weather changes significantly, and temperatures can drop below zero. I also noticed there are fewer outdoor markets and public activities, which I think is related to the colder and more variable weather. On the other hand, the cities here are very well-organized, and I appreciate that many people even outside the university speak English. When I arrived, it was easy to handle daily tasks like buying food or clothes. I feel that Ostrava is open and welcomes people from all over the world.

You are returning to Peru in the summer. Do you have any specific plans after your return?

First, I would like to finish the article we are currently working on and present our results at conferences—not only in Peru but perhaps abroad as well. I would also like to continue collaborating with the CEET centre and the Institute of Environmental Technology. I would certainly like to apply for one of the research projects recently introduced by ProCiencia, or perhaps for a



postdoc position. But we'll see what happens. I haven't decided yet.

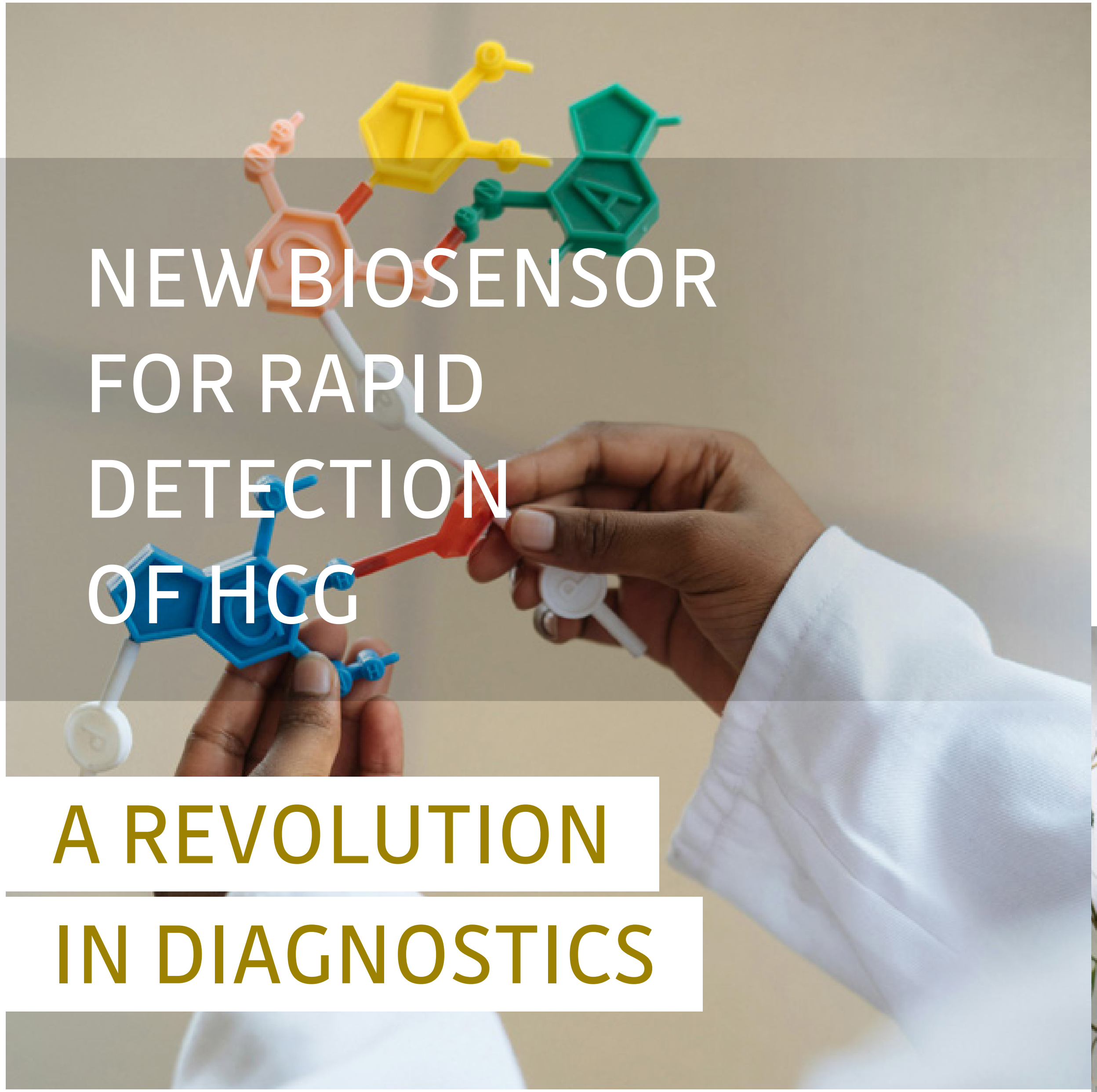
Speaking of comparisons, have you considered conducting your research in other countries as well?

Yes. Some of my supervisors are working on similar research in Mexico, and I would very much like to collaborate with them. They are exploring innovative methods, such as using lasers or radiation to produce biochar and activated carbon by concentrating light energy. I would be thrilled if I could test my material in combination with these new applications.

Finally, let's motivate some potential candidates. What would you say to Peruvian students who are considering doctoral research here at the CEET center but are afraid it will be too difficult?

Well, „no pain, no gain." However, all the experts I've worked with here are incredibly supportive and willing to help you grow. My advice is: Just apply! But English is essential. So, make sure to work on your language skills beforehand, because it really makes a big difference. I always recommend that my students go abroad to get a different perspective. It is valuable to see how people live in other countries, learn what they do better, and consider what we could implement back home.

RESEARCH AND INNOVATION



NEW BIOSENSOR FOR RAPID DETECTION OF HCG

A REVOLUTION IN DIAGNOSTICS

Ajith Manayil Parambil, who was awarded The CEET Director's Award at the CEET Employees' Christmas Gathering last December, has introduced a groundbreaking biosensor for detecting human chorionic gonadotropin (hCG), a key biomarker for pregnancy and certain types of cancer.

Ajith's biosensor is based on advanced nanomaterials, allowing it to detect hCG in just three minutes. This sensor is not only fast but also extremely sensitive, capable of detecting very low levels of hCG in human urine. Unlike traditional methods that require chemical markers, this sensor works without labels, making it simpler and more cost-effective.

What makes this sensor revolutionary? The combination of various materials that ensure effective electron transfer enables faster and more precise operation than methods currently used in labs.

Ajith's research could make diagnostic testing much more accessible and timely, offering practical applications in point-of-care settings. This label-free technology brings a new level of speed and reliability to diagnostic tools, paving the way for future innovations.

Ajith Manayil Parambil

Dr. Ajith Manayil Parambil received his PhD in Environmental Sciences from Jawaharlal Nehru University (JNU), New Delhi, in 2023, where he developed innovative carbon dot-based nanomaterials for pollutant detection and environmental remediation. A first-rank holder and gold medalist during his Master's studies, he has been honored with several prestigious national and international recognitions, including the Government of India's five-year INSPIRE Research Fellowship and the Government of Taiwan's Global Talent Grant. Since 2023, he has been serving as a Postdoctoral Researcher at the Centre for Energy and Environmental Technologies (CEET), VŠB – Technical University of Ostrava, working under the mentorship of Prof. Radek Zbořil on advanced functional nanomaterials for environmental and biomedical applications, supported by a strong global research collaboration network.

Ajith, what inspired you to develop this biosensor? What problem were you aiming to solve?

What inspired me was a very simple but powerful question: Why does detecting something as important as pregnancy or certain cancers still require relatively slow and laboratory-dependent tests?

Human chorionic gonadotropin, or hCG, is not only a pregnancy hormone — it is also a key biomarker for several serious cancers, such as testicular cancer, ovarian germ cell tumors, and some cases of bladder, pancreatic, and prostate cancer. Early and accurate detection can truly change outcomes for patients.

However, many existing diagnostic methods, such as Enzyme-Linked Immunosorbent Assay (ELISA), are time-consuming, require centralized laboratory infrastructure, and are not easily accessible in resource-limited settings.

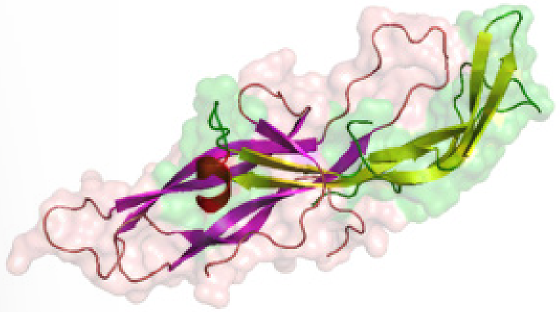
Our goal was to develop a fast, highly sensitive, and portable biosensor that could detect extremely low levels of hCG within minutes — directly from urine — without complicated labeling or processing steps.

In short, we wanted to make advanced diagnostics simpler, faster, and more accessible.

Your technology enables rapid and highly sensitive detection of hCG. What challenges did you face during its development?

The biggest challenge was balancing four things at once: selectivity, sensitivity, speed, and stability.

When you push for ultra-high sensitivity, the system can become unstable. When you aim for rapid detection, you often compromise accuracy.



Another major challenge was engineering the nanomaterials in such a way that they worked together — not just as a mixture, but as a coordinated system. We designed a ternary nanohybrid structure where each component plays a specific role in enhancing electron transfer and biomolecule interaction.

Ensuring that the antibodies remained biologically active while achieving strong electrical performance was also technically demanding.

But overcoming these challenges is what made the breakthrough possible.

Many people may not realize how important fast and accurate testing is, especially when it comes to hCG. How could this technology change standard medical practice?

Fast and accurate testing is critical, especially in early pregnancy monitoring and cancer diagnostics.

Currently, many tests require laboratory processing and may take hours or even days. Our biosensor reduces the detection time to just about three minutes while maintaining excellent accuracy.

This could enable faster clinical decisions, earlier detection of complications, more efficient point-of-care testing, and reduced healthcare costs.

In practical terms, it means a doctor could potentially obtain reliable results during a single patient visit instead of waiting for laboratory reports.

WHY SHOULD THE DETECTION OF SERIOUS DISEASES TAKE HOURS WHEN IT CAN BE DONE IN JUST A FEW MINUTES?

That shift — from centralized testing to rapid point-of-care diagnostics — is very powerful.

Your sensor achieves excellent accuracy even when testing urine. What does this mean for its use in regular clinical settings?

This is actually one of the most important aspects of our work.

Testing directly in urine — without complex purification steps — shows that the sensor works in real biological environments, not just under ideal laboratory conditions.

Biological fluids contain many interfering molecules that can affect sensor performance. Demonstrating high accuracy in *urine proves that our platform is selective, stable, and clinically relevant.*

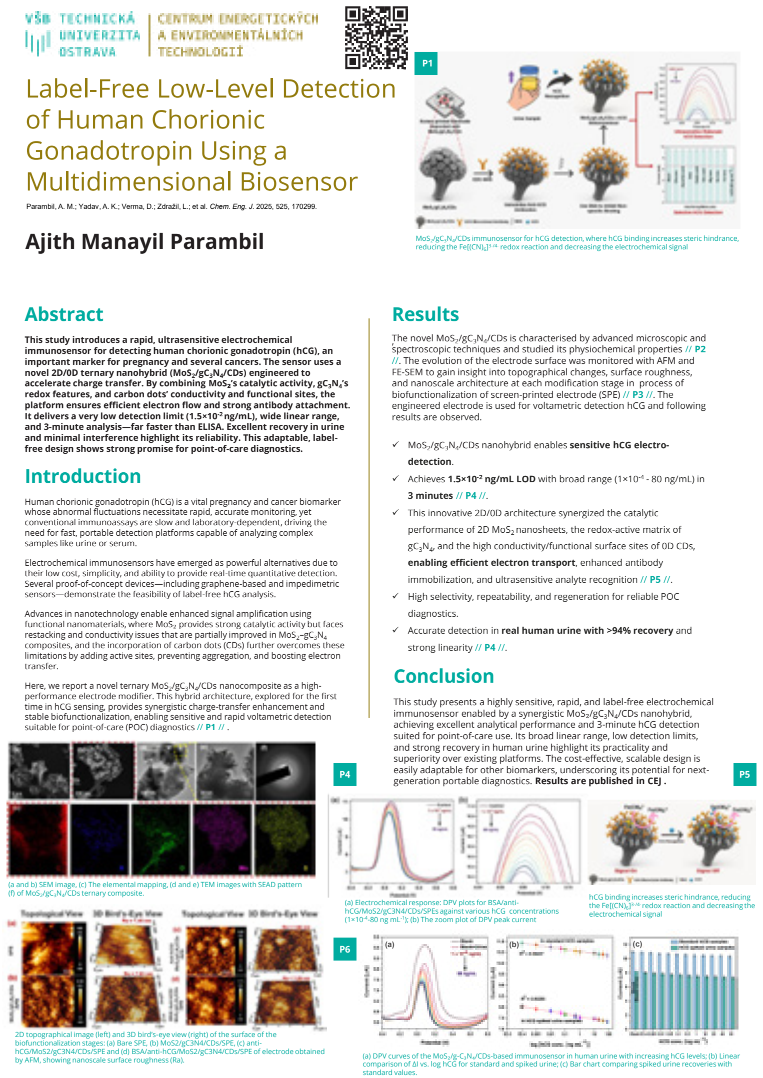
For hospitals and clinics, this means: minimal sample preparation, easier workflow integration, and greater practicality in everyday use.

It moves the technology closer to real-world application.

How would you describe the differences between your technology and existing diagnostic tools? What are its main advantages for patients and healthcare professionals?

There are three key differences.

First, it is label-free. Many conventional assays require additional labeling steps that increase complexity and time. Our sensor directly measures the biological interaction electrochemically.


VŠB TECHNICKÁ UNIVERZITA OSTRAVA | CENTRUM ENERGETICKÝCH A ENVIRONMENTÁLNÍCH TECHNOLOGIÍ

Label-Free Low-Level Detection of Human Chorionic Gonadotropin Using a Multidimensional Biosensor

Parambil, A. M.; Yadav, A. K.; Verma, D.; Zdražil, L.; et al. *Chem. Eng. J.* 2025, 525, 170299.

Ajith Manayil Parambil

P1

MoS_2/gC_3N_4/CDs immunosensor for hCG detection, where hCG binding increases steric hindrance, reducing the $Fe[(CN)_6]^{3-/4-}$ redox reaction and decreasing the electrochemical signal

Abstract

This study introduces a rapid, ultrasensitive electrochemical immunosensor for detecting human chorionic gonadotropin (hCG), an important marker for pregnancy and several cancers. The sensor uses a novel 2D/0D ternary nanohybrid (MoS_2/gC_3N_4/CDs) engineered to accelerate charge transfer. By combining MoS_2's catalytic activity, gC_3N_4's redox features, and carbon dots' conductivity and functional sites, the platform ensures efficient electron flow and strong antibody attachment. It delivers a very low detection limit (1.5×10^{-2} ng/mL), wide linear range, and 3-minute analysis—far faster than ELISA. Excellent recovery in urine and minimal interference highlight its reliability. This adaptable, label-free design shows strong promise for point-of-care diagnostics.

Introduction

Human chorionic gonadotropin (hCG) is a vital pregnancy and cancer biomarker whose abnormal fluctuations necessitate rapid, accurate monitoring, yet conventional immunoassays are slow and laboratory-dependent, driving the need for fast, portable detection platforms capable of analyzing complex samples like urine or serum.

Electrochemical immunosensors have emerged as powerful alternatives due to their low cost, simplicity, and ability to provide real-time quantitative detection. Several proof-of-concept devices—including graphene-based and impedimetric sensors—demonstrate the feasibility of label-free hCG analysis.

Advances in nanotechnology enable enhanced signal amplification using functional nanomaterials, where MoS_2 provides strong catalytic activity but faces restacking and conductivity issues that are partially improved in MoS_2–gC_3N_4 composites, and the incorporation of carbon dots (CDs) further overcomes these limitations by adding active sites, preventing aggregation, and boosting electron transfer.

Here, we report a novel ternary MoS_2/gC_3N_4/CDs nanocomposite as a high-performance electrode modifier. This hybrid architecture, explored for the first time in hCG sensing, provides synergistic charge-transfer enhancement and stable biofunctionalization, enabling sensitive and rapid voltametric detection suitable for point-of-care (POC) diagnostics // P1 // .

Results

The novel MoS_2/gC_3N_4/CDs is characterised by advanced microscopic and spectroscopic techniques and studied its physiochemical properties // P2 //. The evolution of the electrode surface was monitored with AFM and FE-SEM to gain insight into topographical changes, surface roughness, and nanoscale architecture at each modification stage in process of biofunctionalization of screen-printed electrode (SPE) // P3 //. The engineered electrode is used for voltametric detection hCG and following results are observed.

- ✓ MoS_2/gC_3N_4/CDs nanohybrid enables **sensitive hCG electro-detection**.
- ✓ Achieves **1.5×10^{-2} ng/mL LOD** with broad range (1×10^{-4} - 80 ng/mL) in **3 minutes** // P4 //.
- ✓ This innovative 2D/0D architecture synergized the catalytic performance of 2D MoS_2 nanosheets, the redox-active matrix of gC_3N_4, and the high conductivity/functional surface sites of 0D CDs, **enabling efficient electron transport**, enhanced antibody immobilization, and ultrasensitive analyte recognition // P5 //.
- ✓ High selectivity, repeatability, and regeneration for reliable POC diagnostics.
- ✓ Accurate detection in **real human urine with >94% recovery** and strong linearity // P4 //.

Conclusion

This study presents a highly sensitive, rapid, and label-free electrochemical immunosensor enabled by a synergistic MoS_2/gC_3N_4/CDs nanohybrid, achieving excellent analytical performance and 3-minute hCG detection suited for point-of-care use. Its broad linear range, low detection limits, and strong recovery in human urine highlight its practicality and superiority over existing platforms. The cost-effective, scalable design is easily adaptable for other biomarkers, underscoring its potential for next-generation portable diagnostics. **Results are published in CEJ .**

P2

(a and b) SEM image, (c) The elemental mapping, (d and e) TEM images with SEAD pattern (f) of MoS_2/gC_3N_4/CDs ternary composite.

P4

(a) Electrochemical response: DPV plots for BSA/anti-hCG/MoS2/gC3N4/CDs/SPEs against various hCG concentrations (1×10^{-4}-80 ng mL^{-1}); (b) The zoom plot of DPV peak current

P5

hCG binding increases steric hindrance, reducing the $Fe[(CN)_6]^{3-/4-}$ redox reaction and decreasing the electrochemical signal

P3

Topological View 3D Bird's-Eye View Topological View 3D Bird's-Eye View

2D topographical image (left) and 3D bird's-eye view (right) of the surface of the biofunctionalization stages: (a) Bare SPE, (b) MoS2/gC3N4/CDs/SPE, (c) anti-hCG/MoS2/gC3N4/CDs/SPE and (d) BSA/anti-hCG/MoS2/gC3N4/CDs/SPE of electrode obtained by AFM, showing nanoscale surface roughness (Ra).

P6

(a) DPV curves of the $MoS_2/g\text{-}C_3N_4$/CDs-based immunosensor in human urine with increasing hCG levels; (b) Linear comparison of ΔI vs. log hCG for standard and spiked urine; (c) Bar chart comparing spiked urine recoveries with standard values.

Second, it is extremely sensitive — capable of detecting very low concentrations of hCG.

Third, it is fast and portable. It is compatible with disposable screen-printed electrodes, which makes it cost-effective and suitable for decentralized healthcare settings.

For patients, this means: faster results, potentially lower costs, and earlier diagnosis.

For healthcare professionals, it means: rapid decision-making, simplified testing procedures, and reliable performance in real samples.

What does receiving the CEET Director's Award mean to you? How does this recognition influence your future research plans?

Receiving the CEET Director's Award is truly an honor.

It represents recognition not only of my work, but of the collaborative environment and scientific excellence at CEET. This achievement was possible because of strong teamwork, institutional support, and a culture that encourages innovation. Deeply grateful for the mentorship, scientific guidance, and continued support of Prof. Radek Zbořil and the entire MEL team.

Personally, it motivates me to push further — to expand this platform toward multiplex detection of multiple biomarkers and to move closer to practical medical devices.

Awards are encouraging, but what excites me most is the possibility that this research could one day improve real patient care.

That is the ultimate goal.

ANTIBIOTICS NO LONGER WORKING?

THE TRAIL LEADS TO WASTEWATER

Antibiotic resistance is one of the greatest challenges of our time, and it is not limited to hospitals. Traces of antibiotics and antibiotic-resistant bacteria can leak into the aquatic environment. According to the World Health Organization (WHO), bacterial antibiotic resistance was estimated to be directly responsible for 1.27 million deaths globally in 2019. If resistant bacteria pass through wastewater treatment plants into rivers and reservoirs, they can further spread resistance genes—a problem that eventually cycles back into clinical medicine.

At CEET, specifically the Institute of Environmental Technology (IET), scientists are searching for ways to treat wastewater more effectively to remove not only pharmaceuticals but also resistant microorganisms. Research group leader Martina Vráblová and doctoral student Lucie Řepecká describe the development of an innovative filter material that combines a high capacity for capturing drugs with antimicrobial effects. They also speak about collaboration with industry, why transferring laboratory results into practice is challenging, and how they stay motivated even when things do not go as planned.

Martina Vráblová

Martina Vráblová is trained as a biophysicist and experimental biologist. At the Institute of Environmental Technologies, she serves as the Head of the Water Treatment and Analysis Research Group, which focuses on both basic and applied research in the field of water treatment, including the analytical assessment of surface water and wastewater quality. Her current main research topic is micropollutants (pharmaceuticals, pesticides, microplastics, and other contaminants) and their occurrence in the environment. She is involved in the implementation of research projects, including contract research projects. She is a member of the Czech Water Association, which brings together experts, companies, and institutions with the primary goal of achieving efficient and sustainable development across the entire field of water management and water environment protection.

Good morning, Martina and Lucie. If we go back to the very beginning of your story, when did you first realize, you were drawn to understanding nature and protecting the environment?

Martina: For me, my interest in natural sciences was sparked by my physics and math teacher in primary school. I enjoyed those subjects immensely—especially physics, with all the experiments and calculations. In high school, I headed toward science studies. At that time, however, I didn't like chemistry, so I chose biophysics. I only came to chemistry later, indirectly, after maternity leave, here at VSB–TUO.

Lucie: I don't think I ever consciously said I wanted to dedicate myself to environmental protection. It happened naturally. As children, my brother and I were fascinated by disaster movies about weather and natural phenomena where scientists investigated what was happening and how to solve it. Over the roughly 12 years I've been working in chemistry, I have moved through different areas, and environmental issues absorbed me so much that what began as an interest became a profession that gives me great meaning.

Martina, you currently lead a research team focused on water treatment and analysis. What led you to such a specific specialization?

Pure coincidence. Originally, I worked in plant physiology, specifically using instrumental methods to study photosynthesis. After maternity leave, I couldn't find a position in my field in Ostrava, so I applied for a job at VSB-TUO, where I have been working at IET since 2015.

> ANTIBIOTIC RESISTANCE IS NOT JUST A PROBLEM OF HOSPITALS. THE TRAIL ALSO LEADS TO WASTEWATER.

I joined the water laboratory, which back then functioned more as a support facility for other teams. There were only two of us, performing a few basic analyses. Gradually, we got involved in interesting projects, secured funding for equipment, and began building the lab systematically.

Since I originally come from a biological background, we focused on biologically active substances (pharmaceuticals, pesticides, and heavy metals) that can significantly affect organisms. We built the infrastructure for their analysis and started working on ecotoxicity. And because we operate in the Ostrava region, we naturally became involved in industrial wastewater, which is now the main focus of our research. We have direct sources of wastewater and sludge and

solve specific practical problems, which sets us apart from many other workplaces.

Following up on that: practically speaking, what is the hardest part of wastewater treatment today? Where does practice hit its limits?

Clearly, legislative limits and the rapid development of analytical methods. Instruments are improving, and we can measure increasingly lower concentrations. However, there are hundreds of thousands of substances around us, and we mainly monitor those required by law. We still don't know much about the combined effects of substances that aren't routinely measured. We are now focusing heavily on „emerging pollutants“: microplastics and nanoplastics, pesticides, new types of drugs, and their metabolites. In real water, everything mixes into a chemical cocktail that can behave unpredictably.

The second major challenge is cost. Wastewater treatment is expensive, and industrial companies invest primarily when required by legislation. That´s why we strive not only to develop technologies but also to raise public awareness, so there is stronger pressure to invest in advanced treatment. One more thing: in lab conditions, we can remove almost anything with high efficiency. The problem arises when transferring solutions into practice. Large volumes of water, variable composition, and the fouling of membranes or sorbents cause efficiency to drop, meaning cleaning processes must be continuously optimized.

Your new study presents an interesting combination: activated carbon and ionic liquids. What exactly did you investigate and what was the result?

We have long worked with adsorption on activated carbon, modifying materials to target specific types of pollution. With resistant bacteria, the problem is that if they pass through a treatment plant into the ecosystem, they can continue spreading resistance genes. This is critical for medicine because antibiotics then stop working for people.

We wanted to develop a material capable of capturing pharmaceuticals while also having antimicrobial effects. Impregnating carbon materials with ionic liquids is not new in itself. We built on a previous project where we synthesized ionic liquids with proven antibacterial effects. We chose two: one commercial, cheaper and available for larger scales, and one experimental, which our team prepared as one of the few in the world. Results showed that the adsorption capacity for drugs remained high while simultaneously killing bacteria, reducing the risk of spreading resistance.

You mentioned using two different ionic liquids. Was one more effective against „superbugs"?

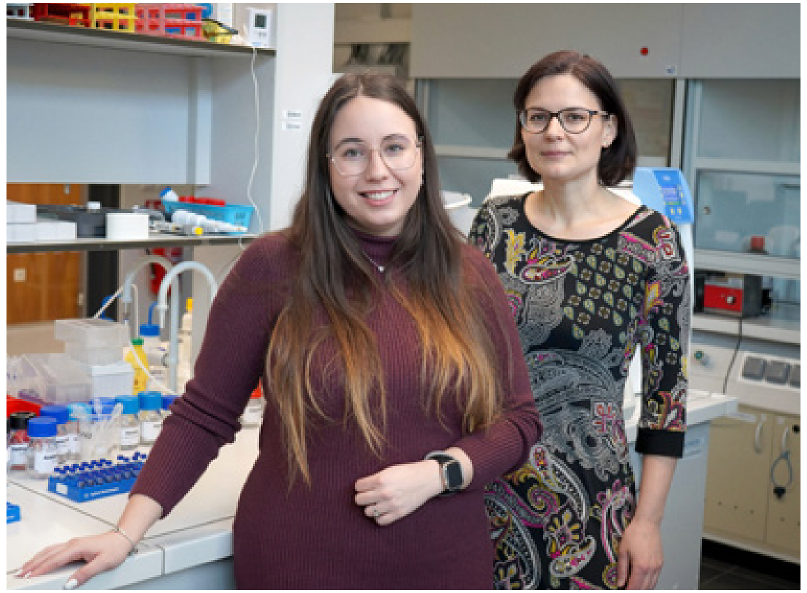
Each works slightly differently, and it also depends on the specific bacterial strain. You can't say one is „better". However, considering cost and practical application, the commercial variant is more advantageous because it is accessible and relatively inexpensive.

How did you get into the topic of antibiotic resistance in the first place?

The first impulse was a conference on antibiotic resistance that connected veterinary medicine, human medicine, and the environment. This initiative has existed in the Czech Republic for several years, but there is still a lack of systemic support to address the issue on a larger scale. Although VSB-TUO doesn't have extensive facilities for all types of analysis, we managed to establish a collaboration with the University of Ostrava, where part of the research was conducted.

What is the next step to get your filter from the lab into practice?

The study is just the beginning. In the lab, we verified that the material works. Now it needs to be tested on a larger scale, and we must verify its regenerability and lifespan — how many treatment cycles it can withstand and how long it remains effective. These are pilot-scale tests. We are targeting mainly „polishing" (final treatment). If we put the material into heavily polluted water, it would quickly saturate and stop working. The idea is that water passes through standard mechanical-biological treatment, and our filter would be the „fourth stage" that eliminates drug residues and resistant bacteria. Then there is the question of whether bacteria will eventually develop resistance to ionic liquids. Bacteria are highly adaptable, so we must monitor how many cycles it takes for survivors to appear. That is another research challenge.



Lucie, you were a co-author of the study. What exactly was your role?

I designed the experimental setup for bacterial testing—how to verify their viability and clearly demonstrate the material's effect. It meant weeks of intense laboratory work.

Let's talk about safety. Ionic liquids can be toxic themselves. How did you verify they don't leak back into the treated water?

First, we analytically tested whether the substance leached from the material. Since even trace amounts below detection limits can be biologically active, we supplemented this with ecotoxicity tests at three levels. We started with Vibrio fischeri bacteria, commonly used in such tests. Then came higher plants, where we germinated mustard seeds and monitored root length. The third level involved earthworms, as substances can move from water into the soil. Results showed the material is stable. For practical use, however, it would be appropriate to expand testing to other organisms.

This isn't your only topic. What else is the team working on, Martina?

We are involved in large projects like Project Refresh and Inovo, which concern industrial and municipal waters. We focus intensely on micropollutants like pharmaceuticals, pesticides, organic substances, and newly, microplastics. We investigate their interactions with drugs and metals, the role of microplastics as potential „carriers“ of pollution, and removal options. We also do ecotoxicity and work with industrial partners directly on-site. Soon, we would also like to focus on algae and other biological water treatment methods.

You are no newcomer to science. If you had to pick one career moment that still brings you joy, what would it be?

As I mentioned, I have worked in several fields. I fondly remember my doctoral thesis on the diffusion of CO_2 into plant leaves, which is still cited today. Another favourite project is the co-composting of treatment plant sludge in collaboration with FCC Czech Republic. We developed a substrate suitable for growing forest trees. What pleases me most is that I can connect my original specialization in plant physiology with the environmental chemistry I do today. The project led to a licensed technology, and the company is now building composting plants for industrial production. It's a beautiful example of research moving into practice, even if it takes years.

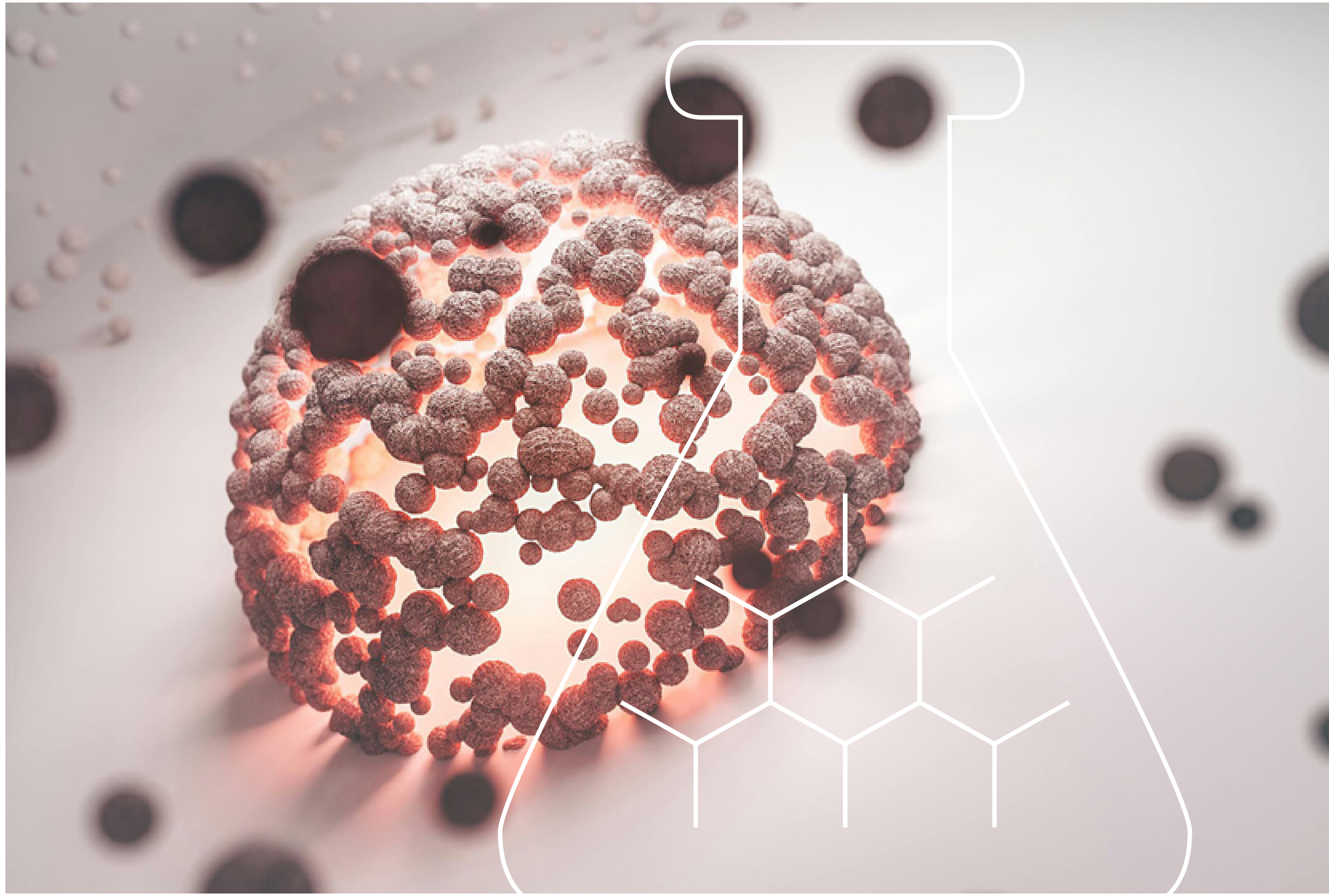
Lucie, you are at the start of your scientific journey. Do you have an inspiration or a vision for life after your PhD?

I don't have one specific role model. I'm inspired by the people around me. After my doctorate, I'd honestly like to continue what I'm doing now. The work fulfills me, and the team I'm part of is my greatest win.

A question for both: Research is a long-distance run. What helps you stay motivated when things don't go well?

***Lucie**: Even a failed experiment is a step forward. Without failures, science could not exist — and without them, there would be no successes. What motivates me most is when we can apply results in practice and truly make a difference.*

***Martina**: For me, the hardest part is when we don't get a grant that we invested a lot of energy into. Fortunately, we also have industrial partners, which provides us with stability. Science is mainly about problem-solving, which I personally enjoy. That moment when you understand or solve something is immensely motivating. And regarding failed experiments—I think it's a shame there aren't journals for „dead ends“ in research. Many people likely repeat the same mistakes because they aren't talked about. We mostly publish successful results, which are just the "tip of the iceberg." That makes having a good team around you even more important.*



DOUBLE SUCCESS FOR OUR TEAM

MSCA POSTDOCTORAL FELLOWSHIP AND ERA FELLOWSHIP

Want to learn more about the research?
Watch the video interview with the author.

Two of our colleagues, Halanur Mruthunjayappa Manohara and Szymon Piotr Abrahamczyk, have been successful in the Marie Skłodowska-Curie Actions (MSCA) Postdoctoral Fellowships 2025 call, one of the most prestigious European Union programmes supporting postdoctoral research and career development.

Halanur Mruthunjayappa Manohara was awarded funding directly through the MSCA Postdoctoral Fellowship, while Szymon Piotr Abrahamczyk succeeded under the complementary ERA Fellowship scheme, which supports high-quality proposals that do not receive MSCA funding but still meet excellent evaluation standards.

MSCA Postdoctoral Fellowships support researchers holding a doctoral degree in conducting research in an international environment, while also strengthening their skills through advanced training and cross-border, cross-sectoral, and interdisciplinary mobility. The programme includes both European Postdoctoral Fellowships and Global Postdoctoral Fellowships. ERA Fellowships build on this framework and contribute to strengthening research excellence in countries participating in the Widening policy.

In the following interviews, we will introduce both fellows, their research, the cooperation they are developing, and how this support is helping to advance their scientific careers.

Halanur Mruthunjayappa Manohara

Mr. Manohara, let's start with a brief introduction. Could you tell us a bit about yourself and your research background?

I am a chemist specializing in developing advanced materials and membrane technologies for sustainable water treatment. I have consistently focused my academic and professional efforts on the design and scale-up of innovative photocatalytic membrane technologies and task-specific nanostructured catalysts to tre-at emerging contaminants and improve the sustainability of water purification systems.

Let me ask you, what motivated you to focus on water treatment technologies?

Access to safe water is one of the most urgent global challenges. Growing up in India, my home country, I saw firsthand how not everyone can afford water purifiers containing RO membranes, which require high pressure, energy input and waste lots of water as brine. Even with technological advancements, emerging contaminants still threaten aquatic life and humans, yet conventional methods fall short. This drives me to develop advanced materials that remove pollutants efficiently while enabling sustainable, energy-efficient, low-waste solutions accessible to more people.

Now, turning to your current work, your MSCA project is called INSPIRE. Could you explain its main objective and what, in your view, made it stand out in such a highly competitive international call?

The main goal of INSPIRE is to develop catalytic membranes incorporating single-atom catalysts capable of degrading persistent micropollutants including PFAS. The project stands out because it integrates nanochemistry, photocatalysis, and membrane technology into a single platform designed for both pollutant capture and in-situ degradation.

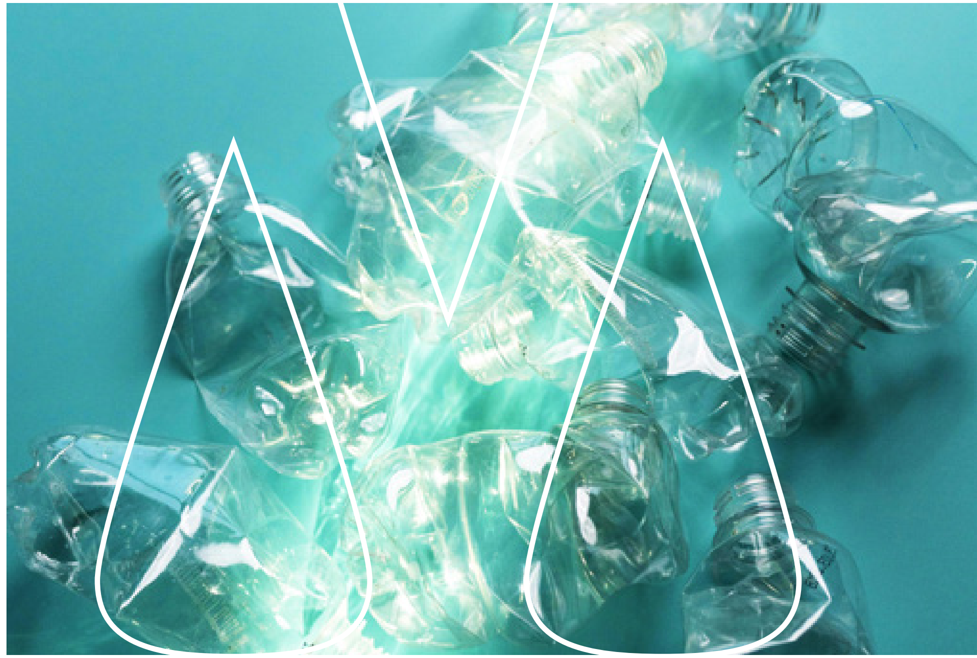
Building on that, how does your approach differ from existing water treatment technologies?

Conventional technologies, like reverse osmosis or activated carbon filters, mostly trap pollutants shifting the problem to toxic sludge that harms the environment and demands high energy. Our INSPIRE membranes go further as they capture contaminants and destroy them on-site through catalysis, turning waste into harmless byproducts with far less energy and no secondary pollution.

The central focus of your project is PFAS. These substances are often referred to as forever chemicals—could you explain why, and what makes them particularly dangerous compared to more common pollutants?

PFAS comprising over 14,000 compounds are called forever chemicals because their carbon–fluorine bonds are extremely strong, making them highly resistant to natural degradation. As a result, they accumulate in water, ecosystems, and even the human body, where long-term exposure has been linked to various health risks like immune disorders and cancer. In 2023, European agencies pushed for a PFAS ban at ECHA, after Denmark's 2022 ban revealed shocking contamination blood levels up to 600 ng/mL, over 20 times the safe limit.

You mentioned the use of single--atom catalysts, which is quite an advanced concept. What makes this approach so innovative?



Unlike nanoparticle catalysts, where many atoms sit idle inside clusters, Single-atom catalysts maximize the efficiency of catalytic sites because every atom can actively participate in the reaction. Single-atom catalysts make every atom work actively—like solo superheroes instead of a bulky team. This boosts efficiency for pollutant breakdown with way less material, faster reactivity plus atomic-level control over reactions. In INSPIRE, we're anchoring them on membranes for continuous, real-world water treatment.

Looking at practical implementation, do you see this technology being integrated into existing wastewater treatment systems, or would it require entirely new infrastructure?

The goal is to design it for seamless integration into existing membrane-based systems, like those using ultrafiltration or nanofiltration already common in plants. This compatibility would ease adoption in real facilities without needing completely new infrastructure, cutting costs and speeding up rollout.

Every ambitious project comes with challenges. Which aspect do you expect to be the most demanding, scaling up from the lab to pilot applications, or ensuring the long-term stability of single atoms on the membrane?

Both are challenging, but ensuring the long-term stability of single atoms on the membrane surface is particularly critical. Maintaining catalytic activity while preventing atom aggregation under real water treatment conditions will be a key focus of the research. We'll tackle this through advanced anchoring techniques and rigorous durability testing.

If we meet again in ten years, what impact do you hope the INSPIRE project will have on drinking water quality in Europe and on the protection of our ecosystems?

I hope the deliverables of INSPIRE project will contribute to practical technologies capable of eliminating persistent pollutants such as PFAS from water systems. Ideally, it would help establish safer drinking water standards and reduce the environmental burden of long-lasting contaminants.

Coming closer to your current environment, what is your role within CEET, and how does the research setting here support your work?

At CEET, I work as a postdoctoral researcher developing advanced catalytic membrane materials for water treatment. The interdisciplinary environment and strong collaboration between materials science, chemistry, and environmental engineering provide an excellent platform to translate fundamental research into practical technologies.

And finally, on a more personal note, what does receiving the MSCA Postdoctoral Fellowship mean to you at this stage of your career?

Receiving the MSCA Postdoctoral Fellowship is a major professional milestone and validation of my research vision. It offers the chance to pursue ambitious ideas, collaborate internationally, tackle critical environmental challenges, establish myself as an independent researcher, and drive long-term career growth.

Want to learn more about the research? Watch the video interview with the author.

CEET

Szymon Piotr Abrahamczyk

Let's begin with a short introduction. Could you tell us about your background and what led you to specialise in nanoscale materials and electron-beam techniques?

By training, I am an analytical chemist, and I have always been passionate about studying and characterising materials. For me, it is like solving a jigsaw puzzle. Analytical science allows us to connect the pieces and reveal the whole picture. I have always been drawn to the nanoscale world, and one of the most powerful tools for studying nanomaterials is electron microscopy, which is the core expertise of the EBEAM team. It therefore made perfect sense to take things a step further and use the electron beam not only to study materials, but also to manipulate and deposit them. I find it a very elegant way to push the boundaries of nanotechnology.

That's a fascinating path. What initially drew you to the field of gas sensing and electronic noses, and why do you see this area as particularly important today?

There are two sides to that question. First, I believe that the science I pursue should make a real difference in the world, so I have always been seeking meaningful, real-world applications for my research. It is well known that films deposited by electron beam are inherently porous and tend to incorporate significant carbon content. For many areas of materials science, these characteristics are considered disadvantages, but from the perspective of gas sensing, they are actually highly advantageous. On the other hand, it is equally important to identify a niche that genuinely needs a fresh approach. I found that electronic noses (eNoses) face substantial challenges in terms of fabrication complexity and device bulkiness. I believe I can begin to address some of these issues through the ERA Fellowship programme, within a project called "SENSE".

Turning to your current project, your fellowship is called SENSE. What is its central objective, and what makes it distinctive in today's competitive research landscape?

Electron beam induced deposition (EBID) is a relatively young deposition technique, and only a handful of groups worldwide are actively working in this space.

I feel very fortunate to be in what I consider a strategically excellent position. Being part of the EBEAM project has allowed me to broaden my expertise, collaborate with international leaders in electron microscopy, nanomaterials, and sensing, and access world-class infrastructure. VSB-TUO is also situated in close proximity to other key regional facilities, including the synchrotron in Kraków, which opens up important complementary characterisation opportunities. All of these factors give SENSE a strong foundation from which to make a genuinely distinctive contribution.

You mentioned some of the current limitations in the field. What would you identify as the main bottleneck in today's electronic nose technologies that your work aims to address?

The elegance of electron beam induced deposition lies in the fact that it not only gives us considerable freedom in the choice of deposition materials, but also allows deposition to be performed with extreme spatial precision, locally, on demand. So instead of having to fabricate four separate sensor chips, each with a different material, I could produce a single chip with four distinct channels, each functionalised with a different sensing material in a single workflow. I hope this approach will allow me to address both the physical bulk and the fabrication complexity that currently limit eNose technology.

TWO SCIENTISTS, TWO PROJECTS, ONE GOAL: PUSHING THE BOUNDARIES OF MODERN TECHNOLOGIES.

Your approach relies on electron beam induced deposition, or EBID. For readers who may not be familiar with it, could you briefly explain how this technique works and why it is so well-suited for fabricating multichannel gas sensors?

I like to describe EBID as sitting at the intersection of chemical vapour deposition (CVD), additive manufacturing, and electron microscopy. CVD involves the decomposition of gaseous precursors using an external stimulus to deposit material onto a substrate. Additive manufacturing is a bottom-up approach that is non-invasive to the substrate and allows materials to be built up layer by layer, in essence, 3D printing. The scanning electron microscope provides a nanoscale, high-energy focused probe. Bringing these together, one can think of EBID as a nanoscale 3D printing technique in which gaseous precursors are locally decomposed by the electron beam, enabling direct-write deposition of material with sub-micrometre resolution.

Your project also focuses on specific types of nanostructured materials. What advantages do these carbon-rich or nanoporous materials offer for sensing applications?

Porosity inherently provides a high specific surface area, which is critical for maximising analyte-surface interactions in sensing. The graphitic carbon component, in turn, imparts electrical conductivity to the deposited material. The combination of these two properties, high surface area and electrical conductivity, creates a particularly advantageous platform for resistive or conductometric chemical sensing.

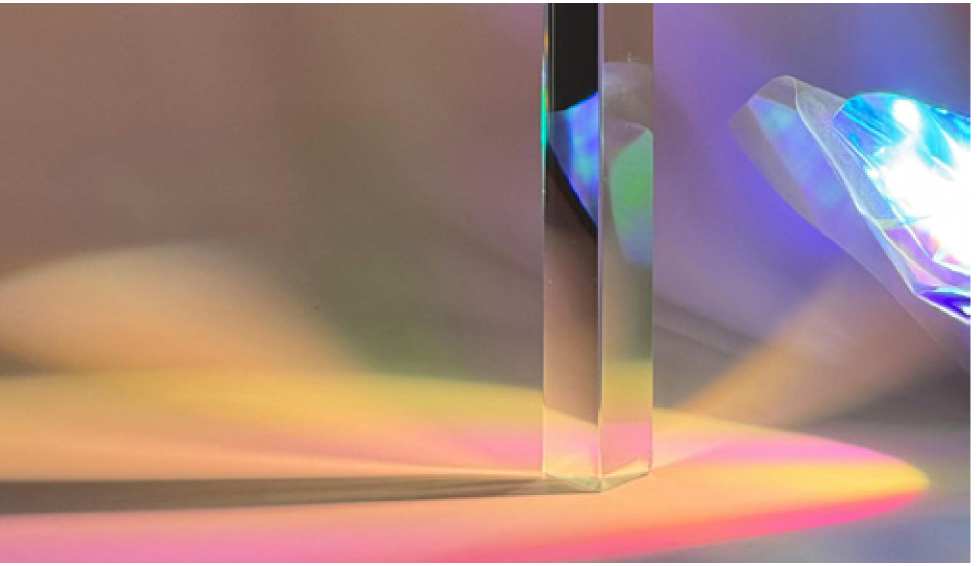
One particularly interesting aspect of SENSE is the integration of multiple sensing materials onto a single chip. Why is this capability so important for improving selectivity in electronic noses?

I believe this capability will be key to enabling both miniaturisation and simplification of eNose systems. Multi-material single-chip integration is actually chosen here as a demonstration of EBID's versatility, because no other direct-write nanofabrication technique could achieve this so straightforwardly and with such spatial precision. It is precisely this kind of capability that sets EBID apart and makes it an exciting platform for next-generation sensor development.

You are also working with beam control and image-guided automation. How does automation contribute to improved reproducibility and reliability at the nanoscale?

Because EBID is performed inside a scanning electron microscope, we can exploit the imaging capability of the instrument as an in situ computer vision system. Between deposition steps, the apparatus can image the substrate to determine its precise position, then autonomously navigate to the next electrode on the microelectrode array and continue deposition with a different precursor gas. For simpler electrode geometries, a basic macro routine may suffice, but for more complex microelectrode arrays, such rigid scripting becomes insufficiently robust. This is where approaches integrating machine learning and AI-driven computer vision become particularly attractive, enabling adaptive, real-time process control that can handle variability and improve reproducibility at the nanoscale.

Looking ahead to the technical side, which challenge do you anticipate will be the most demanding: controlling material composition, ensuring reproducibility, or scaling the fabrication process?



I will admit this is the part that makes me most nervous. There are many things that could go wrong. Controlling material composition, particularly achieving reliable graphitisation and tunable porosity, is one of the central challenge. Developing robust computer vision automation for the deposition workflow will be another challange. Based on the current literature and what we already understand about the process, I am confident that it is achievable but we will not know the full extent of the challenges until we are actually in the laboratory doing it. And honestly, that uncertainty is a large part of what makes science so compelling to me. I genuinely enjoy a challenge.

If everything goes according to plan, how could SENSE influence the future design and performance of gas sensors and electronic noses?

I am hopeful. SENSE, as a project, will ideally mark the beginning of a new research direction for me, one that bridges nanofabrication and chemical sensing in a way that has not been fully explored. We will see where it leads, but I believe that even if we achieve partial success, we will be able to provide meaningful leads and proof-of-concept results that could accelerate progress in the eNose field more broadly.

Beyond sensing, your fabrication approach could have applications in areas such as catalysis, energy storage, or photonics. Which of these directions do you find most exciting, and why?

I have long been fascinated by both catalysis and plasmonics. The carbon-rich and metallic nanostructures produced by EBID have structural features, high surface area, tunable composition, and nanoscale geometry, that are highly relevant to heterogeneous catalysis and localised surface plasmon resonance phenomena. It is difficult to say at this stage exactly which direction will prove most fruitful, but I suspect that some of the materials I will be developing within SENSE may find natural complementary applications in these areas, and I very much look forward to exploring those possibilities.

Let's now turn to your research environment. What is your role within CEET, and how does the local ecosystem support interdisciplinary collaboration?

First of all, CEET is home to a remarkable collection of scientific units. The Centre for Nanotechnology (CNT) houses the EBEAM, where I began my journey as a postdoctoral researcher under the leadership of Prof. Mark Rümmeli. EBEAM not only provides me with outstanding facilities but also connects me with an exceptional group of international researchers, professors, postdoctoral fellows, and PhD students, from whom I learn constantly. The broader CEET environment also enables fruitful collaborations with other groups across CNT, creating synergies that genuinely strengthen the research.

And to conclude, what does receiving the ERA Fellowship mean to you personally and professionally at this point in your career?

At the moment I have an interesting mix of excitement and apprehension. The ERA Fellowship is a fantastic and highly prestigious opportunity, and the fact that it was awarded to me is something I am genuinely proud of, it does help to silence the impostor syndrome. At the same time, it means that the expectations of those around me will be considerably higher, which is both motivating and a little daunting. Ultimately, I know I will have strong support from my mentors, and I am very aware of how significant this opportunity is both for my personal development and for what it could mean for the field. Taking everything into consideration, I expect this will catalyse my professional development.

HELPING TOGETHER

ROTARY CHRISTMAS PUNCH

The Advent season in the centre of Ostrava is not only a time of lights, festive decorations, and social gatherings. Each year, it also hosts one of the largest charitable initiatives organized by local Rotary clubs – the sale of Rotary Christmas Punch. Last year, volunteers from the Centre for Energy and Environmental Technologies (CEET) at VSB – Technical University of Ostrava actively joined this initiative and helped with the sale at Masaryk Square.

Rotary Club Ostrava and Rotary Club Ostrava International are part of Rotary International, a global organization that has long supported projects aimed at helping communities, working with young people, and supporting those who need it most. The proceeds from the punch sales are primarily directed to the long-standing Stružielka project, which supports children with intellectual disabilities from the Czech Republic and Slovakia. Thanks to these contributions, the children can attend a summer recovery camp in the Beskydy Mountains, where rehabilitation naturally combines with games, amateur theatre, and physical activities, all supported by enthusiastic young volunteers.

The event is also supported by other partners. The City of Ostrava provides the sales stand, while Hotel Imperial Ostrava prepares the punch according to a traditional recipe with the idea that the best Christmas punch in Ostrava can also support a good cause.

Volunteers from CEET also played an important role in the success of the third Advent weekend. The sales team – Michaela Vašutová, Stanislava Klečková with her daughter Isabela, Lucie Jezerská, Veronika Sassmanová, Tomáš Heryán, and Jaroslav Zajíc – helped raise more than CZK 120,000 together with other participants. In addition to enjoying the festive pre-Christmas atmosphere in the historic centre of Ostrava, everyone involved left with a strong sense of satisfaction, knowing that their time and energy had helped those who truly need support.

SCIENCE IS NOT THE ONLY WAY TO HELP. SOMETIMES, ALL IT TAKES IS POURING A CUP OF PUNCH.

This initiative serves as a reminder that scientific work and research are not the only ways in which people from the academic community can contribute to society. Sometimes it is enough to spend a few hours behind a stand selling Christmas punch and help fulfil the idea captured by the simple motto of Rotary International: Service Above Self.

CEET

CEET EMPLOYEES' CHRISTMAS GATHERING

See how the Christmas party went.

The CEET Employees' Christmas Gathering, held under the motto "Energy in a New Balance," demonstrated through concrete discussions, doctoral posters, and the presentation of the CEET Director's Award how cutting-edge research is being transformed into practical solutions, and which new projects and partnerships will help shape the future of the energy sector in the coming years.

The fifth anniversary edition of the event provided an opportunity to reflect on the past year while also opening discussion on the future direction of the centre in the context of the energy transition, system integration, and the circular economy. At the same time, the meeting emphasized the connection between research, real-world applications, and industry.

Panel discussions addressed the development of low-carbon energy sources, the integration of renewable technologies, hydrogen, energy storage, and smart grids. They also highlighted the importance of interdisciplinary cooperation and the involvement of regional partners. The second discussion block focused on advanced materials, nanotechnologies, and their applications in modern industry, including approaches based on the principles of the circular economy.

An important part of the programme was the presentation of the CEET Director's Award, which recognized outstanding achievements across basic and applied research, project activities, and collaboration with industry.

In the category Best Applied Research Result, the award was presented to the team for the work Technology for the thermal treatment of end-of-life vehicle waste from the perspective of maximum energy yields and minimum emissions. (Jozef Vlček, Jiří Burda, Jakub Korpas, Marek Velička, Jiří Fiedor, Mario Machů, Petr Jirsa, René Sommr).

The Best Basic Research Result award went to the authors of the publication Harnessing Enhanced Lithium-Ion Storage in Self-Assembled Organic Nanowires for Batteries and Metal-Ion Supercapacitors (Ievgen Obraztsov, Rostislav Langer, Jean G. A. Ruthes, Volker Presser, Michal Otyepka, Radek Zbořil, Aristeidis Bakandritsos).

The Best Research Project award was granted to the project ExPEDite: Enabling Positive Energy Districts through a Planning and Management Digital Twin, while the Best Result of Collaboration with Industry category recognized the EPC (Energy Performance Contracting) Analyses prepared for the National Development Bank.

Considerable attention was also attracted by the new poster section for early-stage doctoral researchers, which enabled the presentation of current research topics across the centre and facilitated direct expert discussions with participants. The Best Poster Award, based on audience voting, was presented to Ajith Manayil Parambil for both the scientific contribution and the quality of the presentation.

The year 2025 represented a period of significant development for CEET, including the launch of new European projects, preparation of strategic investments in research infrastructure, and confirmation of the centre's high performance in the national evaluation of research organisations. The meeting therefore represented not only a social event marking the end of the year, but also a symbolic confirmation of the centre's progress and its role in the field of energy and environmental technologies in the Czech Republic as well as in the international context.

WE MET

CzePoCat 2026: Science Without Borders

Our colleagues hosted the 14th edition of the Czech–Polish Catalytic Symposium CzePoCat. This traditional event once again brought together dozens of researchers from the Czech Republic, Poland, and Slovakia to share the latest advances in catalysis, photocatalysis, hydrogen energy, and climate protection.

The high quality of the scientific programme was ensured by distinguished representatives from VSB – Technical University of Ostrava, Jagiellonian University, Polish Academy of Sciences, the J. Heyrovský Institute of Physical Chemistry of the Czech Academy of Sciences, Warsaw University of Technology, AGH University of Krakow, Maria Curie-Skłodowska University in Lublin, and the Slovak University of Technology in Bratislava.

Infotherma 2026

This year, the exhibition had an even stronger connection to CEET and VSB–Technical University of Ostrava, as we served as honorary partners of the event. This was evident not only in the programme but also in the themes that resonated throughout the exhibition. At the forefront were energy, energy savings, modern technologies, and sustainable solutions currently sought by households, companies, and public authorities. The fair was ceremonially opened on behalf of CEET and VSB–Technical University of Ostrava by Stanislav Mišák and Igor Ivan, together with the Governor of the Moravian-Silesian Region, Josef Bělica, the Director of the State Environmental Fund of the Czech Republic, Petr Valdman, the Deputy Minister of the Environment, Vladislav Smrž, and the Deputy Mayor of the City of Ostrava, Aleš Boháč.

Technology Days: Energy & Environment

The event, held at VSB – Technical University of Ostrava, clearly demonstrated that cooperation between academia and industry is an essential step toward a sustainable future. The expert programme also featured contributions from colleagues from our centre. Jiří Ryšavý focused on the use and development of sustainable catalysts that help reduce emissions from biomass. Grażyna Simha Martynková addressed the important topic of battery safety and recycling, which plays a significant role in the development of electromobility. Maria Zdończyk presented the topic Reactive Hybrid Materials for Energy-Relevant Applications Enabled by Electron Beam Processing – the EBEAM project (Electron Beam Emergent Additive Manufacturing). Petr Praus contributed with a presentation titled Microplastics Research: Analysis and Photoreforming for Hydrogen Production, while Jan Bednárek presented on Adsorption of Pharmaceuticals and Heavy Metals on Activated Carbon Produced from Austrian Pine Cones.

Aquatherm Prague Fair

Our colleagues demonstrated that modern heating is not only about performance, but above all about sustainability. In interviews for estav.tv, they presented solutions that help to improve air quality directly in our homes. Jiří Ryšavý focused on oxidation catalysts for small combustion sources. Alexandr Molčanov introduced the potential of electrostatic precipitators (ESP) for domestic boilers, while František Hopan presented the results of an extensive measurement campaign involving 111 household solid-fuel boilers operating under real household conditions. The results showed that the laboratory classification of boilers in terms of pollutant concentrations in flue gases can differ significantly from measurements obtained during real household operation. In addition to the technology itself, factors such as the way the boiler is operated, the quality of the fuel, and the proper adjustment of the heating system play a crucial role.

Visit of the Primary School Frýdek-Místek, Jana Čapka

Thanks to the foodCIRCUS project within the Interreg CENTRAL EUROPE programme, third-grade pupils from Primary School Frýdek-Místek, Jana Čapka briefly became young researchers and had the opportunity to try hydroponic cultivation of garden cress. This method allows plants to grow without soil, using only water and nutrients provided in the form of pellets made from separated waste collected from the school canteen.

April 2026

8th issue of the newsletter
Centre for Energy and Environmental Technologies

Editor-in-Chief:
Matěj Šponiar

Editorial staff
Marie Neoralová
Štěpán Klos

Design and graphic design
Vladimír Ochman

Photography
CEET
CEET archive
pexels.com
pixabay.com

Editorial staff
Vlasta Tobolíková, Martin Šnicer

Publisher
Centre for Energy and Environmental Technologies (CEET)

VSB - Technical University of Ostrava
17. listopadu 2172/15
708 00 Ostrava-Poruba
Czech Republic
Registration number: 61989100

Periodicity: quarterly
Place of publication: Ostrava

VSB TECHNICAL UNIVERSITY OF OSTRAVA | CENTRE FOR ENERGY AND ENVIRONMENTAL TECHNOLOGIES

ceet.vsb.cz