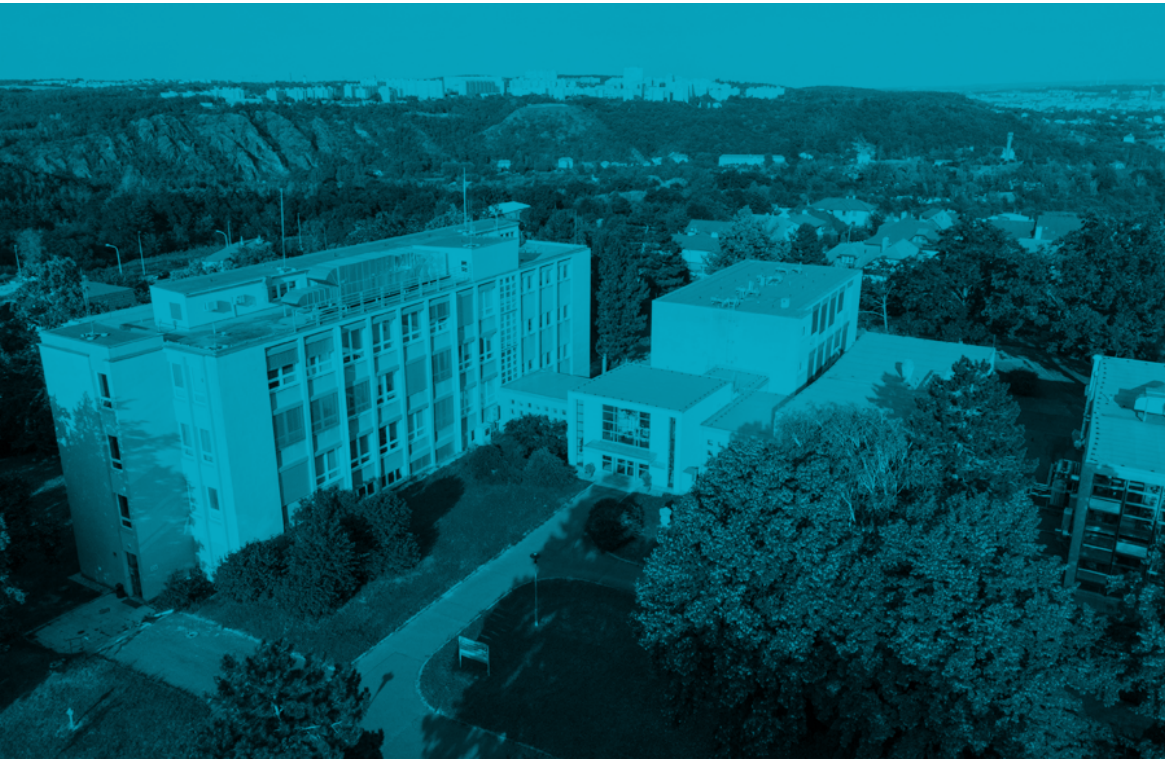
INSTITUTE
OF CHEMICAL
PROCESS
FUNDAMENTALS
OF THE ASCR

RESEARCH FOR CLEANER ENVIRONMENT AND SUSTAINABLE TECHNOLOGIES

Research for cleaner environment and sustainable technologies

The Institute of Chemical Process Fundamentals (ICPF) develops advanced solutions at the intersection of environmental-chemical engineering and materials chemistry. We address key challenges in environmental protection, resource efficiency, and sustainable industry.

Our work bridges fundamental research with real-world applications – from air quality and water treatment to circular economy processes and clean energy technologies.



EUROPEAN INFRASTRUCTURE AND EXPERTISE

ICPF is an integral part of the European Research Infrastructure (ACTRIS), focused on aerosols, air quality and climate. We operate leading facilities such as the Prague Aerosol Calibration Center (PACC) and contribute to the development of measurement standards and advanced methodologies.

SOLUTIONS WITH REAL IMPACT

Our research delivers practical, high-value outcomes for industry and society:

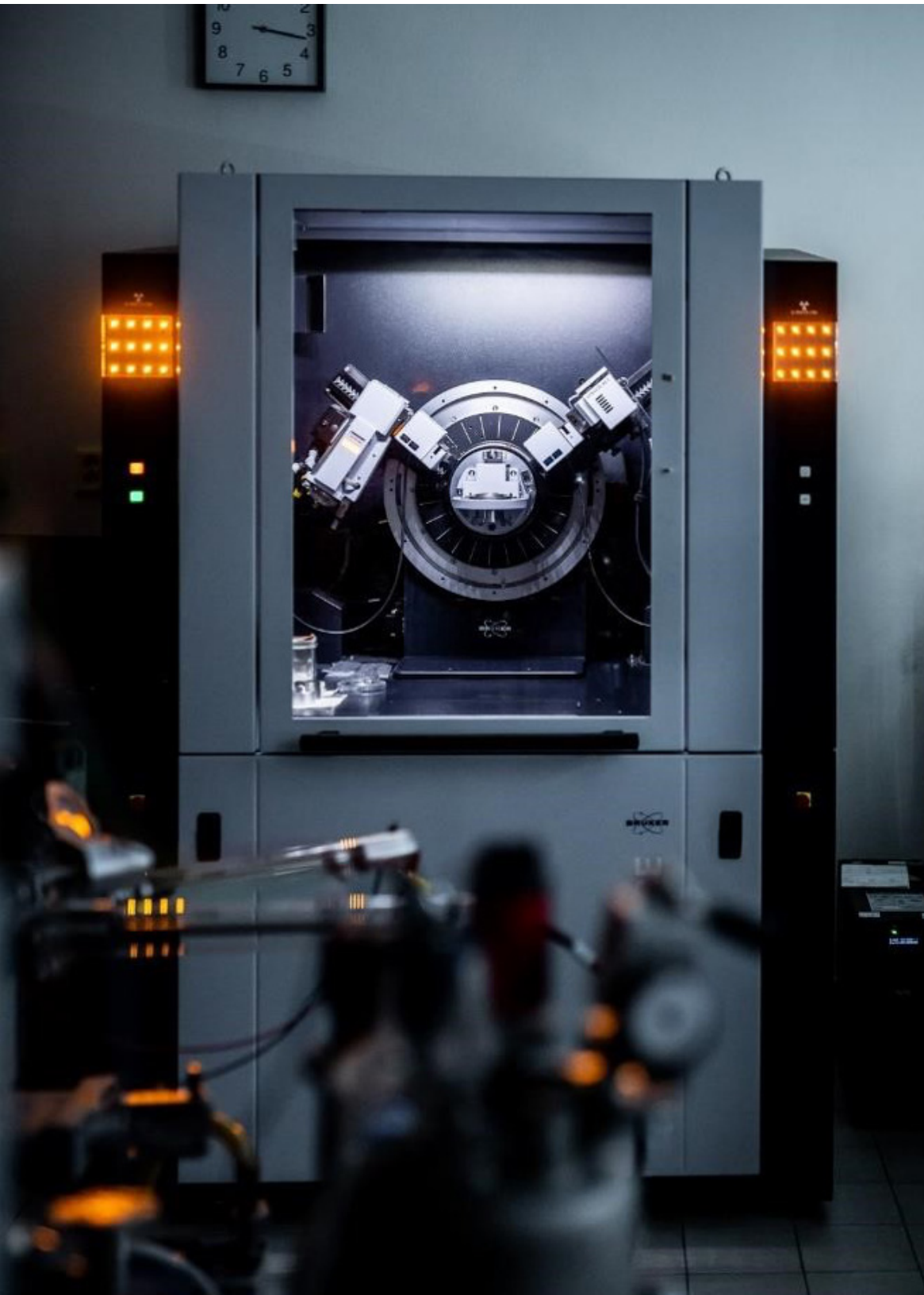
Emission reduction and air quality improvement.

Water treatment technologies.

Resource recovery and waste valorisation.

Sustainable materials and chemical processes.

We collaborate with industrial partners and research institutions across Europe and welcome new partnerships.



RESEARCH GROUP OF WASTE MANAGEMENT AND SUSTAINABLE TECHNOLOGIES

The Research Group of Waste Management and Sustainable Technologies conducts research on waste, secondary resources, and primary raw materials. Its work focuses on material characterization, identification of recoverable value, and development of treatment and processing routes for complex materials. Activities include laboratory research, process development, environmental assessment, and support for implementation in industrial and regulatory settings. Current topics include recovery of critical raw materials, treatment of complex and hazardous waste, and assessment of contaminants such as PFAS and microplastics.

KEY AREAS

- Resource recovery from waste, secondary resources, and primary raw materials
- Material characterization and environmental assessment
- Recycling, treatment, and process optimization
- Waste classification and hazardous property evaluation
- Support for industry, policy, and public administration

ANALYTICAL LABORATORY

The Analytical Laboratory supports research and applied studies focused on characterization of complex materials associated with waste management, recycling, industrial production, and resource recovery. Activities cover waste-derived materials, secondary resources, primary raw materials, industrial residues, technological products, and environmental matrices such as soils, waters, and leachates. Particular attention is given to chemical characterization of electronic waste and related secondary materials. The laboratory supports process development, quality control, environmental assessment, and evaluation of treatment and recycling technologies.

METHODS AND SERVICES

- ICP-OES for multi-element analysis of digested solid and liquid samples
- ICP-MS for trace element analysis, including REEs
- XRF for rapid, non-destructive screening of solid and liquid materials
- DMA for direct determination of total mercury
- XRD for phase identification and structural characterization
- XPS for surface chemical characterization of materials, including elemental composition and chemical state analysis
- Raman spectroscopy for molecular and phase characterization
- Capillary electrophoresis for anion analysis
- Automatic titration systems for acid-base, redox, and related analyses

APPLICATIONS

- Characterization of waste, secondary resources, and primary raw materials

- Environmental analysis of soils, waters, and leachates
- Support for process development, optimization, and quality control
- Assessment of contamination and material properties

ENVIRONMENTAL CHARACTERIZATION AND WASTE CLASSIFICATION

This section supports research and applied studies focused on environmental characterization of waste, industrial residues, and secondary resources. It addresses contaminant release, mobility, and long-term behaviour under environmentally relevant conditions, providing data for waste classification, environmental assessment, and evaluation of material suitability for recycling, recovery, or reuse. Particular attention is given to potentially toxic elements, PFAS, inorganic salts, and other organic and inorganic contaminants. The work also includes chemical speciation of selected elements relevant to environmental behaviour and classification.

METHODS AND SERVICES

- Up-flow percolation tests
- Batch and pH-dependent leaching tests
- Solid–liquid partitioning tests
- Waste classification testing
- Chemical speciation studies of selected elements
- Applications
- Environmental characterization of waste and secondary resources
- Assessment of contaminant release and mobility
- Support for waste classification and hazardous property evaluation
- Evaluation of material suitability for recycling, recovery, and reuse
- Support for environmental assessment and regulatory practice

MINERAL PROCESSING LABORATORY

The ICPF Mineral Processing Laboratory supports research and teaching in mineral processing, process mineralogy, and recycling of secondary resources. It provides laboratory- and bench-scale facilities for characterization and processing of primary raw materials, industrial residues, and waste-derived materials. The laboratory is organized into three complementary sections: Mineral and Waste Processing, Process Mineralogy, and Particle Analysis. This structure links comminution and separation test work with mineralogical and particle characterization in both fundamental and applied research focused on resource recovery, recycling, and treatment of complex material streams.

MINERAL AND WASTE PROCESSING

The Mineral and Waste Processing section supports research and applied test work in comminution, classification, and physical separation of primary and secondary materials. It covers conventional mineral processing operations as well as selected technologies relevant to recycling and waste treatment, including mining waste, end-of-life batteries, and WEEE. Laboratory- and bench-scale equipment enables process development, method verification, and evaluation of separation performance for a wide range of material streams.

COMMINUTION

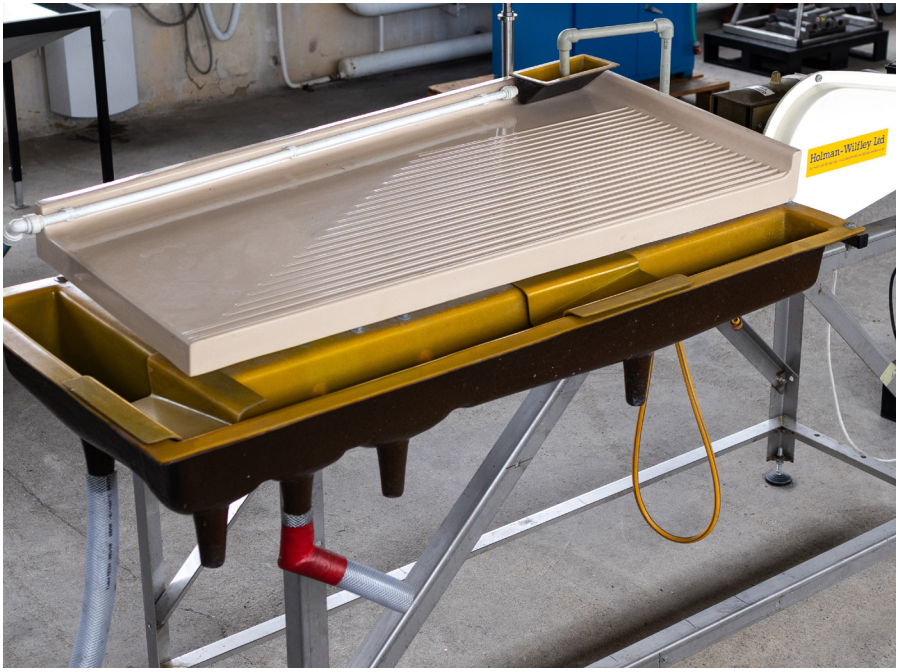
The ICPF laboratory provides a wide range of comminution test work. Available equipment includes:

- Jaw crusher
- Roller crusher
- Hammer mill
- Knife-type shredder
- Blade-type shredder
- Cutting mill
- Laboratory-scale ball and rod mills (various types)
- Vibrating mill
- Classification equipment including laboratory- and bench-scale screens and hydrocyclone

PHYSICAL SEPARATION

ICPF offers comprehensive test work in physical separation techniques employing:

- Magnetic separation (low- and high-intensity separators)
- Electrostatic separation
- Eddy current separation (conductivity-based)
- Spiral concentrators
- Shaking tables
- Jigs
- Knelson concentrators
- Dense Media Separation (LARCODEMS)
- Air Shaking Table
- Flotation
- Filtration and thickening test work



ADVANCED PROCESS MINERALOGY

The Process Mineralogy section provides mineralogical characterization for research and applied studies related to primary raw materials, waste-derived materials, and secondary resources. The facility supports investigation of mineral composition, texture, associations, and liberation characteristics, linking material properties with processing behaviour. These methods are used in studies of separation efficiency, metal recovery, and leaching behaviour.

METHODS AND SERVICES

- SEM–EDS
- XRD (with Rietveld refinement)
- Automated mineralogy and liberation analysis (QEMSCAN/TIMA)

ICPF provides automated mineralogical and liberation analysis using QEMSCAN/TIMA systems. These techniques enable high-resolution, quantitative characterization of mineral phases and their textural relationships.

APPLICATIONS

- Bulk modal mineralogy
- Liberation and mineral locking analysis
- Metal deportment studies
- Mass-balanced mineralogy of process streams
- Characterization of leach feed and residue materials

ADVANCED PARTICLE ANALYSIS

The Particle Analysis section is dedicated to characterization of particle properties relevant to mineral processing, recycling, and material evaluation. It supports research and applied studies by providing data on particle size, shape, density, and surface behaviour for process optimization, material performance

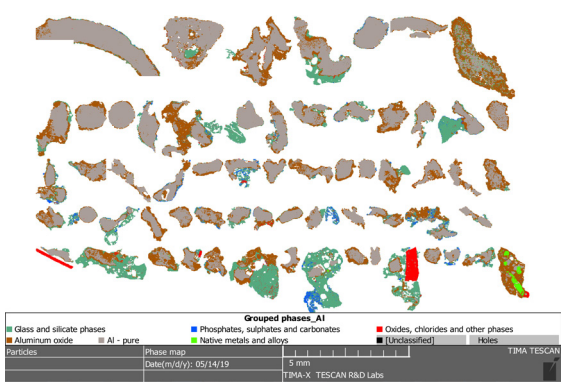
evaluation, and quality control. Complementary analytical approaches enable evaluation of particle systems across a wide range of sizes and material types.

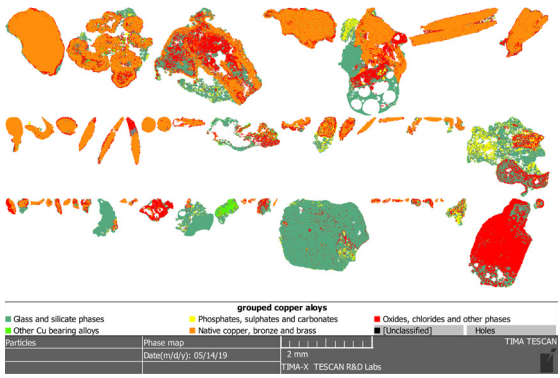
METHODS AND SERVICES

- Surface and interfacial measurements (contact angle, surface tension, particulate contact angle)
- Density measurement
- Particle size and shape analysis (laser diffraction, dynamic imaging particle size and shape analyzer, and sieve analysis)

APPLICATIONS

- Characterization of particle size, shape, density, and surface properties
- Support for process optimization and material performance evaluation
- Quality control of primary and secondary materials
- Evaluation of particle systems in mineral processing and recycling studies





HYDROMETALLURGICAL LABORATORY

The ICPF Hydrometallurgical Laboratory supports research and applied studies focused on metal extraction, solution purification, and metal recovery from complex materials associated with primary raw materials, waste management, recycling, and resource recovery. Activities cover primary raw materials, industrial residues, secondary resources, and waste-derived materials such as electronic waste, battery materials, and other metallurgical or mineral-bearing streams. Particular attention is given to hydrometallurgical treatment routes for selective recovery of valuable metals from complex matrices. The laboratory supports process development, optimization, and assessment of metal recovery technologies.

METHODS AND SERVICES

- Leaching techniques, including agitated atmospheric, column, pressure, and cyanidation leaching
- Thermal pre-treatment and amenability testing
- Solvent extraction and ion exchange
- Precipitation, crystallization, and electrowinning

APPLICATIONS

- Metal extraction from primary raw materials and secondary resources
- Recovery of valuable metals from electronic waste, battery materials, and industrial residues
- Development and optimization of hydrometallurgical processing routes
- Purification of process solutions and selective metal recovery

CASE STUDIES

CASE STUDY: MEMBRANE ELECTROLYSIS FOR TECHNOLOGICAL WASTEWATER TREATMENT

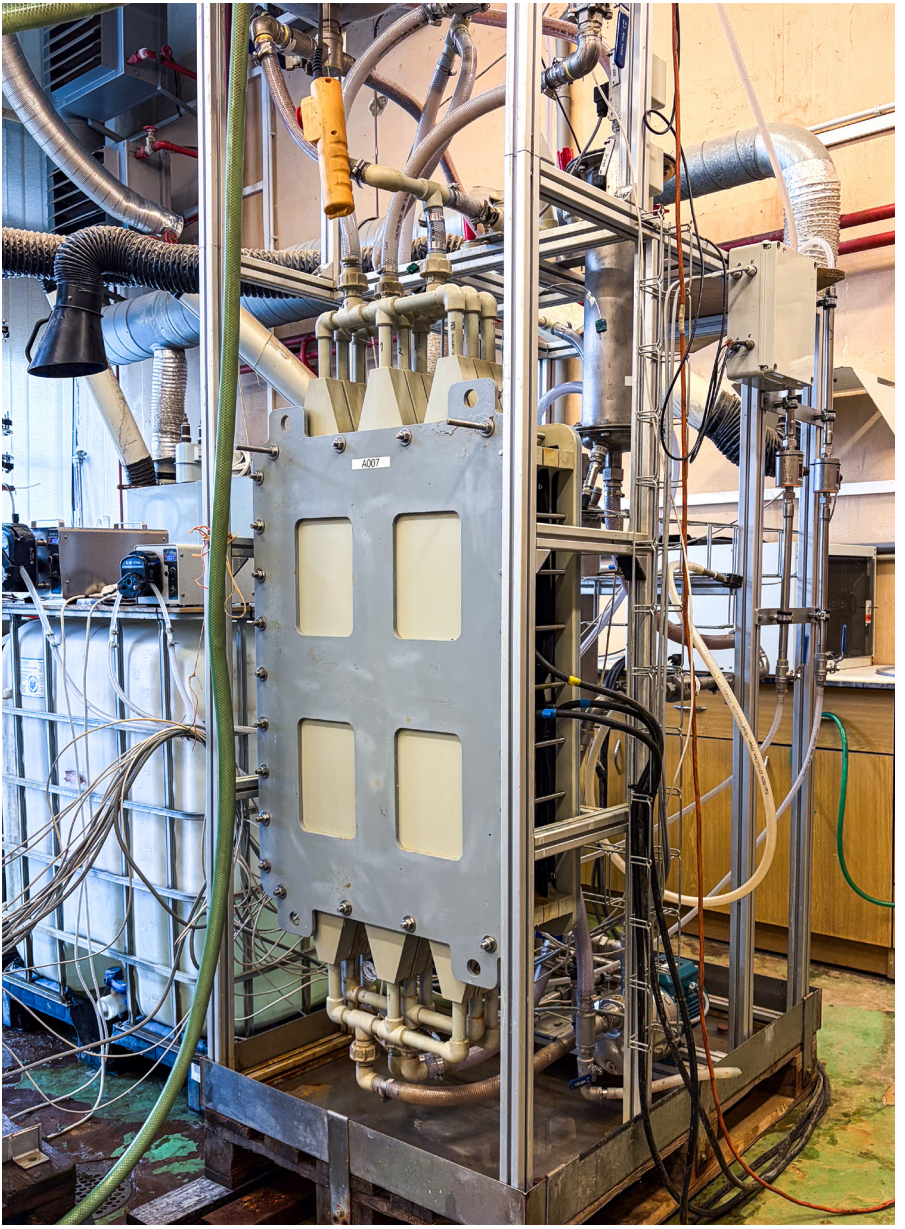
This case study focuses on treatment of acid leachates generated during processing of fly ash and air pollution control residues from waste-to-energy plants. These leachates contain high concentrations of dissolved salts and heavy metals and require effective treatment before discharge or reuse. Membrane electrolysis offers an alternative to conventional multi-step treatment by enabling simultaneous wastewater treatment and recovery of valuable metals, especially zinc.

Laboratory testing confirmed the ability of the process to remove dissolved metals and treat leachates under variable conditions. The technology was patented by ICPF and is now being scaled up to a semi-pilot unit for operation under real waste-to-energy conditions. The objective is to verify process reliability, optimize treatment performance, and produce a zinc-rich filter cake suitable for further use.

KEY OUTCOMES

- **Treatment of technological water with high concentrations of dissolved salts and metals**
- **Recovery of metals, especially zinc**
- **Reduced chemical consumption compared with conventional treatment**
- **Production of zinc-rich filter cake for further use**
- **Reduction of hazardous waste requiring landfill disposal**
- **Technology scale-up and verification under real operating conditions**

- Integration with existing treatment technology
- Support for circular economy and resource recovery strategies



CASE STUDY: INCINERATION BOTTOM ASH

Since 2015, the Research Group of Waste Management and Sustainable Technologies has been involved in the transition of incineration bottom ash management in the Czech Republic from disposal to material recovery and reuse. The work included characterization of bottom ash from Czech waste-to-energy plants, verification of ferrous and non-ferrous metal recovery under real conditions, assessment of treated mineral residue for construction applications, and preparation of technical and environmental criteria for its safe use. The group also contributed to feasibility assessment for full-scale implementation and to pilot demonstration of practical application.

KEY OUTCOMES

- **Characterization of Czech incineration bottom ash and its properties**
- **Verification of metal recovery under real operating conditions**
- **Assessment of treated residue for use in construction**
- **Contribution to technical criteria and legislative framework**
- **Feasibility study and pilot demonstration for full-scale implementation**

CASE STUDY: RECYCLING OF NEODYMIUM MAGNETS

This case study addresses recovery of rare-earth elements from end-of-life NdFeB magnets. The process is based on controlled acid leaching, purification of the leachate, and removal of impurities such as iron and boron, followed by separation and recovery of individual rare-earth elements. The technology is designed to accommodate variable magnet compositions and to support safe handling of gaseous by-products.

The work demonstrates a hydrometallurgical route for recovery of Nd, Pr, and Dy from complex secondary materials, with emphasis on process robustness, product purity, and potential for further scale-up.

KEY OUTCOMES

- **Recovery of Nd, Pr, and Dy from end-of-life NdFeB magnets**
- **Selective leaching and purification of complex magnet-derived materials**
- **Separation of individual rare-earth elements in high purity**
- **Process design suitable for variable feed compositions**
- **Contribution to circular economy approaches in magnet production**

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