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PREDIS COLLABORATION TO ADVANCE THE PREDISPOSAL MANAGEMENT OF RADIOACTIVE WASTE

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ABSTRACT

PREDIS – Predisposal management of radioactive waste is a European Commission funded project to develop predisposal activities on treatment and conditioning methodologies. The target is for wastes, which yet haven't adequate or industrially mature solutions, including metallic materials, liquid organic and solid organic waste. PREDIS project also addresses testing and evaluating innovations and digitalization solutions for cemented waste handling and pre-disposal storage. The scope of the PREDIS project includes characterization, treatment and conditioning of the waste streams, demonstrations and performance evaluation of the waste streams to verify safety and effectiveness of the new solutions. Environmental assessment of the processes and residual products, economic assessment of the treatment processes and finally guidelines for use, to ensure deployment of the new solutions are also in focus of the project.

The four-year PREDIS project that started in September 2020 with 47 seven partners in 17 countries has been strong in development, collaboration and sharing information on predisposal activities both in technical issues and in strategic research agenda, waste acceptance criteria and life cycle assessment. One target of the project has been to develop the knowledge management programme and support training and mobility activities in collaboration with EJP EURAD. PREDIS project has close collaboration with stakeholders and end users, having an End User Group of 25 organisations. PREDIS project has already widely disseminated the project results via webinars, open workshops and international conferences, and had close dialogue with the stakeholders to share the relevant information on predisposal issues. This paper will present the main achievements in the research and development collaboration aspect of the PREDIS project.

Keywords: predisposal, radioactive waste, strategic research agenda, waste acceptance, life cycle assessment

1. INTRODUCTION

To support safe and efficient management of radioactive waste, which is a global challenge, the PREDIS project develops innovative technologies to more efficiently characterize, treat, condition and minimize waste streams at the predisposal phase. PREDIS specifically addresses the challenge to foster research and innovation to predisposal management of radioactive waste streams identified as priority by the majority of radioactive waste producers and waste management organisations. These priorities have been identified in the scope of the European Joint Program in Radioactive Waste Management as metallic wastes, organic wastes and liquids or solids and cemented waste packages. As a European Commission funded project, it targets to development of methods, processes, technologies and demonstrators applicable to benefit several EU Member States. Sharing and transfer of knowledge and competences between national programmes are key elements of the project, but also international collaboration is supported. Strong collaboration with on-going EU projects, European Joint Programming EURAD, end users and international organisations is relevant interaction within the project.

Main objective of the PREDIS project is developing solutions (methods, processes, technologies and demonstrators) for future treatment and conditioning across a number of European countries of waste for which no or inadequate

solutions are currently available, in order to avoid construction of new storage on sites. Project also targets to improve existing solutions with safer, cheaper or more effective alternative processes if they bring measurable benefits to several EU Member States. The project also aims to analyze criteria, parameters and specifications for materials and packages with associated Waste Acceptance Criteria (WAC) for pre-disposal and disposal activities.

The work in the project is divided into three generic work packages: communication and dissemination, strategic implementation and knowledge management, and into four technical work packages focusing on low and intermediate waste streams, as shown in Figure 1.

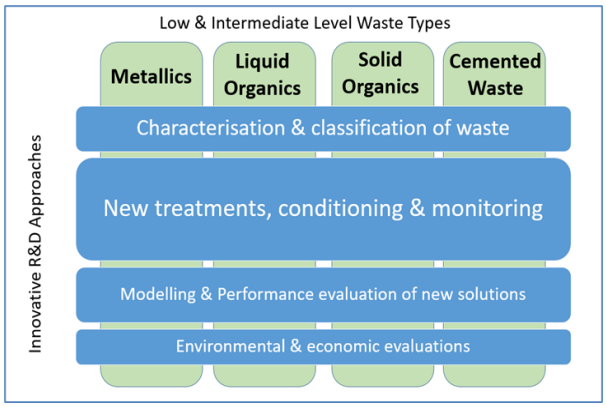

FIGURE 1: PREDIS PROJECT'S FOUR TECHNICAL WORK PACKAGES AND THE HORIZONTAL R&D APPROACHES.

2. COLLABORATION ACTIVITIES

PREDIS project commenced in September 2020 in midst of covid-19 pandemic, which led to active on-line dialogue and dissemination of research activities. PREDIS has organized 16 webinars on the project topics, including all four technical themes, strategic research agenda, waste acceptance criteria, life-cycle and -cost assessment and knowledge management. These webinars have been open to all interested stakeholders and they have been organized in collaboration with end users, EURAD and with other EU projects. IAEA has often been invited to give presentation on the topic. PREDIS has also organized four workshops, where members of the PREDIS End User Group (EUG) have been invited to participate. Two open stakeholder days have been organized in hybrid format to present project results and panel discussions on best practices for transferring industrial needs into used R&D and research communities' role in supporting governmental and industry groups to focus on the most impactful topics in predisposal.

2.1 Strategic research agenda

Baseline Strategic Research Agenda (SRA) was published in August 2021 [1]. The initial development of SRA focused on the consolidation of the existing published SRAs of major European and worldwide stakeholder groups. The SRA describes the scientific and technical domains and sub-domains and needs of common interest in predisposal area. Two open webinars were organized to present views from the EC, PREDIS project gap analysis work, PREDIS technical work packages, other EU projects and also relevant stakeholders such as the Sustainable Nuclear Energy Technology Platform (SNETP), and facilitate the dialogue with the research community and relevant stakeholder to get input to the SRA. Interfaces and predisposal stakeholders are presented in Figure 2. The predisposal SRA covers waste generation, processing and storage and transport. Issues related to waste generation include areas of planning, inventory and classification. Issues related to processing include treatment, conditioning and packaging. Within the storage, themes on monitoring within storage facilities to assess the waste package and waste-form and issues relating to the ageing and degradation of wastes, particularly with respect to prolonged or extended periods of storage were identified. One important topic for future R&D is disposability management, including e.g. disposability assessment and understanding the long-term behavior of waste-forms in a disposal environment. The draft SRA is currently under finalization. The predisposal SRA aligns with EURAD programme's SRA.

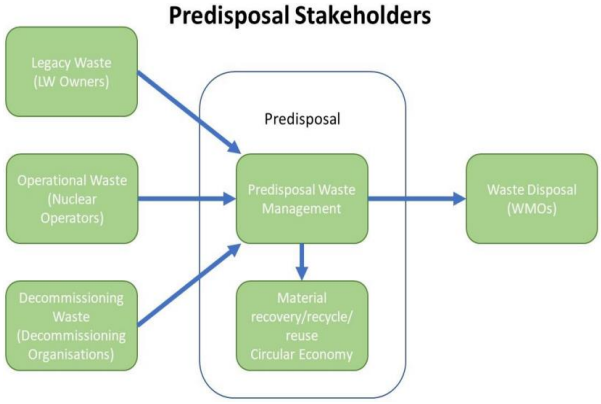

FIGURE 2: PREDISPOSAL STAKEHOLDERS AND WASTE MANAGEMENT INTERFACES. [1]

2.2 Knowledge management

One key horizontal aspect of PREDIS project is knowledge management programme. The programme includes mobility, training and knowledge management. The identification, assessment, structuring and dissemination of existing knowledge of predisposal R&D activities accumulated within the European Commission R&D programmes as well as international and national radioactive waste management organisations, is important for early-stage radioactive waste management programmes, advanced programs and future generations [2]. There has been high activity in mobility, with altogether 26 realized mobilities so far. These have been internal visits between project partners, participation to meetings and conferences, and a couple of longer working visits due to war in Ukraine. Training activities have been started and will be strongly enhanced in the remaining project until August 2024. UJV Rez, CZ, organized on-site training on low and intermediate level waste management and ENRESA, ES, held an open practical-theoretical training session on waste characterization

methodologies in autumn 2022. Next targeted on-site training is School for Waste Acceptance Criteria planned in autumn 2023. The organization is done jointly with EURAD and the contents of the school are being designed via collecting input from end users. In cooperation with EURAD, PREDIS is also producing State-of-Knowledge (SoK) documents and so-called Domain Insights (DI) to the EURAD ROADMAP [3]. These DIs will be used as basis for future on-line training. The types of training activities are shown in Figure 3.

FIGURE 3: TRAINING ACTIVITY TYPES IN PREDIS. [4]

3. RESEARCH HIGHLIGHTS

PREDIS project focuses on low and intermediate metallic and organic radioactive wastes, digitalization and waste packages, with aspects of characterization and classification of waste, new treatments, conditioning and monitoring, modelling and environmental and economic assessments. Some of the research outcomes so far are presented in the following.

3.1 Waste acceptance systems

Work on waste acceptance systems targets to gather and develop guidelines on waste form qualification for disposal and derivation of waste acceptance criteria (WAC). In 2021, a report on international approaches to establishing a waste acceptance was published [5]. The report gathers WAC altogether from 25 countries worldwide, with most of them having established a system that allow performing of safe collection, characterization, processing and storage of radioactive waste. According to the study, a framework of legislation and assigned responsibilities was available in all responding countries. It is stated in the report, that although safety assessment is widely considered as a condition or precursor for the formulation of certain WAC, the actual relation of the criteria to the safety assessment of storage/disposal facilities has not often been clearly identified. If relevant, the relationship should be specified for generic criteria, and for site specific criteria, if possible.

3.2 Metallic waste

Activities on innovations in metallic treatment and conditioning include defining the needs and opportunities for managing of metallic waste streams, development and optimization of decontamination processes, waste characterization optimization and procedures for waste minimization and recycling, and encapsulation of reactive metals in magnesium phosphate cement-based matrices. Results so far include e.g. creation of datasheets for different metal treatment and decontamination technologies, preparation of metallic waste surrogates for decontamination tests performed using chemical solutions and gel technology, secondary waste treatment focusing on electrochemical behavior of ionic liquids, as well as classification of metallic waste streams of different types of reactors and characterization and sorting of metallic waste in different management routes. Figure 4 shows an example of corrosion testing of stainless steel by gel deposition. New radiochemical procedures for difficult to measure (DTM) radionuclides have also been developed. An important field of study concern magnesium phosphate cement-based matrices (MPC), where different formulations have been developed, leaching behavior of MPC pastes studied and corrosion mechanisms in the MPCs. [2]

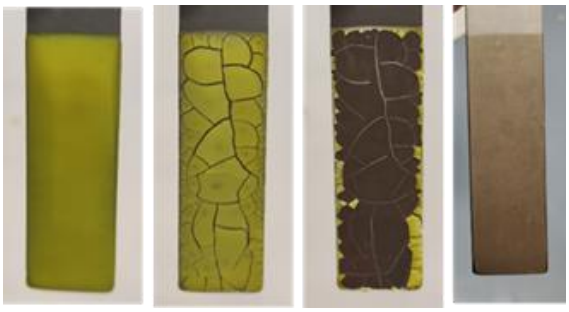

FIGURE 4: CORROSION TESTING OF A STAINLESS STEEL COUPON BY GEL DEPOSITION. [2]

3.2 Organic liquid waste

Innovations in liquid organic waste treatment and conditioning target on collecting and reviewing of waste, regulatory, scientific and technical data, defining experimental protocols, studying of conditioning matrix performances and technical, economic and environmental analysis of radioactive liquid organic wastes (RLOW). The focus of work is on improving waste loadings and waste-form properties aiming to condition RLOW into a form that is compatible with WAC for storage, transport and final disposal. Studies have concentrated on four reference wastes: oils, decontamination solvents, tributyl phosphate/dodecane and scintillation cocktails. Three reference geopolymer matrix formulations have been identified as candidates for direct conditioning solutions for RLOW, and robustness and optimization studies have been performed on them. The target is to develop geopolymer formulations that could be scalable to different countries in Europe by using local raw materials. Leaching and durability testing on the materials are on-going, as well as life cycle assessment (LCA) process. [2]

3.2 Organic solid waste

Work on innovations in solid organic waste treatment and conditioning aim to demonstrate reliability of alkaline binders

for conditioning of residues and secondary wastes stemming from treatment of radioactive solid organic waste (RSOW) and verify the matrix performance of conditioned waste to a set of uniform WAC. Work on RSOW includes thermal treatment methods and characterization of the treated / reconditioned waste, immobilization of wastes by geopolymer or cement-based materials encapsulation or by molten glass coating, and densification. Some of the results so far include physical and chemical characterization of thermally-treated ionic exchange resin surrogates and ashes produced by the incineration process IRIS ('installation for research of incineration of solids'. In a study on ion-exchange resins, they have been thermally treated via gasification and immobilized in a novel metakaolin geopolymer. Results have been promising, as this treatment enables substantially higher loading (more than 90 % volume reduction) into the geopolymer without loss of matrix strength or cohesion. Figure 5. Shows the used gasification process. Design and development of geopolymer and cement matrices to immobilize residues has been performed and the systems have been tested with several percentages of wastes. Tailoring and further testing continues in the project. Molten salt oxidation (MSO) thermal process has been examined, targeting to stabilize the spent salt from the MSO process with high content of alkaline carbonates in the geopolymer matrix. The target is with waste loading up to 25 wt.%. [2]

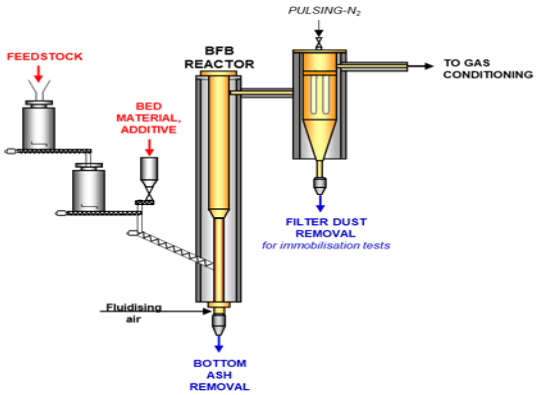

FIGURE 5: SCHEMATIC OF THE GASIFICATION PROCESS. [5]

3.2 Monitoring and waste packages

Objectives of the innovations in cemented waste handling and predisposal storage include compiling state of the art information on current methods and procedures for cemented waste management, identifying, evaluating and demonstrating store and package quality assurance and monitoring technologies. On digital domain, targets include adapting and demonstrating digital twin technology as well as digital decision framework. Some of the results until now are identification, evaluating and developing various radiation detection tools for radwaste characterization and monitoring, e.g. gamma and neutron radiation detectors, which will be tested with a cemented mock-up drum later in the project. Preliminary simulations show that this kind of external monitoring should be capable of detecting counting changes or occurring asymmetries. Muon tomography has been used for detection of metal bodies in concrete matrix. The device shown in Figure 6. Work on demonstrating and implementation of monitoring technologies with a mock-up is on-going, including selection of the technologies and identification of different package options. [2]

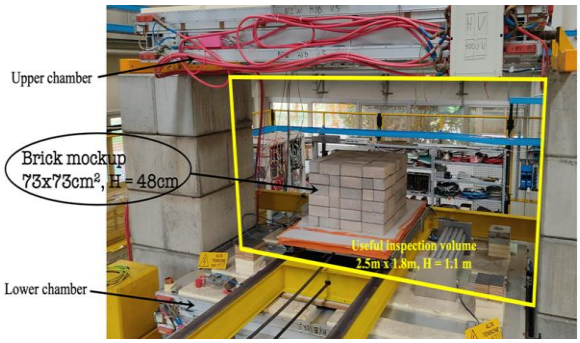

FIGURE 6: MUON TOMOGRAPHY APPARATUS USED FOR DETECTING METAL PIECE IN A THE CONCRETE MATRIX. [5]

4. CONCLUSION

The on-going EU project PREDIS develops technical innovations to safer and more efficient predisposal management of low and intermediate level radioactive waste. PREDIS project is developing the strategic research agenda for future research and development. The project also advances knowledge sharing, training and mobility of younger generation in the predisposal field via a specific Knowledge Management Programme. Some of the main results have been described in this paper and more detailed information can be found in the PREDIS website https://predis-h2020.eu/.

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