RADIONUCLIDE MOBILITY UNDER PERTURBED CONDITIONS (RAMPEC) – WP12

Thursday 24th October • M. Altmaier, (KIT)

Co-funded by the European Union under Grant Agreement n° 101166718

Improve the predictive capacity *of models*

of ***disposal system chemistry*** *and* ***radionuclide mobility***

under ***perturbed conditions***

based on a combination of ***new experimental and modelling studies***

up to the ***cell scale***

RAMPEC PROFILE…

R&D activity

60 months duration, - 6 m. initiation, - 48 m. exp. and mod. activities., - 6 m. finalization and reporting.

EURAD SRA / Roadmap Themes: Engineered Barrier Systems (Theme 3), Geoscience (Theme 4), Safety Case (Theme 7)

EURAD SRA topics: 4.2.1 Perturbations, 4.4.1 Geo-datasets and conceptual models, 7.3.1: Performance assessment and system models

SRA drivers: Implementation Safety, Scientific Insight, Knowledge Management

OVERALL RATIONALE

- Good understanding of radionuclide (RN) behaviour in argillaceous, crystalline and cementitious systems under equilibrium conditions has been derived from past experimental studies in simplified reference systems.
- Radionuclide and gas behaviour under perturbed conditions, however, are poorly constrained and up to date there is no integral (deterministic predictive reactive transport) model based description for perturbed systems, especially regarding the capability of describing the chemical evolution of *in-situ* conditions.
- RAMPEC will provide improved methods and approaches both regarding mechanistic modelling of radionuclide retention and migration on the disposal cell scale (meter to decametre scale).
- Use of existing data from previous projects (FUTURE, CORI, …) and targeted new experimental investigations performed in RAMPEC.
- Restriction three systems (Clay, Granite, Cement) with a limited number of specific perturbations.

RAMPEC TASKS AND BOARD

	Task title	Task leaders	
		Main Task leader	Co Leader if applicable
1	Management/coordination of the WP	**Marcus Altmaier**, [KIT], RE, DE	Jean-Charles **Robinet**, [ANDRA], WMO, FR
2	Knowledge Management	**Tiziana Missana**, [CIEMAT], TSO, ES	
3	RAMPEC experimental program	**Norbert Maes**, [SCK-CEN], RE, BE	*Subtask-Leaders:* **Norbert Maes**, [SCK-CEN], RE, BE **Susan Britz**, [GRS], TSO, DE **Nathalie Macé**, [CEA], RE, FR
4	Development of macroscopic/mechanistic models	**John Provis**, [PSI], RE, CH	**Johannes Meeussen**, [NRG], TSO, NL
5	Upscaling of data and models - benchmarking	**Jean-Charles Robinet**, [ANDRA], WMO, FR	**Andres Idiart**, [AMPHOS21], RE, ES

PMO contact: Delphine Pellegrini (IRSN, France)

32 groups from 13 countries

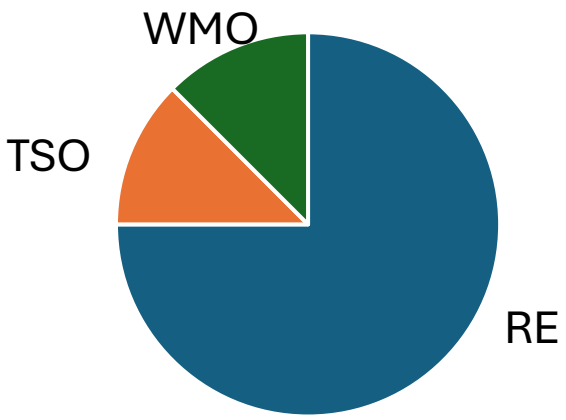
GROUPS ACTIVE IN RAMPEC

Belgium
Czech Rep.
Finland
France
Germany
Hungary
Lithuania
Netherlands
Spain
Sweden
Ukraine
Switzerland
UK

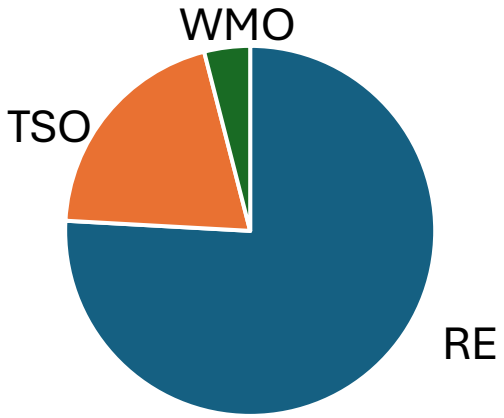
AMPHOS 21
ANDRA
BRGM
CEA
CIEMAT
CNRS-IC2MP
CNRS-ISTO
COVRA
CTH
CTU
EDF
GRS
GTK
HUN-REN EK
HZDR
IRSN
JUELICH
KIT
LEI
NRG
SCK CEN
SSTC NRS
SURAO
TUL
UHelsinki
ÚJV
Empa
PSI
BGS
NNL
NWS
UNIMAN

DISTRIBUTION OF EFFORTS

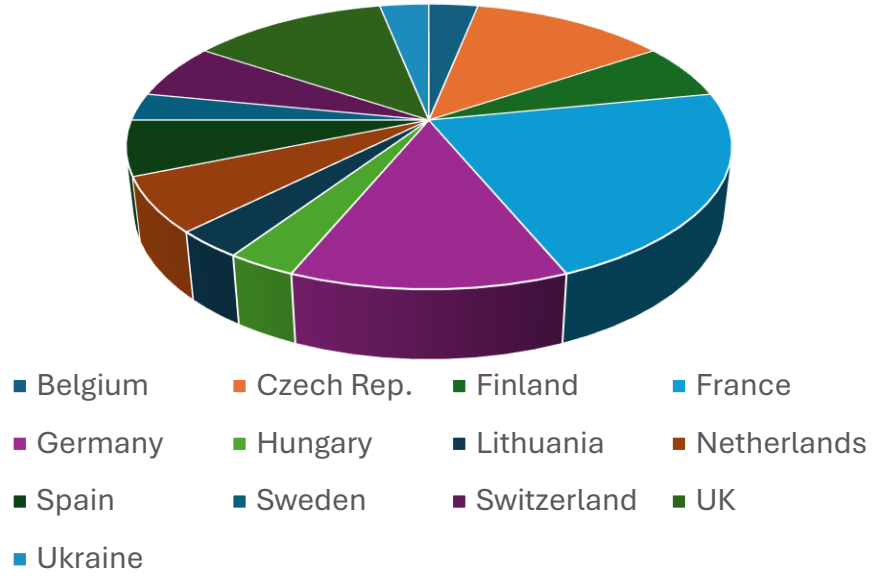
% involvement from college



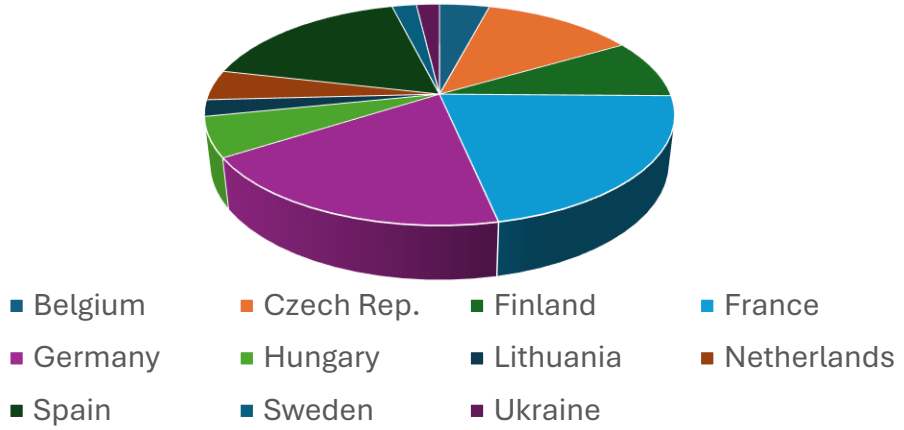
% pm effort from college



participation from countries (32)



% pm effort per country



TASK 1 - MANAGEMENT / COORDINATION OF THE WP

Lead: KIT – Total pm: 28 – Start month 1 – End month 60

WP Leader [KIT] in collaboration with the Task Leaders [CIEMAT], [PSI], [ANDRA], [SCK CEN], [GRS], [CEA], [NRG], [AMPHOS21], constituting the WP Board.

The main goals of Task 1 are the overall management of the WP including scientific-technical coordination, monitoring and reviewing the WP progress and outputs against the work plan and dissemination / outreach of the results.

Subtask 1.1: S/T coordination

Subtask 1.2: Dissemination / outreach / impact

Subtask 1.3: Quality control

TASK 2 - KNOWLEDGE MANAGEMENT

Lead: KIT – Total pm: 14,5 – Start month 1 – End month 60

[CIEMAT], [KIT], [PSI], [ANDRA], [SCK-CEN], [GRS], [CEA], [NRG], [AMPHOS21], [COVRA], [NTW].

The main goal of Task 2 is to capture knowledge relevant for the SRA topic of this WP and to contribute to knowledge transfer to the EURAD-2 community and beyond through the EURAD-2 KM programme.

Subtask 2.1: Knowledge capture (SOTA)

Subtask 2.2: Knowledge transfer

Subtask 2.3: Retention/Transport Parameters Database (RTP-D):

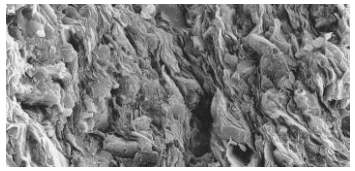
- **Provide a proof of concept for the creation of a substantiated Retention/Transport Parameters (RTP) database, linking RTP values to the main physical/chemical characteristics of solids and equilibrium water chemistry. Valuable tool to document the results of the broad research already performed on RN retention/migration and to make available this knowledge in a well parametrized and generalized (not site specific) database.**
- **Rationale developed on the role of competitive effects, selected ligands, etc…**

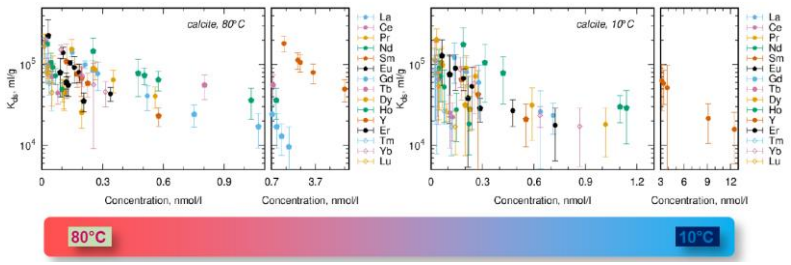
TASK 3 - EXPERIMENTAL PROGRAM

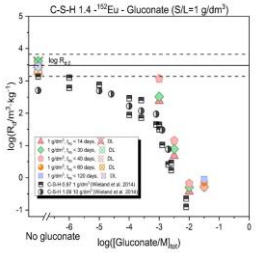
Lead: SCK CEN – Total pm: 303,8 – Start month 1 – End month 54

[Amphos21], [BGS], [BRGM], [CEA], [CIEMAT], [CTH], [CVUT], [EMPA], [FZJ], [GRS], [GTK], [EK], [HZDR], [IRSN], [KIT], [NNL], [PSI], [SCK CEN], [UHelsinki], [UNIMAN], [UJV], [UPOITIERS].

- **Task 3 includes new experimental activities needed to improve the knowledge of radionuclide transport behaviour in the presence of different (combined) perturbations specific to each analysed system**
  - **clay**
  - **crystalline rock**
  - **cementitious materials**



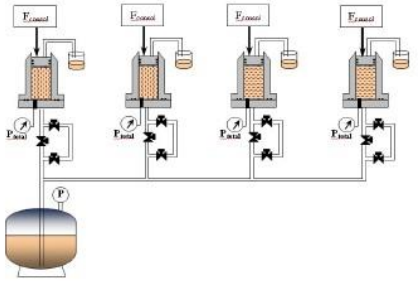


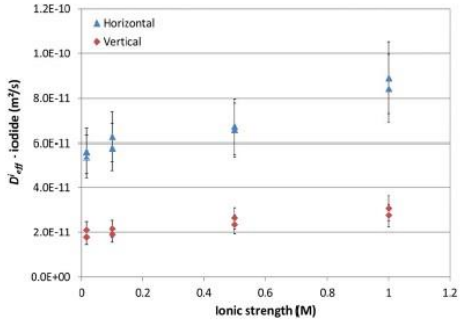


SUBTASK 3.1: EXPERIMENTAL STUDIES IN THE CLAY SYSTEM

Provide experimental data for clay systems to increase the understanding in the radionuclide (dissolved species) transport behaviour for the following perturbations:

- **temperature (higher T in deep underground, heat emitting waste, up to 90°C),**
- **partial desaturation (as result of ventilation & gas production by metallic waste),**
- **chemical perturbations: alkaline plume (cement from waste forms and EBS), ionic strength (nitrates & sulphates releases from "salt" bearing wastes), small organic molecules (organic degradation products, complexing ligands,… in waste).**





Use of experimental techniques - batch sorption studies and transport studies - supported by modern analytical tools.

Sorption data will feed the database developed in Task 2.3. Numerical interpretation and conceptual modelling of experimental data and observations will feed into Task 4. A strong interaction is foreseen

SUBTASK 3.2: EXPERIMENTAL STUDIES IN THE GRANITIC SYSTEM

Study of reactive transport of safety-critical elements/RNs in different crystalline rocks for diverse, perturbed geochemical boundary conditions.

RNs will reflect data gaps involving: influence of secondary phases, changes in pore-water composition, and pore structure.

Complementary experimental approaches will focus on:

(i) Characterization of natural intact and granulate rock samples (e.g. mineralogy, pore structure: connected porosity, fracture geometry).

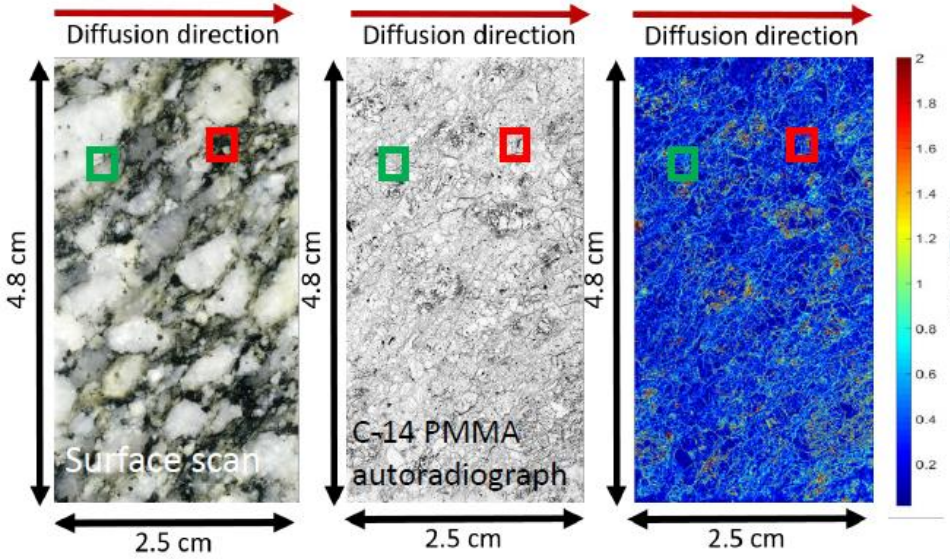
(ii) Heterogeneity of RN sorption (facture fillings, bulk).

(iii) Analyses of sorption processes and RN mobility in realistic systems.

(iv) Diffusion coefficients and anion exclusion.

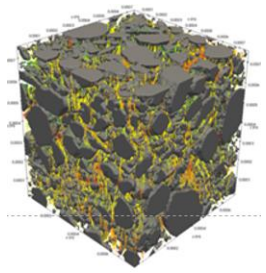
(v) Effects of perturbations (e.g. cementitious waters) on the evolution of mineralogy, geochemistry, and RN transport properties.

Data will be supplied for Task 4 and 5.

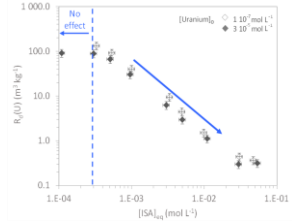


SUBTASK 3.3: EXPERIMENTAL STUDIES IN THE CEMENT SYSTEM

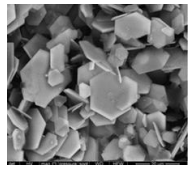
Improve the knowledge on the effect of ionic strength perturbations, limited to sulphate and nitrate, and the impact of the saturation degree on radionuclide migration through cement-based materials.



Model cementitious matrices, mainly hydrated cement paste, HCP, and individual cementitious phases like calcium-silicate-hydrate, calcium-aluminium-silicate-hydrate, magnesium-silicate hydrate, ettringite will be studied.



Describe at different scales the behaviour of the radionuclides in presence of the saline perturbation and eventually scale the results to concrete.



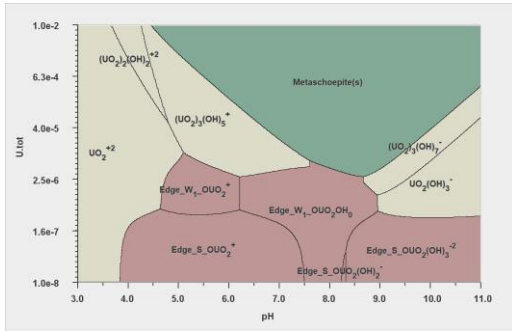
Effect of water saturation will be investigated only in HCP samples describing the evolution of the cement barrier during the operation period of a radioactive waste disposal facility.

Classification of radionuclides of interest to be studied (details currently under discussion): (i) reference radionuclides such as 3H (as tritiated water), (ii) 36Cl and 137Cs to access mobility without a major interaction between radionuclide and the perturbed cementitious matrices. (iii) reactive RN such as 35S, 125I, 63Ni(II), Am(III)/Cm(III), 75Se(IV), Th(IV), Pu and U(VI).

TASK 4 - DEVELOPMENT OF MACROSCOPIC/MECHANISTIC M

Lead: PSI – Total pm: 104,7 – Start month 7 – End month 54

[AMPHOS21], [ANDRA], [CIEMAT], [CTH], [EMPA], [FZJ], [GTK], [GRS], [HZDR], [IRSN], [KIT], [NNL], [NRG], [PSI], [SURAO], [TUL], [UHelsinki], [UJV], [UORLEANS], [UPOITIERS].



Develop combined deterministic models that describe chemical evolution, radionuclide behaviour and migration in perturbed systems. Model development makes extensive use of the results of previous projects (CORI, CEBAMA, FUTURE, DONUT…) additionally benefits from new experimental work conducted within this project (Task 3).

The mechanistic and process-based modelling approach specifically allows studying processes at the boundaries of different materials. Task 4 will provide an overview of the sorption parameters (and possibly types of sorption models) and support the database development in Task 2.3. The models developed in Task 4 will be used in the upscaling and benchmarking exercise that is foreseen in Task 5.

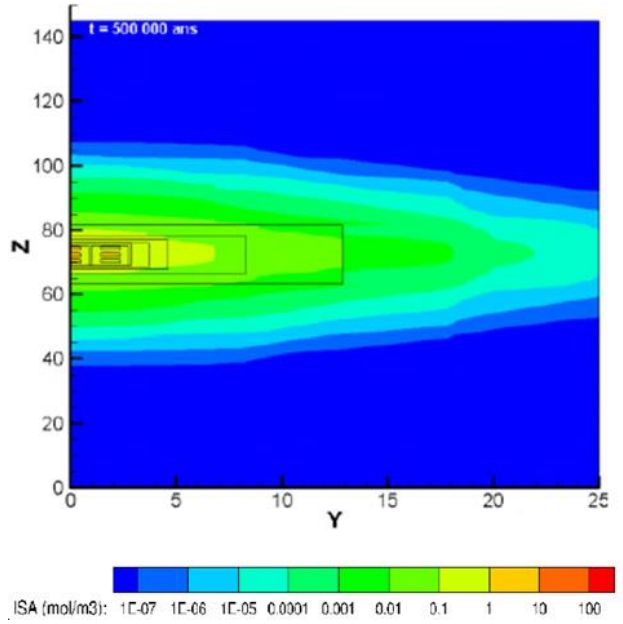
The modelling will be conducted using multiple modelling platforms:

TASK 5 - UPSCALING OF DATA AND MODELS – BENCHMARK

Lead: Andra – Total pm: 88 – Start month 7 – End month 54

[AMPHOS21], [ANDRA], [CIEMAT], [EDF], [GTK], [IRSN], [KIT], [LEI], [NNL], [NWS], [PSI], [SCKCEN], [SSTC NRS], [UNIMAN], [UORLEANS].

Improve the ability of models to represent perturbations and the effects on radionuclides at the disposal cell scale (meter to decameter scale) in support to Performance and Safety Assessment calculations.



Two main activities will be developed in Task 5.

(i) Upscaling define and analyse the appropriate simplifications needed to handle large scale modelling without losing fundamental information from lower-level scales.

(ii) The benchmark will test different modelling approaches in order to evaluate the impact of saline and organic plumes at the cell scale (from the waste to the far field).

EXPECTED STATUS AFTER YEAR 2

- **Full implementation of experimental program. Definition and documentation of experimental and modelling approaches and methodology completed.**
- **Preliminary data transfers. Clear processes developed for data transfers from Task 3 to Task 4 and Task 5. Data input from previous projects established.**
- **Retention/Transport Parameters Database (RTP-D) activity operative with concept for structuring and depositing data defined.**
- **Training Workshop in RAMPEC organised (focusing on early career researcher within a cross-WP perspective integrated in KM).**
- **Establishment of specific interactions and planned joint activities with other EURAD II WPs.**

EXPECTED OUTCOME YEAR 5

Technical outcome includes:

- **Targeted new experimental studies on radionuclide retention and transport (sorption, diffusion) under perturbed conditions. Studies comprise necessary experimental work to allow process understanding in complex systems. (=> Implementation Safety, Scientific Insight).**
- **Development of mechanistic models for retention and transport of radionuclides in complex physico-chemical systems, based on an accurate and realistic description of natural systems and chemical speciation (Task 4). This is including model based descriptions for *in-situ* conditions in the repository near field under external perturbations. (=> Implementation Safety, Scientific Insight).**
- **Development of a Retention/Transport Parameters (RTP) focusing on the specific systems to be investigated in RAMPEC. This will support modelling activities and serve as a proof-of-concept for potential related database projects beyond the scope of RAMPEC (Task 2). (=> KM).**
- **Upscaling and data transfer from small scale laboratory experiments to the disposal cell scale (meter to decametre scale) in view of PA requirements (Task 5). Including choice of « macroscopic » parameters and benchmarking. (=> Implementation Safety).**

DELIVERABLES

Number	Deliverable name	Short description	Lead participant	Type	Dissemi-nation level	Delivery date (in months)
D12.1	SOTA (initial)	Initial SOTA based on literature information	[KIT]	Report	PU	12
D12.2	Mid-Term Progress Report on RAMPEC Tasks 3, 4, 5.	Progress Report highlighting both experimental results and modelling activities in RAMPEC	[CIEMAT]	Report	PU	30
D12.3	Final Report on experimental studies.	Report integrating experimental studies in RAMPEC related to clay, crystalline, and cementitious systems	[SCK CEN]	Report	PU	52
D12.4	Final Report on modelling studies.	Report integrating modelling studies in RAMPEC Tasks 4 and 5 and Task 2.3	[PSI]	Report	PU	52
D12.5	SOTA (final)	Final SOTA updated with RAMPEC results	[KIT]	Report	PU	56
D12.6	Outcome/impacts report to Member States and End Users	Integrated report addressing Member States and End Users	[ANDRA]	Report	PU	58

MILESTONES

No.	Milestone name	Lead participant	Delivery date (in months)	Means of verification
M35	Detailed planning and definition of experimental program and modelling	[SCK CEN]	6	Document
M45	Documentation of R&D status and EUG exchange (with pdf including status summaries from each partner), with annual updates.	[KIT]	11 (23,35,47, 55)	Document
M73	Documentation of data inflow process from previous projects to Tasks 4 + 5.	[ANDRA]	18	Document
M93	Workshop on Sorption Database activity including exchange with external experts	[CIEMAT]	24	Document
M94	Organisation of Training Event focusing on young researchers in RAMPEC on "Radionuclide retention – experimental investigations, modelling and relevance to PA".	[PSI]	24	Meeting minutes
M132	Documentation of benchmark in Task 5.	[AMPHOS21]	48	Meeting minutes
M133	Exchange with Civil Society on RAMPEC research and impact.	[CIEMAT]	48	Meeting minutes
M139	Organisation of RAMPEC related session at large international conference.	[KIT]	54	Conference
M140	Final meeting with RAMPEC User Group to assess impact – documentation.	[KIT]	54	Meeting minutes

KEY PERFORMANCE INDICATORS

EURATOM Call objective	SRA Drivers	KPI at the WP level	Target by end of Y2 (number)	Target by end of Y5 (number)
Contribute to addressing scientific/technical challenges;	Scientific Insight	Number of State-of-the-Arts published	1	2
		Number of open access publications accepted	5	20
		Number of presentations at scientific conferences	15	40
Contribute to addressing the evolving regulatory concerns;	Implementation Safety	Number of events where regulators are invited to participate	2	5
Encourage the efficient use of R&D resources at EU level;	Knowledge Management	Number of interactions between WPs	2	5
		Number of mobility actions (undertake internships/exchange programmes)	3	8
Encourage a better transfer of knowledge across generations of experts and between experts from different fields of expertise.	Knowledge Management	Number of PhD/postdocs/ students	4	6
		Number of trainings lectures provided	2	5
		Number of events where non-EURAD-2 students can participate	2	4
		Number of mobility actions (visits, trainings courses, conferences)	3	8
		Number of networking events allowing cross-disciplinary sharing	1	2

INTERACTIONS OTHER WP2 IN EURAD-2

WP1 - Programme Management Office (PMO)
WP2 - Knowledge Management (KM)

WP5 - Innovative characterisation techniques for large volumes (ICARUS): Discussion on DTM (difficult-to-measure) radionuclides during ICARUS or RAMPEC meeting.

WP13 - HLW repository optimisation including closure (OPTI): Exchange on modeling results (Task 5).

WP14 - Near-surface diposal optimisation based on knowledge and understanding (SUDOKU): Organization of common workshop on radionuclide mobility in cementitious environment. Options for joint training activities exist.

WP16 - High fidelity numerical simulations of strongly coupled processes for repository systems and design optimisation with physical models and machine learning (HERMES): Exchange on modelling activities. Joint meeting / Student Event / Training Event.

WP18 - Development and Improvement of Quality Assured Thermodynamic Understanding for use in Nuclear Waste Disposal Safety Case (DITUSC): Exchange on thermodynamic data required or used in RAMPEC. Joint meeting / Student Event / Training Event.

END USER GROUP

RAMPEC will set up a User Group until PM 12, expected to consist of EU and non-EU partners.

User Group members will be:

- **invited to the RAMPEC Annual Meetings, asked to review project documents, and provide feedback and recommendations.**

At the Annual RAMPEC Meetings, a specific session will be organized with the User Group to enhance exchange and provide feedback options.

As of October 2024, several groups have expressed interest to participate RAMPEC User Group (partly needing confirmation…):

WMOs: SKB (SE), Ondraf-Niras (BE), SURAO (CZ), Posiva (FI), NWS (UK), JAERI (Japan)

REs: PNNL (USA), SNL (USA), POSTECH (Korea), KAERI (Korea).

We expect additional End-Users over the first year in RAMPEC… If interested, contact RAMPEC Board…

FIRST ANNUAL RAMPEC WP MEETING

The Annual RAMPEC Workpackage Meetings are key events in RAMPEC, clustering several activities.
Annual 2-3 day in-person meetings, organised in an effective and cost-efficient way, planned for end of March / start April 2024.

- **Technical presentations by each of the RAMPEC partners.**
- **Topical session focusing on an aspect of particular interest.**
- **Exchange and network with other EURAD-2 WPs and ICS representatives.**
- **PhD oriented specific sessions…**
- **Discussion and exchange with the End-User Group in RAMPEC.**
- **Content of presentations and status of each group summarised in related MS documents.**

PRESENT STATUS AND OUTLOOK TO YEAR 1

- RAMPEC will focus on fully implementing the project, supported by regular communications within the RAMPEC partners, the RAMPEC Board and with the PMO.
- NOW: discussion and definition of details regarding the exp. and mod. program (Tasks 3, 4, 5)… (month 6)
- Start of experimental program and activities on the creation of a Retention/Transport Parameters Database. (from months 7)
- Start of modelling studies in Task 4 and further exchange on methodology and tools. Initiation on the work in Task 5 related to the upscaling studies, e.g. discussion on appropriate simplifications.
- Organisation of the in-person Kick-off meeting in RAMPEC will be a key activity in Year 1! (03/04 2025)
- Interactions with KM, completion of Del and MS – initial SOTA, reporting, start of interactions with other WPs in EURAD-2, Exchanges with past projects, definition of RAMPEC User Group…
- Dissemination of RAMPEC, e.g. at FISA-EURADWASTE or Migration ’25 conference.

Thank your for your attention !

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