FISA EURADWASTE 2025

SNETP Forum

RAMPEC: A WORKPACKAGE IN EURAD-2 FOCUSING ON RADIONUCLIDE MOBILITY UNDER PERTURBED CONDITIONS

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RAMPEC – scope and projected results

RAMPEC is an R&D activity in EURAD-2 with a 5 year duration (2024-2029).

Aim of RAMPEC is to 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 disposal cell scale.

- 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 provides 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 of three systems (Clay, Granite, Cement) with a limited number of specific perturbations investigated.

RAMPEC INCLUDES 32 GROUPS FROM 13 COUNTRIES

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

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

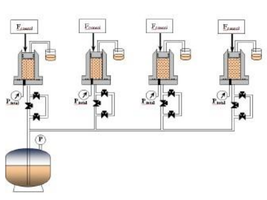
TASK 2 - KNOWLEDGE MANAGEMENT

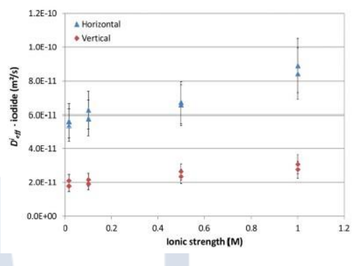
In addition to the overarching KM Tasks in EURAD-2, RAMPEC will provide a proof of concept for the creation of a substantiated Retention/Transport Parameters (RTP) database, linking RTP values to the main physical/chemical characteristics of solids and equilibrium water chemistry. => Valuable tool to document the results of the research already performed on RN retention/migration and to make available this knowledge in a well parametrized and generalized (not site specific) database.

TASK 3.1: EXPERIMENTAL STUDIES IN THE CLAY SYSTEM

Provide experimental data for clay systems to increase understanding of 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 released from "salt" bearing wastes), small organic molecules (organic degradation products, complexing ligands,... from waste).





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

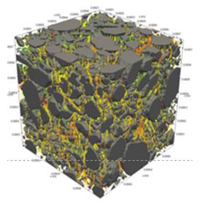
TASK 3.2: EXPERIMENTAL STUDIES IN THE GRANITIC SYSTEM

Study of reactive transport of safety-critical elements/RNs in different crystalline rocks for diverse, perturbed geochemical boundary conditions. RNs investigated reflect data gaps involving: influence of secondary phases, changes in pore-water composition, and pore structure.

Complementary experimental approaches focus on:

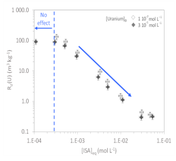
(i) Characterization of natural intact and granulate rock samples (e.g. mineralogy, pore structure: connected porosity, fracture geometry).
(ii) Heterogeneity of RN sorption (facture fillings, bulk).
(iii) Analyses of sorption processes and RN mobility in realistic systems.
(iv) Diffusion coefficients and anion exclusion.
(v) Effects of perturbations (e.g. cementitious waters) on the evolution of mineralogy, geochemistry, and RN transport properties.

TASK 3.3: EXPERIMENTAL STUDIES IN THE CEMENT SYSTEM

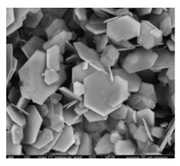


Improve the knowledge on the effect of ionic strength perturbations, limited to sulphate and nitrate, and the impact of the saturation degree on radionuclide migration through cement-based materials.

Cementitious model matrices, mainly hydrated cement paste, HCP, and individual cementitious phases are studied.

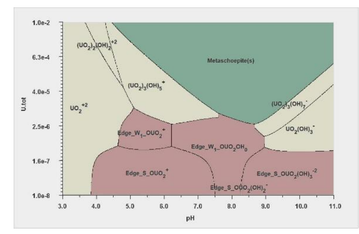


Effect of water saturation is investigated only in HCP samples describing the evolution of the cement barrier during the operation period of a radioactive waste disposal facility.



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

TASK 4 - DEVELOPMENT OF MACROSCOPIC/MECHANISTIC MODELS

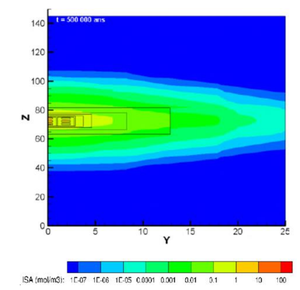


Develop combined deterministic models that describe chemical evolution, radionuclide behaviour and migration in perturbed systems. Model development makes use of the results of previous projects (CORI, CEBAMA, FUTURE, DONUT...) and new experimental work in RAMPEC.

The mechanistic and process-based modelling approach specifically allows studying processes at the boundaries of different materials. Task 4 provides an overview of the sorption parameters (and possibly types of sorption models) and support the RTP database development in RAMPEC Task 2.

The models developed will be used in the upscaling and benchmarking exercise that is foreseen in Task 5. The modelling is conducted using multiple modelling platforms: Thermodynamics in PhreeqC and GEMS; Pore scale molecular dynamic simulations using LAMMPS; pore-scale and reactive transport by coupling OpenFOAM or another transport code with PhreeqC or ORCHESTRA.

TASK 5 - UPSCALING OF DATA AND MODELS – BENCHMARKING



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.

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

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

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