EURAD-2 WP description Template #2

Please see Instructions for Work Package Preparation Team, public document for guidance (available on EURAD and PREDIS websites)

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Short Acronym and full Title	SUDOKU: Near-SUrface Disposal Optimization based on Knowledge and Understanding		
Type of activity	☒R&D	☐Strategic Study	Knowledge Management – covered by a separate committee and template
Budget estimation (total budget in M€, i.e ~ 1.5 M€)	5 M€	Duration of the WP (inmonths)	60
Links with EURAD SRA / Roadmap Themes (if multiple choices, indicate the primary link **in bold – maximum 3**)	☐Programme Management (Theme 1) ☐Pre-disposal (Theme 2) ☒Engineered Barrier Systems (Theme 3) ☐Geoscience (Theme 4) ☒**Disposal facility design and optimisation (Theme 5)** ☐Siting and Licensing (Theme 6) ☒Safety Case (Theme 7)		
Links with EURAD SRA topics (if multiple choices, indicate the primary link **in bold – maximum 3)**	*Please indicate the corresponding Domains (number) and Description of R&D, StSt or KM needs (second column of SRA)* 3.3.2 - Improved quantification and understanding of cement-based material evolution (including low pH cements) to improve long-term modelling and assessments for near-surface and geological disposal **5.1.1 Conditions for Closure** 5.2.1 Verify robustness of disposal system designs using large scale mock ups		
SRA drivers**(maximum 3)**	☒Implementation Safety	☐Tailored Solutions	☒Scientific insight
	☒Innovation for Optimisation	☐Societal Engagement	☐Knowledge Management
Objective (What) **– 1 sentence**	Understanding the behaviour and performances of (i) covers and (ii) cementitious barriers of near-surface disposal facilities for short lived waste (ground level facilities) and ILW (shallow deep facilities) in view of these barriers optimization to ensure the long-term safety of disposal facilities.		

Justification: impact / innovation / added-value (Why) – bullet points or short paragraph **(maximum quarter of a page)**	In the context of surface disposal facilities for short-lived LLW/ILW, the properties evolution with time of the multilayer cover and the cementitious barrier system are key parameters in terms of dose calculations which are closely related to mobile radionuclides. The water flux passing through the disposal facility is strongly linked to the durability of the cementitious barriers and influences the migration of mobile radionuclides. The impacts of cracks and the presence of steel corrosion products on radionuclide transfer are not yet very well described and need to be appropriately addressed in the safety assessments. The SUDOKU approach is to combine the investigations on the multilayer cover with the durability of cementitious barriers to assess the transfer properties of mobile radionuclides (^{36}Cl, ^{14}C, ^{99}Tc,..) ,..) in damaged cementitious barriers according to the chemo-mechanical evolution. The novelty of SUDOKU consists of (i) evolution of hydraulic properties of the cover with on-site experiments, (ii) experimental and modelling data about degradation of reinforced and unreinforced concretes in near surface disposal conditions, and (iii) transport properties of mobile radionuclides in cracked and corroded reinforced cement-based materials. SUDOKU will provide understanding and assessing of the long-term integrity evolution of the multilayer cover under different climate change scenarios contributing to the optimization of this important barrier designed to seal the surface disposal facilities. The better characterization of the durability of the cover and the cementitious barriers achieved by the work proposed to be performed in SUDOKU will reduce the uncertainties and improve the safety assessments, in particular by taking into account the chemo-mechanical evolution of cement-based materials in terms of radionuclide transfer parameters. The use of proven models in combination with on-site and laboratory studies will ensure the necessary reliability of the results and the determination of the optimal EBS configuration from the point of view of the safety of LLW/ILW disposal.
List of planned tasks / subtasks with % of effort per task (5% increments) **(Maximum 10 bullets)**	• **Task 1: Management/coordination of the WP, 5%** • **Task 2: Knowledge Management (incl. training materials development and State-of-the-Art for R&D WPs, layout, etc.), 10%** • **Task 3: Performance of multilayer covers, 35%** - Sub-task 3.1: Lab scale experiments on long-term interactions (different time-developing conceptual stages) affecting the mechanisms that control cover effectiveness; - Sub-task 3.2: On-site experiments on an existing multilayer cover mock-up (including instrumentation systems); • **Task 4: Chemo-mechanical evolution of reinforced and unreinforced cementitious barriers and the effect on the migration of mobile radionuclides, 35%** - Sub-task 4.1: Cementitious materials ageing and degradation - CMH evolution(lab-scale and possible on-site experiments) - Sub-task 4.2: The corrosion of steel reinforced materials (lab-scale experiments) - Sub-task 4.3: Effect of CMH evolution of cementitious materials

	and steel corrosion products on the migration of mobile radionuclides (lab-scale experiments) • **Task 5: Modelling of the evolution of the EBS and its effect on radionuclide migration on the basis of the experimental results obtained in Tasks 3 and 4, 15%**
List of expected outcomes linked to the identified SRA drivers **(Maximum 6 bullets)**	• Understanding the factors that control different combinations of layers in the multilayer cover structure (water and energy flows, erosion, …) and the long-term performances of the cover (*Innovation for optimisation*); • Improve the understanding of the cementitious barriers degradation and its effect on the transfer properties of mobile radionuclides (*scientific insight* and *implementation safety*); • Recommendations for future optimizations of repository designs to improve the repository safety (*implementation safety*).
Deliverables **(Maximum 6 – including the prescribed deliverables)w**	• D1. Initial SOTA on repository concepts, safety functions and performances of engineered barriers, and optimisation requirements (from cost and safety point of view) • D2. Updated SOTA on repository concepts, safety functions of engineered barriers, their durability and ageing, and optimisation requirements (from a cost and safety point of view) • D3. Technical report on the R&D results on multilayer covers performances (Task 3) • D4. Technical report on R&D results on the transfer of mobile radionuclides in cementitious barriers as a function of their chemo-mechanical evolution (Task 4) • D5. Technical report on the modelling of the processes occurring in the cementitious barriers (Task 5) • D6. Final Report integrating the RD&D performed, including recommendations for optimization to be included in the Safety Assessment and the impact of the outcomes on Member States and End User
Critical input requirements & identified risks	Critical input: - Experimental data to be used as input for the modelling performed in Task 5 Identified risks: • delays in the modelling activities
Major achievements expected by end of Year 2 (Go/No Assessment)[1] **(Maximum 5**	• Setting-up the on-site experiments to assess the multilayer cover performance and the first outcomes on the cover sustainability, development of freeze/thaw and drying/wetting cycles. • First outcomes on the chemo-mechanical evolution of the cement-based materials for several formulations (W/C, cement type,..) and input data regarding the steel corrosion products to assess the

[1]EC budget being only allocated for the first 2 years, each work package progress will be reviewed at the end of Year 2, to assess its continuation based on the total budget that EURAD-2 will be granted.

bullets)	influence on the migration of mobile radionuclides • Preparation of diffusion experiments on damaged cement-based materials for mobile radionuclides • Definition of the numerical tools for the modelling activities
(Optional - Explain what is out of the scope?)	Modelling for safety assessment
List of preliminary interested organisations as partners in the WP contributing effort; **% of effort (person months, by College)**	REs (65%): Amphos 21/ES, CEA/FR, CNRS/FR, CSIC/ES, CTU/CZ, EDF/FR, EGIS/UK, EK/HU, ENEA/IT, GLS/UK, IFE/NO, IJS/SI, LEI/LT, POLIMI/IT, PSI/CH, RATEN/ RO, SCK-CEN/BE, TUL/CZ, UAM/ES, UJV/CZ, Univ-Lille/FR, UniHelsinki/FI, ZAG/SL TSOs (20%):BEL V/BE, CIEMAT/ES, EIMV/SL, GI-BAS/BG, IRSN/FR, Mine Paris/Fr, SURO/CZ, SSTC NRS/UA, VTT/FI, NTW WMOs (15%): ANDR /RO, ANDRA/FR, ARAO/SL, ENRESA/ES, NWS/UK, ONDRAF/NIRAS/BE End-users: NAGRA/CH; NRG
If applicable - links with previous projects / work packages	MODATS, MAGIC, CORI, ACED, CEBAMA, FUTURE, CAST
WP Preparation Team (1 member per College) contact (**organisation + person**, email)	RE: RATEN, Crina Bucur, crina.bucur@nuclear.ro TSO: SSTC NRS, Oleksandr Solovyov, os_soloviov@sstc.ua WMO:ANDRA, Pierre Henocq, pierre.henocq@andra.fr CG observer: Amphos 21, Lara Duro, lara.duro@amphos21.com