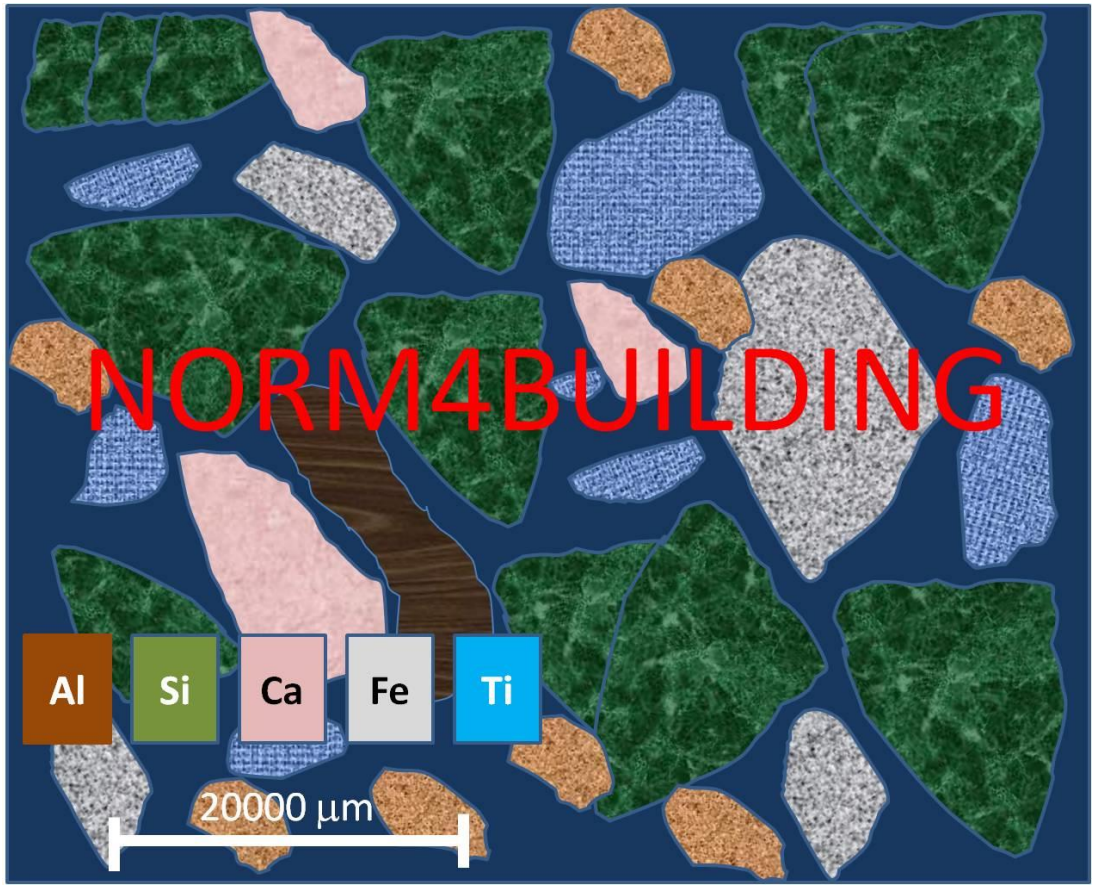
How can NORM4BUILDING support the management of NORM residues?



Scientific Seminar BVS/ABR - 'Why should we be concerned about NORM?'

Wouter SCHROEYERS,

NuTeC, UHasselt, Belgium

Transport and Urban Development (TUD)

NuTeC

Nuclear **Te**chnological **C**enter (NuTeC, www.nutec.be)

Center of Environmental Studies (CMK, www.uhasselt.be/cmk)

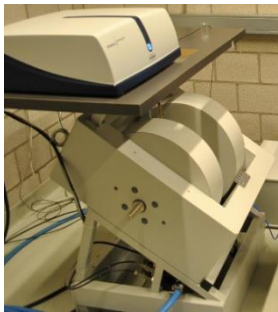
Industrial Sciences: **"Nuclear and environmental Engineering"**

- Environmental Technology-Radiochemistry
- Medical Nuclear Technology

Application and development of nuclear measurement methods

Environmental and energy related research

Dosimetry



Introduction

- During the 20th Century
  - ➔ **fossil fuel use** of the world increased **12 times**
  - ➔ **34 times** more **raw materials** were extracted

- An average European consumes 16 tons of materials per year (2011)

- Era of cheap and abundant resources is ending.
  - Europe, as a **resource poor continent** is particularly vulnerable
  - Reuse of secondary raw materials becomes a **necessity**

COM(2011) 571 (*Roadmap to a Resource Efficient Europe*)
COM(2011) 25 (*Communication on Commodity Markets and Raw Materials)*
COM(2011) 25 *(Communication on Commodity Markets and Raw Materials)*

“NORM processing Industries”

By-products (with interesting properties for reuse in construction materials)	Codification EU-Waste Catalogue?	Estimated production (Milion Tons/year)
coal fly-ash	001 02 or 10 01 16	44 (2003, EU 15) [1]
slag and bottom ash from a coal-fired power plant	10 01 01 or 10 01 14	8 (2003, EU 15) [1]
phosphorous slag from thermal phosphorus production	06 09 02	-
phosphogypsum from phosphoric acid production,	-	180 (2003, World) [2]
red-mud, (bauxite residue), from alumina production	01 03 07	120 (2003, World) [3]
unprocessed slag from primary iron production	10 02 02	260-310 (2011, World) [4]
steel or stainless steel, lead slags	10 04 01	130-210 (2011, World) [4]
copper slags, from primary and secondary production.	10 06 01	24,6 (2009, World) [5]
tin slags from primary and secondary production	-	-
specific residues originating from pyro- and hydro-metallurgies producing platinum group metals or rare earth elements	-	-

[1] Ecoba - SPECIAL PRINT CPI 04/06
[2] A.B. Parreira, A.R.K. Kobayashi Jr., O.B. Silvestre, J. Environ. Eng. 129 (2003) 956–960
[3] www.redmud.org/Disposal.html
[4] U.S. Geological Survey, Mineral Commodity Summaries, January 2012
[5] S.H. Chew, S.K. Bharati, Proc. Of Int. Symp. On Geoenvironmental Eng., ISGE2009, 705, 2009

Concrete: replacing the cement and/or aggregates with by-products

- Conservatively estimated:

	Current by-product use (wt%)		Studied by-product use in the future (wt%)	
	Cement	Aggregates	Cement	Aggregates
Fly ash	25	–	25	35 (fine)
Blast furnace slag*	50	–	50	50 (coarse)

* Granulated for cement and slowly cooled for aggregate.

New perspectives and issues arising from the introduction of NORM residues in building materials: A critical assessment on the radiological behaviour, C. Nucceteli et al, Construction and building materials 82 (2015) 323-331

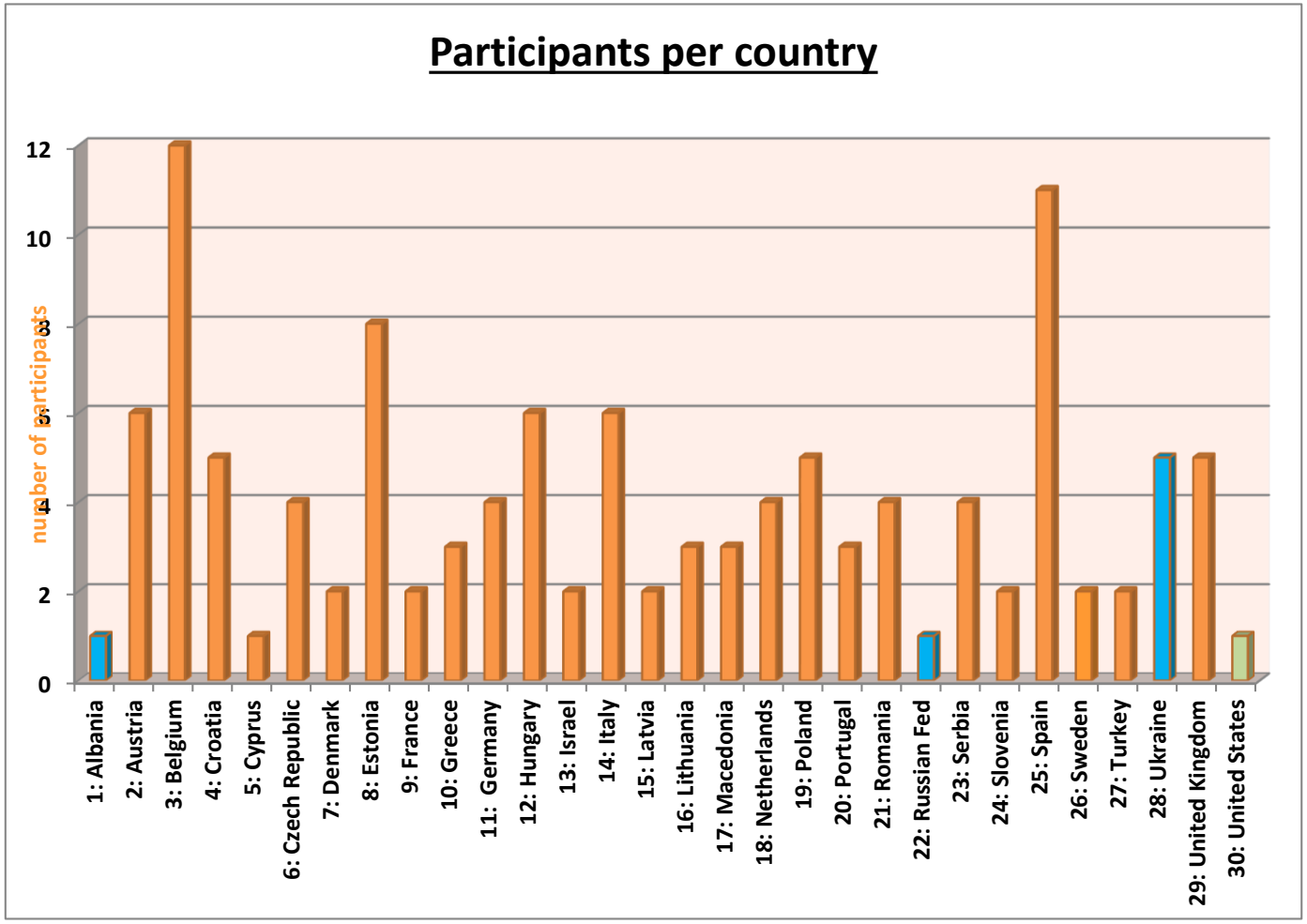
Main objective ‘NORM4BUILDING’

- Exchange of multidisciplinary knowledge and experiences (radiological, technical, economical, legislative, ecological, …)

Stimulate the
reuse of by-products in new tailor-made sustainable building materials

While
assuring (radiation) protection of the population / environment

Collaboration in the Cost network



- 120 experts from 30 countries

How can NORM4BUILDING support the management of NORM residues?

COST Action

NORM4BUILDING

1. **Building a database on by-products & construction materials**
2. Exploring new reuse options
3. Optimizing measurement protocols
4. Tools for evaluation of practises

Data mining

1. Selection → 2. Text Mining filter → 3. Natural Language Processing → 4. Extraction → 5. Text Link Analysis → 6. Structuring

Building the NORM4Building database:

- **By-products & reuse options**

- **Semi-automatic approach for data collection**
  - ~68.000 publications processed (from Science Direct, Web of Science, etc…)
  - ~7.300 samples have been identified from the relevant publications.
  - **Manual validation of entries**

www.norm4building.org

G. Bator et al, V. Terrestrial Radioisotopes in Environment International Conference on Environmental Protection, 17-20th May (2016), Veszprém

Manual and semi-automatic data collection

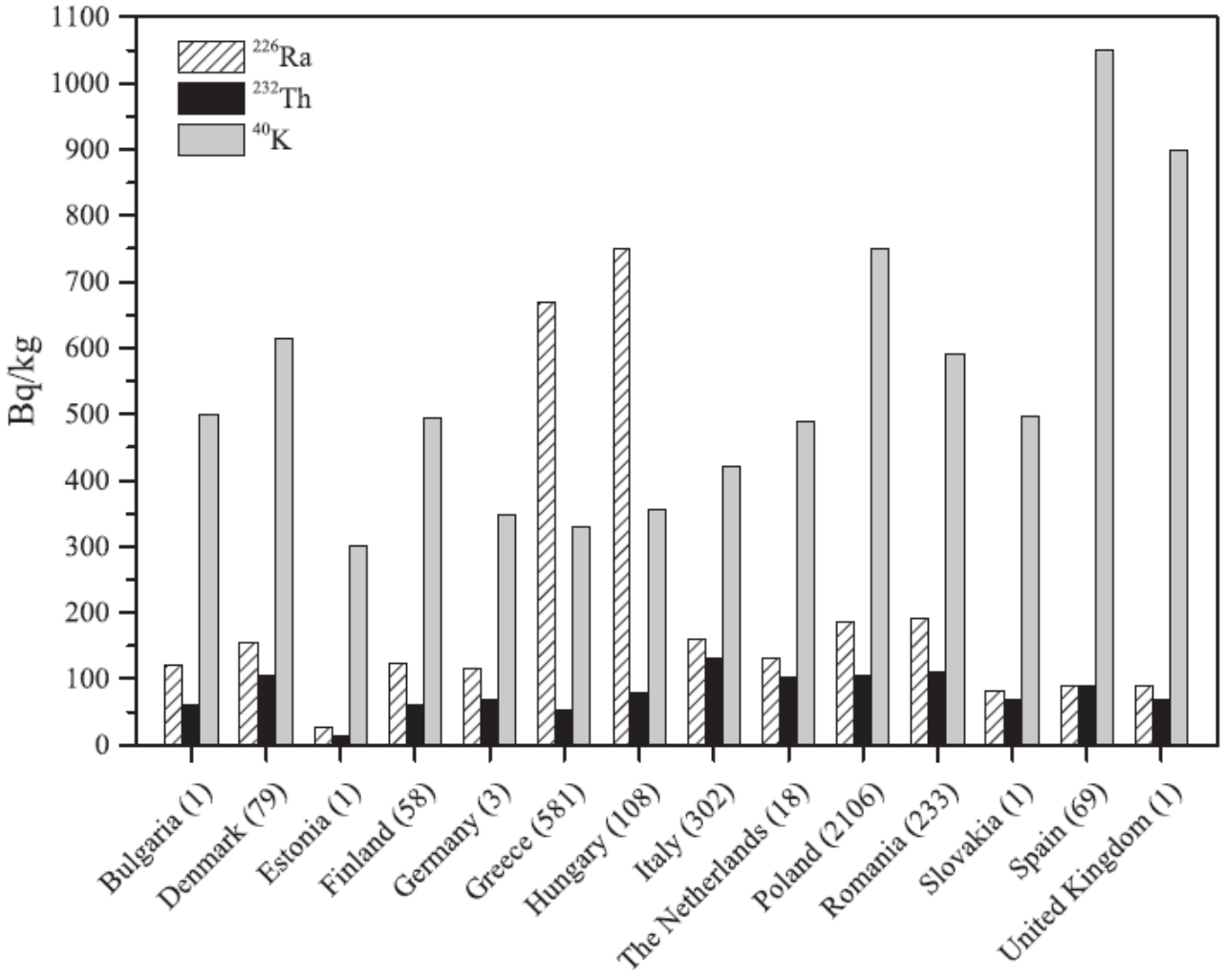


Fig. 1. Natural radionuclides concentrations in fly and bottom ashes used in building materials (14 EU_MS – 3561 samples)

C. Nuccetelli et al, New perspectives and issues arising from the introduction of (NORM) residues in building materials: A critical assessment on the radiological Behaviour, Construction and building materials 82 (2015), 323-331

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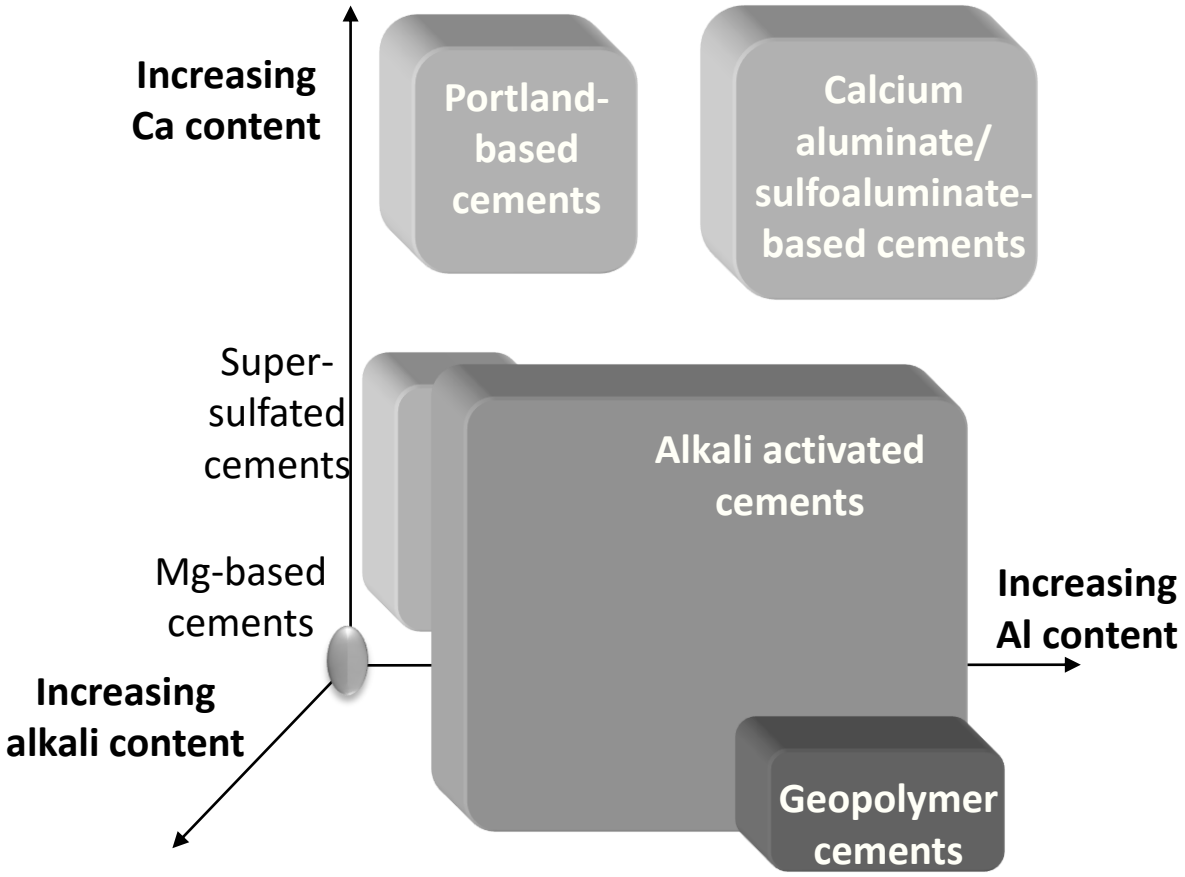
Technical properties determine reuse options

Portland cements & concretes	Alkaline activated cements & concretes	Ceramics
Coal fly ash / bottom ash	Coal fly ash	Coal fly ash
Slags from iron and steel production	Steel melting slag	Steel slag
Copper slag	Nonferrous slag	Zircon and zirconia
Red mud	Red mud	Aluminium-rich wastes
Phosphogypsum	Blast furnace Slag	Refractories

C. Nuccetelli et al, New perspectives and issues arising from the introduction of (NORM) residues in building materials: A critical assessment on the radiological Behaviour, Construction and building materials 82 (2015), 323-331

Traditional & non-traditional cements



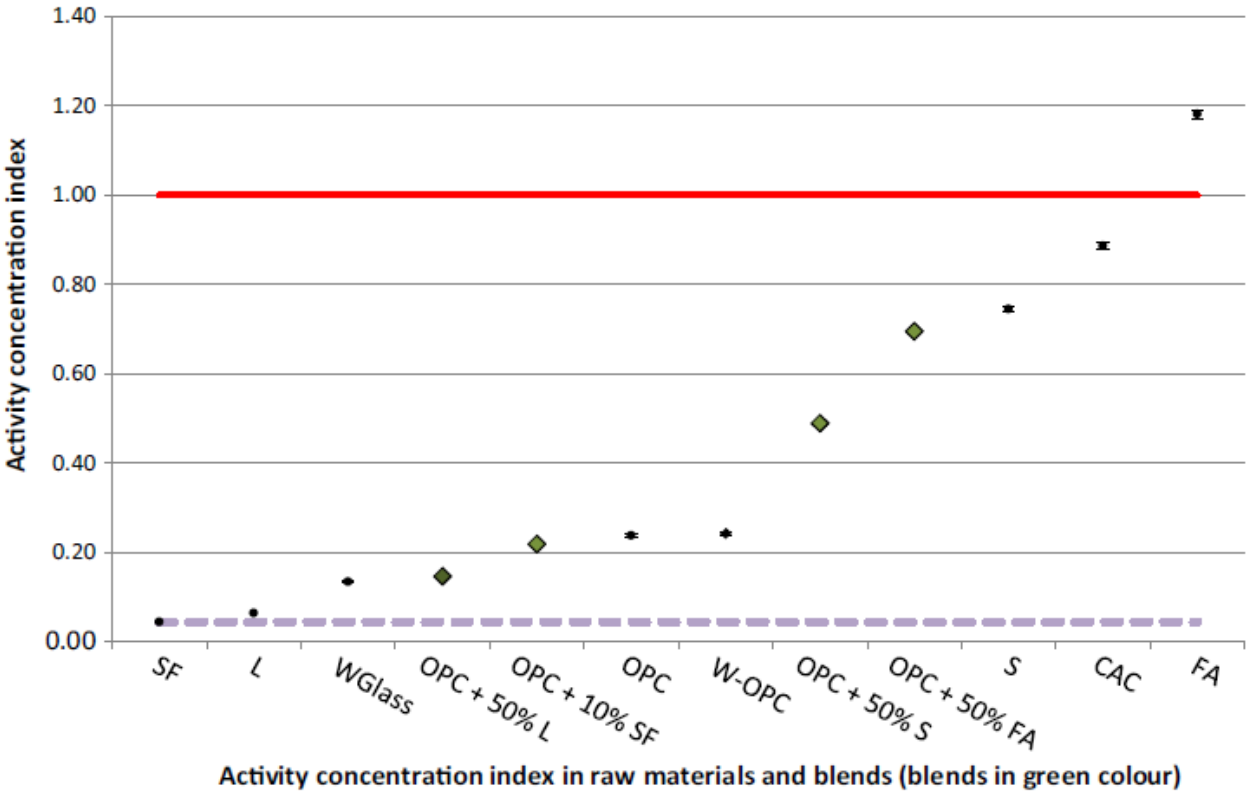
Moving from a single universal cement to an array of cement types

Offering a toolkit to deal with country specific circumstances

Most important: Designing materials that are fit for purpose!

J.L. Provis & J.S.J. van Deventer (eds.), State of the Art Report of RILEM TC 224-AAM, 2014

Studies combining chemical & radiological information



- SF (Silica Fume)
- L (Limestone)
- Wglass (Glass waste)
- W-OPC (White ordinary Portland cement)
- S (Slag)
- CAC (Calcium aluminate cement)
- FA (Fly ash)

Dedicated issue of NORM4Building will soon be published in Journal of environmental radioactivity

F. Puertas et al, Radiological characterisation of hydrated cements and geopolymers, construction and building materials, 101 (2015) 1105-1112

Reuse of NORM in construction?

- **Size** of the by-product stream?
- **Environmental and health** issues?
- Potential **market?**
- **Acceptance/perception** aspects?
- **Cost** aspects throughout the chain?
- **Competition** with other by-products?
- CE marking and other **certification** aspects?
- …

Acceptance/perception aspects?

- Terminology is important for reuse
- “Waste” – “Residue” – “By-product”
- “NORM”
  - If it’s not subject to regulation, it’s not NORM

NORM4Building 'the book'

- Title: "**Use of by-products in construction materials considering natural radioactivity**"

- Expected publication date: **June 2017**

- Topics:
  - Technical, chemical, radiological, economical,… aspects of reuse of NORM in construction
  - End of life and reuse of NORM containing construction materials
  - Measurement challenges for characterization of NORM containing construction materials

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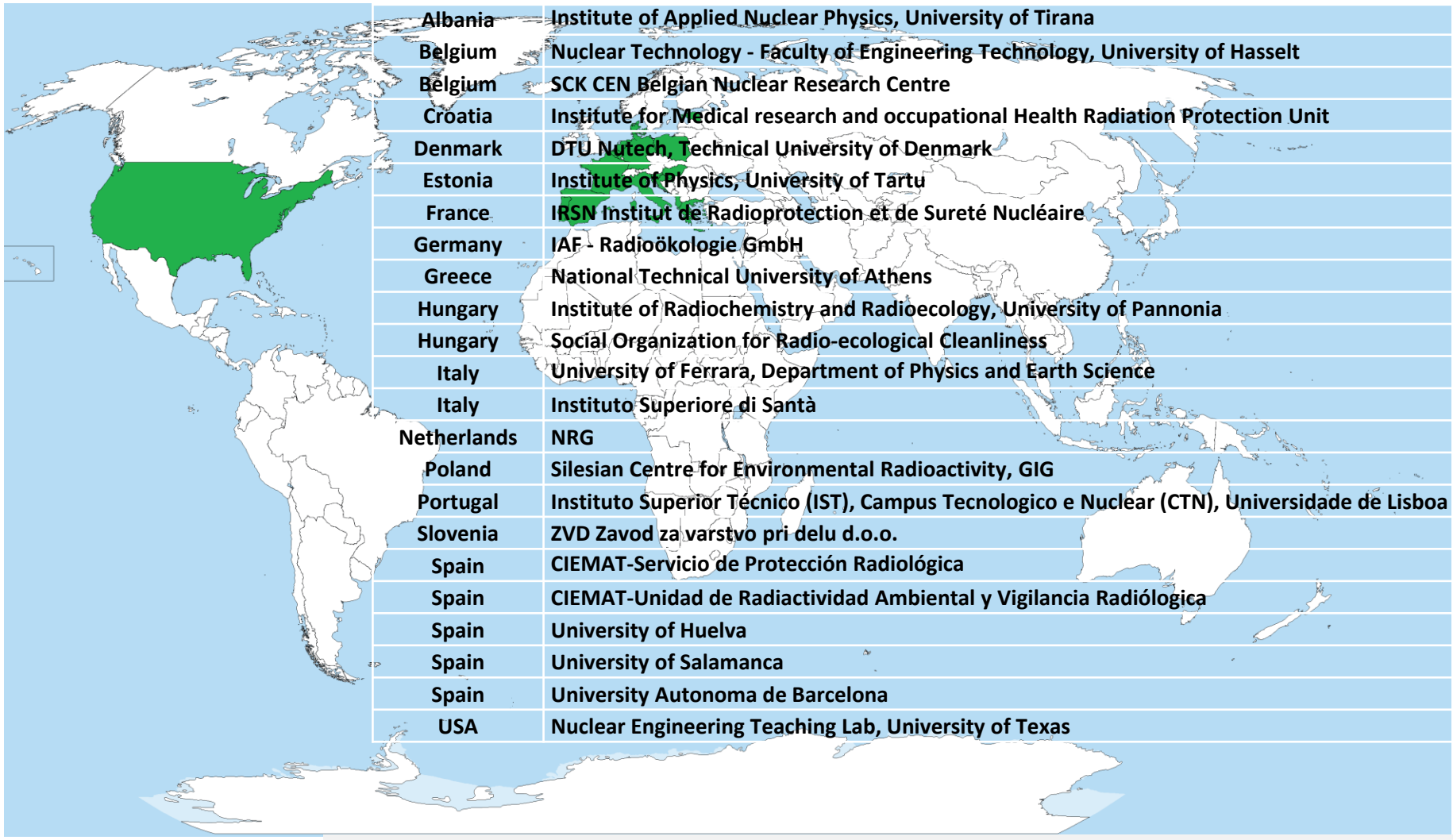
Intercomparison



Country	Organization/Institute
Albania	Institute of Applied Nuclear Physics, University of Tirana
Belgium	Nuclear Technology - Faculty of Engineering Technology, University of Hasselt
Belgium	SCK CEN Belgian Nuclear Research Centre
Croatia	Institute for Medical research and occupational Health Radiation Protection Unit
Denmark	DTU Nutech, Technical University of Denmark
Estonia	Institute of Physics, University of Tartu
France	IRSN Institut de Radioprotection et de Sureté Nucléaire
Germany	IAF - Radioökologie GmbH
Greece	National Technical University of Athens
Hungary	Institute of Radiochemistry and Radioecology, University of Pannonia
Hungary	Social Organization for Radio-ecological Cleanliness
Italy	University of Ferrara, Department of Physics and Earth Science
Italy	Instituto Superiore di Santà
Netherlands	NRG
Poland	Silesian Centre for Environmental Radioactivity, GIG
Portugal	Instituto Superior Técnico (IST), Campus Tecnologico e Nuclear (CTN), Universidade de Lisboa
Slovenia	ZVD Zavod za varstvo pri delu d.o.o.
Spain	CIEMAT-Servicio de Protección Radiológica
Spain	CIEMAT-Unidad de Radiactividad Ambiental y Vigilancia Radiólogica
Spain	University of Huelva
Spain	University of Salamanca
Spain	University Autonoma de Barcelona
USA	Nuclear Engineering Teaching Lab, University of Texas

16 Countries
23 Labs

G. Xhixha et al., first intercomparison among laboratories involved in COST Action-TU1301 "NORM4Building": Determination of natural radionuclides in ceramics, Journal of Environmental Radioactivity (2016) accepted article

Optimizing measurement protocols

- Efficiency calibration using certified reference materials of natural origin
  - Validation of efficiency calibration:

Reference material	Matrix	Radionuclide	Certified activity (Bq/kg)	Measured activity (Bq/kg)	Relative bias (%)	Within 1σ agreement
IAEA-434	Phosphogypsum	^{226}Ra[a]	780 ± 62	747 ± 45	−4.23	Yes
IAEA-448	Soil from oil field	^{226}Ra[a]	19,050 ± 260	18,376 ± 1060	−3.54	Yes
		^{208}Tl[b]	555 ± 26	521 ± 32	−6.13	Yes
		^{212}Pb[b]	1623 ± 69	1578 ± 97	−2.77	Yes
		^{228}Ac[b]	1166 ± 55	1020 ± 65	−12.52	No
		^{40}K[b]	234 ± 12	244 ± 32	4.27	Yes

[a] Certified value

[b] Informative values

G. Xhixha et al, Calibration of HPGe detectors using certified reference materials of natural origin, journal of radioanalytical and nuclear chemistry, 307 (2016) 1507-1517

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Improving screening tools

$$I = \frac{C_{Ra-226}}{A(\rho d)_{Ra-226}} + \frac{C_{Th-232}}{A(\rho d)_{Th-232}} + \frac{C_{K-40}}{A(\rho d)_{K-40}} \leq 1$$

- New index to estimate the gamma dose rate from the activity concentration in building material taking into account the density and the thickness of the materials

C. Nuccetelli et al, A new accurate and flexible index to assess the contribution of building materials to indoor gamma exposure, journal of environmental radioactivity, 143 (2015) 70-75

Conclusion

- Datamining & the NORM database can aid to provide (continuously) updated information
- The book = a tool of guidance
- Interaction between experts regarding construction & radioactivity
  - More realistic scenarios, models,…
- A lot of research in on the way in a field where a lot of information is lacking…
  - New reuse and management options are being explored

Upcoming events

- Meeting in Stockholm, Sweden
  - **05-07/12/2016,**
  - **Linked to EAN-NORM** workshop on "**Building materials & the new EU-BSS**"

NORM4BUILDING

EANNORM

www.norm4building.org

http://ean-norm.eu/stockholm/

Upcoming events

“Use of by-products in construction: dealing with natural radioactivity”

FINAL Symposium of “NORM4Building”

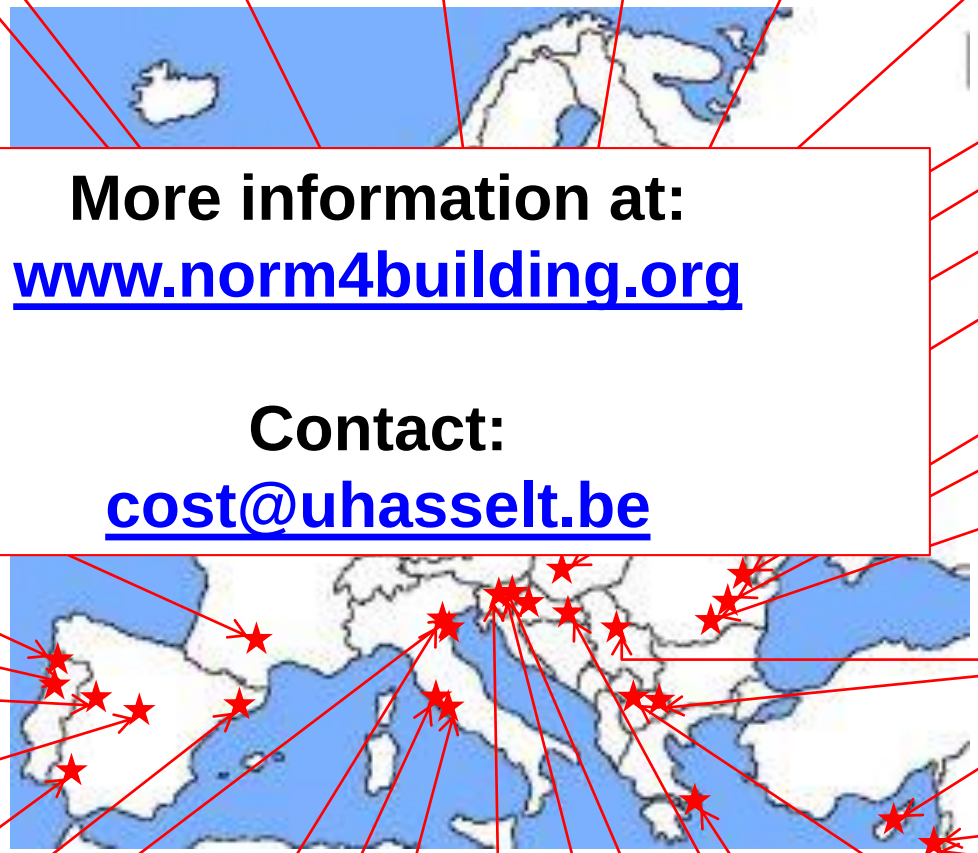
More info @ www.norm4building.org

Venue: National Institute of Health, **Rome**

Dates: **06-08th June 2017**

Supporting Partners:

NORM4Building COST Network



More information at:

www.norm4building.org

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