A new pathway to recycle NORM in building materials – a COST Action initiative

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Since the birth of the Earth, very long-lived natural occurring radionuclides and their decay products have been present in the planet's crust. These radionuclides occur in the mineral ores that we mine to produce the materials that we need. Upon extracting metals from ores or burning resources for the production of electricity and heat, the naturally occurring radionuclides are concentrated in (waste) residues that are produced in very large quantities. Typical examples of residues that, depending on the origin of the ores and the used industrial process, can contain enhanced concentrations of naturally occurring radioactive materials (NORM) are:

- fly ash produced in large quantities from coal burning;
- phosphorous slag from thermal phosphorus production;
- unprocessed slag from primary iron production;
- lead, copper and tin slags from primary and secondary production;
- phosphogypsum of the phosphate industry;
- red mud of the aluminum processing industry.

Wouter Schroeyers measuring NORM residues. A small detection portal for radiological material in the background

The depletion of energy resources and raw materials demands the introduction of sustainability in the construction sector and construction material production. In the development of new synthetic building materials, the reuse of (waste) residue streams, especially residues that are produced in large quantities, becomes a necessity. This is even more the case if the reuse can increase the energy efficiency of the production process or can contribute to a reduction in CO2 emissions. The listed NORM containing residues have excellent technical properties for reuse in cement, concrete or ceramics and can bring this kind of added value.

Estimations suggest that cement production is responsible for 5% to 7% of the worldwide CO2 emission. Adding alternative raw materials with low embodied CO2 as well as supplementary cementitious materials reduces the cement CO2/mass. Several of the listed NORM containing residues can be used as alternative raw materials or as supplementary cementitious materials. In the case of residues with a high calorific value, they can be introduced as an alternative fuel where the remaining ash is typically incorporated in the cement clinker.

In Europe, a substantial amount of residues is currently used and included in use cases for several concrete applications and civil engineering works. This not only offers improved material performances and engineering properties, but also great environmental gains by saving the natural resources and lowering the CO2 footprint per tonne of concrete produced. Nevertheless, this brings also along some major health concerns which have only been considered on the basis of their potential environmental impacts (hazardous elements and their leaching behaviour), but not on the basis of their natural radionuclide contents.

Using NORM residues in the production of new types of synthetic building materials raises concerns among authorities, public and scientists on the potential gamma exposure to building materials among

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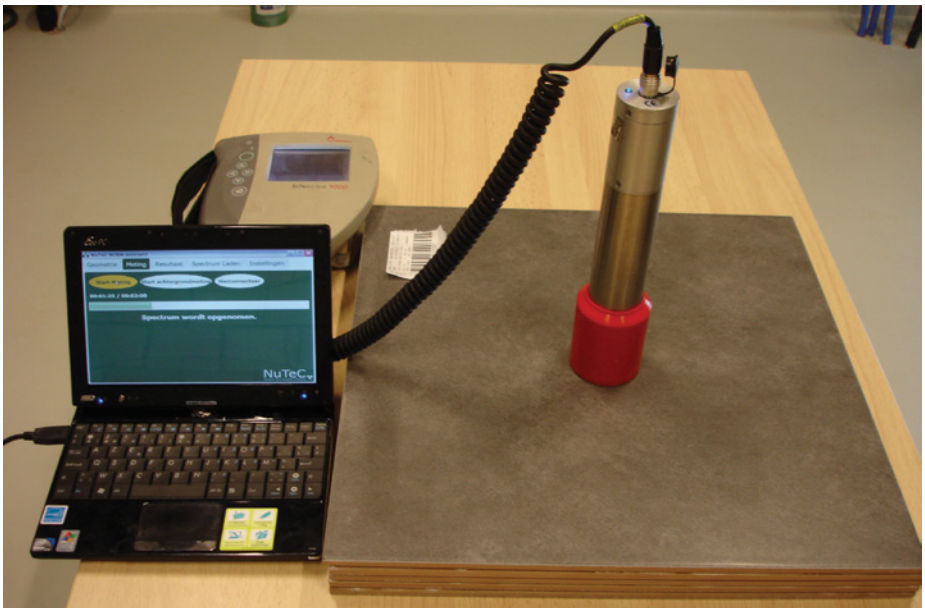

occupants and on indoor air quality. Several exposure pathways must be investigated to assess the impact of natural radionuclides in buildings on residents. In addition to direct gamma radiation, an important pathway of radiation exposure comes from radon, originating from building materials or the soil.

WHO (World Health Organisation) and ICRP (International Commission on Radiological Protection) studies have shown that public is exposed to a non-negligible amount of radiation caused by radon.

Introducing the new Euratom-Basic Safety Standards (EU-BSS, December 2013) resulted into new legislative requirements that developers of new building materials have to meet. There are many comments and questions from industry on the EU-BSS and on the options of recycling of NORM residues in building materials. More precisely, there is a need for more practical and technical support and reliable research data on this topic.

To deal with the lack of knowledge on the radiological aspects of the building materials, the COST Action '**NORM4Building**' was launched in January 2014. The main objective of this research network is the exchange of multidisciplinary knowledge and experiences (radiological, technical, chemical, economical, legislative, ecological) to stimulate the reuse of NORM containing residues in new, tailor-made sustainable building materials while considering exposure to external gamma radiation, the resulting indoor air quality and the lifetime of the building materials. Currently, more than 95 researchers from 25 different European countries are participating in the COST Action and there is a strong involvement from industry representatives and national and European legislators that are involved via discussion via roundtable discussions. IAEA (International Atomic Energy Agency), US and Japan representatives are keen on joining the Action as international participants. A first key publication (Nuccetelli, C. et al.), that deals with improved radiological impact models for building materials has been accepted and will be published in May 2015, in the *Journal of Environmental Radioactivity*[1].

In three years' time we hope to have had a big impact on the way that the new EU-BSS will be implemented in the Member States. COST Action members are involved in the technical working groups that are preparing the technical documents linked to the implementation of the new EU-BSS. We hope to provide support for researchers, legislators and companies to the safe reuse of NORM in building materials. A lot of the information can be found on the website of this COST Action: www.NORM4Building.org. Results of the '**NORM4Building**' COST Action will be combined in a database of good practices for the reuse of NORM residues in building materials and in a book that will compile the most outstanding findings of this Action network.

COST (European Cooperation in Science and Technology) is a pan-European intergovernmental organisation allowing scientists, engineers and scholars to jointly develop their ideas and initiatives across all scientific disciplines. It does so by funding science and technology networks called COST Actions, which give impetus to research, careers and innovation.
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1 The paper is already accessible online: http://www.sciencedirect.com/science/article/pii/S0265931X15000387