

# Impact assessment of the use of NORM residues in alkali activated materials for building applications

EU-NORM NPL 2017



Wouter Schroeyers, Zoltan Sas, Gergo Bator, Tibor Kovacs, Katrijn Gijbels,  
Tom Croymans, Niels Vandevenne, Yiannis Pontikes, Federica Leonardi,  
Cristina Nuccetelli, Rosabianca Trevisi, Sonja Schreurs

# **Radiological screening for use of by-products in alkali activated materials for building applications**

Wouter Schroeyers, Zoltan Sas, Gergo Bator, Tibor Kovacs, Katrijn Gijbels, Tom Croymans, Niels Vandevenne, Yiannis Pontikes, Federica Leonardi, Cristina Nuccetelli, Rosabianca Trevisi, Sonja Schreurs

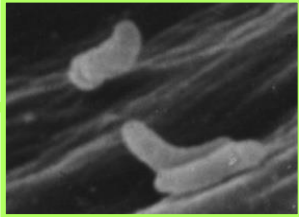


# Outline

- **Introduction**
- Methodology: scenarios for impact assessment
- Results & discussion
  - By-products
  - Building materials
- Conclusion

# Centre of Environmental Sciences: Research Themes

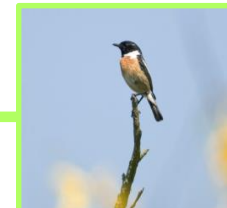
## 1. Effect of environmental stressors on organisms



## 2. Sustainable and Clean Technologies



## 3. Biodiversity, Ecosystem Services and Climate Change



**NuTeC**  
Nucleair Technologisch Centrum

**UHASSELT**  
KNOWLEDGE IN ACTION

# Use of by-product in Alkali Activated Materials (AAMs)

Industrial by-products



**Red Mud**  
**Fly ash**  
**Slags**  
*Phosphogypsum*  
*Siliciumdioxide waste*

From NORM  
processing  
industries



Activation  
solution



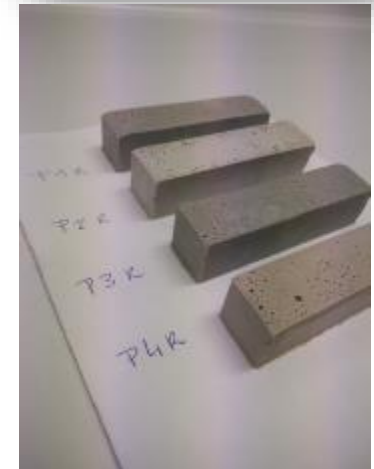
**NaOH**  
*KOH*  
*Na<sub>2</sub>SiO<sub>3</sub>/NaOH*  
...

T, t



Curing

Inorganic  
polymer



Production  
@MTM  
KULeuven

# Production Alkali activated materials (AAM)

Solid aluminosilicate source + Alkali silicate/hydroxide activating solution

**NORM precursor**

*Dissolution*  
*Oligomerization*  
*Polymerization*

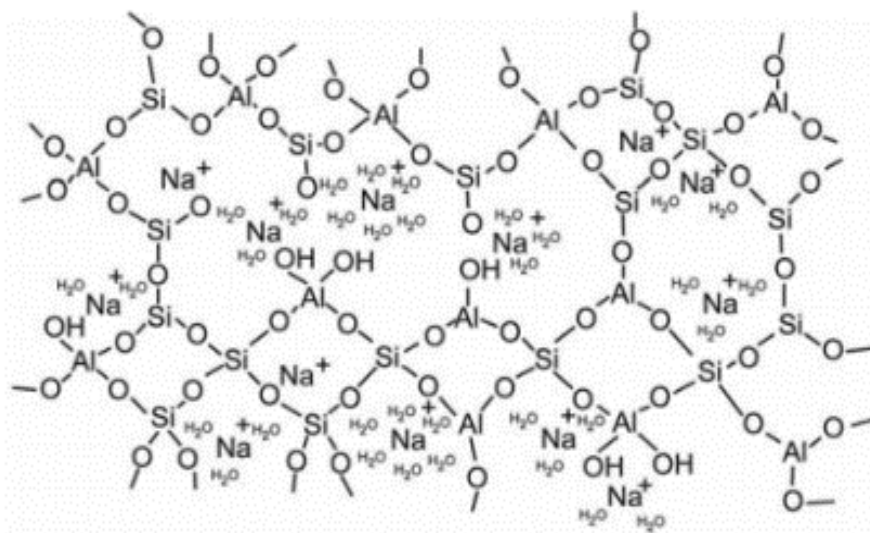
**Activator**

**Synthesis parameters**

Aluminosilicate polymer

*Adapted from Deventer (2007)*

**AAM**

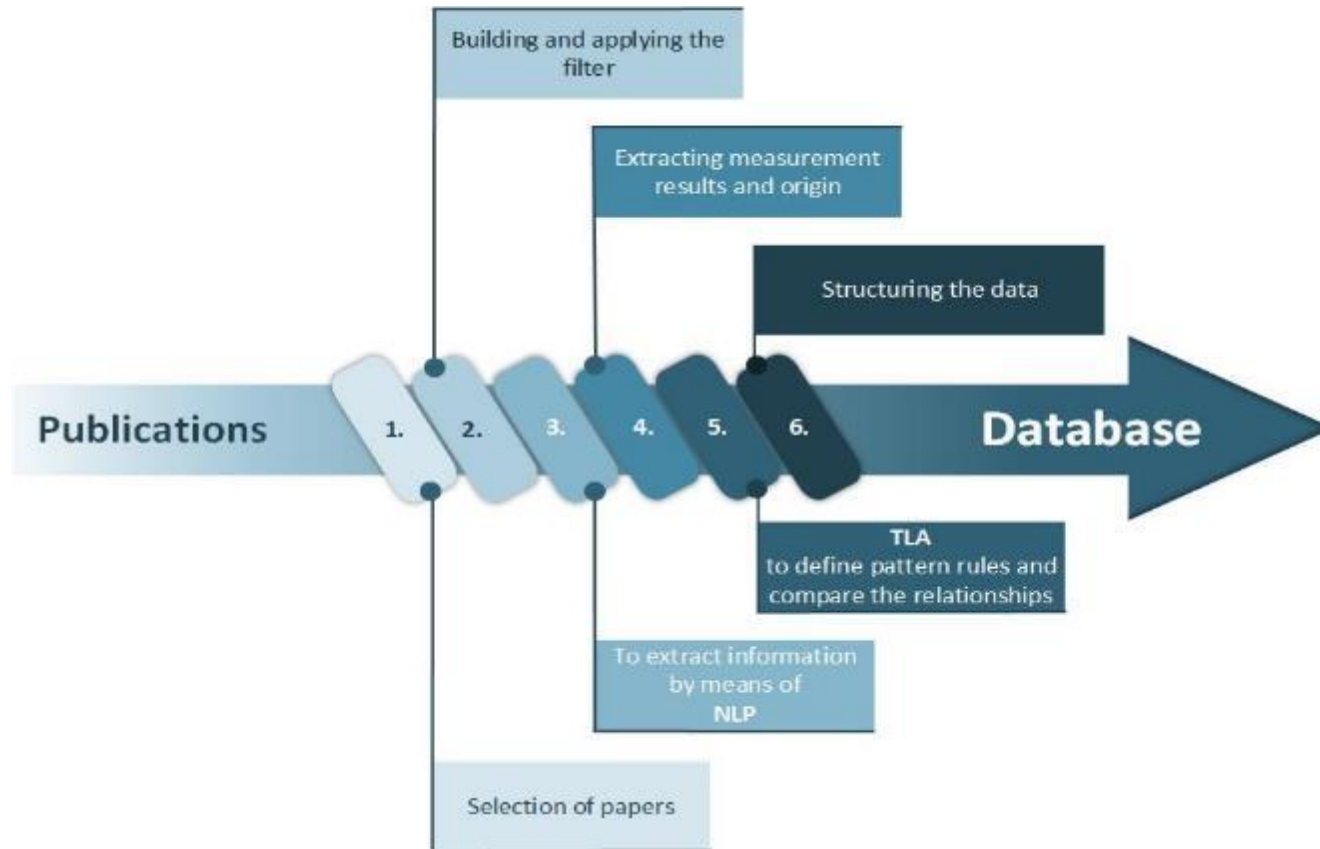


*Adapted from Rowles (2008)*

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# NORM4Building database ([www.norm4building.org](http://www.norm4building.org))



- Number of entries: 1452 (date: 01/07/2017)
- Current presentation: limited dataset (490 entries)
- 'More realistic' scenarios



# I-index calculations

$$I - index = \frac{Ac_{226Ra}}{300 B q/kg} + \frac{Ac_{232Th}}{200 B q/kg} + \frac{Ac_{40K}}{3000 B q/kg}$$

- First screening to verify if I-index < 1 to assess which materials need further investigation
- **Only used for building materials** (or for their constituents if the constituents are also building materials) EU-BSS, 2013
- Values used in calculations:
  - Cement: I-index 0,38 (\*)
  - Soil/aggregates: I-index 0,45 (\*)

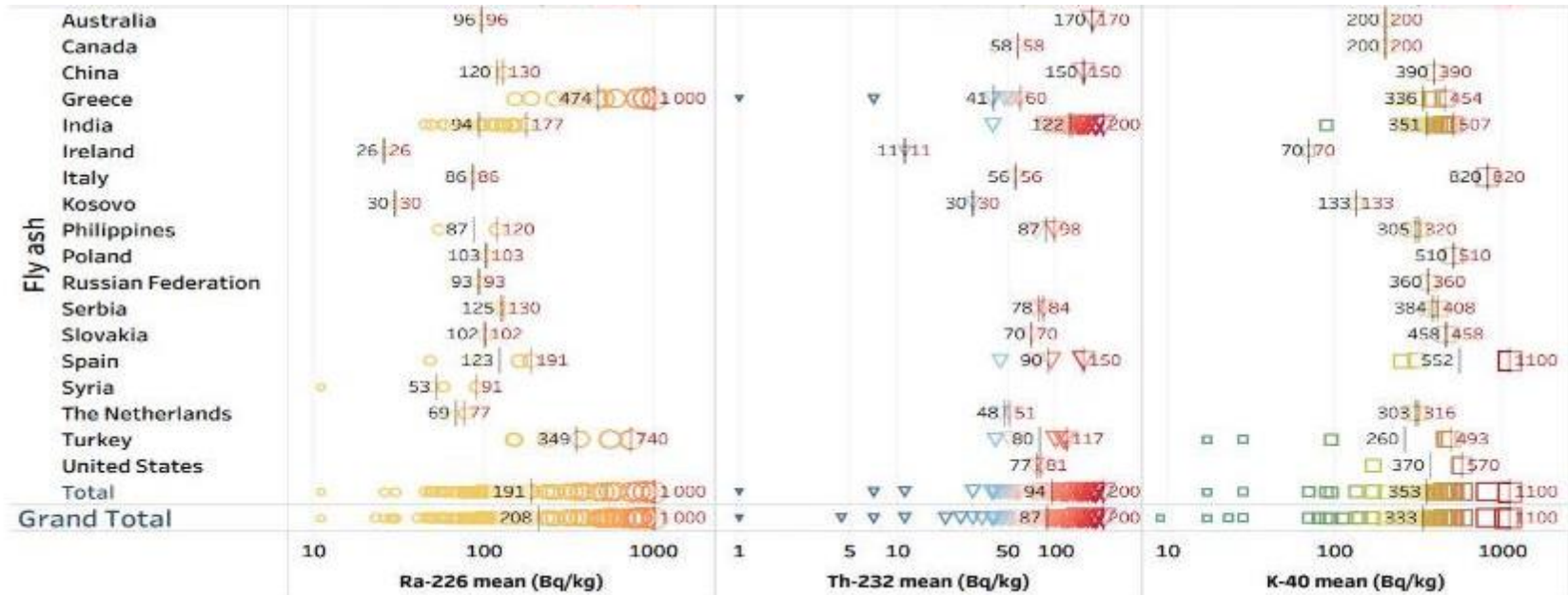
# Realistic scenarios for evaluation use of by-products

Scenario ID	Construction Material	Composition (kg/m <sup>3</sup> )			
		Cement	By-product	Aggregates	Water
1	Reference concrete	400		1850	150
2	High volume fly ash (HVFA) concrete	160	220 (fly ash (FA))	1700	140
3	Concrete with FA as partial replacement of cement and sand'	320	130 (FA)	1750	150
4	Concrete with FA as partial replacement of sand	360	90 (FA)	1800	150
5	Concrete with slag as partial replacement of cement and aggregates'	80	720 (slag)	1850	150
6	Concrete with slag as partial replacement of cement	80	320 (slag)	1850	150
7	Concrete with slag as partial replacement of aggregates'	400	400 (slag)	1450	150
8	Alkali activated concrete containing red mud as partial replacement of cement and aggregates		1800 (red mud)	450	150

# Outline

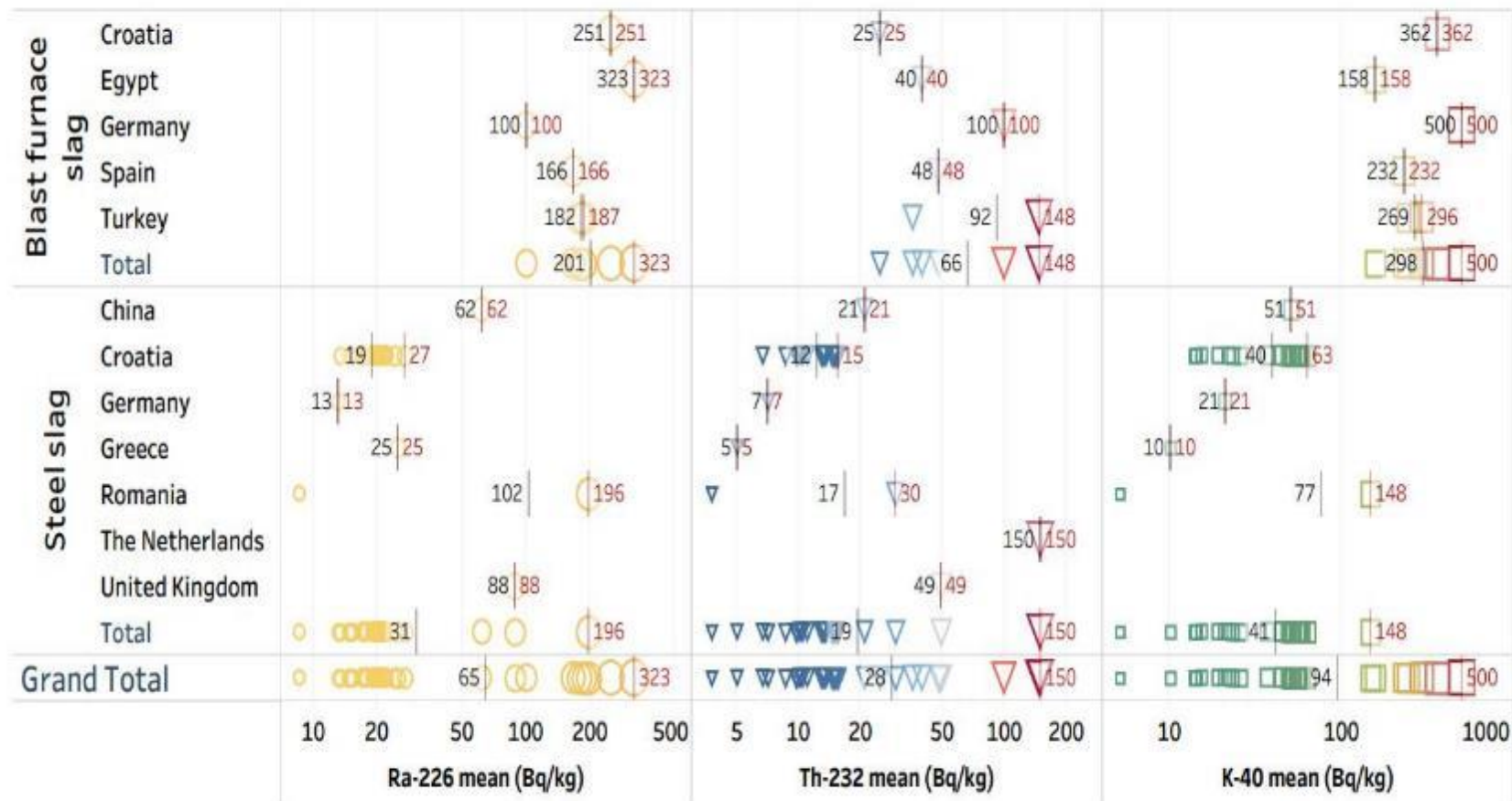
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# Fly ash from coal, peat and heavy oil fired power plants



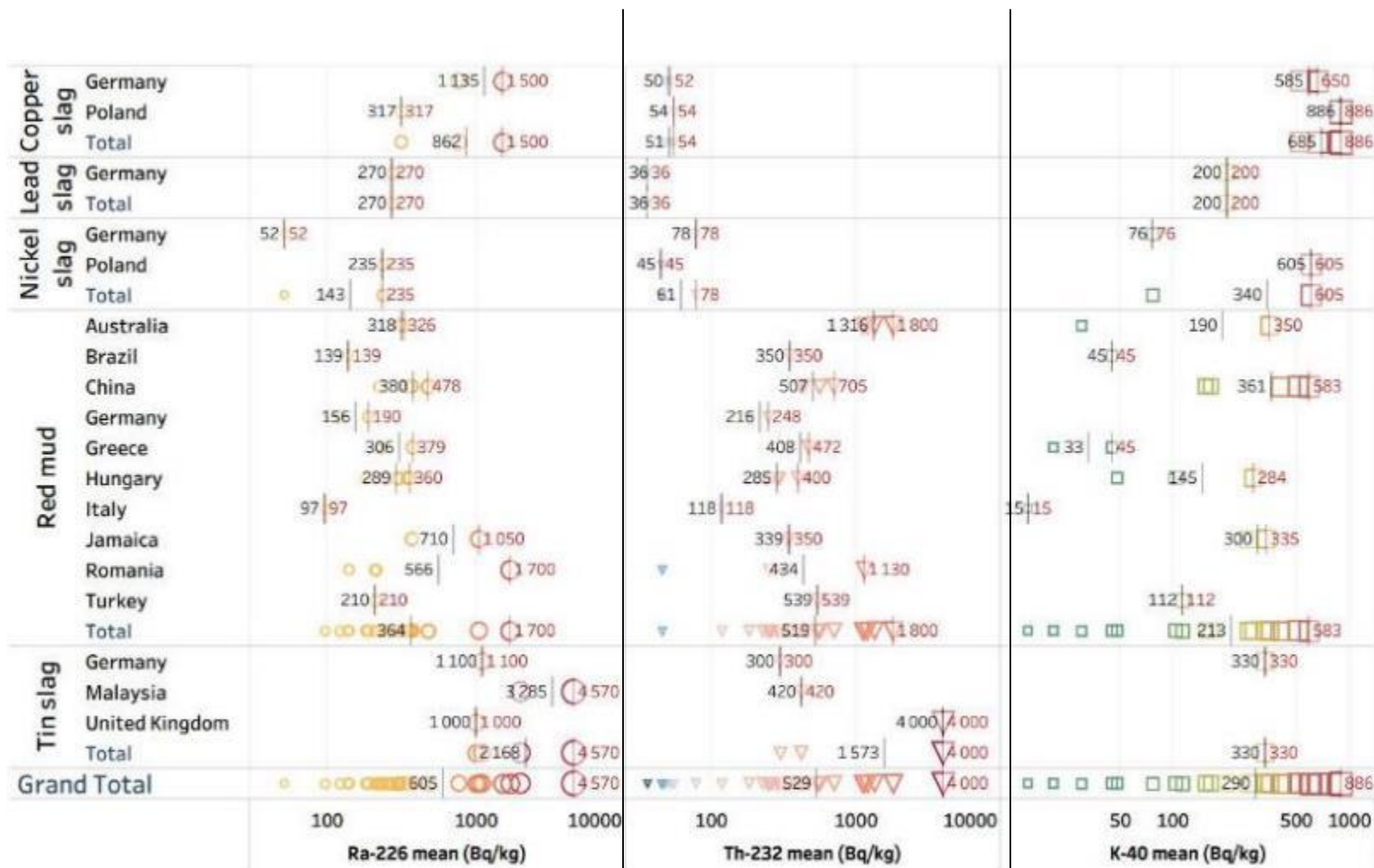
NORM4Building database ([www.norm4building.org](http://www.norm4building.org))

# By-products from ferrous industry



NORM4Building database ([www.norm4building.org](http://www.norm4building.org))

# By-products from non-ferrous industry



NORM4Building database ([www.norm4building.org](http://www.norm4building.org))

# Discussion: evaluating datamining approach

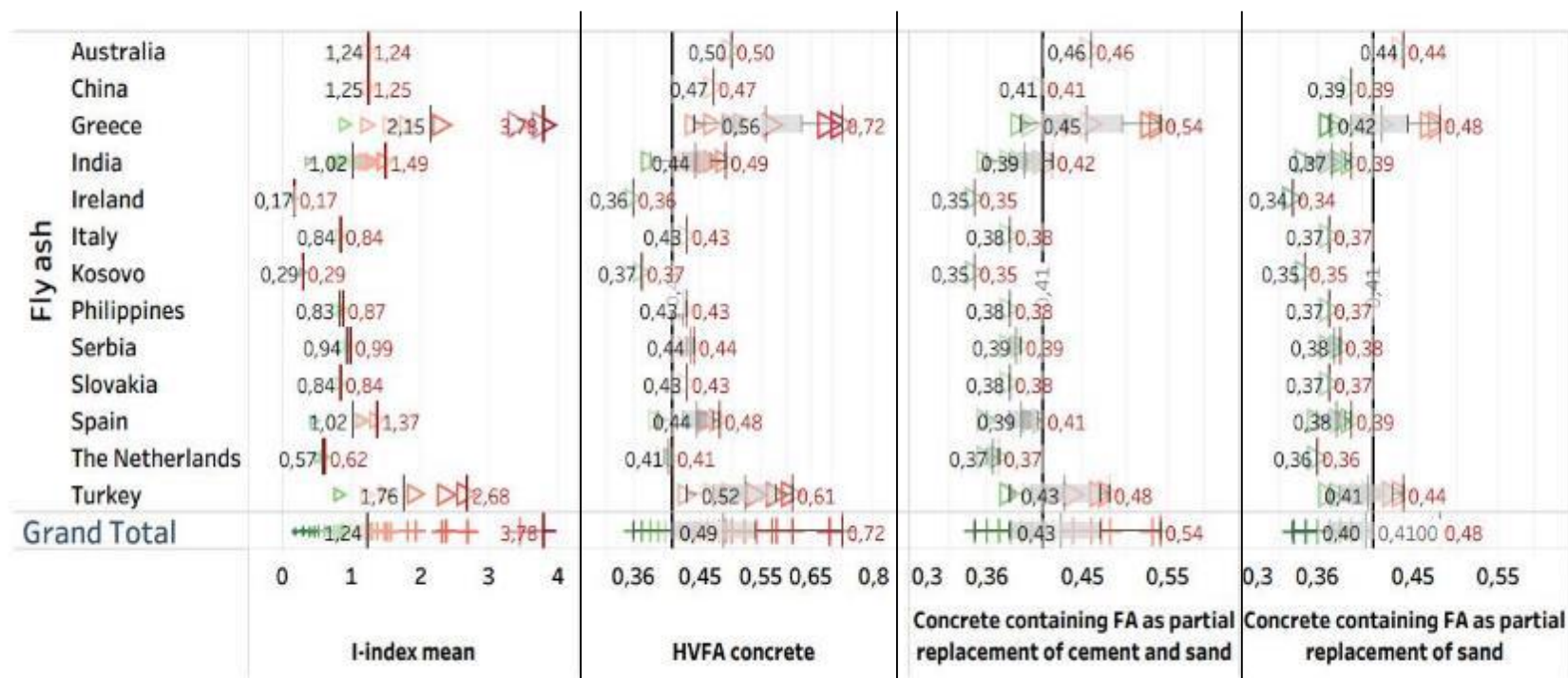
- Strength:
  - **Hundreds of publications** can be **processed monthly**
  - Finds data very **accurately**
  - Allows **continuous (automated) search** for new data: stimulus for keeping our inventory up to date
  - Can run again on collected data using **different key-words**
- Limitations
  - Reliability of the data is strongly dependent of the **reliability of the published results:**
  - Validation is a **labour intensive step**
  - Data from **graphical images** (eg.: histograms) is currently not collected
  - Licence for datamining software is **expensive**

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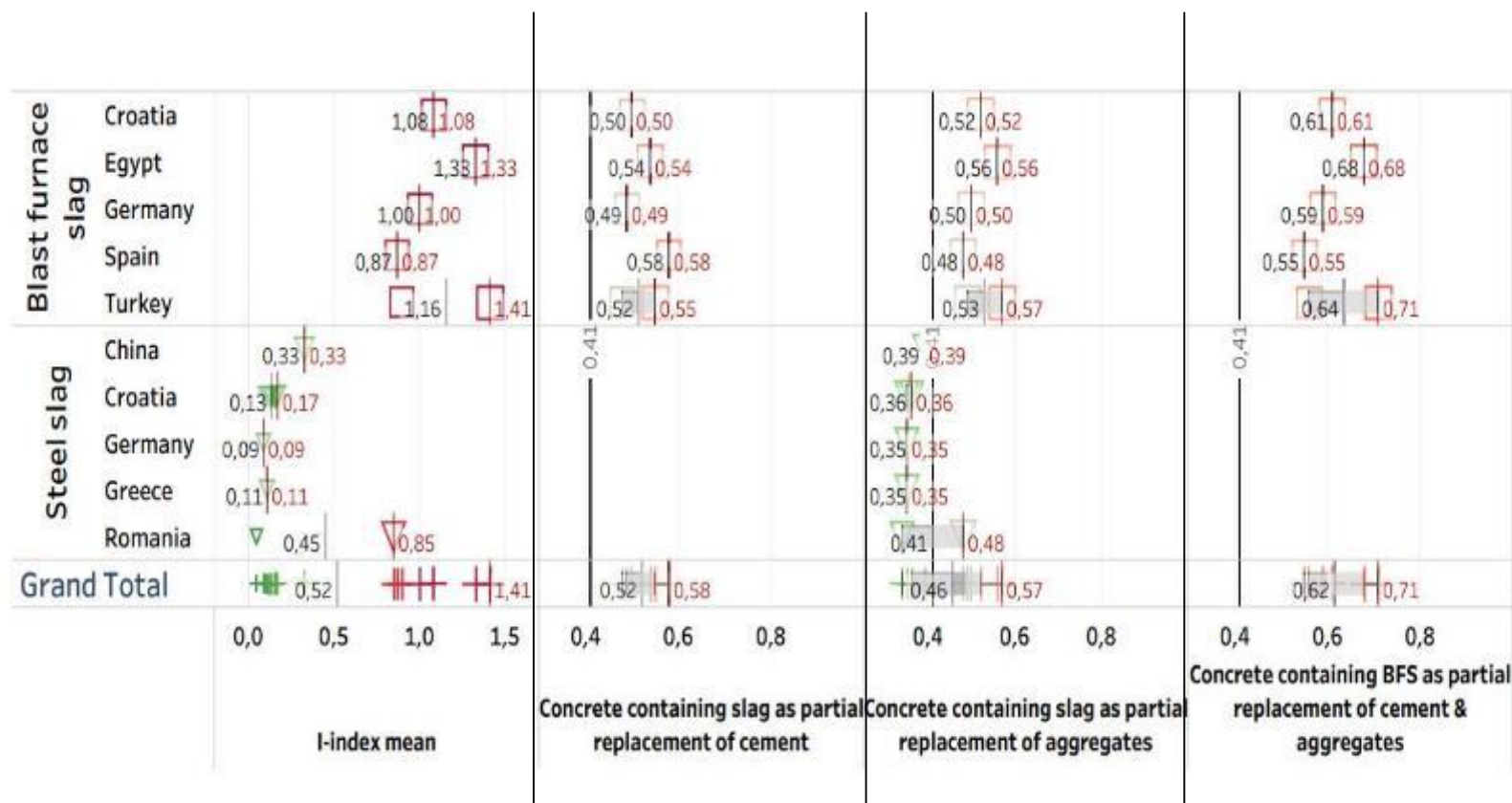


# I-index concretes containing fly ash



NORM4Building database ([www.norm4building.org](http://www.norm4building.org))

# I-index concretes containing blast furnace slag



NORM4Building database ([www.norm4building.org](http://www.norm4building.org))

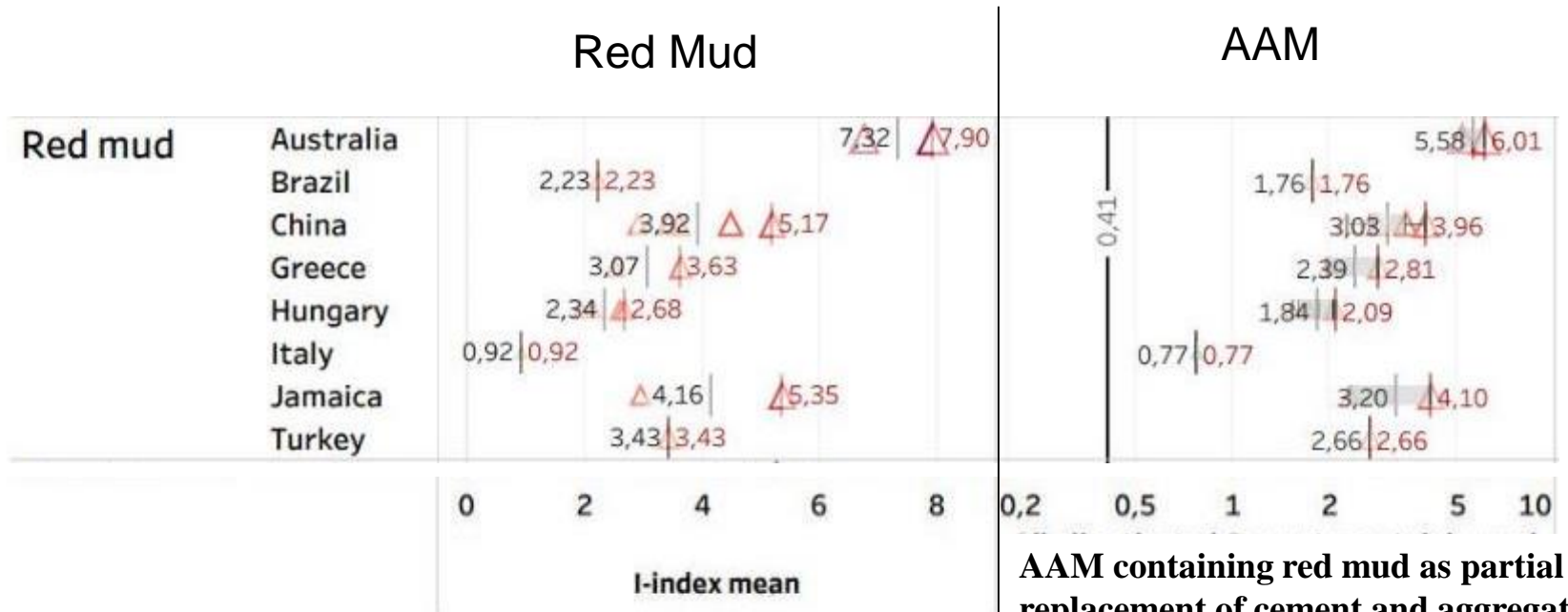
# I-index concrete containing non-ferrous slag as replacement aggregates



Concrete containing slag as partial replacement of aggregates

NORM4Building database ([www.norm4building.org](http://www.norm4building.org))

# I-index AAM containing red mud



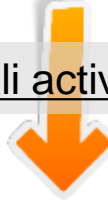
AAM containing red mud as partial replacement of cement and aggregates

NORM4Building database ([www.norm4building.org](http://www.norm4building.org))

# Ongoing PhD research

## By-products (NORM)

Alkali activation



Use in publicly accessible environment

Use in nuclear safety applications

- gamma dose evaluation

- Radon exhalation
- Leaching

- Leaching

- Durability prediction in gamma radiation field



Tom.Croymans



Katrijn.Gijbels



Niels Vandevenne



Bram Mast

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# Conclusion

- **AAMs** allow the incorporation of a **large % of by-products** in building materials
  - The database can support the identification of AAMs incorporating residues that require further radiological evaluation
- **Maintenance, updating and expanding the database**
  - New management strategy required if we want to keep the database alive
- Control of entries is a **very labour intensive process!**
  - Especially kicking out overlapping information is cumbersome
  - Evolving towards a database of original initial entries



# Cost project NORM4Building ([www.norm4building.org](http://www.norm4building.org))

WOODHEAD PUBLISHING SERIES IN CIVIL AND STRUCTURAL ENGINEERING



Naturally Occurring Radioactive  
Materials in Construction

## Naturally Occurring Radioactive Materials in Construction

Integrating Radiation Protection in Reuse  
(COST Action Tu1301 NORM4BUILDING)

Schroeyers

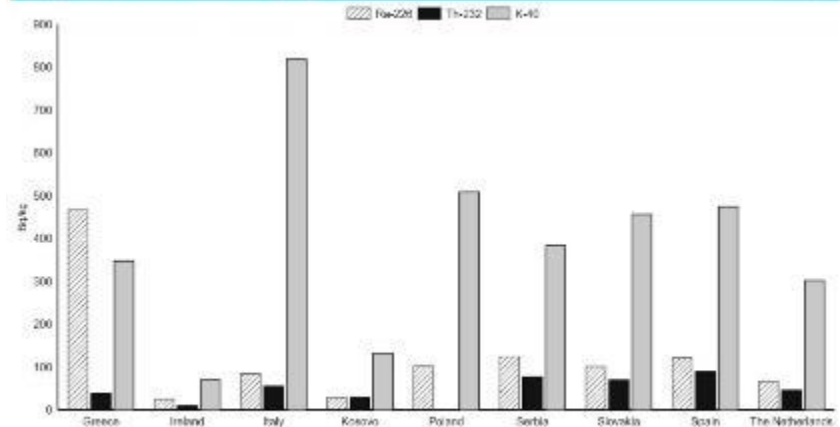
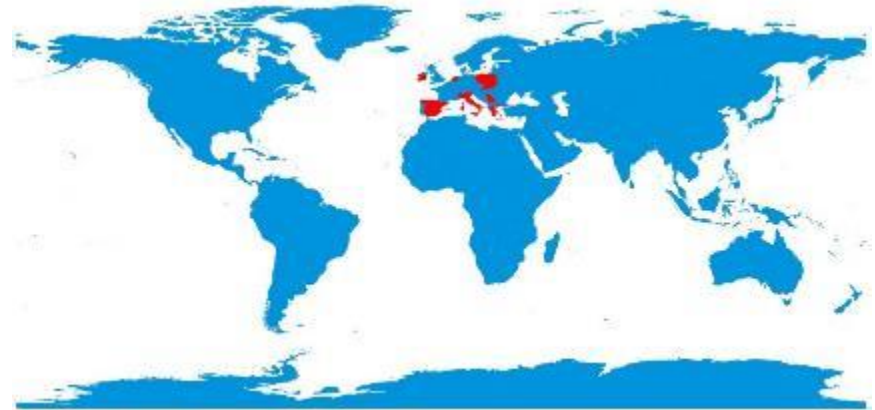
Edited by Wouter Schroeyers

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cost  
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This values based on the following and the mean values from the table

NORM4  
BUILDING

cost

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