Development of cementitious materials for successful radon immobilization

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INTRODUCTION

In case phosphogypsum (PG) is being used in the production of cementitious materials, the presence of ^{226}Ra as main radionuclide in PG requires particular evaluation of ^{222}Rn exhalation[1,2]. Ideally, cementitious materials are capable to immobilize ^{222}Rn in their solid matrix, while the degree of immobilization is dependent on their porosity features and durability. Alkali-activated binders, cement and hybrid cement matrices are assessed. Alkali-activated binders were composed of ground granulated blast furnace slag (GGBFS) and PG, cement samples were a combination of Ordinary Portland Cement (OPC) and PG, while hybrid cement samples consisted of GGBFS, OPC and PG. Gamma spectroscopy was performed for the determination of the ^{226}Ra activity concentration of the samples. ^{222}Rn exhalation was measured after variable curing times. The total open porosity was estimated with a water absorption test after 4 weeks of curing.

EXPERIMENTAL

Table 1: sample's mix design

Sample	GGBFS (wt%)	CEM I (wt%)	PG (wt%)	Solution	L/S	Curing time (weeks)
A	80	10	10	1M NaOH	0.5	1, 2, 3, 4, 12
B	0	90	10	Distilled water	0.5	1, 2, 3, 4, 12
C	90	0	10	SiO_2/Na_2O 0.75; H_2O/Na_2O 20	0.6	4
D	90	0	10	4M NaOH	0.6	4
E	90	0	10	6M NaOH	0.6	4

RESULTS

Table 2: ^{226}Ra activity concentration determined by gamma spectroscopy

Sample	A	B	C	D	E
^{226}Ra (in Bq/kg)	183 ± 15	120 ± 8	190 ± 16	190 ± 16	190 ± 16

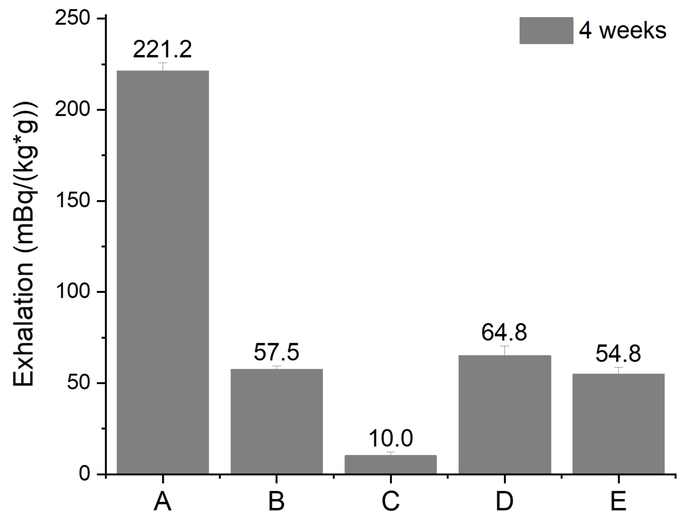

Figure 1: ^{222}Rn exhalation

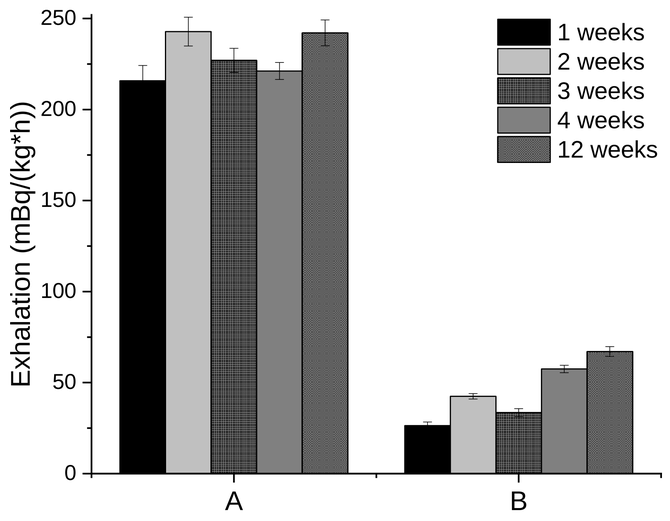

Figure 2: ^{222}Rn exhalation

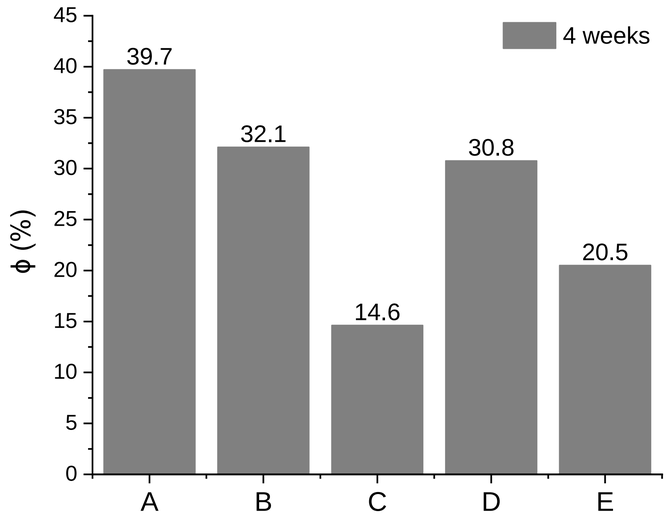

Figure 3: total open porosity (ϕ)

CONCLUSIONS

Radon exhalation shows correlation (R^2 = 0.7) with the total open porosity (ϕ), with lowest exhalation and porosity achieved for sodium silicate activated binders (i.e. sample C). Radon immobilization was the least successful for hybrid cement samples. For cement samples, the radon exhalation was increasing over time. Further study should focus more in depth on the pore structure and specific surface area evolution and their influence on radon release, in parallel with other effects such as freeze-thaw or carbonation. The radon exhalation over time of alkali-activated binders forms a subject of future research as well.

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