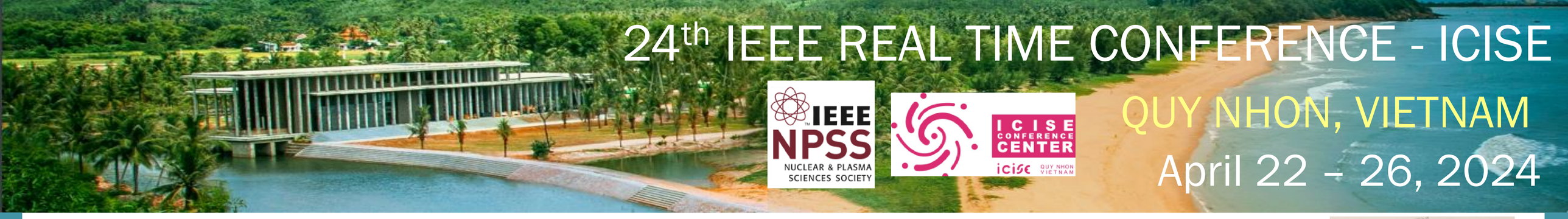

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AN ASSESSMENT OF EXTERNAL DOSE FROM NATURAL RADIOACTIVITY IN BUILDING MATERIALS BY USING SIMULATION MONTE CARLO

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INTRODUCTION

☞ Determination of external dose due to the radiation emitted from building materials is important.

☞ The radioactive isotopes of ^{226}Ra, ^{232}Th, and ^{40}K exist naturally in soil, rocks, and sand. When these materials are used in construction, the gamma radiation of natural radionuclides emitted from walls, floors, and ceilings could cause human exposure to radiation.

1. **Assess the external dose from the natural radioactivity of building materials on the human body.**
2. **Using MCNP6 code and RESRAD-BUILD to build the standard room model.**
3. **The results showed a good agreement between the two methods and experience measurement.**

MATERIALS

Sample preparation

Collect samples: cement (C1–C4), brick (B1–B4), sand (S1–S5), rock (R)

→ Finely ground into powder (particle size < 200 μm)

→ Dried in the furnace at 105°C

→ Concentratrion of elements were examined by X-ray fluorescence method

→ Calculation of the average value of concentration of elements: C_{mean}, B_{mean}, S_{mean}

METHODS

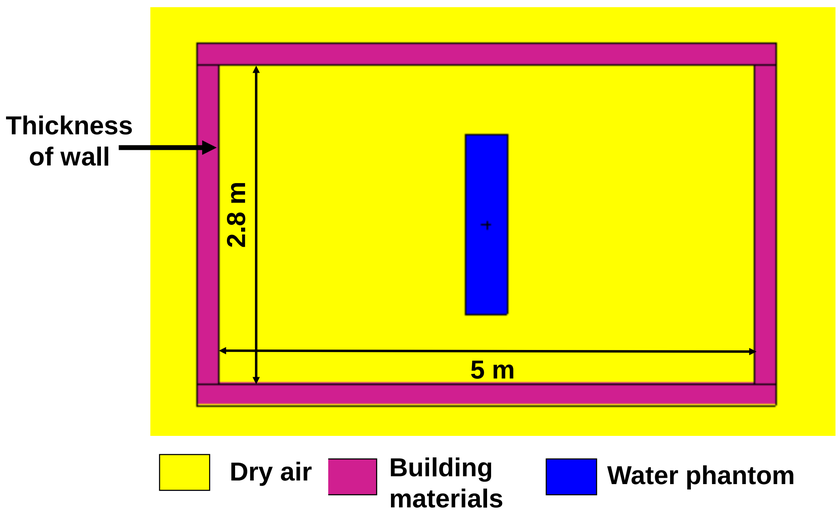


Figure 1. A room model was built by MCNP6 code

A room model: 5 × 4 × 2.8 m

Water phantom: 1.68 × 0.4 × 0.2 m

MODE P, NPS = 2E10, Tally F6

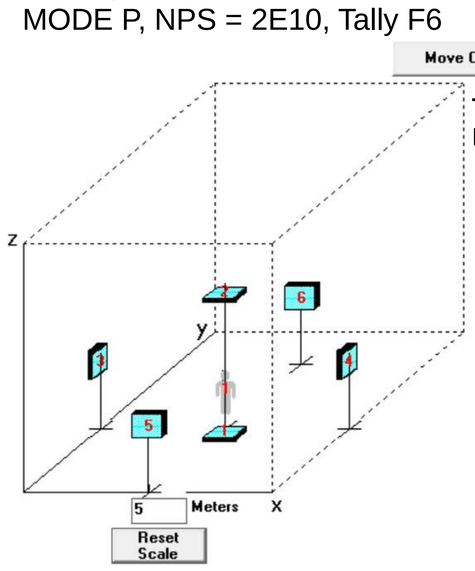


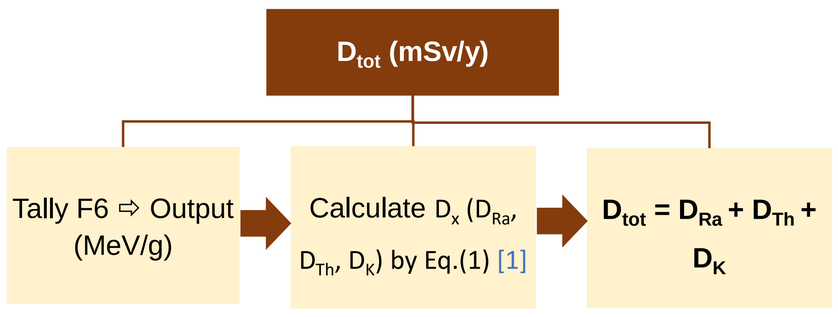
Figure 2. 3D simulation room model in RESRAD-BUILD (use ICRP 38 library)

Table 1. Important input parameters for RESRAD-BUILD

Parameters	Value
Breathing rate	20.29 m^3/day
Deposition velocity	0.01 m/s
Resuspension rate	5 × 10^{-7} 1/s
Exchange rate	0.8 1/h
Type of the source	Volume (x, y and z-direction)
Shielding thickness	No shielding
Exposure Duration	365 day with indoor fraction 0.8

In Figure 2: The receptor stands at the center of the room at a height of 1m.

CALCULATION



$$D_x\,(Gy/s) = D(MeV/g) \times A\,(Bq/kg) \times N_{\eta d} \times M_{wall}\,(kg) \times 1.6 \times 10^{-10}\,(Gy.g/MeV) \qquad (1)$$

D_{tot}: the total dose rate in the water phantom

D: the absorbed dose in water phantom calculated by MCNP6

A: the activity concentration of ^{226}Ra, ^{232}Th, and ^{40}K for the variety of building materials.

$N_{\eta d}$: average number of gamma emitted per disintegration, for ^{40}K, ^{238}U and ^{232}Th are 0.107, 2.41 and 4.13, respectively.

M_{wall}: the mass of building material covering the room walls

Table 2. The activity concentration of for the variety of building materials [2]

Sample	The activity concentration (Bq/kg)		
	^{226}Ra	^{232}Th	^{40}K
C1	38.3 ± 0.3	19.6 ± 0.3	94.7 ± 2.5
C2	25.9 ± 0.3	23.8 ± 0.3	248.9 ± 4.8
C3	26.9 ± 0.3	26.6 ± 0.3	226.4 ± 4.4
M4	53.5 ± 0.4	32.0 ± 0.4	277.9 ± 5.3
M_{mean}	36.2 ± 0.3	25.5 ± 0.3	212.0 ± 4.3
C1	51.2 ± 0.4	83.6 ± 0.8	516.6 ± 9.4
C2	38.9 ± 0.4	59.1 ± 0.6	457.4 ± 8.3
C3	32.9 ± 0.3	46.5 ± 0.5	600.1 ± 10.4
C4	48.7 ± 0.4	71.7 ± 0.7	449.3 ± 7.7
B_{mean}	49.2 ± 0.4	65.2 ± 0.7	505.9 ± 9.0
S1	14.2 ± 0.2	18.7 ± 0.2	296.2 ± 4.9
S2	10.4 ± 0.1	12.1 ± 0.2	35.1 ± 1.3
S3	20.2 ± 0.2	23.9 ± 0.3	467.7 ± 7.6
S4	5.2 ± 0.1	5.8 ± 0.1	14.9 ± 0.8
S5	14.5 ± 0.2	12.6 ± 0.2	203.4 ± 4.0
S_{mean}	12.9 ± 0.2	14.6 ± 0.2	203.5 ± 3.7
R	26.7 ± 0.3	38.1 ± 0.4	664.9 ± 10.6

RESULTS

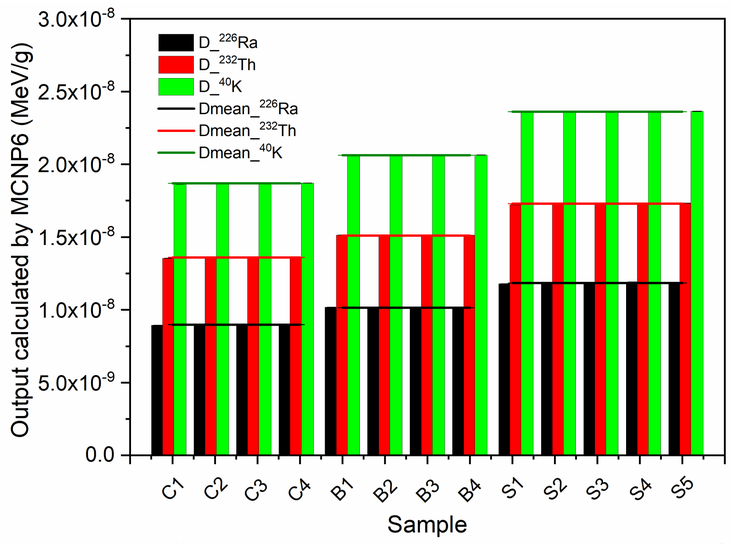


Figure 3. Dose difference between component and mean value

❖ **In Figure 3:** The component dose value is less than 0.6% compared to the average value, for each type of building material.

❖ **In Figure 5:**

☞ Result 1 and Result 2 are external dose when changing the building material densities of MCNP6 (cement 2.35 g/cm^3), (brick 2.1 g/cm^3), (sand 1.7 g/cm^3), (rock 2.66 g/cm^3)

☞ Result 3 and Result 4 are the external dose of RESRAD-BUILD when using the same building material density of 2.35 g/cm^3.

☞ Result 5 is referred to our previous work [2].

☞ There are no “outliers” in the entire data.

☞ A good agreement when comparing the results.

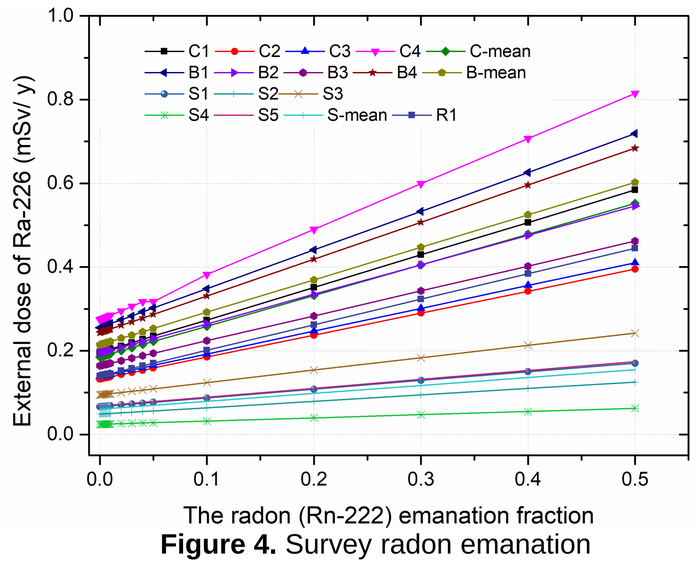


Figure 4. Survey radon emanation

❖ **In Figure 4:** Dose were increased linearly when surveying radon emanation from 0 to 0.5.

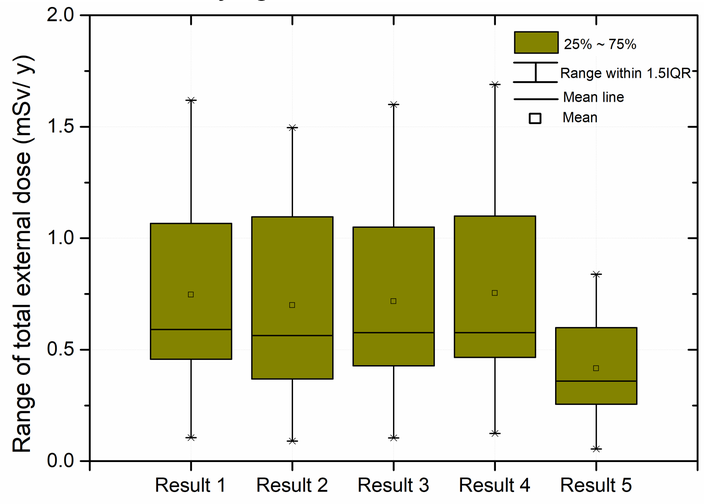


Figure 5. Comparison between MCNP6 code and RESRAD-BUILD

CONCLUSION

1. Average element concentration values can used to calculate concrete composition.

2. The MCNP code and RESRAD-BUILD calculation methods agree with each other (in case the radon (^{222}Rn) emanation rate is 0).

❖ **References:**

[1] Nahis Rostamani, Rahim Khabaz (2021). Monte Carlo simulation estimates of absorbed in human organs due to the external exposure by decorative granite stones. Radiation Physics and Chemistry, (189), 1-6.

[2] Le Quang Vuong, Huynh Dinh Chuong, Lam Duy Nhat, Hoang Duc Tam, Tran Thien Thanh, Vu Tuan Minh, Le Dinh Hung, Phan Long Ho, and Chau Van Tao (2023). Assessing radiation hazards associated with natural radioactivity in building materials in Ho Chi Minh City, Vietnam. Nuclear Technology & Radiation Protection, (38), 30-38.