Assessment of Natural Radioactivity in Moroccan Building Materials

M. Messouli[1], A. Laissaoui[2], N. Mejjad[2], N. Ziad[3], A. Benkdad[2], H. Ait Bouh[2], O. El Hammoumi[1], A. Fekri[1]

Faculty of Sciences Ben M'Sik, University Hassan II, Casablanca, Morocco

NATIONAL CENTER FOR ENERGY, SCIENCES AND NUCLEAR TECHNIQUES

Abstract

In addition to terrestrial and cosmic radiation, it is important to consider the impact of building materials on indoor gamma radiation. Materials, such as cements, bricks, gypsums were collected from various locations in Morocco, and carefully examined using HPGe spectrometry to determine the concentrations of naturally occurring radionuclides. The obtained results show significant variations in the radionuclides concentrations among analyzed materials. The main objective is to determine if these materials pose any potential health risks to humans.

background

What is Radioactivity ?

Radioactivity is a natural phenomenon that has been present on Earth since its formation. It is the spontaneous emission of particles or radiation from unstable atomic nuclei. Some elements found in the Earth's crust, such as uranium, thorium, and potassium, have radioactive isotopes that decay over time, releasing various types of radiation. These radioactive materials can be found in varying concentrations within different geological formations, including building materials.

Why is it important to study natural radioactivity ?

In recent years, there has been growing concern regarding the potential health risks associated with exposure to natural radioactivity, particularly in the context of building materials used in construction.

Building materials contribute to environmental radioactivity in two ways. First, by gamma-radiation, mainly from 226Ra, 232Th, 40K and their progenies to a whole body dose and in some cases by beta radiation to a skin dose, and second by radon exhalation to an internal dose exposure due to the deposition of radon decay products in the human respiratory tract (Faheem et al., 2008).

Prolonged exposure to elevated levels of such radiation has been linked to adverse health effects, including an increased risk of lung cancer (Edward P. Radford, 1985). By the determination of the radioactivity level in building materials, the indoor radiological hazard to human health can be assessed (Eva Singovszka et al, 2028)

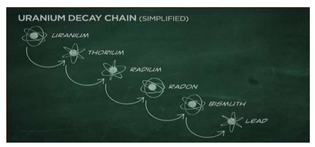

Fig. Uranium decay chain

Methodology

The investigated materials (brick, cement, White cement and gypsum) were obtained from building material suppliers and manufacturers located across different regions in Morocco .

The samples were ground, homogenized, and then placed in a 500ml Marinelli beaker. A standard was prepared in the same counting geometries as the samples to be analyzed and used for calibrating the measurement chain. This standard is a multi-gamma source containing several radionuclides (with a wide range of energy levels).

Gamma-ray spectroscopy was employed as the primary analysis technique. A high-purity germanium crystal detection system was utilized (**HPGe**). This detection system exhibits a relative efficiency of 30%, which ensures a significant fraction of emitted gamma-rays can be captured for analysis.

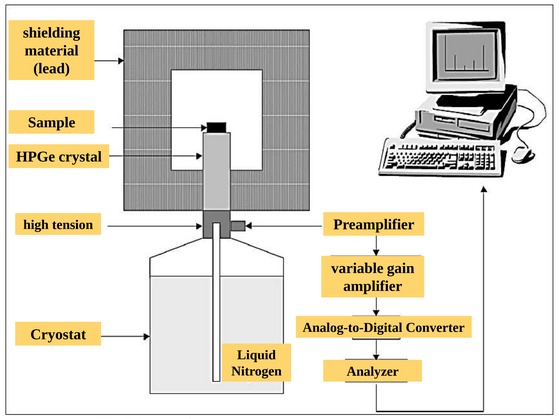

Fig. Schema of gamma-ray spectrometry analysis chain (Tessier, 2003)

Results

the specific activity (mean) of 40K, 226Ra and 232Th (in Bq/kg) :

The analyzed building materials, namely cement, white cement, red brick, and gypsum, revealed distinct concentrations of (226Ra), thorium (232Th), and potassium (40K)

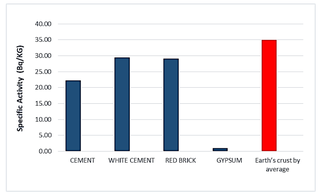

Fig. Mean specific activity (Bq/kg) of 226Ra in building materials

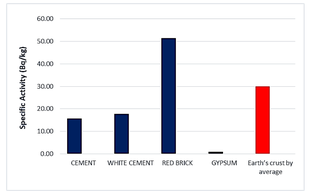

Fig. Mean specific activity (Bq/kg) of 232Th in building materials

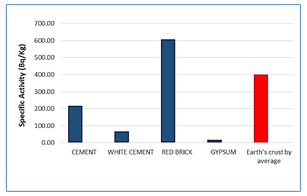

Fig. Mean specific activity (Bq/kg) of 40K in building materials

Radiological hazard indexation :

The European Commission guidance document (European Commission 1999b) advises on the determination of the **Activity Concentration Index (*I*)**, The following activity concentration index (I) is derived for identifying whether a dose criterion is met:

$$I = \frac{C_{Ra}}{300} + \frac{C_{Th}}{200} + \frac{C_K}{3000}$$

Where *C*Ra, *C*Th, and *C*K are the radium, thorium, and potassium activity concentrations (Bq/kg) in the building material. The values of *I* were calculated for all the samples studied.

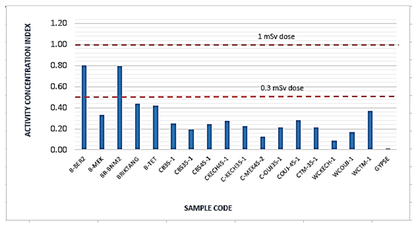

Fig. Activity concentration indices of the Moroccan building materials studied

Perspectives

- introduction of new materials, including marble, sand, and aggregates, to assess their natural radioactivity
- Examination of the radon emanation rate using the Rad7 detector to quantify the release of this radioactive gas
- Study of industrial byproducts used in construction materials.

Conclusion

- Materials derived from rock and soil contain mainly radioisotopes of the 226Ra and 232Th series and radioactive isotope of 40K. Gamma ray spectrometry is an experimental toll in studying natural radioactivity and determining elemental concentration in various building materilas
- In the context of Moroccan building materials, our analysis reveals that the activity concentrations of 226Ra, 232Th, and 40K typically found in materials like cement, white cement, and gypsum are lower than the average world .
- The use of these materials to construct buildings is unlikely to expose occupants to significant radiation (less than 0.3 milliSievert per year). These findings align with the rules set out in the global guidelines related to radiation safety in construction.
- However, when we specifically examine red brick, we've noticed that the average concentrations of thorium and potassium are higher than the average found in the Earth's crust. Moreover, these elevated levels could potentially result in radiation doses exceeding the lower dose threshold of 0.3 milliSieverts per year, as outlined in the European Commission's official publication (European Commission 1999b

Acknowledgements

This project is supported by the national center of Energy, Sciences and Nuclear Techniques and conducted under the guidance of Mr. A.Laissaoui, Head of Soil/ Radioactivity Unit at the National Center for Energy, Sciences and Nuclear Techniques , and Ms. N.Mejjad, Doctor and Researcher at {CNESTEN}