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Indoor radon and ambient equivalent dose measurements using a locally manufactured low-cost smart electronic device and validation with reference instruments

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This work reports the realization of a low-cost smart electronic device for Gamma ionizing radiation monitoring and its implementation in real-time external ambient dose rate detection and indoor radon tracing. The device is developed according to the principle of nuclear signal processing in order to obtain the standard radiation protection signal (a slow positive logic pulses) and calibrated in the presence of Cesium (137Cs). The device uses a ZP 1200 Geiger-Müller (GM) tube detector, low-cost components namely the microcontroller board, the DHT11 temperature (T) and relative humidity (RH) sensor and XBee-based Internet of Things (IoT) wireless transmission modules. The environmental radiation monitoring and nuclear security developed device is also low energy consumption, easily deployable in the field (in-situ), adapted for real-time measurements and data transmission to a remote-controller PC.

A first comparative analysis of the data obtained from the developed survey meter was carried out with those of an in-situ gamma spectrometry chain (outdoor reference method) previously used at the same place and under the same conditions in Yaoundé-Cameroon. This analysis gave an acceptable mean value of 64.30 nGy/h, of the developed device, compared to 50.67 nGy/h of the gamma spectrometer. The indoor reference device measures radon concentration, temperature, and relative humidity in indoor spaces. Typically, the developed device also provides data of atmospheric parameters (T, RH) and the ambient dose equivalent rate. From this ambient dose equivalent rate (in μSv/h), radon activity concentration (in Bq/m3) is deducted using standard and recognized conversion coefficients. The coefficients vary according to the ambient radiation strength and are ranging from 5500 to 8900 (Bq/m3)/(μSv/h). The developed device and the indoor reference instrument were exposed during one month in several dwellings in the city of Yaoundé, and periodic average values of 27.51 ℃ (developed device) and 26.19 ℃ (RadonEye) for temperature, 74.10 % (developed device) and 73.00 % (RadonEye) for relative humidity, and 1499.19 Bq/m3 (developed device) and 1464.91 Bq/m3 (RadonEye) of cumulated radon activity concentrations, for a 24 hours exposure period were evaluated. Statistical analyzes carried out on the results of these two devices provide a linear regression coefficient of R2 = 0.9978. This shows a good agreement between the data of the developed device and the reference instrument RadonEye. The prototype thus developed is simple, precise, and made for Environmental radiation protection.

Keywords: Radiation monitoring, radon tracing, smart electronic device, Internet of Things (IoT), Geiger-Müller (GM) tube detector, temperature and relative humidity sensor

Abstract Category

Instrumentaions & Detectors

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