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Technical Report

Seasonal variations of radon and the radiation exposure levels in Nerja cave, Spain

C. Dueñas [a,*], M.C. Fernández [a], S. Cañete [a], M. Pérez [b], E. Gordo [a,b]

[a] Department of Applied Physics I, Faculty of Sciences, University of Málaga, Málaga 29071, Spain
[b] Department of Radiology and Health Physics, Ophthalmology and ORL, Faculty of Medicine, University of Málaga, Málaga 29071, Spain

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ABSTRACT

^{222}Rn concentrations in the air in Nerja cave (Spain) (3° 52′35″W 36° 43′50″N) were measured by continuous monitoring using Alpha-Guard, Genitron instrument equipment. The ^{222}Rn measurements were carried out for a complete annual cycle in the different halls: Vestibule hall from July 2003 to June 2004, Ballet hall from July 2004 to June 2005 and Mirador hall from July 2005 to June 2006. Starting from the entrance of the cave we successively find the Vestibule hall, the Ballet hall and the Mirador hall .The range of ^{222}Rn levels were of 8–627 Bq m^{-3} for the Vestibule hall, 28–575 Bq m^{-3} for the Ballet hall and 38–578 Bq m^{-3} for the Mirador. The aim of this study was to detect seasonal variation patterns of ^{222}Rn concentrations. The seasonal variations of ^{222}Rn concentrations are discussed in relation to various meteorological factors measured inside and outside the cave. The radiation exposure levels for workers and tourists with different equilibrium factors have been evaluated. The radiation exposure levels for workers and tourists only represent a low percentage of the exposure guides for the general population.

1. Introduction

Radon is the greatest source of natural radioactivity. Prolonged exposure to radon may cause a negative effect on our health since a high concentration of radon gas has been identified to cause lung cancer and bronchial tissue damage (Yamada, 2003). Radon monitoring at radioactive locations such as underground mines or caves, is important in order to be able to assess the radiology hazards caused to occupational workers and visitors.

On the one hand, radon levels in karstic systems depend on a complex interrelation of several factors, both external and internal (Kies et al., 1997) such as outside-inside temperature differences, wind velocity, atmospheric pressure variations, humidity, karstic geomorphology, porosity and radium content of the sediments and rocks. Moreover, the geological and morphological features of the cave play an important role in identifying the atmospheric radon concentration. The complex dynamic of radon in natural underground atmospheres makes continuous monitoring useful and even necessary in visiting caves for radioprotection purposes.

In Spain, according to the 96/29/EURATOM Council Directive of the European Union, the regulations of protection against ionizing radiation (Real Decreto 783/2001, 2001) established, for the first time, the need to monitor activities to establish the presence of natural radiation sources that may lead to a significant increase in the exposure to workers or members of the public. This cannot be disregarded from the radiation protection point of view. These activities include workplaces such as spas, caves, mines, underground and aboveground workplaces in identified areas.

The objectives of this study in the Nerja cave were: (1) to find out the levels of ^{222}Rn concentrations in different halls of the cave continuously throughout the year; (2) to determine the factors that most affect the ^{222}Rn concentrations in the cave air; (3) to estimate the typical ^{222}Rn exposure levels in the cave environment.

2. Study site

Nerja cave was discovered in 1959. It is one of the most significant karstic cavities in Andalusia. Its evolution in the recent geological history of Betic Cordillera allows the explanation of many geological events that took place during the last five million years, in this region. Moreover, the geomorphologic, aesthetic and geoarcheological values of the morphological and sedimentary records preserved in this cave are very important situating this cave as one of the most interesting geological points in the Andalusian heritage.

These caves are the formation of karstic cavities, originating from geological processes. In the Triassic period, significant quantities of calcareous mud settled on the floor of the ancient Mediterranean Sea, later transforming into calcareous-dolomite marble, which at

* Corresponding author.
E-mail address: mperezm@uma.es (C. Dueñas).

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