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^{222}Rn concentrations of water in the Balaton Highland and in the southern part of Hungary, and the assessment of the resulting dose

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Abstract

In this study the ^{222}Rn concentration of mains water in 120 settlements in Hungary (Southern Hungary, the Balaton Highland region) was measured. The average ^{222}Rn concentration was 5.56 (0–24.3) Bq l^{-1}. On the basis of the ^{222}Rn concentration of mains water inspected in the Southern Great Plain region, it can be stated that the ^{222}Rn concentration of mains water here is, as an average, half of the ^{222}Rn concentration of fountains in the same region. This decrease in radon probably happens during the water management and storage of mains drinking water. The ^{222}Rn concentration of spring-water examined in the region of the Balaton Highland exceeds the average ^{222}Rn concentration of drinking water (average 27.1 Bq l^{-1}).

The radiation dose originating from the consumption of mains drinking water in case of adults does not reach the value of 0.1 mSv year^{-1}, even as a conservative assessment (1 l day^{-1} water consumption and 10^{-8} Sv Bq^{-1} dose conversion factor).

Keywords: ^{222}Rn; Drinking water; Spring water; Dose assessment

1. Introduction

Radon (^{222}Rn) is a naturally occurring radioactive noble gas with a half-life of 3.82 days. It is a member of the ^{238}U decay series and its presence in the environment is associated mainly with the trace amounts of its immediate parent, ^{226}Ra, in rock and soil. Since radon is an inert gas, it can move through porous media such as soil or fragmented rock (Tanner, 1980; Soonawala and Telford, 1980; Csige, 2003). Where the pores are saturated with water, radon is dissolved into the water and is then transported by it (Andrews and Wood, 1972). The concentrations of radon in water vary markedly, generally being highest in well water (Hopke et al., 2000), intermediate in ground water (Akerblom and Lindgren, 1996; Przylibski et al., 2004) and lowest in surface water (reference values 100, 10, and 1 kBq m^{3}) (Al-Masri and Blackburn, 1999). Information on the radon concentration of drinking water is extremely important as radon causes half of the radiation dose of natural origin in humans; a part of it is absorbed into the human organism with the drinking water consumed (Ishikawa et al., 2003; World Health Organization, 1993). For that very reason, several research workers have been surveying the radon concentration of drinking water and surface water, and the radon and radionuclide concentration of drinking water in the Carpathian basin generally exceeds the average values (Kovacs et al., 2003; Kasztovszky et al., 1996; Žunić et al., 2006; Cosma et al., 1996; Baradács et al., 2001). Knowing the radon concentration values of some surface and other water is not only important from the perspective of dosimetry, but also from that of

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understanding the geological and hydro-geological characteristics of the environment (Gingrich, 1984), especially as it can also act as a natural tracer (Cook et al., 2003).

However, the ^{222}Rn concentration of drinking water is surveyed from the dosimetry aspect, because nowadays more and more attention is paid to the control of natural radiation exposures on human beings. The WHO (World Health Organization, 1993) and the EU Council (Council Directive 98/83/EC, 1998) recommend the determination of the reference level of an effective dose received from drinking water consumption at 0.1 mSv year^{-1}. This value excludes the doses received from ^{3}H, ^{40}K, ^{222}Rn.

There are difficulties in applying the reference level of a dose to derive activity concentrations of ^{222}Rn in drinking water as radon is released from water during handling, stirring, transferring water from one container to another. Water that has been left to stand will have reduced activity and boiling will remove radon completely. Radon in domestic water supplies causes human exposure through ingestion and inhalation pathways (Ishikawa et al., 2006). Radon can be ingested by direct consumption of tap water or fresh spring-water. The limit value of ^{222}Rn related to drinking water is regulated by the European Union in one of its publications. (Commission recommendation on the protection of the public against exposure to radon in drinking water supplies, 2001/928/Euratom.) On the bases of these recommendation, for water supplied as part of a commercial or public activity, the following actions should be taken: above a concentration of 100 Bq l^{-1}, a Member State should set a reference level for radon, so that this can be used for consideration as to whether remedial action is needed to protect human health; with a level higher than 1000 Bq l^{-1}, remedial action is deemed to be justified on radiological protection grounds.

Seven countries in the EU (Denmark, Finland, Germany, Greece, Ireland, Sweden and the Czech Republic) have set reference levels for radon in drinking water. Reference levels are in the range of 20–1000 Bq l^{-1}, which is in accordance with EU recommendations.

2. Measurements and methods

2.1. Sampling

Sampling locations are shown in Fig. 1. In the springtime 120 tap waters, 29 wells and 27 frequently visited and regularly used springs were measured.

For sampling of drinking waters generally the fountains on the street, installed on the mains water pipeline, were used. Approximately 20 l of water was let out before sampling, and then water was poured into the sampling cylinder, which was immediately closed. When sampling could only be carried out inside a building, water was let run for 10 min before taking the sample, in order to let out the water from the possibly stagnant pipe section, and to obtain parameters characteristic of the fresh water. Spring waters were mostly continuously pouring, so samples could be directly taken from these and also from operating fountains.

2.2. Measurement of ^{222}Rn concentration

^{222}Rn was measured from 190 cm^{3} water samples, from which the radon gas was bubbled out into an evacuated Lucas-cell of Pylon 110 A type, with the help of a Pylon WG 1001 portable equipment. After waiting for 3 h, in order to ensure equilibrium between the radon and its daughters, Lucas-cells were connected to the Pylon AB-5 radon monitor and the intensity was measured for 3 × 10 min.

The efficiency of the Lucas-cells was determined by measuring a well-defined radon concentration. This was produced using a Genitron EV 03209 calibrated radon chamber with a Pylon RN 2000 A calibrated radon source.

Fig. 1. Water sampling locations.