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Low radon concentrations accurately measurable for the first time

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You can't see it, you can't smell it, you can't taste it – but at high doses, it can be lethal: the natural radioactive noble gas radon occurs especially in places where the subsoil consists of granite. It can, however, also occur in construction materials.

It has been known for a long time that radon at high doses can cause lung cancer – numerous workers from the Wismut-Werke uranium mines in the former GDR died of it. Now, scientists, however, deem radon to be dangerous also at low concentrations and therefore have increased the classification of its radiation effects: radon gas is now officially classified as contributing just as strongly to the exposure rate of the general public as medical diagnostic and therapeutic procedures. The EU-wide applicable standard values for radon in buildings have thus been lowered. However, the measuring instruments have, to date, not been able to measure the typical everyday radon concentrations with sufficient accuracy. A low-level radon reference chamber – developed at the Physikalisch-Technische Bundesanstalt (PTB) by Diana Linzmaier – with the appurtenant transfer standard allows radon measuring instruments to be calibrated for the first time with low measurement uncertainties in this range which will, in the future, be decisive. This is the only facility of this kind in the world.

The amount of exposure to noxious radiation which people are faced with in their lifetime can differ considerably from person to person. Higher doses are usual, e.g., in astronauts in space or in cancer patients who must undergo radiotherapy. For an average citizen, there are two main sources of radiation exposure: one is man-made, the other originates in nature. These are medical diagnostic and therapeutic methods, on the one hand, and naturally occurring radon, on the other hand. "In medicine, the major part of this exposure can be attributed to CT", explains PTB physicist Dr. Annette Röttger.

In contrast in the case of natural exposure, it is radon mostly which is responsible: if a house happens to be built on an earth fissure through which large quantities of radon escape from underground, this could put the inhabitants of the house at risk, especially in the event of poor ventilation causing the radon to accumulate in the ambient air. Radon-222 is a radioactive noble gas. It decays into different heavy metals which, in turn, decay radioactively. This decay process is accompanied by the emission of alpha radiation. "In air, an alpha emitter becomes ineffective after a few centimetres", explains Dr. Röttger. "In the body, however, it is extremely effective: if it penetrates the lung together with radon gas, it can damage the bronchia and cause lung cancer." It is possible to protect oneself against this natural risk from the underground or from construction materials (such as, e.g., granite flooring or plasterboard, which can also release radon). "This can, however, be expensive", says Dr. Röttger. Before starting to equip their basement with a permanent ventilation system or tearing out drywall sheets, house owners should at any rate first take accurate measurements.

And this is where the dilemma appears: Radon may occur at activity concentrations of up to approx. 100 000 Bq/m^3 in German houses. But on average, usually no more than 50 Bq/m^3 to 200 Bq/m^3 occur in a house. Measuring instruments could previously only be calibrated at concentrations of at least 1000 Bq/m^3. "At lower concentrations, they definitely become less accurate, sometimes even incorrect. And we hardly ever know by how much", says Dr. Röttger. A very uncomfortable situation – not only for house owners, but also for the manufacturers of these measuring instruments who will probably soon have to make sure that their devices are also suitable for the testing of reference values – the International Commission on Radiological Protection (ICRP) having increased the estimated biological effectiveness of radon. Thus, radon contributes to a much higher effective dose than previously thought. This has consequences: a Europe-wide uniform reference value has, for the first time, been laid down for the mean radon concentrations in buildings. This reference value is 300 Bq/m^3 and is thus clearly lower than the previous (non-binding) recommendations.

Within the next three years, these specifications will have to be transposed into national law. In Germany, this could already be the case this autumn. From then on, there will, for the first time, be binding reference values for the radon concentration in public buildings such as, e.g. schools, instead of the previous recommendations.

PTB has prepared itself for this development in good time. Within the scope of PTB's doctoral programme, Diana Linzmaier, together with the team of the "Radon Measuring Technique" Working Group, developed a novel measuring facility that allows also the low everyday activity concentrations to be measured accurately for the first time. The apparatus consists of several parts: first, there is a newly developed radium-226 activity standard that generates radon (Rn-222, the progeny of Ra?226) continuously for a much longer period of time than previous radon activity standards. With the latter, the measuring time ended at the latest after four days – radon's half-life. This new source makes the radon gas, whose quantity and activity are exactly known, flow into a chamber continuously where it is mixed with air. In this way, a reference atmosphere is generated. "Hence, we have an exactly known quantity of air with an exactly known quantity of radon: this means a known activity in a defined volume", says Dr. Röttger. After calibration, a measuring instrument should indicate these values as accurately as possible. And since the new activity standard does not put us under time pressure, greater accuracy can be achieved by means of measurements that can last several weeks. As an alternative, the generated radon atmosphere can also be transported to a new, highly sensitive measuring instrument (see Figure). This highly sensitive transfer standard can measure a concentration of 200 Bq/m^3 with a measurement uncertainty of 2 % – and much faster than previously.

Manufacturers of radon measuring instruments can already have their devices calibrated at PTB or at the Federal Office for Radiation Protection (*Bundesamt für Strahlenschutz, BfS*) which has also been provided with a transfer standard by PTB. One can assume that the improved measurement capabilities will have an influence on future studies dealing with the re-assessment of the risks of lung cancer due to radon.

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