The mathematical model of radon-222 accumulation in underground mines

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Necessity to control underground mine air radon level arises during building and operating mines as well as auto and railway tunnels including those for metros. Calculation of underground mine air radon level can be fulfilled for estimation of potential radon danger of area for underground structure building. In this work the new mathematical model of radon accumulation in underground mines has been suggested. It takes into consideration underground mine dimensions, air exchange factor and soils ability to emanate radon.

The following assumptions have been taken for model development. It is assumed that underground mine is a cylinder of length L and of base area S. Due to ventilation atmosphere air of volume activity C_{atm}, is coming in through one cylinder base and is going out of volume activity C_{ind} from underground mine.

Diffusion radon flux is coming in through side surfaces of underground mine. The sources of this flux are radium-226 atoms distributed evenly in rock. For simplification of the task it considered possible to disregard radon emanation by loosened rock and underground waters. As a result of solution of the radon diffusion equation the following expression for calculation of radon volume activity in underground space air has been got:

$$C_{ind} = \frac{2 \cdot r_0 \cdot \lambda_v \cdot C_{atm} \cdot l \cdot K_0(r_0/l) + D \cdot K_1(r_0/l) \cdot C_0}{2 \cdot (\lambda + \lambda_v) \cdot r_0 \cdot l \cdot K_0(r_0/l) + D \cdot K_1(r_0/l)}.$$

The following designations are used in this expression:

$K_\nu(r)$ – the second genus modified Bessel's function,

C_0 – equilibrium radon volume activity in soil air,

l – diffusion radon length in soil,

D – radon diffusion factor,

r_0 – radius of underground tunnel,

λ_v – factor of air exchange.

Expression found may be used for calculation of the minimum factor of necessary air exchange for ensuring safe radon levels in underground spaces. With this worked out model expected levels of radon volume activity were calculated for air in the second metro line underground spaces in the city of Yekaterinburg, Russia.