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Analysis of the research activities in Bulgaria related to evaluation of the degree of water saturation in the near-surface layer in connection with the assessment of the radon potential

Анализ на изследванията в България, свързани с оценка на степента на водонасищане на приповърхностния слой във връзка с оценка на радоновия потенциал

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Introduction

Natural radon (^{222}Rn) is a radioactive noble gas that occurs as a result of the content of radium (^{226}Ra), part of the ^{238}U family in the geological environment. The gas is a product of the decay of natural uranium, found to varying degrees in a wide range of rocks and soils, as well as in building materials. The content ^{226}Ra and permeability vary between the different types of rocks and soils. Radon gas has high mobility and migrates by diffusion and convection with the soil gas through connected and water-unsaturated pores and/or cracks in permeable rocks and soils. The physical characteristics of the soil layers, particularly its permeability, can also affect the flow of ^{222}Rn (Porstendorfer, 1994). Therefore the radon potential of an area depends not only on geology as the constant source of the gas but is affected also by varying saturation state of the ground.

Relationships between the radon potential and moisture content of the medium have been established by different researchers, e.g., Pinault and Bauron (1996), etc. Two tendencies have been reported (Sadoka et al., 2011) for the radon potential in large areas. The first one is based on results indicating increase of radon potential with the increase of moisture content in the medium (Arvela et al., 2016). In this case, the geological medium is represented by granites and similar magmatic rocks. The second tendency is opposite – increase of the water content results in decreasing radon potential, or so-called “screening effect” (Jönsson, 2001; Sadoka et al., 2011). With regard to radon potential tendencies, currently there is insufficient data from detailed investigations of the hydrogeological conditions and hydraulic properties.

The aim of the study is to present an overview and analyse the existing research activities as regards the observation and/or evaluation of the degree of water saturation of the near-surface layer.

Research activities and discussion

The studies concerning moisture dynamics in the near surface layers may generally be distinguished in two main groups: the first one includes investigations of hydraulic characteristics (parameters) of the soils in the vadose zone. These form the basis for conclusions, or even for performing computer simulations. The other group includes in situ observations (with sensors) of the change in moisture content with time.

From the first group, the earliest published investigation results are from studies by Spassov (1966, 1969). In them, the problems of the approximate calculation of the natural movement of moisture in the zone of aeration is based on three methods – tensiometric, centrifugation and adsorption (Spassov, 1966), and the nature of the total soil moisture potential (Spassov, 1969) had been discussed. The latter concerns especially loess and argillaceous-sandy

soils. It is not a surprise, as loess soils are largely unsaturated and cover about 13% of the Bulgarian territory. The most recent investigations of the hydraulic characteristics of these soils are connected with the *in situ* field-scale soil hydraulic parameters derivation for all unsaturated layers in area close to Kozloduy NPP by using large scale infiltrometer tests, *e.g.*, Mallants et al. (2007). For the second group, consisting in real time observation of the moisture and matrix (suction) potential on the loess complex, are those of Gerginov et al. (2018) and Antonov et al. (2018a). In these studies, results are discussed, that were obtained by sensors installed at three levels below the ground tensiometers and sensors for soil moisture content.

To the first group belongs modeling studies implementing the PTF`s hydraulic characteristics with regard to flow and arsenic transport in the Ogosta River floodplain. The simulation results showed complete water saturation of the floodplain deposits at some of the arsenic polluted spots, while only the upper layers were saturated at other sites (Benderev et al., 2015; Antonov et al., 2018b). In connection with the observation of moisture dynamics at the upper part of a soil profile is the study presented by Kolev (2016) discussing the surface-groundwater interaction at the region of Vulche Dere, SW Bulgaria.

Conclusion

The hydrogeological investigations concerning the moisture dynamics in the vadose zone are mainly for the Northern Bulgaria due to the widespread loess deposits. These studies can serve as the base for further detailed investigation at sites with specific radon potential.

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References

Antonov, D., T. Orehova, P. Gerginov, S. Kolev. 2018a. Seasonal changes of the soil-water potential in loess deposits, Northeastern Bulgaria case. – *Rev. Bulg. Geol. Soc.*, *79*, 3, 133–134.

Antonov, D., K. Nakamura, T. Kotsev, V. Stoyanova, R. Kretzschmar. 2018b. Application of hydrus-1D for evaluation of the vadose zone saturation state in connection with arsenic mobilization and transport in contaminated river floodplain – Ogosta Valley case study, NW Bulgaria. – In: *Proceedings of the 18th International Multidisciplinary Scientific GeoConference "SGEM`2018"*, Albena, 83–90.

Arvela, H., O. Holmgren, P. Hänninen. 2016. Effect of soil moisture on seasonal variation in indoor radon concentration: modelling and measurements in 326 Finnish houses. – *Radiation Protection Dosimetry*, *168*, 2, 277–290.

Benderev, A., P. Gerginov, D. Antonov, N. van Meir, R. Kretzschmar. 2015. Conceptual hydrogeological model of the Ogosta river floodplain (Western Balkan, Bulgaria) and its application for predicting of groundwater contamination with arsenic. – In: *Proceedings of the 15th International Multidisciplinary Scientific Conference "SGEM 2015"*, Albena, 195–202.

Gerginov, P., T. Orehova, V. Petrova, D. Antonov. 2018. Moisture regime in the upper part of the loess complex in North-Eastern Bulgaria. – *Rev. Bulg. Geol. Soc.*, *79*, 3, 139–140.

Jönsson, G. 2001. Soil radon depth dependence. – *Radiation Measurements*, *34*, 415–418.

Kolev, S. 2016. Surface-groundwater interaction at the region of Vulche Dere, downstream of "Eleshnitsa" tailing pond. – In: *Proceedings of the National Conference with International Participation "CEOSCIENCES 2016"*, Sofia, Bulg. Geol. Soc., 153–154 (in Bulgarian with English abstract).

Mallants, D., D. Karastanev, D. Antonov, J. Perko. 2007. Innovative in-situ determination of unsaturated hydraulic properties in deep loess sediments in North-West Bulgaria. – In: *Proceedings of the 11th International Conference on Environmental Remediation and Radioactive Waste Management, ICEM07-7202*, Bruges, Belgium, 7 p.

Pinault, J. L., J. C. Baubron. 1996. Signals processing of soil gas radon, atmospheric pressure, moisture and soil temperature data: a new approach for radon concentration modelling. – *Geophysical Research Letters*, *101*, B2, 3157–3171.

Porstendorfer, J. 1994. Properties and behaviour of radon and thoron and their decay products in air. – *J. Aerosol Sci*., *25*, 219–263.

Sadoka, A., Y. Ishimori, K. Yamaoka. 2011. A comprehensive review of radon emanation measurements for mineral, rock, soil, mill tailing and fly ash. – *Applied Radiation and Isotopes*, *69*, 1422–1435.

Spassov, V. 1966. Moisture dynamics in the zone of aeration and its effect on the regime and balance of shallow groundwaters. – *Works on the Geology of Bulgaria, Series Engineering Geology and Hydrogeology*, 5, 45–60 (in Bulgarian with English abstract).

Spassov, V. 1969. On the total soil moisture potential and methods of its determination. – *Hydrology and Meteorology*, *28*, 1, 55–61 (in Bulgarian with English abstract).