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ALTERNATIVE ENERGY SOURCES, MATERIALS AND TECHNOLOGIES

AESMT ’21

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MAIN TOPICS

ALTERNATIVE ENERGY SOURCES
• Solar and Hybrid Thermal Systems
• Solar Photovoltaic Systems
• Solar Radiation Measurement and Sun-tracking
• Geothermal Energy Applications
• Phase Change Materials (PCM) Applications
• Wind Energy
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FOREWORD

The Fourth International Scientific Conference "Alternative Energy Sources, Materials & Technologies AESMT'21" was held between 14th and 15th June 2021 in Ruse, Bulgaria. Representatives of 34 countries (Austria, Bulgaria, Chile, China, Cyprus, Egypt, France, Germany, Greece, Hungary, India, Iran, Iraq, Israel, Italy, Kazakhstan, Kosovo, Kuwait, Latvia, Lebanon, Lithuania, Macedonia, Nigeria, Norway, Portugal, Romania, Russia, Serbia, Spain, Tajikistan, Turkey, United Kingdom, and Yemen) sent their works to the conference. Selected reports (69 works) have been published as short papers in the proceeding of the conference.

It is my pleasure to be an editor of the presented short papers, which focus on new international scientific results in the field of Alternative Energy Sources, Materials and Technologies (Solar and Hybrid Thermal Systems, Solar Photovoltaic Systems, Solar Radiation Measurement and Sun-tracking, Geothermal Energy Applications, Phase Change Materials (PCM) Applications, Wind Energy, Biotechnologies, Hydrogen Energy, Ocean/ Tidal Energy, Energy Materials Science, Mechanical Engineering and Technologies, Electrical Engineering, Low-Carbon Technologies, Energy Efficiency).

Prof. Aleksandar Georgiev, PhD (European Polytechnic University, Pernik, Bulgaria)

Chair of the AESMT'21 conference

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Alternative Energy Sources, Materials & Technologies (AESMT'21), Volume 3, (pp. 53-54) 2021
ALTERNATIVE ENERGY SOURCES, Geothermal Energy Applications

Daily variation of the indoor radon in Bulgarian spas using geothermal water

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The territory of Bulgaria is abounding on geothermal springs. International studies report that elevated levels of radon have been found in some geothermal waters. Radon is a naturally occurring radioactive gas formed as the decay product of radium. Currently radon is recognized as the second cause of lung cancer in the population after tobacco. The radon levels in spas buildings using geothermal water depends on the following factors: soil underneath, weather conditions and time of day, thermal water and the ventilation. The purpose of the study is analysis the daily variation of radon concentration in balneotherapy premises using mineral water in Bulgarian spas. The concentrations vary widely (from 8 – to 5485 Bq m^{-3}) in different spa and during the day. A statistically significant difference (WS, $p < 0.0001$) between day and night radon concentrations for all spa buildings was found. The comparison of the radon values in premises with and without ventilation system shown the statistically significant difference (MW, $p < 0.0001$).

Keywords: Indoor radon, geothermal water, daily variation, Bulgarian spas, spectra

INTRODUCTION

The territory of Bulgaria is abounding in thermal springs [1, 2]. Traditionally, one of the applications is in the field of balneology. Radon (^{222}Rn) is a naturally occurring radioactive gas formed as the decay product of radium (^{226}Ra). In the open atmosphere the radon concentration varies between 10 and 100 Bq.m^{-3}, depending on weather conditions and time of day [3]. The variation of the radon concentration shows a pronounced maximum during the night and early in the morning hours. The radon levels in buildings depend on the following factors: soil underneath, weather conditions and time of day, thermal water and the ventilation. The concentration of radon varies considerably depending on various parameters: [1]source (topography, soil characteristics, type of buildings); [2]metrological parameters (pressure, humidity, temperature, time) and [3]other variables such as habits and mode of life of the inhabitants. It is known that a large number of spas used for thermal therapy have a higher concentration of radon [4, 5]. The requirements of ICRP and WHO include the control of indoor exposure due radon with reference level for the annual average activity concentration up to 300 Bq.m^{-3} for dwellings and public buildings. This article presents the results of direct measurements of indoor radon in premises using geothermal water for treatment in 11 spas in Bulgaria. The aim of the study is to analyze the variations of the day and night indoor radon concentrations in the treatment rooms of the spas.

MATERIALS AND METHODS

Objects of study

Eleven branches on Specialized Hospitals for Rehabilitation - National Complex (SHR-NC), whose location is throughout the territory of Bulgaria, were surveyed. These sites use geothermal water for treatment and we accepted to call them a spa. In five spas there is a ventilation system that works for several hours during the day.

Radon measurements

Direct measurements of radon concentrations in spas air with Alpha Guard PQ2000, AlphaE and TERA (TSR3D) system were performed. The spectra of the premises for a period of 24 hours were considered for analysing the indoor radon variations during the day and night.

All the data were compiled into Microsoft Excel spread sheets, and the statistical analysis was performed with the software IBM SPSS Statistics, v. 23. Descriptive analysis and non-parametric tests (Wilcoxon Signed ranks test and Mann-Whitney test) are applied for data processing.

RESULTS AND DISCUSSION

The spectra of the premises in which geothermal water is used for treatment are considered, divided into day and night radon concentration. In a larger number of rooms (9 numbers) the indoor radon at night are lower than during the day which has been established as regularity for external radon since the 90s [3]. Measurements of radon levels in rooms with available ventilation system (5 premises) and without such (6 premises) are considered. The descriptive statistic of direct measurements of indoor radon concentration in spa premises is presented in Tab.1.

Table 1. Descriptive statistic of indoor radon concentrations measured in 11 premises with mineral water

Groups premises	AM CRn	SD CRn	Min CRn	Max CRn	CV
	$Bq.m^{-3}$	$Bq.m^{-3}$	$Bq.m^{-3}$	$Bq.m^{-3}$	%
CRn-nigth	324	725	10	4397	224
CRn-day	463	1065	8	5485	230
With ventilation	181	294	9	1102	162
Without ventilation	570	1178	8	5485	207

The indoor radon varies widely (from 8 to 5485 $Bq.m^{-3}$) in different spas rooms and during the day. The evaluated value of AM=181 $Bq.m^{-3}$ for premises with ventilation is more than twice lower in comparison than those without ventilation system AM=570 $Bq.m^{-3}$.

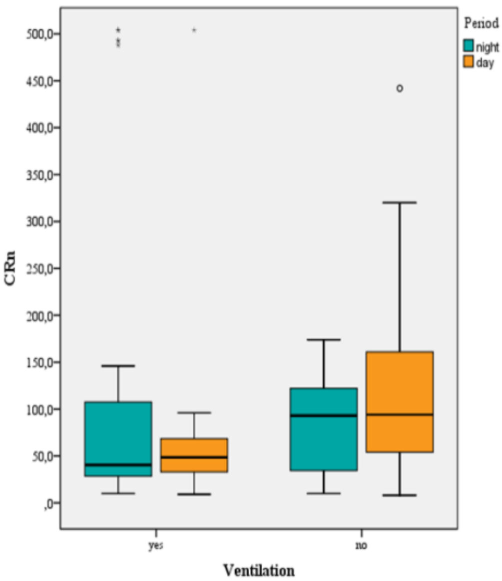

Fig.1. Distribution of the indoor radon depending on the period and of the presence ventilation system

Fig.1 presents the results of the studied groups: daily (orange) and night values (blue) of radon and the presence of ventilation ("yes" with a ventilation system and "no" without one. A statistically significant difference was found of radon values during the day and night (WS, $p < 0.001$). The difference is statistically significant and when comparison of indoor radon values of the premises with the presence of ventilation system and without ventilation system (MW, $p < 0.001$).

CONCLUSIONS

Radon that enters in spa buildings may reach high concentration. One of the effective way to improve the air quality in the premises using geothermal water is to install a mechanical ventilation system. Such places must be subjected to a special investigation, taking into account the whole mobility of radon.

ACKNOWLEDGEMENTS

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NOMENCLATURE

AM CRn – arithmetic mean of radon;
SD CRn – standard deviation of radon;
Min – minimum;
Max – maximum;
CV – coefficient of variation;
WS – Wilcoxon Signed Ranks test;
MW – Mann-Whitney test.

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