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Short communication

Radioactivity of peat mud used in therapy

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ABSTRACT

The aim of the study was to determine the contents of natural and artificial isotopes in peat mud and to estimate the radiation dose absorbed via skin in patients during standard peat mud treatment. The analysis included 37 samples collected from 8 spas in Poland. The measurements of isotope concentration activity were conducted with the use of gamma spectrometry methods. The skin dose in a standard peat mud bath therapy is approximately 300 nSv. The effective dose of such therapy is considered to be 22 nSv. The doses absorbed during peat mud therapy are 5 orders of magnitude lower than effective annual dose absorbed from the natural radiation background by a statistical Pole (3.5 mSv). Neither therapeutic nor harmful effect is probable in case of such a small dose of ionising radiation.

1. Introduction

Natural peat mud is a therapeutic peloid used for centuries in the treatment of many diseases (Priegnitz, 1986). Chemical composition of peat mud depends on the type and conditions of its formation (McCarthy, 2001; Beer et al., 2013). Peat mud is mainly composed of water, organic compounds such as: humic substances (HS) humic acids (HA), fulvic acids, lignin, cellulose and bitumen as well as inorganic compounds.

Various degrees of radioactivity of peat mud baths were first observed in Russia. The results were presented by Prof. Borgman on 24th May 1904 (The Lancet, 1904). Already in 1982, Bondietti observed that the presence of humic substance (HS) in natural waters resulted in an increased uptake of radionuclides from the waters (Bondietti, 1982). Similarly, in 1985 Owen and Otton observed increased radioactivity of sediments obtained from numerous wetlands of Colorado (Owen and Otton, 1995). The sediments in many of these wetlands contained 3 to 5 orders of magnitude more uranium than the proposed maximum contamination level for drinking water. Also Hungarian authors confirmed that peat mud binds ^{226}Ra present in water in great amounts (Somlai et al., 2007).

Peat mud therapy is used in the treatment of a wide range of diseases of the musculoskeletal system, gynaecologic disorders as well as skin diseases (Fioravanti et al., 2007; Baatz, 1988; Matz et al., 2003).

Since peat mud shows ion exchange properties, it can be assumed that it may contain more radioactive substances compared to soil. However, neither comprehensive measurements of radionuclides in peat mud nor any data on the dose of ionising radiation absorbed by patients during peat mud bath treatment can be found in the available literature.

The aim of the study was to determine radionuclide contents in peat mud used in bath therapy and to evaluate the skin dose and effective dose absorbed by patients via skin.

2. Material and methods

The study included the measurement of activity concentrations of particular isotopes collected from 8 spas. The study material comprised 37 samples of peat mud of approximately 6 dm^3 of volume collected from 8 various spa localizations in Poland. The material prepared for the therapeutic bath procedures was collected directly before its use.

Liquid peat mud was dried in laboratory conditions in order to obtain dry constant mass. The samples were placed in a Marinelli-

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type vessel in geometry of 600 cm^3. The measurements of sample activities were carried out using gamma spectrometry method, CANBERRA spectrometric set with 34.8% coaxial germanium detector and computer system for collection and analysis of spectra Genie2000. The programme includes the interference of other isotopes on a particular energetic spectral line. Moreover, in case of certain isotopes, the measurement of IAEA 375 reference source was conducted. The obtained values were within the confidence limits.

The measurement method with the use of Marinelli geometry and Lloyd A. Currie's calculation applied in the study ensured lower limit of detection (Currie, 1968) at the level of 0.1 Bq kg^{-1}.

As the distribution of activity concentration of radionuclides in the examined group was close to lognormal, non-parametric tests were used for statistical analyses of the results. The analysis of correlations between particular analysed properties was conducted using the Spearman's correlation coefficient. Statistical analyses were performed at the level of significance of 0.05.

3. Results

3.1. Radioisotopes determined in peat mud

The recorded radionuclides, except for ^{137}Cs and ^{40}K, belong to two radioactive series. No radionuclides were observed in the actinide decay chain. Four of the detected radionuclides belong to the thorium decay series and five to the uranium one. Other radionuclides that are parts of both chains were not observed which may be caused by the type of radiation or by their low content in peat.

The following radionuclides were determined in all the examined samples: ^{40}K, ^{137}Cs, ^{208}Tl, ^{210}Pb, ^{212}Bi, ^{212}Pb, ^{214}Bi, ^{214}Pb, ^{226}Ra, ^{228}Ac and ^{234}Th. Table 1 presents the values of arithmetic mean, geometric mean, standard deviation and geometric standard deviation of specific activity of the elements measured in dry peat mud mass. Fig. 1 presents median and range of changeability of the 1st and 2nd quartile of the radionuclide activity concentration.

3.2. Skin dose and effective dose calculation

The activity concentrations of radionuclides in peat mud are low. However, taking into account direct contact with the skin, we tried to assess the radioactive dose absorbed by patients during the therapy. We assume here, that radionuclides does not penetrate skin during treatment and in dose assessment we consider only radionuclides, for which activity was determined in this study. Alpha radiation of ^{226}Ra was omitted as it fails to reach the cells of the basal layer which are most sensitive to radiation (ICRP, 2010), as

Table 1
Arithmetic mean (AM), geometric mean (GM), standard deviation (SD), and geometric standard deviation (GSD) activity concentration radionuclides in the whole group of examined samples.

Radioactive series		AM Bq kg^{-1}	GM Bq kg^{-1}	SD Bq kg^{-1}	GSD
	^{40}K	32.2	18.9	31.8	3.1
	^{137}Cs	2.2	0.9	3.1	3.7
^{232}Th	^{208}Tl	1.5	1.4	0.7	1.7
	^{212}Bi	4.0	3.1	2.8	2.1
	^{212}Pb	3.1	2.2	2.5	2.5
	^{228}Ac	3.2	2.4	2.4	2.3
^{238}U	^{210}Pb	12.3	8.7	9.9	2.4
	^{214}Bi	4.3	3.5	2.5	2
	^{214}Pb	4.2	3.1	2.9	2.4
	^{226}Ra	12.0	7.1	10.4	3.1
	^{234}Th	10.6	6.5	10.4	2.8

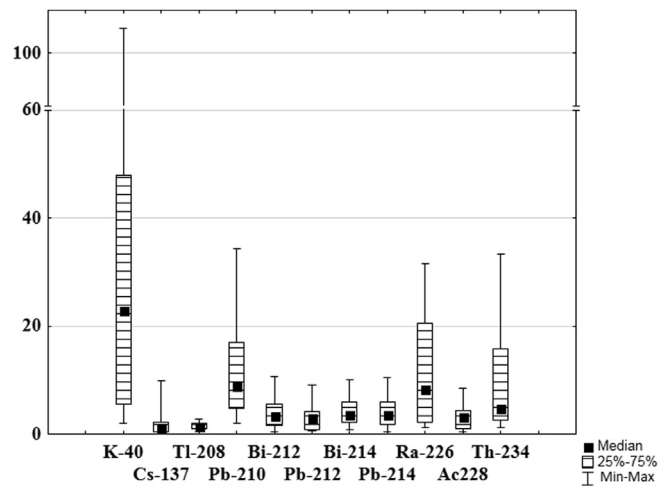

Fig. 1. Concentration activity of particular radionuclides in peat mud samples.

presented by Schirren in his clinical study in 1964 (Schirren, 1964).

The evaluation included the doses from beta and gamma radiation. In order to calculate the dose, we used the activities of elements in the bath and not the dry mass. Fivefold lower concentrations of radionuclides than those determined in dry substances were used for dose calculation. If was assumed that the content of water in peat mud bath mass amounted to 80%.

The equivalent beta dose on the skin as well as the effective dose absorbed at the depth of 7 mg cm^{-2} during peat mud baths were assessed. The approximate time of the bath procedure was 30 min and the number of sessions in one therapeutic cycle amounted to 10. Activity concentration per unit area on the skin A was established

$$A = \rho \cdot r \cdot A_p$$

where: ρ – density of peat mud,

r – β particle range in peat mud,
A_p – activity concentration Bq kg^{-1},

Next, calculate the equivalent dose to the skin area H:

$$H = A \cdot T \cdot \hat{a}$$

where:

T – exposure time in hours,
$\hat{a}$– beta equivalent dose rate coefficients in the skin from radionuclides deposited uniformly on the body surface to basal layer of the skin epidermis Sv h^{-1}/Bq cm^{-2} (Kocher and Eckerman, 1987).

The following equation was used in order to determine the effective dose (E)

$$E = A \cdot T \cdot w \cdot S \cdot \hat{a}$$

where:

w – tissue weighting factor for skin (0.01),
S – submerged body surface fraction (0.94).

Maximal values of radionuclide activities were used in our calculations in order to estimate absorbed doses. No sample showed