Gamma dose rate and radionuclides content in beach sands of Western Pomerania, Poland

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Natural background gamma radiation depends on high-energy cosmic radiation and terrestrial radionuclides content in the earth's crust. Main terrestrial radionuclides which are gamma-emitters responsible for external exposure to human beings are radionuclides of the ^{238}U and ^{232}Th decay series as well as ^{40}K. The worldwide average outdoor absorbed dose rate that arise from the presence of these radionuclides in the environment is equal to 58 $nGy{\cdot}h^{-1}$ (UNSCEAR, 2000).

Terrestrial radiation reflects geological background. In general, the igneous rocks (especially rich in alkali and silica) are more radioactive than the sedimentary rocks. Nevertheless, there are some exceptions, such as shales or phosphate rocks which may contain relatively high concentrations of radionuclides (UNSCEAR, 2000). Sands usually are characterised by low radioactivity, but some beach sands may contain elevated concentrations of U and Th. A few coastal regions of high background gamma radiation, e.g. in Brazil, India or Egypt are well investigated. Radioactivity of beach sands results from the presence of heavy minerals, such as monazite and zircon, which are carriers of U and Th (Abd El Wahab & Nahas, 2013). Contribution of monazite in heavy-mineral sand deposits may reach 4% (Tamil Nadu, India) and contribution of zircon 8% (Kerala, India) (IAEA, 2011).

Heavy minerals, as high-density material, tend to concentrate in areas of beach erosion; meanwhile minerals of lower density are deposited in areas of beach accretion. Heavy-mineral accumulations form dark strips parallel to the shoreline and situated in foreshore or backshore. Heavy minerals may also be concentrated behind obstacles (Vassas *et al*., 2006).

The aim of the research was to investigate background gamma radiation and radionuclides concentration in beach sands in Międzyzdroje, Dziwnów and Rewal (western coast of Poland), especially in zones enriched with heavy minerals.

Measurements of uranium ^{238}U (in ppm), thorium ^{232}Th (in ppm) and potassium ^{40}K (in %) content in beach sands have been conducted in situ by means of the portable gamma spectrometer RS230 with a BGO detector. A single measurement lasted 180 s. Measurements have been performed directly on the sands and 1 metre above the ground level. Two profiles, in Międzyzdroje and Dziwnów, with measurements at approximately 2 meters between shoreline and dunes have been arranged. In Rewal measurements have been performed directly on heavy-mineral sands concentrated behind obstacles.

Absorbed dose rate in $nGy{\cdot}h^{-1}$ was calculated using the formula:

$$D = 0.043{\cdot}S_K + 0.43{\cdot}S_{Ra} + 0.66{\cdot}S_{Th}$$

where S_K, S_{Ra} and S_{Th} are activity concentrations of K, U and Th in $Bq{\cdot}kg^{-1}$.

Additionally, mineralogical analyses of beach sands from Międzyzdroje have been performed at the University of Silesia in Katowice by means of X-ray diffraction (XRD) technique.

One, 2-metre width, strip of heavy-mineral sands was observed in Dziwnów at a distance of approx. 8 m from the shoreline. Two strips were observed in Międzyzdroje. The first one, 3-metre width, was situated approx. 10 m from the shoreline and the second one, 1-metre width, was located approx. 35 m from the shoreline, close to the dunes. In Rewal, accumulations of heavy minerals were observed behind a breakwater and behind an unused fishing boat.

Average absorbed dose rate in Międzyzdroje and Dziwnów at the level of 0 m was equal to 42.8 and 28.4 $nGy{\cdot}h^{-1}$, respectively and at the level of 1 m 33.0 and 24.5 $nGy{\cdot}h^{-1}$, respectively. The greatest values of absorbed dose rate were observed in zones of heavy minerals accumulation (Fig. 1.).

Average concentrations of K, U, Th in beach sands at the level of 0 m in Międzyzdroje were 151.6, 30.1, 35.4 $Bq{\cdot}kg^{-1}$, respectively and in Dziwnów 178.0, 37.7, 6.9 $Bq{\cdot}kg^{-1}$, respectively. Average concentrations of K, U, Th in heavy-mineral sands at the level of 0 m in Międzyzdroje were 117.4, 70.7, 114.1 $Bq{\cdot}kg^{-1}$, respectively and in Dziwnów 151.3, 52.9, 8.4 $Bq{\cdot}kg^{-1}$, respectively.

XRD analysis of PW sample from Międzyzdroje showed the presence of zircon (4.3%). Concentrated PW sample contains 4.6% of zircon and 0.5% of monazite; meanwhile concentrated PB sample contains 8.4% of zircon.

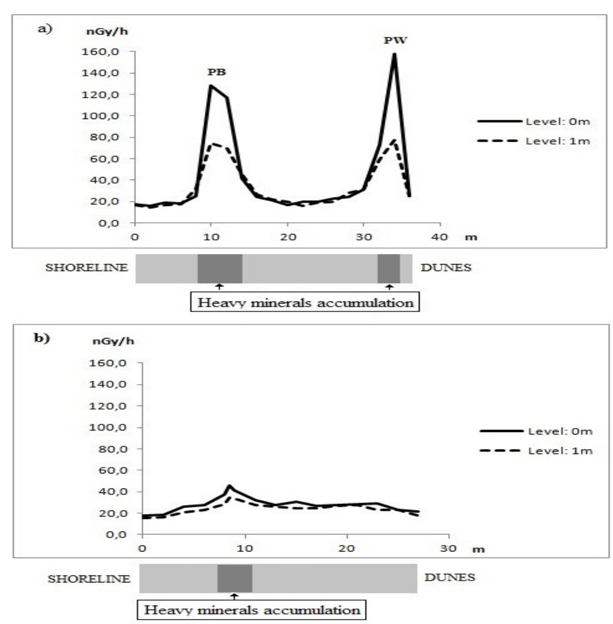

Fig.1. Absorbed dose rate ($nGy{\cdot}h^{-1}$) between shoreline and dunes along the profile in Międzyzdroje (a) and Dziwnów (b)

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