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RESEARCH ON CHANGE OF NATURAL RADIONUCLIDE RADIATION ABOVE HIGHWAYS PAVEMENT IN LITHUANIA

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Abstract. Average *Equivalent Dose Rate* (*EDR*) caused by natural radionuclide gamma (γ) radiation has been measured above the pavement of the following highways: Vilnius–Panevėžys, Vilnius–Rokiškis, Vilnius–Klaipėda. The estimated *EDR* values vary from 116 to 142 nSv/h above asphalt concrete pavement and from 79 to 122 nSv/h depending on the composition of soil above the highways sides. Spectrometer research of asphalt concrete and samples of various types of soil have been made. Natural radionuclide specific activity (*A*, Bq/kg) in asphalt concrete is higher than in clay loam and sandy loam: potassium (^{40}K) and radium (^{226}Ra) – about 3, thorium (^{232}Th) – 4 times.

Keywords: gamma (γ) radiation, *Equivalent Dose Rate* (*EDR*), specific activity (*A*), gamma (γ) spectrometer.

1. Introduction

Based on the report of European Commission the major constant sources of human radiation is ionizing radiation of natural radionuclide and cosmic radiators. According to the data of *Great Britain National Security Board (UNSCEAR)*, each hour human body receives 0.5 mln secondary cosmic radiators and neurons, about 7000 uranium (^{238}U) and 15 mln potassium (^{40}K) atoms break in the entire body, about 30 000 atoms break in lungs themselves; 200 mln gamma (γ) quanta access human body from soil and building material.

Building material can be polluted by natural radionuclide when during their production industrial by-products and waste with high degree of radionuclide specific activity are used (Xinwei 2005; Al-Jundi *et al.* 2003), besides, building materials also include natural radionuclide. Building of roads affects not only natural landscape but also radiation phon which has been stabilized for million of years.

Lithuanian Road Administration under the Ministry of Transport and Communications informs that the types of highway pavements are asphalt concrete (AC) (1675.9 km), cement concrete (72.2 km) and sett paving (0.38 km) in the Republic of Lithuania. The quality of road pavement depends on its composition and structure (Sivilevičius, Šukevičius 2009; Petkevičius, Sivilevičius 2000; Skuturna *et al.* 2008).

In this paper the ionizing radiation was investigated above highways the structure of which consists of AC pavement, the layer of macadam and sand layer. Underneath the highway structure the subgrade is situated – mostly from, sand, seldom from clay. AC – depending on the producer – might have about 90% of granite chippings. Granite is a rock mostly consisting of plutonium (*Pu*). It is formed during the great ice-age, covers thousands of km^2 and are closely related to quartz and various granular crystalline rock. Granite indicates the increased concentration of natural radionuclide: *U* and thorium (*Th*) in comparison to low quantity of these elements in Earth mantle and crust. Quantity of natural radionuclide ^{40}K is frequently high: 33 times higher than ^{232}Th, 23 times higher than ^{238}U (Osmanlioglu 2006; Papaefthymiou 2008; Kumar *et al.* 2003). Excavated granite in different countries is characterized by different activity concentration (*A*) (Papaefthymiou 2008).

Building material influences human health in several ways. Firstly, ^{238}U, ^{232}Th family radionuclide as well as ^{40}K γ radiation causes external human radiation, secondly, exhalation of radon (^{222}Rn and ^{220}Rn) from material causes internal radiation because of split products of radon and thoron that appear in human respiratory system. Particular focus is on radium (^{226}Ra) (^{238}U family split product) *A* in building material because radon emanation depends on it.

Equivalent Dose Rate (*EDR*) is important parameter reflecting the ionizing radiation influence upon human body. *EDR* of γ radiation equal *EDR* from the reasons determining the same values in the regions and locations re-

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mote from the highways. It is important to identify major reasons for *EDR* fluctuation and its limits near highways. Values of *EDR* above pavement of highway and its sides are compared to average values characteristic to the region in which the highway extends. The influence of radionuclide radiation in AC pavement on *EDR* is analyzed The identified values can be used for comparison while investigating various happenings in the region related to the pollution with radioactive materials.

The objective of this research is to investigate ionizing radiation near highways in Lithuania and to determine the *EDR* fluctuation there. It is aimed to evaluate major reasons of *EDR* fluctuations and its limits near highways. It is pursued to compare how and why it differs from *EDR* values identified near the highway and locations remote from highways.

2. Investigation methods

Dosimetry investigations have been carried out above highways and their sides using the below described measurement methodology. *EDR* was estimated by applying transverse profile perpendicular to the highway on both sides. The scheme of the measurement is presented in Fig. 1. Each transverse profile included from 5 to 50 points remote from each other in 0.5 m distance in estimations. The highways chosen for measurements were remote from the villages and towns due to the industrial activity in towns and villages and many other factors which influence various levels of pollution (different buildings and etc.).

Highway zones are specific territories therefore the results of dosimetry measurements in the regions were analyzed prior to the measurements themselves. The measurements were taken in highway side zones and the areas beyond them. Dosimetric studies were performed using an automated, completed measurement equipment connected to the *Global Positioning System* (*GPS*) (Pečiulienė *et al.* 2006).

To ensure the efficiency of research not only dosimetric but also spectrometric measurements
were carried out.

The γ spectrometric system (*CANBERRA*) with a semiconductor *HPGe detector (resolution 2 kiloelectron volt (keV), efficiency 15%)* was used to establish the specific activity of natural radionuclides (Pečiulienė *et al.* 2004). The specific activity in the materials of the main γ radiation sources is identified. Radionuclides were identified according to the following lines: ^{40}K –1460 keV, ^{226}Ra – 186 keV, thallium (^{208}Tl) – 583 keV. The background was evaluated continuously during the measurement period, its level varied insignificantly. The chosen exposition of measurements was such that the variation of background values did not change the signal size for more then 5%.

3. Measurement results

Marked differences of γ radiation fluctuations have been identified in highway zones. Considering the influence of anthropogenic activity for fluctuation of γ radiation above ground surface, the detailed dosimetric researches above AC pavement of highways and their side zones were performed. The following factors able to influence radiation fluctuation have been taken into account: traffic flow, geographical highway position and structure, soil type at the roadside and meteorological factors.

Values of *EDR* above different surfaces (grass, AC, ground) are shown in Fig. 2.

It is estimated that the max values of *EDR* are above surface of AC, min – above grass and ground. The increased *EDR* values in some zones can be explained by the analysis of radio isotopic composition of those surfaces.

The heavy-traffic highways Vilnius–Klaipėda, Vilnius–Utena and Vilnius–Panevėžys were chosen for *EDR* measurements above surface of highway sides and above highway pavement.

The scheme of measurement locations in Lithuania is shown in the map in Fig. 3. The measurements of *EDR* were performed at points in the ground-level air perpendicularly to the roadside. It was observed how ionizing radiation changes receding from the carriageway.

The dosimetric measurements above the roadsides were performed and fluctuations of *EDR* from 79 to 122 nanosievert per hour (nSv/h) were identified. *EDR* above AC pavement fluctuates from 116 nSv/h to 142 nSv/h. The lowest γ radiation values were measured above grass and the highest one – above AC and roadside gravel.

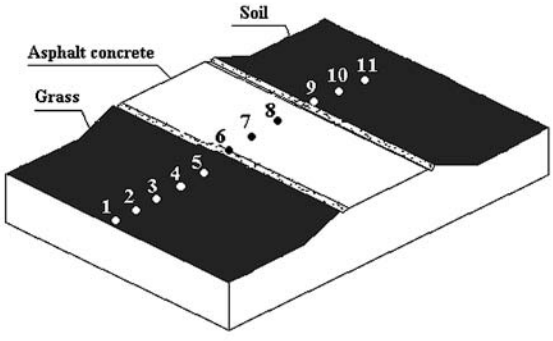

Fig. 1. Scheme of mesurement places of *EDR* above pavement of highway and its sides

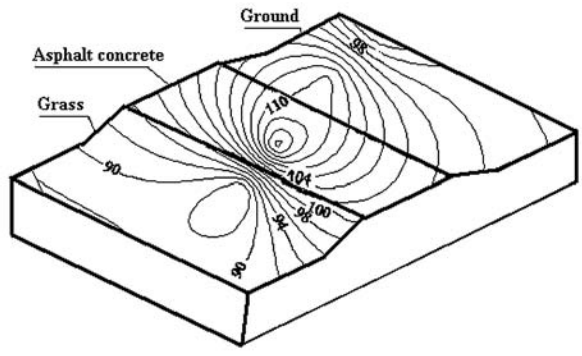

Fig. 2. Distribution of values of *EDR* above some different surfaces

Fig. 3. Measurement locations in the map of Lithuania: 1 – Vilnius–Klaipėda, 283rd km; 2 – Vilnius–Kaunas, 65th km; 3 – Vilnius–Panevėžys, 122nd km; 4 – Vilnius–Panevėžys, 12th km; 5 – Utena–Vilnius, 11th km; 6 – Utena–Vilnius, 84th km

The proportion of *EDR* above highway and soil surfaces is presented in Table 1. According to the literature, *EDR* above any surface is determined by ionizing radiation of radionuclides in it.

Table 1. Proportion of *EDR* above some AC of highways and their sides

Measurement location (Fig. 3)	Highway	Proportion of *EDR*
1	Vilnius–Klaipėda, 283rd km	1.2
2	Vilnius–Kaunas, 65th km	1.3
3	Vilnius–Panevėžys, 122nd km	1.5
4	Vilnius–Panevėžys, 12th km	1.3
5	Utena–Vilnius, 11th km	1.4
6	Utena–Vilnius, 84th km	1.2

The proportion of *EDR* values of natural radionuclides above AC pavement and above the roadside surface varies from 1.2 to 1.5. Differences in proportions are determined by differences of natural radionuclide *A* in some asphalt sectors and different composition of roadside soil.

Fig. 4 shows examples of principle variation of natural radionuclide *EDR* above the surfaces of highways and their sides: Vilnius–Panevėžys (Figs. 4a, 4b), Vilnius–Klaipėda (Fig. 4c) (*EDR* fluctuation going away from the starting point on dual carriageway). Analyzing the research results (Fig. 4a) it is seen that the *EDR* values above pavement of the highway (distance from the dual carriageway from 0 to 4 m) are higher than above the roadside surface (distance from 5 m). The γ radiation of radionuclides in the highway is 1.3 times higher than in the soil (Fig. 4a). This fact shows the influence of anthropogenic activity on natural γ radiation. Analogous results were detected in another highway distance (Fig. 4b). In the latter case the γ radiation volume above the soil surface is 1.5 times lower than it was measured above AC highway pavement. Disagreement with the first earlier described case in 12th km is explained by different radioisotopic composition of the soil. In all cases of *EDR* measurements above highway and its sides the same distribution profiles as in Fig. 4 have been identified.

The margin of error of the measured *EDR* values in the distance more than 4 m from the carriageway coincides. It indicates that sources of radiation are of the same nature. The same cannot be said about the doses above AC pavement and at the distance of 1–4 m from it. It is evident that the *EDR* values depend on radionuclides γ radiation in AC. The statistics of dosimetric measurements are presented in Table 2.

Table 2. Statistical data of *EDR* above AC and soil

Statistical parameter	AC	Distance from AC pavement, m					
		0.5	1	5	10	20	25
Average value, nSv/h	132	93	86	95	101	100	96
Min value, nSv/h	116	79	79	74	82	86	87
Max value, nSv/h	142	111	91	113	122	111	108
Median	135	94	87	96	103	101	96
Average superficial error, nSv/h	9	7	3	9	10	8	5
Number of measurements	93	94	93	98	101	99	99

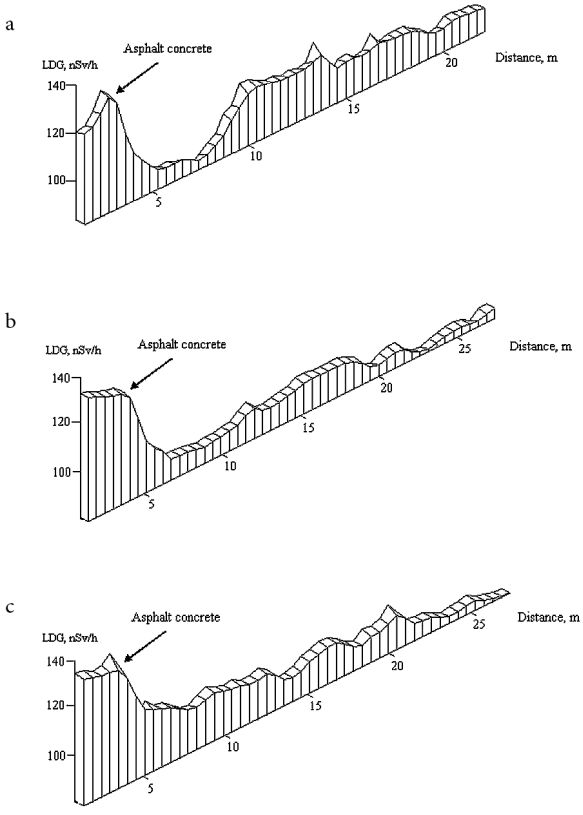

Fig. 4. *EDR* values near the highway: a – Vilnius–Panevėžys, 12th km; b – Vilnius–Panevėžys, 122nd km; c –Vilnius–Klaipėda, 283rd km

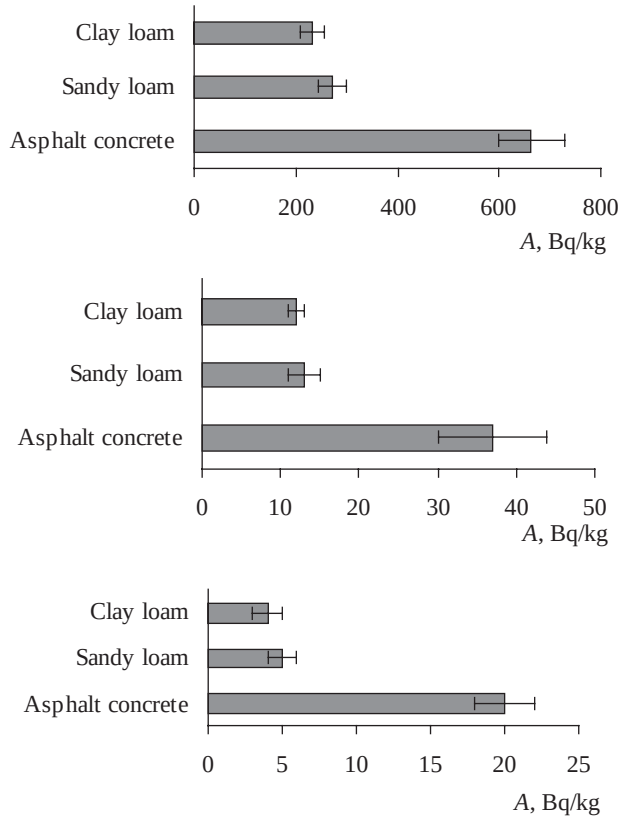

Fig. 5. *A*, becquerel for kilogram (Bq/kg) of main natural radionuclides ^{40}K, ^{226}Ra and ^{232}Th measured in soil and AC

With the purpose to evaluate fluctuation of γ radiation due to anthropogenic activity the *A* of main natural radionuclides ^{40}K, ^{226}Ra and ^{232}Th was measured in AC and soil samples. Clay loam and sandy loam dominate in the researched area. The spectrometric research results are given in Fig. 5.

The measured *A* of ^{226}Ra in AC samples are 3 times higher than in soil. *A* of ^{40}K in asphalt samples are 60% higher than in soil.

Experiment results show that road building (especially AC) changes a natural radiation background. Basically, the values increase. It is registered that in some cases γ radiation changes twice. Naturally this alternation is due to building materials which were used for road construction. Different constructions and artificial surfaces distort a natural background; therefore the measured values of *EDR* vary.

Having performed disimetric and spectrometric research, it can be stated that the measured values do not exceed the limits, therefore do not cause any danger to human health. The research results have only a scientific value.

4. Conclusions

Complex research showed that road building affects a natural radiation background, i.e. the latter basically in-

creases. The estimated *EDR* values vary from 116 to 142 nSv/h and from 79 to 122 nSv/h respectively above the AC pavement of highways and their sides. It obviously proves that anthropogenic activity influences the ionizing radiation phon.

EDR above AC pavement of highway and its sides can differ 1.5 times. This alternation is due to *A* of natural radionuclides in separate AC samples and different composition of soil near highways.

Natural radionuclides *A* in AC is higher than in clay loam and sandy loam: ^{40}K and ^{226}Ra – about 3, ^{232}Th – 4 times.

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