



Milda PEČIULIENĖ

**THE RESEARCH AND EVALUATION OF
ANTHROPOGENIC CHANGES OF NATURAL
IONISING RADIATION**

Summary of Doctoral Dissertation

**Technological Sciences, Environmental Engineering and
Landscape Management (04T)**

1301



Vilnius LEIDYKLA TECHNICA 2006

VILNIUS GEDIMINAS TECHNICAL UNIVERSITY

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VILNIAUS GEDIMINO TECHNIKOS UNIVERSITETAS

Milda PEČIULIENĖ

**GAMTINĖS JONIZUOJANČIOSIOS
SPINDULIUOTĖS ANTROPOGENINIŲ POKYČIŲ
TYRIMAS IR ĮVERTINIMAS**

Daktaro disertacijos santrauka
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General characteristic of the dissertation

Problem of the thesis

A human being has been constantly influenced by the so-called background ionising radiation since his/her coming into Earth. Despite the benefit which is received by using the sources of ionising radiation for practical purposes, it may do a serious harm to people's health if the requirements are neglected. The change of many natural radionuclides is becoming more intensive because of man's economic activities (constructions, road building, the usage of fertilizers, mining, metallurgy etc.). Apart from radionuclides of natural origin, technogenic radionuclides (due to the tests of nuclear bombs, nuclear energetics, the usage of radioactive isotopes etc.) such as radioactive strontium (^{90}Sr), caesium (^{137}Cs), plutonium ($^{239}, ^{240}\text{Pu}$) and others are getting into our environment causing serious society's anxiety. It is understandable that society inevitably causes certain damages of the environment, which can rarely be reduced or completely avoided.

The ionising radiation of long-lived natural radionuclides is common both to a human being and the environment that surrounds him/her. Man's activities related to the rapid growth of industry and cities as well as the usage of nuclear technologies have raised the level of specific activity of certain radionuclides to a such limit that it pretty well exceeds a natural background at the same time, according to the radioecological standpoint, making them sources of additional exposure.

It is inevitably necessary to identify the radionuclides of natural and anthropogenic origin which got into the environment because of man as well as to analyze their distribution in the atmosphere, hydrosphere, lithosphere, vegetation and fauna. Also, it is especially important to determine the causes of the increase of the intensity of ionising radiation in urbanized territories.

Topicality of the problem

The anthropogenic evaluation of the change of natural ionising radiation is especially essential regarding ecological aspect. Therefore, it is necessary to carry out experiments that would allow to determine how much a human being influences the environment.

A lot of scientists analyze the issues related to the quantities of radionuclides, their spread and influence on the environment as well as they deliver separate solution ways to them, but there are only few works analyzing the problem of natural radiation changes due to man's activities. Concerning that, the specific activities of natural radionuclides and their migration regularities in the environment surrounding man were identified in this thesis. The ionising radiation changes due to man's activities were analysed in the

thesis. The results of dosimetric and spectrometric research were presented. The geophysical places related to man's activities mostly such as construction objects, roads, pavements, tunnels, quarries etc., and the territories in which anthropogenic activities are quite insignificant (the Curonian Spit) were chosen to perform measurements. Since people spend most of their life indoors, the change of gamma radiation in buildings was evaluated and the specific activities of the main gamma emitters in the most frequently used building materials were measured, and the contribution to their caused exposure was evaluated. Having determined the changes of gamma radiation in the environment by carrying out experiments, it is possible to model and predict the potentials of the changes of gamma background.

Aim and tasks of the works

The aim of the thesis was to carry out a set of experiments of natural ionising radiation in the urbanised and natural environment as well as to evaluate its changes due to people's activities.

- To perform the analysis of scientific references on ionising radiation changes due to anthropogenic activities.
- To improve and apply the methods of registration of parameters of ionising radiation, relating them to the processes going on in the environment.
- To create a computer model which would help evaluate the intensity of ionising radiation change due to anthropogenic activities.
- To carry out the measurements of the equivalent dose rate in the air layer close to the ground surface in a non-urbanized surrounding (forests, fields, above water reservoirs) and in the territories related to man's activities (close to building constructions, in buildings, above roads and roadsides etc.).
- To identify the specific activities of natural radionuclides found in the soil of different granulometric composition and in building materials most frequently used in Lithuania.
- To evaluate the contribution of natural radionuclides present in the soil and building materials to the dose of their caused exposure.
- Having performed a set of experiments to evaluate the contribution of man's activities to the changes of gamma radiation.

Scientific novelty

By dosimetric, radiometric research and by modelling the formation of exposure dose in the air layer close to the ground surface, by a set of experiments in the urbanised and non-urbanised environment it was identified that man while building houses, digging quarries, building roads etc., changes

the intensity of natural ionising radiation at the same time changing the distribution of natural radionuclides. While identifying that:

- the ionising radiation changes due to anthropogenic activities, caused by natural radionuclides, were evaluated.
- the methodology of dosimetric research using global positioning system (GPS) was improved.
- a computer model was created with the help of which it is possible to evaluate the change of ionising radiation, moving away from or approaching different buildings.

Practical value

On the grounds of the results of the thesis it is possible to predict the factors influencing the increase of ionising radiation in the environment. According to the evaluations of small dose impact, any increase of radiation causes danger to people's health, therefore, the collected results in urbanised and non-urbanised environment can be applied while evaluating additional man's exposure. According to the results of the thesis, identified correlations and described methodology, it is possible to evaluate additional man's exposure in home and manufacturing premises and to predict its reduction possibilities. The created computer model allows us to evaluate ionising radiation changes due to people's activities not requiring a great amount of time and finance.

The research carried out in this thesis is very useful when evaluating the impact of radiation on a human being, when modelling mechanisms of distribution, when predicting its caused exposure and determining the contribution of man's activities to the changes of gamma radiation.

Defended propositions

- The intensity of natural radiation in the environment increases most frequently due to man's activities.
- The equivalent dose rate caused by natural radionuclides increases exponentially when approaching many buildings.
- There is a tight relation between the quantities of natural radionuclides found in natural and urbanised environment whereas there is no relation between artificial radionuclide (^{137}Cs) and natural radionuclides.

Work approval

The topic of the thesis was analysed in 19 scientific publications, 6 articles were published in reviewed periodical scientific publications in Lithuania and 1 article was published in international conference publication of reviewed reports and it was reviewed in a paper of MII in databases (ISI proceedings). The

results of the thesis were discussed in 4 international and 7 republic conferences. 12 scientific publications were published in the volumes of conference reports.

The scope of the scientific work

The scientific work consists of introduction, 4 main sections, thesis conclusions, 163 references and the list of 19 publications. Total: 148 pages of the text, 90 figures and 15 tables.

1. The research on the changes of ionising radiation caused by radionuclides

Larger quantities of ionising radiation destroy cells, they also break tissues of organism and they may cause a sudden death. Even small quantities of ionising radiation may become reasons for various illnesses, that is why, it is necessary to reduce amounts of the additional sources of exposure as much as possible.

The annual exposure dose of the population of Lithuania caused by the sources of natural origin is 2.2 mSv, most of which-roughly 1 mSv is caused by radon and its ionising radiation of its decay products. The radiation emitted from the objects (buildings, roads etc.) created by a human being as well as the changes in the lithosphere also have an impact on the exposure of residents. Since a human being spends about 70–80 % of his/her life in buildings, therefore, it is very essential to pay much attention to the building materials used for constructions so that they would possess fewer quantities of radionuclides. It was noticed that the increased specific activities of natural radionuclides are in building materials made of either raw materials, mined in the radiological regions, or the materials of side products of phosphate or other industries.

2. Methodology of experimental investigations

A set of experiments of the change of ionising radiation were carried out evaluating man's impact on the environment. Gamma spectrometry method to identify gamma radionuclides and to measure their specific activities was used as well as dosimetric experiments allowing us to identify equivalent dose rate caused by natural radionuclides found in different materials were carried out.

The assembled automated equipment of radiometric measurements was used while carrying out all the dosimetric experiments at the same time using a global positioning system (GPS). This is a new mobile method to measure the

equivalent dose rate of the environment. This method permits to register the dose rate and the coordinates of the measurement location continuously using GPS. The equipment consists of scintillation radiometers SRP-88N, the readings of which were compared to the readings of the radiometer that has a state certificate, and SRP-68-01; global positioning system (GPS); a laptop (a portable computer). The places that are mostly related to man's activities such as construction objects, roads, tunnels, quarries etc. were chosen to carry out dosimetric measurements. The territories, which are less related to man's activities such as water reservoirs, forests, fields were also researched in detail. To identify the specific activity of natural and artificial radionuclides, the activity of the samples of bottom deposits, soil and most frequently used building materials was measured by gamma spectrometric system (CANBERRA) with semiconductor HPGe detector (resolution 2 keV, efficiency – 15 %). The radionuclides were identified according to the following energy lines: ^{226}Ra – 186 keV, ^{212}Pb – 239 keV, ^{214}Pb – 352 keV, ^{208}Tl – 583 keV, ^{214}Bi – 609 keV, ^{228}Ac – 911 keV, ^{40}K – 1 460 keV. The measured activity of the sample was calculated for one mass unit (the specific activity, Bq/kg).

To evaluate ionising radiation changes due to anthropogenic activities a new computer model was created and applied. The model consists of three main models: the evaluation of the radiation emitted from cosmos, soil and buildings (roads). Having connected these separate models into one unit and having introduced additional appropriate parameters, it can be used to evaluate the influence of anthropogenic activities. The results of mathematical modelling were visualised by using SURFER 32 program. The program was chosen to maintain an equal data visualisation of modelling and experiment. The model was calculated using a program packet Maple 9. Applying this model, it is possible to calculate the values foreseen and to predict ionising radiation changes due to man's activities: due to road, house, quarter or city built. It is also easy to evaluate what building materials should be used to construct new houses and to predict the amount of exposure dose. While modelling the change of equivalent dose rate moving away from building constructions, the main parameter is a radioisotopic composition of building materials used. The external ionising radiation emitted by buildings was also evaluated in the model.

3. Research results and their analysis

The exposure of people by natural sources depends on natural radionuclides found in the underground, the amounts of which differ because of

soil composition. The evaluations of the amounts of the main gamma emitters found in the soil of Vilnius city were carried out in this thesis and their influence on the exposure was identified. The intensity of natural radiation and its caused exposure depends on the geological and geographic environment, that is why, in various regions it is different.

In Vilnius city where like in all east southern Lithuania the dominating types of soil are sand, sandy loam and clay loam. The samples of different types of soil were taken for the research, and the specific activities of natural radionuclides ^{232}Th , ^{226}Ra and ^{40}K were measured as well as their external equivalent dose rate estimated. A tight correlative bond between the equivalent dose rate in the air layer close to the ground surface with the main gamma emitters ^{40}K and ^{226}Ra specific activities in the soil was identified. Correlation coefficients obtained are 0.66 and 0.70 respectively. During the research it was identified that dose rate in the air layer close to the ground surface is mostly influenced by ^{40}K found in the soil. Statistically processed specific activities of natural radionuclides in the soil are presented in Table 1.

Table 1. The specific activities of natural radionuclides in the soil of Vilnius city

Radionuclide	Specific activity, Bq/kg				
	Maximum value	Minimum value	Average value	Median	Mean square deviation
^{232}Th	8.5	3.2	4.8	5.0	± 1.2
^{226}Ra	23.3	7.0	12.9	12.5	± 3.2
^{40}K	479.3	146.1	263.1	245.5	± 67.4

The external equivalent dose rate caused by natural radionuclides in the soil was estimated because it directly depends on the specific activity of radionuclides found in the soil. In Vilnius city the radiation of the equivalent dose rate makes up 12 nSv/h due to ^{40}K existent in the soil, 6 nSv/h – due to ^{226}Ra , 3 nSv/h – due to ^{232}Th on average.

Having carried out dosimetric experiments above arable and non-arable soil, it was identified that the ionising radiation above arable soil increases on average 1.2 times (Fig 1). Having overviewed the results of these experiments, it is possible to say that human being's activities strongly influence a geological substance and the consequences of that influence should also be evaluated in more detail while determining how one or another economic activity, changing geological environment, affects the whole background of natural ionising radiation of landscape.

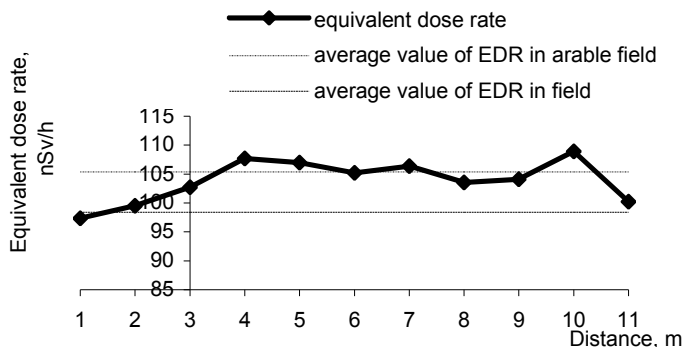


Fig 1. The measurements of the equivalent dose rate (EDR) above arable and non-arable soil (1–3 non-arable, 4–11 arable)

Distinct changes of gamma radiation were obtained concerning road areas. Evaluating the influence of anthropogenic activities on the change of gamma radiation above the ground surface, quite a few dosimetric experiments were carried out above asphalt roads and above roadsides. The flow of car passing by, the geographic position of the road, road construction, the type of roadside soil and meteorological factors which may affect the change of radiation were evaluated.

The equivalent dose rate above roads and roadsides was measured using a cross profile, perpendicular to the road area, on both sides. In Fig 2 the principled scheme of such measurements and the values of average equivalent dose rate above various surfaces are presented.

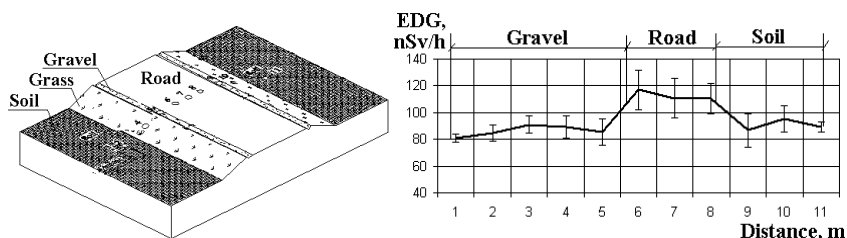


Fig 2. The measurement scheme of the equivalent dose rate in roadsides and the values of average equivalent dose rate above different flooring surfaces and coverings (gravel, asphalt, soil, grass)

It was identified that the maximum values of the equivalent dose rate are above the road (6, 7 and 8 points), the minimum values-above gravel and soil (1–5 and 9–11). Out of all the experiments carried out, the identified relations of the equivalent dose rate caused by natural radionuclides above the asphalt surface and the soil close to it reach from 1.2 up to 1.5 times. The discrepancy between the identified relations is due to different amounts of natural radionuclides in separate areas of asphalt and different composition of the soil of roadsides.

Trying to evaluate gamma radiation changes due to anthropogenic activities more precisely, the specific activity of the main gamma emitters ^{40}K , ^{226}Ra and ^{232}Th in the roadside soil and in asphalt samples was measured.

Sandy loams and clay loams prevail in the researched roadsides (Fig 3). The limits of errors of the value of equivalent dose rates measured further than 4 m away from the surface of the road are the same. That means that the sources of radiation are of the same origin.

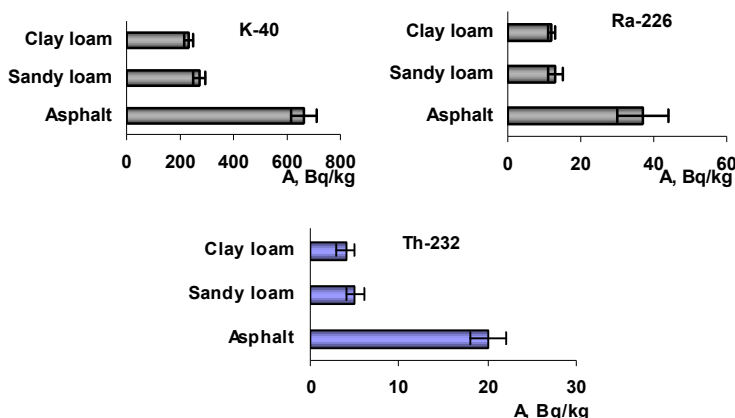


Fig 3. The specific activity of the main natural radionuclides in asphalt and in the soil

However, that could not be said about the doses above asphalt and 1–4 meters away from it. It is obviously seen that the values of dose rates depend on the radiation of radionuclides found in the surface of asphalt.

While evaluating the influence of asphalt surfaces on the changes of ionising radiation, dosimetric experiments were carried out in the whole territory of the Curonian spit (Fig 4).

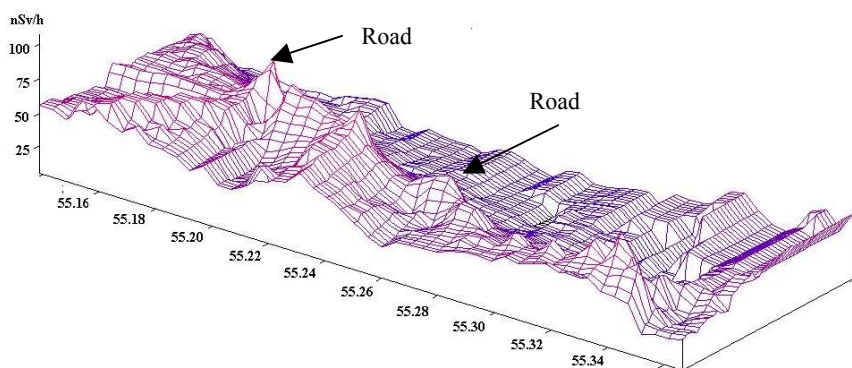


Fig 4. The distribution of equivalent dose rate values in the region of the Curonian Spit

Most of all, a natural background is changed by using building materials. It was identified that building materials increase radiation most frequently, though there are cases when they decrease it. It was also determined that building materials are one of the main human being's sources of exposure since in the premises man is affected by external and internal exposure from radionuclides present in building materials. Having carried out experiments, it was identified that wood contains quite a smaller quantity of natural radionuclides than other widely used building materials (Fig 5).

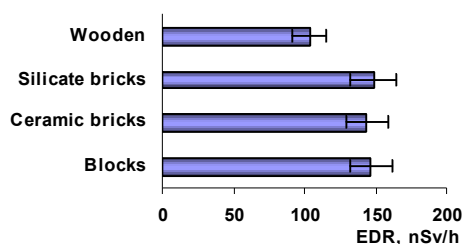


Fig 5. The change of the equivalent dose rate (EDR) in different buildings

However, only in products of wood relatively small amounts of artificial radionuclides, having accessed plants through roots and leaves, are recorded quite often.

The values of the measured dose in wooden buildings are about 1.5 times smaller. It was identified that the relation of the exposure inside the building and in the air is 1.4. This value depends on the sort of building materials and on

the thickness of building walls very much because building materials are not only a source of ionising radiation but also a screen preventing people from the influence of cosmic radiation.

The maximum values of the equivalent dose rate are measured in the buildings of blocks, ceramic bricks and silicate bricks.

It was identified that the equivalent dose rate caused by natural radionuclides while approaching a building increases exponentially. While analysing the results of experiments, it was determined that moving away from a building, the intensity of ionising radiation in many cases decreases about 1.5 times. Having carried out the measurements of the equivalent dose rate close to wooden houses, a distinct change was not noticed. The average value is about 78 nSv/h. It is about 1.6 times less than near block buildings and about 1.3 times less than near the buildings made of silicate blocks.

According to the results of many experiments, a parallel tendency of the equivalent dose rate change because of buildings was noticed. It was identified that a human being building a house increases ionising radiation on average 1.5 times, sometimes even up to 2 times. The exception is wooden buildings which alter a natural background up to 5 %. It was also noticed that various artificial coverings and surfaces (pavements, paved with different slabs, paths, stairs, city squares etc.) significantly change a natural radiation background.

Geological processes (gravitation, wind) and technogenic processes (soil ploughing, crop harvesting) affect radionuclide accumulation changes in the soil surface (scattering or concentration) causing the increase of radionuclide concentration in some areas and the decrease in other areas. One of the anthropogenic sources which is valued in many different ways is fertilizers which may contain big quantities of natural radionuclide ^{40}K . The experiments of the specific activity of radionuclides in the most frequently used fertilizers were carried out. The fertilizers made both in our country and abroad were chosen for these experiments. The average specific activity of ^{40}K in the researched fertilizers was $(7\,220 \pm 340)$ Bq/kg. In some of the fertilizers it reached a few thousand becquerels for 1 kg. It is necessary to remark that only in potassium fertilizers a bigger amount of ^{40}K is found. In spite of the fact that in some fertilizers the specific activity of ^{40}K reaches a few thousand Bq/kg, only a certain amount of this radionuclide gets into food products, not regarding the amount of it found in the soil.

The changes of the equivalent dose rate were modelled moving away from various buildings. Houses built from different building materials such as silicate (white) bricks, ceramic (red) bricks and blocks were chosen to model. The emitted radiation of buildings outside it was evaluated in the model. Having performed modelling, the values received were compared to the results of

experiment measurements. The results of modelling and experiment research close to block buildings are presented in Fig 6.

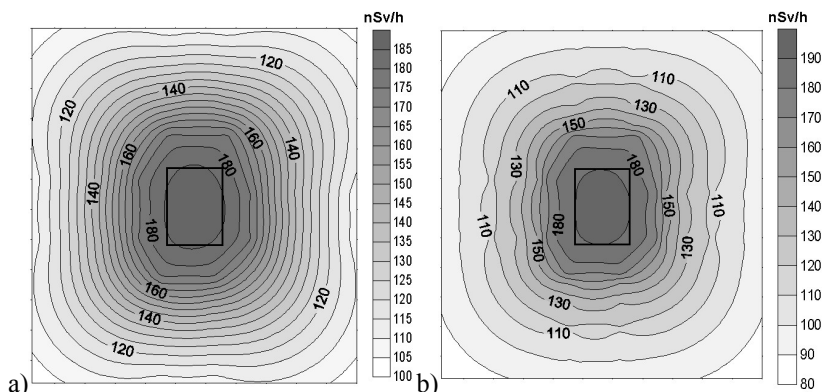


Fig 6. The radiation emitted by a block house: a) while modelling, b) while carrying out the measurements experimentally

A correlation coefficient was calculated to match function of data distribution of experiment and computer models. According to the collected data, it was calculated that a correlation coefficient between experimental dose rate and computer modelling equivalent dose rate data approximates 1, i.e. 0.96. High value of correlation coefficient shows a good correspondence between modelling and the results of experimental research.

General conclusions and recommendations

1. With the help of a set of experiments it was identified that natural radiation background changes (most frequently increases) due to anthropogenic changes of environment in many locations. It was also identified that in many cases the intensity of ionising radiation varies from 1.3 up to 1.7 times.
2. The quantities of natural radionuclides in most often used building materials were compared to the ones presented in scientific references. It was noticed that they differ up to many times (e.g. the specific activity of ^{40}K in sand in Lithuania is four times bigger than in Israel, in India, Germany and Algeria the specific activity of ^{40}K in the sand is three times less).
3. The measurement method of environment equivalent dose rate was improved by using GPS (global positioning system) as well as the methodology of sample taking and preparation for spectrometric analysis

acquired. In the thesis methodologically related methods of dosimetry and spectrometry widened the possibilities of experiment performance.

4. The specific activities of natural radionuclides in different types of soil and in most frequently used building materials were identified by means of spectrometry, the contribution of radioisotopes (found in them) to their caused exposure was identified. It was identified that radiation of natural radionuclides found in building materials is about 1.5 times more intensive than in the soil.
5. High correlation dependence between ^{40}K and ^{226}Ra specific activities in the soil and the equivalent dose rate above the sample taking place was identified (respectively 0.66 and 0.69).
6. A computer model was created enabling us to evaluate gamma radiation change due to anthropogenic effect. A tight correlation bond between modelling and the results of experiments was identified. That shows a good correspondence between modelling and the results of experiments, therefore, the application of the created model allows us to widen the research limits of ionising radiation changes due to anthropogenic activities.

Recommendations

1. Trying to reduce doses of additional exposure, it is recommended to choose building materials having a rate as low as possible. It is also recommended to screen building constructions, the radiation intensity of which is impossible to be reduced by using less active materials.
2. It is advisable to apply the created computer model for calculations while designing buildings, especially the ones a human being will spend a lot of time in.

Published works on the topic of the dissertation

ISI Proceedings

1. Jasaitis, D., Pečiulienė, M., Girgždys, A. The variations of radon and its short – term decay products in living rooms. In: *Proceedings of 6th International Conference “Environmental Engineering”*. Vilnius: Technika, Vol 1, 2005, p. 114–117. ISSN 9986-05-850-3.

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2. Pečiulienė, M., Jasaitis, D., Grigaliūnaitė-Vonsevičienė, G., Girgždys, A. Equivalent dose rate of ionizing radiation above water reservoirs in Vilnius. *Journal of Environmental Engineering and Landscape*

- Management*, Vol XII, No 2, Vilnius: Technika, 2004, p. 53–57. ISSN 1648-6897. (Compendex, ICONDA).
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 4. Pečiulienė, M., Jasaitis, D., Girgždys A. The equivalent dose rate above the water fields of Vilnius (Jonizuojančiosios spinduliuotės lygiavertės dozės galia virš Vilniaus miesto vandens telkinių). *Health sciences* (Sveikatos mokslai), Nr. 2 (14), 2004, p. 52–55 (in Lithuanian). ISSN 1392-6373. (Index Copernicus).
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GAMTINĖS JONIZUOJANČIOSIOS SPINDULIUOTĖS ANTROPOGENINIŲ POKYČIŲ TYRIMAS IR ĮVERTINIMAS

Problema

Žmogus nuolat veikiamas vadinamosios foninės jonizuojančiosios spinduliuotės. Be naudos, kuri gaunama jonizuojančiosios spinduliuotės šaltinius naudojant praktinėje veikloje, ji spinduliuotė, gali kelti rimtą grėsmę žmonių sveikatai. Dėl ūkinės žmogaus veiklos (statybos, kelių tiesimo, trąšų naudojimo, kasybos, metalurgijos ir pan.) intensyvėja daugelio gamtinių radionuklidų apykaita. Be gamtinių radionuklidų, į aplinką skverbiasi ir technogeniniai radionuklidai (dėl atominių bombų bandymų, atominės energetikos, radioaktyviųjų izotopų naudojimo ir kt.): radioaktyvusis stroncis (^{90}Sr), cezis (^{137}Cs), plutonis ($^{239}, ^{240}\text{Pu}$) ir kt., kurie sukelia pagrįstą visuomenės nerimą.

Natūralios kilmės ilgaamžių radionuklidų jonizuojančioji spinduliuotė įprasta žmogui ir jį supančiai gyvajai gamtai. Žmogaus veikla, susijusi su sparčiu pramonės, miestų augimu ir branduolinių technologijų naudojimu, kai kurių gamtinių radionuklidų savitojo aktyvumo lygį pakėlė iki tos ribos, kai jis gerokai viršija natūralų foną, ir jie tampa radioekologiniu požiūriu svarbiais papildomos apšvitos šaltiniais. Būtina identifikuoti dėl žmogaus kaltės į aplinką patekusius gamtinius ir antropogeninius radionuklidus, išnagrinėti jų pasiskirstymą – atmosferoje, hidrosferoje, litosferoje, augmenijoje ir gyvūnijoje. Taip pat, ypatingai svarbu nustatyti priežastis, lemiančias jonizuojančiosios spinduliuotės intensyvumo padidėjimą urbanizuotose teritorijose.

Darbo aktualumas

Pramonės vystymasis, žmogaus poreikių didėjimas ir kt. natūraliai keičia aplinką. Antropogeninis gamtinės jonizuojančiosios spinduliuotės pokyčio

įvertinimas yra ypač svarbus gamtos saugos aspektu. Todėl būtina atlikti tyrimus, kurie leistų nustatyti, kiek žmogus paveikia aplinką.

Daug mokslininkų nagrinėja problemas, susijusias su radionuklidų kiekiais, jų sklaida ir poveikiu aplinkai, pateikia atskirus jos sprendimo būdus, tačiau darbų, konkrečiai nagrinėjančių gamtinės spinduliuotės pokyčių dėl žmogaus veiklos problemą, yra labai mažai. Atsižvelgiant į tai, šiame darbe plačiau nagrinėti gamtinių radionuklidų kiekiai bei jų migracijos dėsningumai žmogų supančioje aplinkoje. Darbe nagrinėti gama spinduliuotės pokyčiai dėl žmogaus veiklos. Pateikti dozimetrijos ir spektrometrijos tyrimų rezultatai. Matavimams parinktos labiausiai su žmogaus veikla susijusios geofizinės vietos, t. y. statybos objektai, keliai, šaligatviai, tuneliai, karjerai ir pan., bei teritorijos, kuriose antropogeninė veikla gana menka (Kuršių nerija). Kadangi žmogus didžiąją savo gyvenimo dalį praleidžia patalpose, įvertinta gama spinduliuotės kaita pastatuose bei išmatuoti pagrindinių gama spindulių savitieji aktyvumai dažniausiai naudojamose statybinėse medžiagose ir įvertintas indėlis į jų sukeltą apšvitą. Eksperimentiniais tyrimais nustatius gama spinduliuotės pokyčius aplinkoje, galima modeliuoti ir prognozuoti gama fono pokyčių galimybes.

Darbo tikslas ir uždaviniai

Darbo tikslas – atlikti kompleksinius gamtinės jonizuojančiosios spinduliuotės tyrimus urbanizuotoje ir natūralioje aplinkoje bei įvertinti jos pokyčius dėl žmogaus veiklos.

Darbo uždaviniai:

- Atlikti mokslinės literatūros analizę apie jonizuojančiosios spinduliuotės pokyčius dėl antropogeninės veiklos.
- Tobulinti ir pritaikyti jonizuojančiosios spinduliuotės parametrų registravimo metodikas, siejant jas su procesais, vykstančiais gamtinėje aplinkoje.
- Sukurti kompiuterinį modelį, kuriuo būtų galima įvertinti jonizuojančiosios spinduliuotės intensyvumo kaitą dėl antropogeninės veiklos.
- Atlikti lygiavertės dozės galios pažemio ore matavimus neurbanizuotoje aplinkoje (miškuose, pievose, virš vandens telkinių) bei teritorijose, susijusiose su žmogaus veikla (šalia įvairių statybinių konstrukcijų, pastatuose, virš kelių ir šalikelėse ir pan.).
- Nustatyti gamtinės kilmės radionuklidų savituosius aktyvumus skirtingos granulometrinės sudėties dirvožemyje bei dažniausiai Lietuvoje naudojamose statybinėse medžiagose.
- Įvertinti gamtinės kilmės radionuklidų, esančių dirvožemyje bei statybinėse medžiagose, indėlį jų sukeltam apšvitai.

- Atlikus kompleksinius tyrimus, įvertinti žmogaus veiklos indėlį gama spinduliuotės pokyčiams.

Darbo naujumas

Dozimetriniais, radiometriniais tyrimais bei modeliuojant apšvitos dozės susidarymą pažemio ore, kompleksiniais tyrimais urbanizuotoje ir neurbanizuotoje aplinkoje nustatyta, kad žmogus statydamas namus, kasdamas karjerus, tiesdamas kelius ir pan., keičia gamtinės kilmės jonizuojančiosios spinduliuotės intensyvumą, keisdamas gamtinės kilmės radionuklidų pasiskirstymą. Tai nustatant buvo:

- Įvertinti gamtinės kilmės radionuklidų sukeltos jonizuojančiosios spinduliuotės pokyčiai dėl antropogeninės veiklos.
- Patobulinta dozimetrijų tyrimų metodika, naudojant globalinio pozicionavimo sistemą (GPS).
- Sukurtas kompiuterinis modelis, kuriuo galima įvertinti jonizuojančiosios spinduliuotės kaitą, tolstant arba artėjant nuo įvairių statinių.

Praktinė disertacijos reikšmė

Remiantis darbo rezultatais galima numatyti veiksnus, lemiančius jonizuojančiosios spinduliuotės padidėjimą žmogaus aplinkoje. Pagal mažų dozių poveikio vertinimus, bet koks spinduliuotės padidėjimas sukelia grėsmę žmonių sveikatai, todėl šio darbo rezultatai, gauti urbanizuotoje ir neurbanizuotoje aplinkoje, gali būti pritaikyti vertinant papildomą žmogaus apšvitą. Pagal darbo rezultatus, nustatytas priklausomybės bei darbe aprašytas metodikas galima įvertinti papildomą žmogaus apšvitą buitinėse ir gamybinėse patalpose bei numatyti jos mažinimo galimybes. Sukurtasis kompiuterinis modelis leidžia įvertinti jonizuojančiosios spinduliuotės pokyčius dėl žmogaus veiklos, nereikalaudamas didelių laiko ir finansinių sąnaudų. Šiame darbe atlikti tyrimai yra naudingi, vertinant spinduliuotės poveikį žmogui, modeliuojant sklaidos mechanizmus, prognozuojant jos sukeltą apšvitą ir nustatant žmogaus veiklos indėlį gama spinduliuotės pokyčiams.

Ginamieji disertacijos teiginiai

- Dėl žmogaus veiklos aplinkoje dažniausiai padidėja jonizuojančiosios spinduliuotės intensyvumas.
- Gamtinių radionuklidų sukurta lygiavertės dozės galia, artėjant prie daugelio pastatų, didėja eksponentiškai.
- Tarp gamtinės kilmės radionuklidų kiekių natūralioje ir urbanizuotoje aplinkoje yra glaudus ryšys, o tarp dirbtinės kilmės radionuklido ^{137}Cs ir gamtinių radionuklidų ryšio nėra.

Darbo aprobavimas

Disertacijos tema paskelbta 19 mokslinių publikacijų, iš jų 6 straipsniai recenzuojamuose periodiniuose mokslo leidiniuose Lietuvoje bei 1 straipsnis tarptautinių konferencijų recenzuotų pranešimų leidinyje, referuotame MII duomenų bazėje (*ISI Proceedings*). Disertacijos rezultatai aptarti keturiose tarptautinėse ir septyniose respublikinėse konferencijose. Išspausdinta 12 mokslinių publikacijų konferencijų pranešimų rinkiniuose.

Apimtis ir struktūra

Disertaciją sudaro įvadas, 4 pagrindiniai skyriai, darbo išvados, 163 literatūros šaltinių ir 19 publikacijų disertacijos tema sąrašai. Iš viso: 148 puslapiai teksto, 90 paveikslų ir 15 lentelių.

Bendrosios išvados ir rekomendacijos

1. Kompleksiniais tyrimais nustatyta, kad antropogeniškai veikiant aplinką, kinta gamtinis radiacinis fonas (dažniausiai padidėja). Nustatyta, kad daugeliu atvejų jonizuojančiosios spinduliuotės intensyvumas kinta nuo 1,3 iki 1,7 kartų.
2. Mokslinės literatūros analizė parodė, kad būtina nagrinėti papildomos žmonių apšvitos priežastis, atlikti monitoringą žmogaus sukurtuose objektuose bei numatyti priemones, mažinančias apšvitą.
3. Darbe išmatuoti tiegi gamtinių radionuklidų kiekiai dažniausiai naudojamose statybinėse medžiagose palyginti su mokslinėje literatūroje pateiktaisiais. Pastebėta, kad jie dažniausiai skiriasi iki keleto kartų (pavyzdžiui, Lietuvoje naudojamo smėlio ^{40}K savitasis aktyvumas yra 4 kartus didesnis nei Izraelyje, o Indijoje, Vokietijoje ir Alžyre ^{40}K savitojo aktyvumo vertės 3 kartus mažesnės nei Lietuvoje). Ši analizė naudinga nustatant kokią statybinę medžiagą verta importuoti.
4. Patobulintas aplinkos lygiavertės dozės galios matavimo metodas. Jis leidžia matavimo trasoje nenutrūkstamai registruoti dozės galią ir matavimo vietos koordinates, naudojant GPS (globalinę pozicionavimo sistemą), bei įsisavinta bandinių paėmimo ir paruošimo spektrometrinei analizei metodika. Darbe metodiškai susieti dozimetrijos ir spektrometrijos metodai praplėtė eksperimentų atlikimo galimybes.
5. Spektrometriškai nustatyti gamtinių radionuklidų savitieji aktyvumai skirtingos granulimetrinės sudėties dirvožemyje bei dažniausiai naudojamose statybinėse medžiagose, įvertintas jose esančių radioizotopų indėlis jų formuojamai apšvitai. Nustatyta, kad statybinių medžiagų spinduliuotė yra apie 1,5 karto intensyvesnė nei dirvožemio.

6. Sukurtas kompiuterinis modelis, leidžiantis įvertinti gama spinduliuotės kaitą dėl antropogeninio poveikio. Gautas glaudus ryšys tarp modeliavimo ir eksperimentinių rezultatų rodo gerą modeliavimo ir eksperimento rezultatų atitikimą. Sukurtas modelis sudaro sąlygas išplėsti spinduliuotės pokyčių dėl antropogeninės veiklos tyrimų ribas.

Rekomendacijos

1. Siekiant mažinti papildomos apšvitos dozes, rekomenduojama rinktis statybines medžiagas, turinčias kuo mažesnius gamtinių radionuklidų kiekius. Statybines konstrukcijas, kurių spinduliuotės intensyvumo neįmanoma sumažinti, naudojant mažiau aktyvias medžiagas, rekomenduojama ekranuoti.
2. Sukurtą kompiuterinį modelį rekomenduojama taikyti skaičiavimams projektuojant statinius, ypač tuos, kuriuose žmogus praleis daug laiko.

Trumpos žinios apie autore

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**THE RESEARCH AND EVALUATION OF ANTHROPOGENIC
CHANGES OF NATURAL IONISING RADIATION**

Summary of doctoral dissertation

**Technological Sciences, Environmental Engineering and Landscape
Management (04T)**

Milda Pečiulienė

**GAMTINĖS JONIZUOJANČIOSIOS SPINDULIUOTĖS
ANTROPOGENINIŲ POKYČIŲ TYRIMAS IR ĮVERTINIMAS**

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