University of West-Hungary

a PhD Thesis

Inspection of natural radioisotopes in built environments

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1. Introduction

Since its discovery, there have been various views of radioactivity. In the very beginning, it was credited with supernatural attributes and was considered to be a kind of life elixir. But with the progress of researches, its dangerous nature was being discovered. Numerous scientists became victims of the researches, among others, one of the most famous researchers, Marie Curie, too.

The most important achievements in this field of science happened after people started to use nuclear energy. Hundreds of nuclear bomb tests followed World War II, which caused previously unusual radioactive contaminations to appear in the environment.

The peaceful use of nuclear energy became more widespread, too. In many countries across the world, nuclear power stations have been built. But on April 26, 1986 a huge reactor disaster happened on the territory of the Soviet Union.

Due to this nuclear accident and the contaminations caused by the nuclear bomb tests, the view of the people on radioactivity and thus on nuclear power stations is getting more negative. The opening of a new power station or the extension of the life of an old one attracts always the attention of the media and is accompanied by heavy protests. Many people are scared even of only hearing the words nuclear power station and nuclear energy. But the peaceful way of using of nuclear energy does not normally lead to accidents, though such things have already happened. Most of these were caused by human failure or ignorance, not by errors of technical equipment.

Although most people are afraid of radioactivity, as a possible cause of an accident, they are not aware of the natural radioactive radiation at their homes and workplaces, which in most cases means a greater threat for their health.

All things surrounding us radiate. Nowadays people spend most of their lives in urban surroundings, namely at home, at the workplace or in the streets, among buildings. Consequently, we are exposed to a much greater natural radiation load, due to the radioactive materials in building materials, and mainly the radon emitted from the soil and building materials, accumulated in buildings.

Radon is highly significant, even among the group of natural isotopes, since many researches proved that people living in areas with higher radon concentration are more likely to get lung cancer.

A big problem in Hungary is the lack of legal regulation. The valid decree law number 16/2000, issued by the Ministry of Health, gives a limit for workplaces but does not include regulations about homes, although people spend most of their time at home. Because of the lack of legal regulation, people are left by themselves.

The aim of the author, based on measurements made in Sopron, was to estimate the natural dose of the city’s citizens depending on their lifestyle, age and home location, and thus discover the areas of the city with higher dose rate. He strived to create a model, with which the dose of a citizen of Sopron could be estimated without measurements, but unfortunately based on the measurements, it can be concluded, that in most cases measurements cannot be replaced.

The aim of the work was also, to find the points of the city, which are interesting from the perspective of radioactivity; thus the gamma background radiation map of the city was made. The author set as his task, to find those building materials, which, from a radiological point of view, pose a potential threat on citizens.

2. The summary of the results

The author examined the natural radio-isotopes in urban sorroundings and the estimated the exposition to radiation in a sample area of Sopron, Hungary. He examined the locations where the natural background radiation was higher and investigated their cause.

In the first part of the paper he prepared the background radiation map of the city of Sopron, Hungary, with a grid a 200 m resolution, on an area of 24 km^2, doing measurements of gamma dose rate on more than 700 locations of the city. The map was created with the help of the DigiTerra software developed in the University of West-Hungary. On the basis of the measurements it can be stated, that several interesting anomalies may be observed.

The highest values were observed in a parking place covered with slag. The dose rate was as high as 402 nSv/h. After his examinations and due to the results the parking site was closed and the slag was carried away. The average gamma dose rate in the city was 89 nSv/h. On three public places in the city, on the market place, the Orsolya place and the Pálos place, the measured values were approximately twice as high. Here, the high ^{40}K activity concentration (1322 Bq/kg) of the the granite cubes covering the location caused the high background radiation.

He also observed higher radiation dose in the neighborhood of the old coal power plant. A maximum value of 212 nSv/h was measured at a distance of 60m from the funnel, in the direction of the prevailing wind. In this main spreading direction he observed even at a distance of 150 m from the power plant higher than average values. In other direction, already at a distance of 100 m the average values could be observed. The author stated the increment of background radiation even after years of opearation may be observed, due to the spilling of ash. Similar results were found in the neighborhood of the old coal-burning brick field.

The radiation map clearly shows the geological difference between the northern part (Soproni-medence) and the southern part (Soproni-hegység) of the city. On the side of the hills the average dose rate was 122 nSv/h whereas an average of only 72 nSv/h was observed in the northern part.

After these outdoor measurements he concluded the gamma spectrometry measurements of building materials. In the series he examined 19 of the building materials available on the market in Hungary.

In the case of the conventional building materials, the concentration of radioactive isotopes never exceeded the upper mark of the normal level. In the case of slag, collected in buildings, he observed extremely high ^{226}Ra content, the highest value was 2403 Bq/kg.

As a next step he examined residential areas. Due to the previous research and the measurements of building materials he devoted special attention to the examination of buildings with slag.

He published an article in a local newspaper to be able ~~the~~ to perform measurements in homes in the city of Sopron, Hungary. Altogether he performed gamma dose rate measurements in 97 homes, in 54 cases of that nuclear track-etch detector radon concentration measurements as well. On the basis of the measurements it can be stated, that in private buildings the slag burned from the coal mined in the Trans-Danubian-hills was used even far away from this area, as an insulation material. In those buildings, where no slag was used, the average dose rate was 113 nGy/h, that exceeds the world average of 84 nGy/h (20-190 nGy/h) but approximates the Hungarian average of 116 nGy/h, determined by Nikl. In those 23 houses, where slag from foundry was built in, the average of the effective dose rate was 138 nGy/h. In 49 cases, where the slag from the power plant was built in, the dose rate was 223 (107-792) nGy/h, that means an exposition of 1.05 (0.63-2.14) mSv to the inhabitants. In many cases this means an increment that cannot be neglected.

The values of the radon measurements in the examined houses changed between 137-1526 Bq/m3 in the months of October, November. The average concentration of radon (422 Bq/m3) and the maximal value (1050 Bq/m3) in the houses where slag was used as a building material exceeds approximately twofold that of house, where no slag is built in (221 Bq/m3, 422 Bq/m3). It exceeds in some cases the suggested threshold limit of 400 Bq/m3.

The author showed with his gamma spectrometry measurements of slag that there is a tight correspondence between the gamma dose rate of the house and the ^{226}Ra concentration of the slag.

On the basis of the measurements it can be stated that in those houses, built by hand between 1960 and 1985 can a higher background radiation expected, where slag from the power plant was used.

The high radon concentration in the research station cut the middle of the Nándor-magaslat in Sopron was known, so as a next step the researcher also investigated the radon concentration in the neighboring streets.

He made 64 measurements in the area of the Nádor-magaslat with nuclear track-etch detectors to determine radon-concentration, which means 62 town houses. Based on the measurements, he asserted that the southern and northern side of the hill have dissimilar radon-concentration values ((42-701, avg. 261 Bq/m3) and (96-2051, avg. 507 Bq/m3) respectively). The reason for this is the different geology of the two sides. The average radon-concentration of the northern side exceeds the 400 Bq/m^3 suggested threshold limit of the European Community. Taking into consideration that this is an average of measured values over a bigger area, this can be classified as very high. The maximum value (2051 Bq/m^3) measured on the northern side is so high that technical intervention is suggested. The calculated average radiation for the whole area (populations radiation load) that inhabitants suffer is 8,4 mSv/year which is a 4-fold increment compared to the worldwide average natural radiation load of 2,4 mSv/year. There are town houses on the northern side where inhabitants suffer a yearly effective dose from radone radiation of 41 mSv.

Finally, the author compared the measurement results with statistical data and appointed the number of town houses and people that can face the raised risks introduced above.

He concluded that radon-concentration cannot be well forecast in one storey town houses since the high-concentration locations have a random distribution. Measurements are suggested in each town house in the area of the Nádor-magaslat.

3. Thesis

1. I proved with measurements that those flats and houses in which slag was built in there is a strong correspondence between the gamma-dose rate and the ^{226}Ra concentration of the slag. Hence it can be declared that the main radiation source in these buildings is the slag and the radon it contains.

2. Slag from the coal mined in mountain Bakony that is built into the private houses as isolation mean real threat in Hungary in settlements further away from Ajka, as well. More background radiation can be expected in the buildings built 1960-85 in Sopron where slag originates from thermal power stations.

3. Gamma-dose rate values can show big diversity in built environments in hick town areas depending on the paving materials. Even 4-5-fold divergence from the average can be observed.

4. The geology of a given area influences the gamma-dose rate measured outdoors on a large scale. As a result of this, a difference in dose-rate of 50 nSv/h can be observed between the mountainous and flat areas in Sopron, Hungary.

5. The radon-concentration in the buildings on the north side of the Nádor-magaslat in Sopron exceeds the threshold limit of 400 Bq/m^3 (suggested limit of the European Community). It is strongly recommended that all the flats and buildings in this area be inspected.

6. Based on the measurements made in the buildings in Sopron it can be stated that radon-concentration cannot be forecast: measurements are necessary to determine it in each case.

7. Even a 3-4-fold background radiation increment can be observed in the environments of idle (not anymore operated) coal power plants in the main wind direction at a distance of 150 metres, as well. The anomaly rings off in other directions within a shorter distance (<100m).

4. Publications

Article published in journal:

Spaits T. (2004): RODOS, a decision support. Élet és tudomány, 2004/22. Budapest 684-686 .

Presentations on foreign languages published in international conference proceedings

Spaits, T. - Divós, F. - Kávási, N. - Bóka, Z. (2006): Evaluation of the Natural Background Radiation in City Sopron, Second European IRPA Congress on Radiation Protection, Paris.

Presentations published in Hungarian conference proceedings

Spaits T. – Divós F. (2005): Gamma spectrometry research of building materials. Issue of the Research and Development Discussion of the MTA Agricultural –Technological Committee, Gödöllő.

Spaits T. – Divós F.(2006): Radiation Measurements in Sopronban. Issue of the Research and Development Discussion of the MTA Agricultural –Technological Committee, Gödöllő.

Spaits T. – Divós F. (2005): Radon concentration of the flats in the neighborhood of the Nándor-magaslat in Sopron. Publication of the XV. National Conference of Environmental Injuries and Respiratory, Hévíz.

Spaits T. – Divós F. – Kávási N. (2006): Radon concentration measurements of the flats in the neighborhood of the Nándor-magaslat in Sopron. Publication of the I. National Radon Forum, Veszprém.

Spaits T. –Simon T. (2007): Radon measurements in flats in Sopron. Publication of II. National Radon Forum, Veszprém

Presentations:

Spaits T. – Divós F. (2005): Radon concentration of the flats in the neighborhood of the Nándor-magaslat in Sopron. Publication of the XV. National Conference of Environmental Injuries and Respiratory, Hévíz.

Spaits T. – Divós F. – Kávási N. (2006): Radon concentration measurements of the flats in the neighborhood of the Nándor-magaslat in Sopron. Publication of the I. National Radon Forum, Veszprém.

Spaits T. – Tóth K. (2007): EURANOS Demonstrations Activities – Hungarian experience. RUG-meeting 2007, Lisszabon.

Poster presentations:

Spaits, T. - Divós, F. - Kávási, N. - Bóka, Z. (2006): Evaluation of the Natural Background Radiation in City Sopron, Second European IRPA Congress on Radiation Protection, Paris.

Spaits T. – Divós F. (2005): Gamma spectrometry research of building materials. Issue of the Research and Development Discussion of the MTA Agricultural –Technological Committee, Gödöllő.

Spaits T. – Divós F.(2006): Radon koncentráció mérések Sopronban. MTA Agrár-Műszaki Bizottság Kutatási és Fejlesztési Tanácskozásának kiadványa, Gödöllő.

Spaits T. –Simon T. (2007): Radon measurements in flats in Sopron. Publication of II. National Radon Forum, Veszprém

Articles are submitted for publication:

Spaits T. – Simon T. – Divós F. (2007): Dose contribution from buildings containing coal slag insulation with elevated concentrations of natural radionuclides, Radiation Measurements. (Impakt factor 1,048)

Spaits T. – Simon T. – Divós F. (2007): Radon measurements in flats in Sopron, Acta Sylvatica.