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# THE DISTRIBUTION OF RADON CONCENTRATION AND DEBIT GAMMA DOSE IN BUCHAREST AREA

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**abstract:** This paper is the first complex approach regarding geochemical characterization of Bucharest municipality area by determination of debit gamma dose and radon concentration in subway stations, houses, public institutions and also apartment blocks. Investigated area of Bucharest municipality and marginal areas up to belt line have approximately circular shape with 12 km beam and 450 km$^2$ surface.

**key words:** debit gamma dose; radioactive pollution; gamma spectrometry; action level; irradiation; inhalation.

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## 1. Introduction

The urban area plays an important role in EU Strategy for Durable Development objectives. In these areas, environmental, economical and social dimension strongly interference. In cities, are concentrated the most environmental problems, and also there is the place where are found the majority of economical factors and investments. Most of the cities [1] confront with a common set of basic problems, such as small quality of air, congestion of traffic, high level of ambient noise, abandoned lands, emission of gases with greenhouse effect and no systematized areas, generating the waste and used waters.

The cause of these problems include changes in life style (increasing the dependence of property cars, the number of individual houses, of resources used for every habitant) and demographic changes, which have take into account for solutions development.

The environmental cities problems are extremely complex, because the causes are interdependent. Local initiatives to resolve some problems can generate new problems in contradiction to policy at national and regional level.

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## 2. Experimental measurements and applied methodology

To evaluate the pollution degree soil from Bucharest municipality were taken samples from 356 $km^2$ surface, through belt line, with density of 2.25 samples/$km^2$. The samples [2] are taken from boulevards vicinity, pathways, roads or green spaces areas. In points of soil sampling, debit gamma dose was determined, and in some buildings and subway stations were made investigations regarding $^{222}$Rn and $^{220}$Rn (thoron).

To determine the elements from soil samples, the following methods are used:

- *Gamma spectrometry (for U, Ra, Th and K)*
  - device: multichannel analyzer with HPGe detector;
  - uranium was determined using gamma lines emitted by $^{214}$Bi when the radioactive equilibrium between radium and its descendants was established (indirect determination);
  - Th was dosed after gamma lines emitted by $^{228}$Ac and $^{208}$Tl (indirect determination).
- Debit gamma dose was measured at 1 m height from soil surface in points whence soil samples were taken. Determination was made with FAG-H-40F2 (Germany) radiometer, with 0.01 µSv/h detection limit, certified by Legal Metrology Bureau.

The determinations of radioactive gases ($^{222}$Rn and $^{220}$Rn) are made with RAD 7 device which measure $Rn^{222}$ (radon) and $Rn^{220}$ (thoron) by alpha spectrometry in air from 4 to 400.000 Bq/$m^3$. The device is equipped with printer in which are recorded: medium concentration, measured value, temperature, number of cycles measured. Results are obtained after 20 minutes.

Regarding soil samples localization, it made by division of those on 4 areas, namely: northern area, southern area, eastern area and western area.

## 3. Results and discussions

a. External gamma irradiation

The measurements data, made at 1 m height from soil surface in points whence soil samples were taken, shows values between 0.09-0.26 µSv/h, appropriate to background, taking into account the geological structure and area altitude (90 m). The values over 0.20 µSv/h are found especially in Militari industrial area. The small values characterized the north area of Bucharest municipality.

b. Determination of $^{222}$Rn and $^{220}$Rn concentrations

$Rn^{222}$ is produced by Ra disintegration from $U^{238}$ series. This natural isotope of uranium is many thousands of times stronger than Au in ground. It is unequally distributed on earth due to geochemical composition of soil. The radon content, easier in atmosphere into certain place, depends by radium concentration from soil (rock), physical and chemical properties of soil and also by meteorological factors in the area (pressure, humidity, wind conditions, etc.). The building materials containing radium represent a source for radon found in houses. The classical building materials (clay, sand, stone, granite, etc.) containing natural radioelements – so radium too – in different concentrations, depends by specific of provenance place.

In recent years, are produced and experimented a series of new building materials who replaced classical building materials.

Radon is an instable element (table 1), which disintegrated, having 3.823 days half – value life. By disintegration, alpha particles are emitted, with 5.48 MeV maximum energy [3].

**Table 1** The main characteristics of radon and its short lived descendants [1-3].

| Isotope | Historical label | Half – value life | Time of disintegration and energies (MeV) | | |
|---|---|---|---|---|---|
| | | | Alpha | Beta | Gamma |
| $^{222}Rn$ $\downarrow \alpha$ | Rn (radon) | 3.823 days | 5.49 | - | - |
| $^{218}Po$ $\downarrow \alpha$ | RaA (radiu A) | 3.05 min. | 6.00 | - | - |
| $^{214}Pb$ $\downarrow \beta\gamma$ | RaB (radiu B) | 26.8 min. | - | 1.02<br>0.70<br>0.65 | 0.35<br>0.30<br>0.24 |
| $^{214}Bi$ $\downarrow \beta\gamma$ | RaC (radiu C) | 19.9 min. | - | 3.27<br>1.54<br>1.51 | 0.61<br>1.77<br>1.12 |
| $^{214}Po$ $\downarrow \alpha$ | RaD (radiu D) | $164x10^{-4}$ sec | 7.69 | - | - |

By successive disintegration result short lived descendants of radon who emitted alpha and beta radiations with different half – value life time (table 1). These descendants are presented as positive and negative ions. A part of radon descendants attached on small particles (dust, cigarette smoke, etc.) from fresh air forming radioactive aerosol. By respiration, radon and unattached descendants and also radioactive aerosol enter into organism. From the point of view of environmental pollution and effects on organism, $^{218}Po$ and $^{214}Po$ are extremely important.

By inhalation, radon gas and its unattached descendants arrived in lung whence, by blood circulation, are transported to the other organs, the irradiation produced in that manner, is not a considerable danger [3].

The attached radionuclides deposit on respiratory tracks from where irradiated directly: bronchi and mucous bronsic, and also bronsic epithelium, which covers the bottom of lungs. Because the alpha particles conceded the whole energy to tissue, irradiation produced by them is significant. Thus, alpha active descendants of radon, $^{214}Po$ and $^{218}Po$, have a major importance in production of lesions at respiratory tracks level. The possible biological response is directly proportional with energy absorbed in tissue.

If the radon concentration (and descendants) is higher, the possible risk is major. We mention that react individuals for the same value of irradiation.

Radon emanated from soil, building materials, water, natural gases, is dissolved in atmosphere, the concentration average on globe is 5 – 10 Bq/m$^3$ [3]. In the closed spaces (mines, buildings) the radon is accumulated and its concentration can be higher than in open spaces. The radon and its accumulation inside houses [4], due to risks which implies on health, became research subject.

The ventilation is one of the most significant factors which influence accumulation of radon in places.

International Commission on Radiological Protection [5] elaborates in 1993 some regulations and recommendations regarding radon content in closed spaces. Thus, ''the action level'' for radon concentration in houses is between 200 Bq/m$^3$ and 600 Bq/m$^3$, taking into account that medium period spending into house on a year is 7000 h. The experts of every country decide their action level (between above-mentioned values), taking into account the specific local, economics possibilities and laws in force. For houses who present radon concentrations over level action it is recommended to found some methods to diminution. These solutions involve a series of problems concerning the costs afferent to reduce the radon content, for private and state houses. Every citizen must to know the radon level from his own house, and the consequences for health which implies the existence of high radon values.

In Romania, Ministry of Health [6] determined, for buildings constructed after 2005 that level concentration of Rn$^{222}$ not exceeds 200 Bq/m$^3$ and 400 Bq/m$^3$ for buildings made before 2005.

As we have mentioned before, the radon from different sources is accumulated in houses atmosphere. It is very important to determine the main source who determines the quantity of radon inside house. The possibilities to reducing the radon content from houses are treated separately for existing houses than for those who must build in future.

Radon quantity from already built house can be reduced by some methods:

- Assuring an efficiency ventilation;
- Achievement of cavity under the building (vault, etc.);
- Isolating the foundation, eventually the walls;
- Application of some tubes under the building to capture and supervise the radon in free air;
- Complete renovation of house.

The selection of adequate method is achieved considering the size of radon concentration, the cost and expected effect.

For houses that must be projected is necessary to allow the following:

- Determination of radon content emanated from soils on lands where the constructions are made;
- Determination of radioelement concentrations in the building materials, such as, in the final product, the concentrations of $^{226}$Ra, $^{232}$Th and $^{40}$K respect relation [6-8]:

$$\frac{^{226}\mathrm{Ra}\left(\mathrm{Bq/kg}\right)}{300\,\mathrm{Bq/kg}}+\frac{^{40}\mathrm{K}\left(\mathrm{Bq/kg}\right)}{300\,\mathrm{Bq/kg}}+\frac{^{232}\mathrm{Th}\left(\mathrm{Bq/kg}\right)}{200\,\mathrm{Bq/kg}}£0.5$$

meaning that the building constructions must have the following maximum contents in: U = 4 ppm (at equilibrium with $^{226}$Ra); $^{232}$Th = 10 ppm; K = 1%.

In this work, the field measurements, made on subway stations, industrial or civil new and old constructions are presented in table 2. The measurements shows that $^{222}$Rn concentrations have values between 20 – 225 Bq/m$^3$ and $^{220}$Rn between 0-20 Bq/m$^3$, values situated up to „action concentrations level'' limit, between 200 – 600 Bq/m$^3$ [6]. Thus, buildings where determinations are made were selected thereby to include: different building years and different materials.

**Table 2** The measurement results made in different locations, using different building materials [2].

| No. | Buildings | Investigated area | Concentration of $^{222}$Rn [Bq/m$^3$] |
|---|---|---|---|
| 1 | New buildings | Pipera industrial house | 21.3 |
| | | Giurgiului area industrial house | 211 |
| | | RATB Titan industrial house | 30 |
| 2 | Old buildings | University of Bucharest (basement) | 10.7 |
| | | Academy of Economic Studies | 10.7 |
| | | Gh. Şincai Highschool | 35 |
| | | Mihai Viteazu Highschool | 31 |
| | | Polizu (Faculty of Chemistry) | 63 |
| 3 | Subway station | Corridor of Bucur-Obor | 53 |
| | | Victoriei Square | 31 |
| | | Romană Square | 22 |
| | | Pipera | 37 |
| | | Iancului | 36 |
| | | Grozăveşti | 30 |
| | | Titan | 37 |
| | | Eroilor | 34 |
| 4 | Apartment blocks | Titan (block with 4 floor, built in 1974, prefabricated, bath without glass, with sandstone and faience) | 217 |
| | | Titan (10 floor, prefabricated, built in 1974), bath without glass, with sandstone and faience | 89 |
| | | Militari (4 floor, prefabricated, built in 1976), bath without glass, with sandstone and faience | 197 |
| | | Militari (10 floor, prefabricated, built in 1976), bath with glass, sandstone and faience | 62 |
| | | Berceni (4 floor, prefabricated panes, built in 1974), bath without glass | 150 |
| 5 | Houses | Militari, brick house, built in 1939, kitchen with sandstone and faience | 205 |
| | | Giurgiului Road (Aluniş Street), brick house, built in 1960, bath with glass | 45 |
| | | Pantelimon, brick house, built in 1952, kitchen with sandstone and faience | 84 |

Observation: the concentration of $^{222}Rn$ in different buildings types and subway stations shows variations, while $^{220}Rn$ (thoron) is found in insignificant concentrations, under detection limit.

## 4. Conclusions

The presented data shows a small concentration for $^{222}Rn$ in buildings, because the geological basement of Bucharest municipality is made by rocks with small contents in radioelements.

The higher values in some cases for $^{222}Rn$ are due to building materials used (sandstone, faience, possible phosphor-gypsum used in '65-'75 years) having high concentrations in radioelements.

Concerning debit gamma dose determinations and $^{222}Rn$ radioactive gas, the following aspects are observed:

- Debit gamma dose (µSv/h) have values between 0.11-0.25 µSv/h – characteristic to background [9];
- The concentrations of $^{222}Rn$ radioactive gas in different types of buildings and subway stations shows variations due to buildings materials and especially to type of ventilation;
- The admitted Rn concentration (400 Bq/m$^3$) is not exceeded for buildings made before 2005.

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