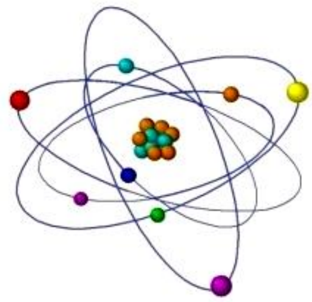
A BRIEF OVERVIEW OF THE CAUSES OF LUNG CANCER AND MEASUREMENTS OF RADON CONCENTRATIONS



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ABSTRACT**:** *Ionizing radiation is a well-established carcinogen. A great number of epidemiologic and experimental studies demonstrated that radiation can cause most forms of cancer. Largest contribution to the exposure of general population by ionizing radiation comes from natural sources. Sources of ionizing radiation in a human's normal living environment are cosmic rays, terrestrial and internal radiation. In average, natural background radiation is responsible for annual effective dose of about 2-3 mSv although this value varies in wide range around the world and one can easily find the areas with up to 10 times greater exposures, mainly due to high levels of radioactive gas – radon. In general, inhalation of radon gas and its progeny is responsible for the greatest component of annual exposure of an average person (about 50%). In the article the causes of lung cancer are discussed. The most important cause of lung cancer is tobacco smoke. According to some estimates, about 90% of lung cancer cases are resulted from smoking. However, it is generally recognized that there are other risk factors, as well. The radon represents the second most important cause of lung cancer after tobacco. Indoor radon concentrations can vary greatly between different geographic regions and different types of building structures. In addition, they exhibit a large range of temporal variations. Since radon emanates from the soil beneath the building, the highest concentrations will be found in basements and first-floor rooms. However, more extensive and large-scale measurements and studies are needed. Assessment of radon concentration levels in different types of buildings throughout the country will allow to estimate the radiation doses due to radon exposure and associated risks for different population groups in Georgia.*

The results of the research obtained at some test objects in three districts of Tbilisi - Vake, Saburtalo, Nadzaladevi settlements, are also presented. Radon concentrations in apartments and soil gas has been measured, and gamma radiation background was determined also.

Key words*:* radon, cancer, radiation, exposure, soil

INTRODUCTION

Radon is a natural inert radioactive gas that is produced by the radioactive decay of uranium and thorium present in the Earth's crust. Radon migrates from the soil into the air and depending on a building's construction type and other geological and environmental factors, it may accumulate in practically all parts of the building – living, working, and other areas. Radon enters the human body mainly through inhalation. Although radon, as an inert gas, mostly leaves the respiratory organs during exhalation, its radioactive decay products, especially polonium isotopes ^{218}Po and ^{214}Po, are deposited in the lungs and cause the irradiation of sensitive cells of the respiratory tract with high ionization potential alpha particles.

Although the main reason of elevated radon concentrations in indoor air usually is emanation of this gas from the subsoil, under some circumstances the building materials enriched by ^{222}Ra and radon dissolved in water may become the significant sources of exposure.

Radon decays into a series of short-lived radionuclides (fig. 1). Some of them – ^{218}Po, ^{214}Po, ^{214}Pb, and others – are also alpha-emitting. In general, under normal circumstances, the largest dose from radon and its decay products will be delivered to the lung. Doses to other organs and tissues are much smaller [1] and, therefore, when considering the radiological impact of radon and its progeny, the focus is usually placed on the risk of lung cancer.

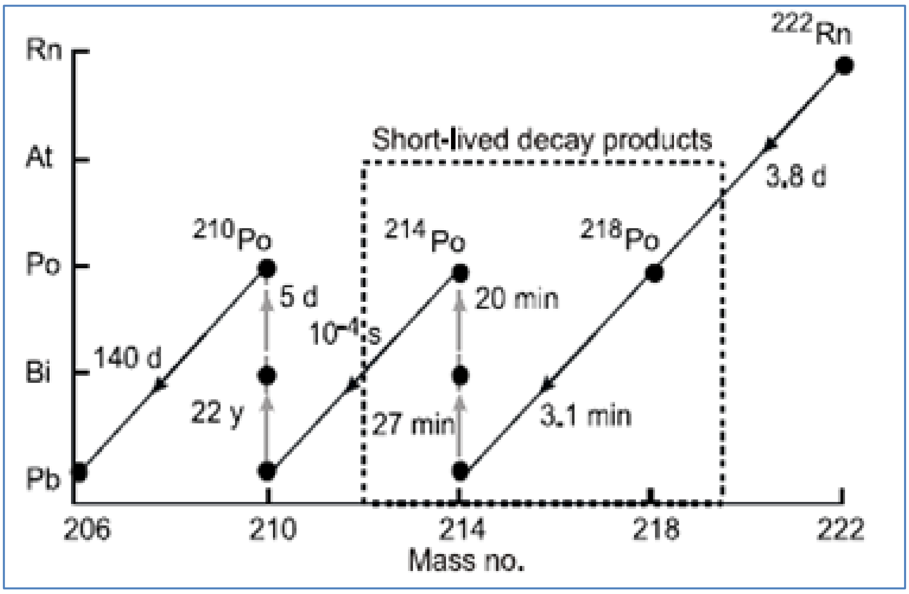

Fig. 1 Radon decay chain [1]

If radon gas is inhaled during normal respiration process, some fraction will be absorbed through the lung, but the majority will be exhaled. However, the short-lived radon progeny which are the isotopes of solid elements tend to be deposited on the bronchial epithelium and will decay there irradiating the cells lining the respiratory tract by high-LET alpha radiation.

Using sophisticated mathematical modeling methods, indicated that the doses resulted from inhaled radon progeny are non-uniformly distributed within the respiratory tract, with the highest values in the bronchial and bronchiolar airways [2].

The basal and secretory cells, located at the depth of 10-50 μm, are assumed to be the most probable target cells from which lung cancer originates [3]. Alpha particles emitted during the decay of ^{214}Po and ^{218}Po have the range of 48 to 71 μm in tissue and, therefore, are able to damage the DNA molecules of these cells, thus, giving rise to the potential malignant change, especially taking into account a bystander mutagenic effect which may amplify significantly the risk [4].

Radon Exposure

The first documentary evidence of carcinogenic effect of radon exposure comes as early as from the 16th century, in particular, from the German scholar Georgius Agricola (1495-1555) who described in his greatest work *De re metallica* the high mortality rates among the miners in the Carpathian Mountains of Eastern Europe. Autopsy studies of miners from that region carried out more than 300 years later, demonstrated that lung cancer should have been a common cause of death [5].

Discovery of high radon levels in underground mines in the early 20th century and epidemiologic studies of radon-exposed miners during the 1950s and 1960s confirmed the association between radon exposure and lung cancer (fig. 2) (The working level (WL) is defined as any combination of the short-lived radon progeny in one litre of air that results in the ultimate release of 1.3 x 105 MeV of potential α-particle energy. Exposure to this concentration for 170 h (or twice this concentration for half as long, etc.) is defined as a working level month (WLM). An individual living in a house with a radon concentration of 20 Bq m~3 will be exposed to around 0.08 WLM per year) [6, 7].

On the basis of these epidemiologic evidence, cellular mutagenesis studies and experimental research on animal species, World Health Organizati on (WHO)'s International Agency of Research on Cancer has classified radon as an A class human carcinogen [8, 9]

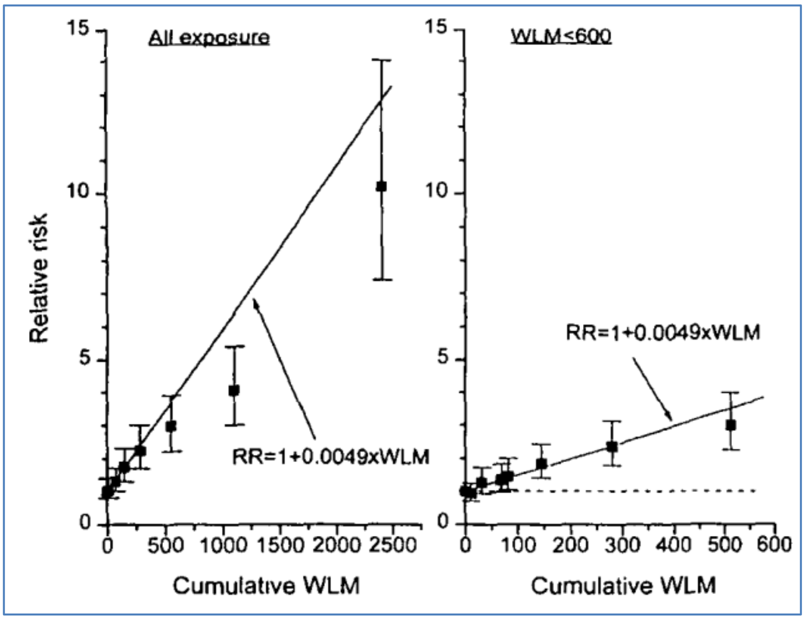

Fig. 2 Relative risk of lung cancer with cumulative radon exposure [6]

The established connection between radon and lung cancer in miners had raised concern for the possibility that exposure to radon in homes might also cause lung cancer in the general population, especially, taking into account that the risk of lung cancer from radon is related to both the radon level and the exposure duration [10]. Interest to this problem enhanced dramatically in the 1970s and 1980s when the residential buildings with significantly elevated indoor radon levels were discovered in a number of countries. One of the examples of such dwellings is the so-called Castleisland House in South-West Ireland where the radon concentration of approximately 49,000 Bq/m^3 has been observed [11]. It is almost 250 times higher than the reference level of 200 Bq/m^3 for EU countries and 300 times higher than the action level of 4 pCi/l (148 Bq/m^3) established by US EPA [12].

Risk Estimates.

The US National Academy of Science BEIR VI committee published a comprehensive report on the health effects of radon in 1999. The committee used the results of 11 major studies of underground miners involving together about 68,000 men, of whom 2,700 have died from lung cancer. On the basis of these data, the committee derived two models for lung-cancer risk from radon exposure: "exposure-age-concentration model" and "exposure-age-duration" model. The calculations indicated that radon can be responsible for about 1 in 10 or 1 in 7 of all lung-cancer deaths, depending on which of these two models are used. The number of radon-related lung-cancer deaths resulting from that analysis could be between 3,000 and 33,000 each year [13].

However, extrapolation of the data derived from miner studies to the radon exposure of general population in homes is associated with some limitations and uncertainties due to differences in the age and sex composition of these two groups, environmental conditions in mines and residential buildings, dosimetric methods used, and the percentage of cigarette smokers within the considered populations [14]. The risk analyses conducted more recently usually take into account exposure-response relations derived both from cohorts of miners and from residential studies and consider the observed synergistic interaction between radon and smoking. Two examples of recent publications on this subject are the radon induced lung cancer risk analyses performed in Canada and France [15,16].

Within the Canadian study [Brand et al., 2005], the excess lifetime risk of lung cancer from radon in Canada is estimated on the order of 5/1,000 for the general population and as 40/1,000 for ever-smokers. Catelinois et al. concluded that "of the 25,134 lung cancer deaths in France during 1999, indoor radon probably caused 5-12%" [16].

In addition, to take into consideration the age dependence of radon induced lung cancer, published the practical tables of calculated lifetime relative risks for exposures between any two age intervals from 0 to 110, for various radon concentrations from 100 to 1,000 Bq/m^3 [10]. These data indicate that exposure in the first 33 years of life contributes to about half of the total excess risk and, consequently, the risk is higher for individuals in middle age (30-50 y), compared to the later years.

Experiment.

New research into radon-related lung cancer continues today. For example, according [17] researchers endeavor to ascertain the potential risk of lung cancer associated with measured radon concentrations. To this end, an extensive, long-term (2–3 months) radon monitoring campaign was executed by strategically positioning Columbia Resin-39 (CR-39) solid-state nuclear track detectors at 28 distinct locations. The overarching aim of this effort is to comprehensively assess the health hazards posed to both staff and students and subsequently institute any requisite mitigating measures. Also, the article [18] presents new research methods. In the publication [19] it is mentioned that public information materials about radon require revision. Specifically, they emphasize that radon causes lung cancer.

Measurements of radon concentrations at test facilities in different areas of Tbilisi [20], [21] showed how important it is to carry out these works in populated areas, take safety measures and transferring of information to the population. Radon concentrations and gamma radiation dose values was measured in individual apartments and soil gas located in Vake, Saburtalo and Nadzaladevi administrative districts of Tbilisi.

Relatively low (0.1 ÷ 5.0) kBq/m^3, medium (5.1 ÷ 10.0) kBq/m^3 and relatively high (10.1 ÷ 19) kBq/m^3 concentrations of radon were recorded in the soil gas. Gamma-dose distribution is not characterized by sharp features in the interval of 100-130 nSv h^{-1}. Relatively high concentrations of radon in soil gas were observed in three (northern, central, and southern) sub-latitudinal (east-west) bands characterized by strong and thick-bedded Paleogene rocks. All three bands represent a hypsometrically raised terrain, where fissured rocks directly protrude from the ground surface or are covered by a thin layer of soil. Average and relatively low concentrations of radon in soil gas were observed in the areas between the north, central and south sub-latitudinal direction bands, with hypsometrically depressed terrain, built with upper Paleogene-lower Neogene clays and sandstones, where dense rocks are overlain by typical, fluvial and slope rocks of Quaternary (anthropogenic) age. with alluvial (deluvian) clay-sand formations and a thick soil cover (Fig. 3).

Radon concentrations were measured in the air of basements and first floors of apartments and public buildings located in the study areas (Vake, Saburtalo and Nadzaladevi). Unlike the concentrations of radon observed in soil gas, their value does not exceed the legal concentration limit of the USA, EU and Georgia (Fig. 4). However, a large-scale study is necessary.

Risk associated with radon exposure is particularly relevant for Georgia, because the country's geological formations are characterized by a high content of uranium; in addition, many buildings are constructed with locally produced materials. Therefore, radon is a potentially serious problem in Georgia. Although the "National Environmental Hygiene Action Plan" and the "National Health Policy" recommend monitoring radon exposure, systematic assessment has not been conducted in Georgia to date, and there are practically no data on radon concentrations in buildings. According to the International Atomic Energy Agency, information on radon concentrations in Georgia cannot be found in international radiation information databases, as well as on global and regional radiological maps, unlike other European countries [22].

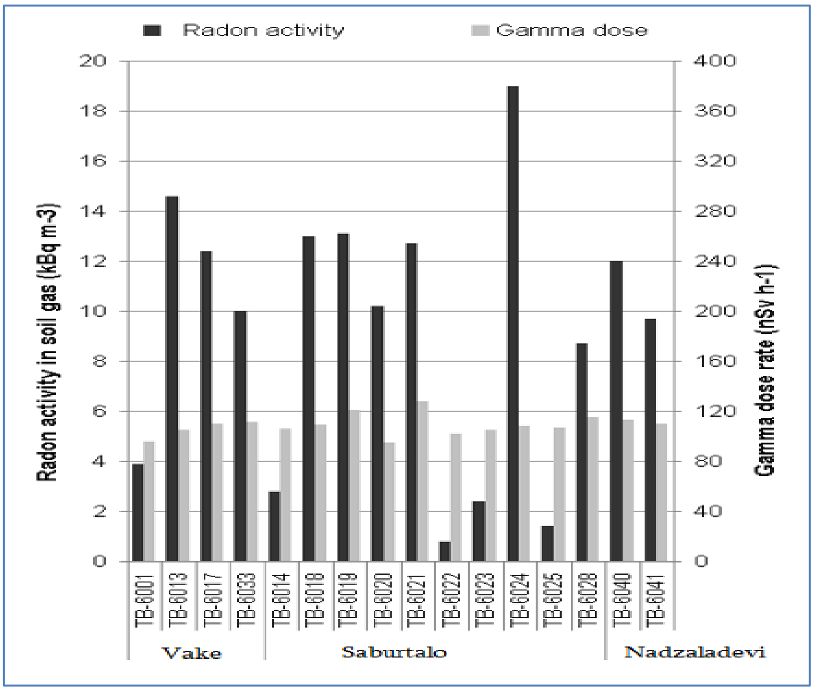

Fig. 3 Values of radon concentration and gamma radiation dose in soil gas

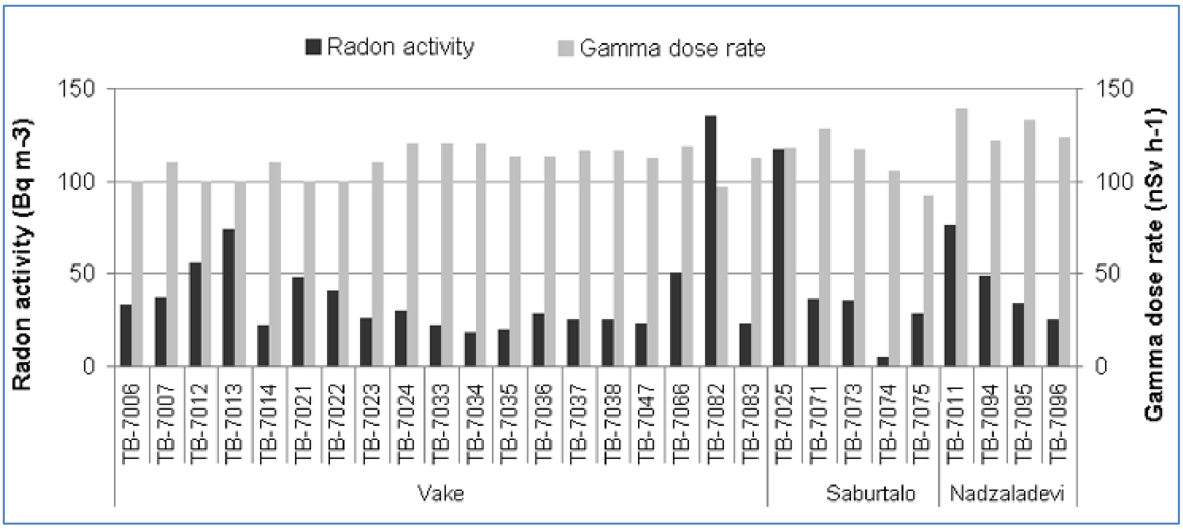

Fig. 4 Values of radon activity and gamma radiation dose in individual apartments

CONCLUSION

Because the risk of lung cancer is very high under conditions of constant radiation [23], it is very important to measure radon concentrations both in residential buildings and in spaces where people have to stay for a long time, such as offices, schools, gardens, etc.

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