

## POSSIBLE POSITIVE EFFECTS OF CHRONIC LOW-DOSE IONIZING RADIATION ON HUMAN LIFE-SPAN IN TALYSH, AZERBAIJAN

Aliyev Ch.S.<sup>1</sup>, Kamilova N.M.<sup>2</sup>, Mahmudova F.F.<sup>1</sup>, Baghirli R.J.<sup>1</sup>, Aliyeva A.R.<sup>1</sup>

<sup>1</sup>Ministry of Science and Education of the Republic of Azerbaijan,  
Institute of Geology and Geophysics, Azerbaijan

119, H.Javid ave., Baku, AZ1143: [aliyev.chingiz47@gmail.com](mailto:aliyev.chingiz47@gmail.com)

<sup>2</sup>Azerbaijan Medical University, Ministry of Health of the Republic of Azerbaijan, Azerbaijan  
100, Mardanov Qardashlar str., Baku, AZ1078

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**Summary.** Radiation hormesis is the hypothesis that low doses of ionizing radiation (within the region of and just above natural background levels) are beneficial, stimulating the activation of repairing mechanisms that protect against disease, that are not activated in absence of ionizing radiation. The paper describes research results supporting hormesis through exposure to low-dose ionizing radiation conducted in the Talysh region of Azerbaijan. According to the International Committee on Radiation Protection, 40-75% of total human exposure to natural radioactive sources comes from radon and its decay products. Radiometric studies covered five districts of the Talysh region: Masalli, Lankaran, Astara, Yardimli and Lerik. The volume activity of radon in residential areas was measured with radon Scout and radon Scout Plus radiometers from SARAD. Based on the obtained results, maps of the distribution of radon volume activity are constructed separately for each region. According to this map, the Lerik district, known for its long-lived inhabitants, is characterized by a relatively high level of radon. The ECG (electrocardiograph) of cardiac activity is written in the modern cardiograph Cardi Max Fx 8222 produced by the Japanese company Denshi Fukuda. The results of the research showed that there is a certain correlation between the level of radon in homes and life expectancy. According to the current regulatory document, the indoor radon volume activity should not exceed 200 Bq/m<sup>3</sup>. Based on research results, in villages where centenarians are living, the level of indoor radon varies between 100-200 Bq/m<sup>3</sup>, averaging 150 Bq/m<sup>3</sup>.

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### Introduction

The exposure of humans to radiation from natural sources is unavoidable. Radiation exposure from natural sources varies globally and within a country depending on the geology and altitude where people live. Studies of the health of populations living in areas with high levels of background radiation conducted during the past 25 years are a potential source of information on the effects of low-dose protracted exposures. Radiation hormesis is the hypothesis that low doses of ionizing radiation (within the region of and just above natural background levels) are beneficial, stimulating the activation of repair mechanisms that protect against disease, that are not activated in absence of ionizing radiation. The reserve repair mechanisms are hypothesized to be sufficiently effective when stimulated as to not only cancel the detrimental effects of ionizing radiation but also inhibit disease not related to radiation exposure. The International Commission on Radiological Protec-

tion (ICRP 2007), National Academy of Sciences Biologic Effects of Ionizing Radiation (National Research..., 2006), the United Nations Scientific Committee on the Effects of Atomic Radiation and the National Council on Radiation Protection and Measurement (NCRP) have adopted 100 mSv or less as low dose (UNSCEAR, 2010; Boice, 2017). Previously, the UNSCEAR Scientific Report (UNSCEAR, 2011) had defined low doses as those of  $\leq 200$  mGy, and low-dose-rate 0.1 mGy per minute (averaged over one hour or less) for external X- and  $\gamma$ -rays. Recently, Multidisciplinary European Low Dose Initiative (MELODI), a European radiation protection research platform, have defined low doses as those between 10 and  $< 100$  mGy and moderate doses from 100 mGy to 1 Gy and  $> 1$  Gy as high doses (Seibold, 2020; Kreuzer, 2018).

According to the International Committee on Radiation Protection, 40-75% of total human exposure to natural radioactive sources comes from radon

and its decay products. In 1987 radon and its decay products were classified by the International Agency for Research on Cancer as being carcinogenic to humans. Investigations conducted in Europe and USA showed that radon is the second cause after smoking providing lung cancer diseases (Cohen, 1993). Radon is the main factor of lung cancer among non-smokers. A study of the radon problem in Azerbaijan shows that its distribution in space is uneven and mosaic in nature. The regions with the highest concentrations are confined to the mountainous folded massifs of the G.Caucasus and Talysh, while those with the lowest concentrations are confined to the lowlands (Aliyev et al., 2017). In this regard, it is interesting to note that the longest duration of life in Azerbaijan is also noted among the people living in mountainous regions (in the Caucasus, especially in Talysh). According to the official statistics, the duration of life of women in Azerbaijan is higher than men. So, currently there are 838 people (814 women and 24 men) in Azerbaijan who have reached a hundred and more years. In this connection, it is very interesting that statistical analysis and experimental studies on the effect of radon exposure on human health have established that men are more susceptible to irradiation as compared with women.

The main objective of the study was to assess the results of the current monitoring of the radiation situation in the Talysh region and the correlation analysis between the life expectancy and quality of the population and radon levels in their places of residence.

### Materials and methods

Radiometric works of the studied region included measurements of the radon volume activity in residential premises and in water of mineral springs, the water of which is used by local residents, and measurements of radiation levels in the environment. Radon volume activity in residential premises was measured with Radon Scout and Radon Scout Plus radiometers from SARAD. They were installed in residential premises for several days. Radon volumetric activity in soil and water was measured by using RAD7 radiometers (DURRIDGE). The radiation level was measured by using dosimeter radiometer MKC-AT1125. Based on the averaged values of the obtained data, the maps of the distribution of the radon volume activity in areas of the studied region have been constructed. Maps were constructed by using the Surfer program (production of Golden Software).

For medical studies 3 types of questionnaires were developed, differing from each other in questions. This was due to the fact that the studies were conducted with different age groups. Also among

the surveyed citizens, psychophysical tests adapted to local conditions were conducted. The ECG of cardiac activity is written in the modern cardiograph Cardi Max Fx 8222 produced by the Japanese company Denshi Fukuda. Participation in the studies was voluntary. The study participants were fully acquainted with the aspects of participation in the study, which fully complied with the requirements of the Helsinki Declaration.

### Results and discussion

Radiometric studies had covered five districts of the Talysh region: Masalli, Lankaran, Astara, Yardimli and Lerik. As mentioned above, measurements of volumetric radon activity in residential buildings were carried out in the populated areas of the studied region. Indoor radon concentrations are measured in the living rooms of houses at ground level. Regarding the recruited of participants, the priority was given to the older houses by selecting 3-5 dwellings from each district randomly. The majority of the houses examined were built 30 to 50 years ago using bricks composed of sand and cement along with cemented floors. In the Masalli district, studies were carried out in 17 settlements. The radon concentration here varied within 20-170 Bq/m<sup>3</sup>. In 38 surveyed settlements of the Lankaran region radon concentration varied within 20-600 Bq/m<sup>3</sup>. In the Astara region, studies were conducted in 23 localities. The radon concentration here varied within 50-190 Bq/m<sup>3</sup>. In Yardimli region 19 settlements were surveyed. The radon volume activity here varied within 50-730 Bq/m<sup>3</sup>. In Lerik region, studies were conducted in 32 localities. The radon concentration here varied within 89-215 Bq/m<sup>3</sup>. On the basis of the obtained data the map of distribution of radon volume activity for the Talysh region has been constructed. According to this map, the Lerik region, known for its long-livers, is characterized by a relatively high level of radon (Feyzullayev et al., 2021). According to the current regulatory document, the indoor radon volume activity should not exceed 200 Bq/m<sup>3</sup>. In villages where centenarians are living, the level of indoor radon varies between 100-200 Bq/m<sup>3</sup>, averaging about 150 Bq/m<sup>3</sup>.

During the study, 24 long-livers, 30 their close relatives and 30 members of the control group have been investigated. Among the studied centenarians, the number of women (14 people) exceeds men. It should be noted that the genetic factors are an important component of longevity.

Analysis of electrocardiographic indicators of centenarians showed that the pathological changes noted in cardiac activity do not exceed the age-related changes (Fig.). Thus, in 35% of the studied centenarians, deep hypoxia in the heart muscle, T-negative

(disorders of blood circulation in the heart), ecstrocystolias, ischemic changes, bundle branch block, rupture of the heart vessels (acute disorders of nutrition of the heart muscle, T - negative), cardiosclerosis changes were recorded. In 25% of studied centenarians a normal ECG was observed. Also in ECG of 45% of the studied centenarians age-related changes were observed. At this time, all teeth and complexes of the ECG had a small amplitude. Despite severe pathological changes on the ECG (damage of the myocardium, hypertrophy of the left ventricle, complete or partial blockade of the bundle branch block), the average indicator of arterial pressure among centenarians is 145-85 mmHg, the average indicator of heart rate was 75-78 beats per minute. In only one of the studied centenarians, the amount of sugar in the blood was slightly higher than the norm.

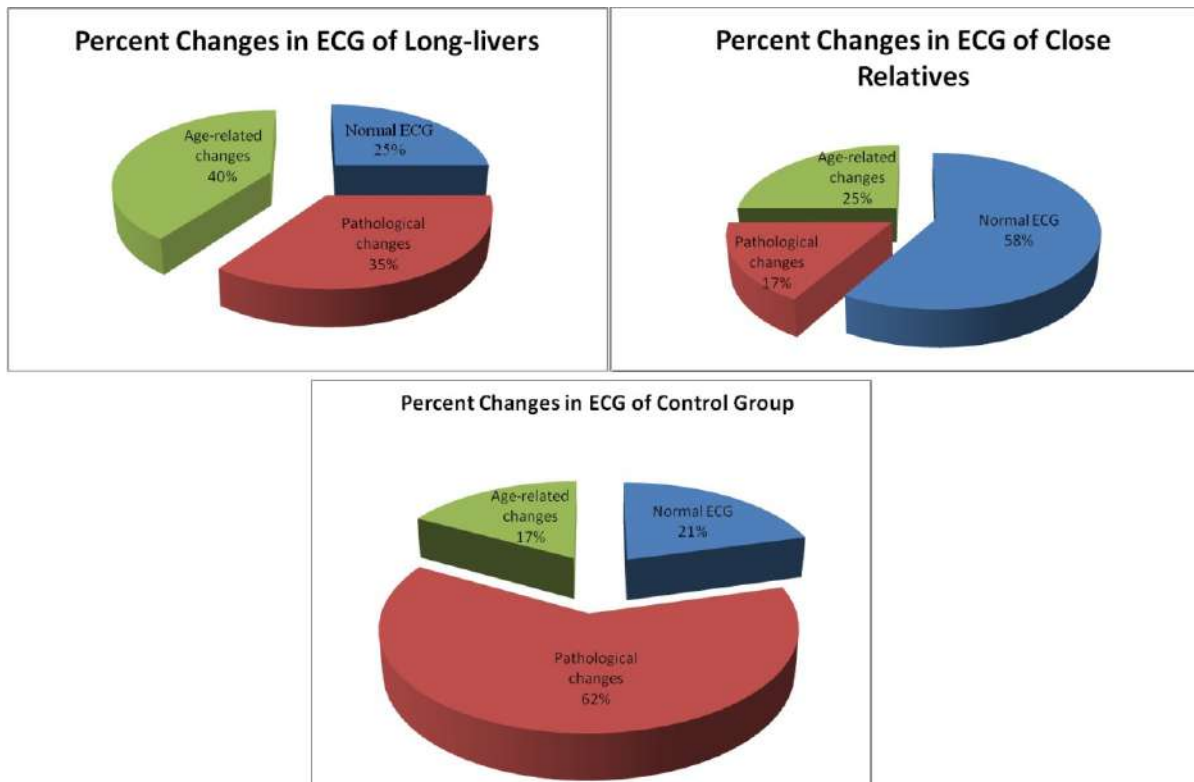
The analysis of the ECG of close relatives of centenarians showed that deep pathological changes in this group are much less common than the control group. From the 24 studied relatives, the ECG was normal only in 14 people. Pathological changes were noted in 4 people (T-negative, blockade of the bundle branch block). In 6 people were observed age-related changes (hypoxia, disorders of the nutrition of the heart muscle). In this group, hypoxic and neurotic (T- vagus) changes in ECG were most common.

Among the group at age 100, there were not noted cardiovascular pathologies. Heart rate and blood pressure were in full compliance with the norm.

In the process of aging, the cardiovascular system undergoes involution changes which lead to the development of cardiac dysfunctions. The hormetic effect of low-dose ionizing radiation has been reported to promote growth and development, also to suppress the ageing process, enhancing immune functions, and delaying cancer progression (Cui, 2017). The obtained results showed that due to the strong adaptive compensatory and genetic factors pathological changes among centenarians do not lead to lethal outcome. This fact shows the presence of strong mechanisms and a strong vitaut system of the organism against various external stress factors.

### Conclusion

The results of the conducted studies have shown that radon volume activity between 100-200 Bq/m<sup>3</sup> can have a beneficial effect on people's health and their life expectancy. However, this does not mean that radon can definitely be considered the main factor of longevity. Thus, further studies are required to rigorously determine the circumstances of how the chronic low-dose ionizing radiation can affect cellular senescence and aging. To demonstrate the effect of chronic low-dose ionizing radiation on human health more robust evidence is required and there are several unanswered questions that require further investigation.



Percent changes in ECG of long-livers, close relatives and control group

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### ВОЗМОЖНОЕ ПОЛОЖИТЕЛЬНОЕ ВЛИЯНИЕ ХРОНИЧЕСКОГО ИОНИЗИРУЮЩЕГО ИЗЛУЧЕНИЯ В МАЛЫХ ДОЗАХ НА ПРОДОЛЖИТЕЛЬНОСТЬ ЖИЗНИ НАСЕЛЕНИЯ В ТАЛЫШЕ, АЗЕРБАЙДЖАН

Алиев Ч.С.<sup>1</sup>, Камилова Н.М.<sup>2</sup>, Махмудова Ф.Ф.<sup>1</sup>, Багирли Р.Дж.<sup>1</sup>, Алиева А.Р.<sup>1</sup>

<sup>1</sup>Министерство науки и образования Азербайджанской Республики, Институт геологии и геофизики, Азербайджан AZ1143, Баку, просп. Г.Джавида, 119: [aliyev.chingiz47@gmail.com](mailto:aliyev.chingiz47@gmail.com)

<sup>2</sup>Министерство науки и образования Азербайджанской Республики, Азербайджанский Медицинский Университет, Азербайджан AZ1078, Баку, ул. братьев Мардановых, 100

**Резюме.** Понятие «радиационный гормезис» предполагает, что ионизирующее облучение, являясь при больших дозах губительным для живых организмов, в малых дозах может индуцировать положительные биологические процессы и оказывать стимулирующее благоприятное действие на организм, которое регистрируется как повышение плодовитости, роста, деления клеток и увеличение продолжительности жизни различных биологических объектов. В статье описаны результаты исследований, подтверждающих радиационный гормезис от воздействия низких доз ионизирующего излучения, проведенных в Талышском районе Азербайджана. По данным Международного Комитета по Радиационной защите на радон и дочерние продукты его распада приходится 40-75% от суммарной дозы облучения, получаемого от природных источников. Радиометрические исследования охватили пять районов Талышской области: Масаллинский, Лянкяранский, Астаринский,

Ярдымлинский и Лерикский. При радиометрических исследованиях проведены мониторинги уровня концентрации радона в жилых помещениях. Измерения объемной активности радона в жилых домах проводились в населенных пунктах исследуемого региона. Объемную активность радона в жилых помещениях измеряли радиометрами Radon Scout и Radon Scout Plus от SARAD. На основе полученных данных построена карта распределения объемной активности радона для Талышского региона. Согласно этой карте Лерикский район, известный своими долгожителями, характеризуется относительно высоким уровнем радона. Функциональное состояние сердечной деятельности регистрировалось с помощью современного кардиографа Cardi Max FX 8222 производства японской компании Denshi Fukuda. Результаты исследования показали, что существует определенная корреляция между уровнем радона в домах и продолжительностью жизни. Согласно действующим нормативным документам объемная активность радона в жилых помещениях не должна превышать 200 Бк/м<sup>3</sup>. По результатам исследования установлено, что категория населения старше 90 лет проживает в основном в районах с умеренным радиационным фоном.

**Ключевые слова:** радиационный гормезис, Талыш, объемная активность радона, продолжительность жизни, здоровье населения

## AZƏRBAYCANIN TALİŞ BÖLGƏSİNDƏ XRONİKİ KİÇİK DOZADA İONLAŞDIRICI ŞÜALANMANIN UZUNMÜDDƏTLİ TƏSİRİNƏ MƏRUZ QALMANIN ƏHALİNİN UZUNÖMÜRLÜLÜYÜNƏ MÜMKÜN MÜSBƏT TƏSİRLƏRİ

Əliyev Ç.S.<sup>1</sup>, Kamilova N.M.<sup>2</sup>, Mahmudova F.F.<sup>1</sup>, Bağırılı R.J.<sup>1</sup>, Əliyeva Ə.R.<sup>1</sup>

<sup>1</sup> Azərbaycan Respublikasının Elm və Təhsil Nazirliyi, Geologiya və Geofizika İnstitutu, Azərbaycan AZ1143, Bakı, H. Cavid pr., 119; aliyev.chingiz47@gmail.com

<sup>2</sup> Azərbaycan Respublikası Səhiyyə Nazirliyi, Azərbaycan Tibb Universiteti, Azərbaycan AZ1078, Bakı, Mərdanov qardaşları küç., 100

**Xülasə.** Radiasion hormezis fenomeni radiasiyanın zəif və orta dozalarının hüceyrə, toxumaların və ümumilikdə insan orqanizminin həyat fəaliyyətinə stimullaşdırıcı, bərpəedici və dəstəkləyici təsir etməsidir. Aparılmış tədqiqatlar zamanı radiasiyanın kiçik dozalarının mezenximal sütün hüceyrələrində orqanizmdə gedən apoptoz prosesinin yavaşılmasına yönəlmiş siqnal mexanizmini aktivləşdirdiyi təsdiq edilmişdir. Beynəlxalq Radiasiyadan Müdafiə Təşkilatının məlumatlarına əsasən əhalinin təbii mənbələrdən şüalanmasının ümumi miqdarının 40-75 %-i radon və onun parçalanma məhsullarının payına düşür. Bütün bunlar nəzərə alınaraq məqalədə uzunömürlülərin daha çox məskunlaşdığı Talış regionunda aparılmış ətraflı radiometrik, tibbi-bioloji və tibbi-sosioloji tədqiqatların, həmçinin region üçün xarakterik olan yaş xüsusiyyətləri analiz edilmiş, uzunömürlülərin qan-damar sisteminin funksional vəziyyətinin qiymətləndirilməsinin nəticələri təsvir edilmişdir. Talış vilayətinin beş rayonunda radiometrik tədqiqatlar aparılmışdır: Masallı, Lənkəran, Astara, Yardımlı və Lerik. Yaşayış yerlərində radonun həcmli aktivliyi Radon Scout və Radon Scout Plus radiometrləri vasitəsilə ölçülmüşdür. Ürək fəaliyyətinin funksional vəziyyəti Yaponiyanın Denshi Fukuda şirkəti tərəfindən istehsal olunan Cardi Max Fx 8222 müasir kardiografi vasitəsilə qeydə alınmışdır. Aparılmış tədqiqatlar nəticəsində yaşayış yerlərində radon qazının həcmi aktivliyi və əhalinin ömür uzunömürlülüyü arasında müsbət korrelyasiya aşkar edilmişdir. Mövcud normativ sənədlərə əsasən yaşayış yerlərində radonun həcmi aktivliyi 200 Bq/m<sup>3</sup>-dən çox olmamalıdır. Tədqiqat nəticələrinə əsasən, uzunömürlülərin məskunlaşdığı kəndlərdə radonun həcmi aktivliyi 100-200 Bq/m<sup>3</sup> arasında dəyişir və orta hesabla 150 Bq/m<sup>3</sup> təşkil edir. Tədqiqatın nəticələrinə əsasən 90 yaşdan yuxarı əhali kateqoriyasının əsasən zəif və orta radiasiya fonlu ərazilərdə yaşadığı müəyyən edilmişdir.

**Açar sözlər:** radonun həcmi aktivliyi, Talış, uzunömürlülük, radiasion hormezis, insan sağlamlığı