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С. Ж. Асфендияров атындағы Қазақ ұлттық медицина университеті

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## ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК  
РЕСПУБЛИКИ КАЗАХСТАН  
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## NEWS

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**HUMAN TEETH ENAMEL AS A TEST FOR ASSESSING THE CONSEQUENCES OF RADIATION POLLUTION OF THE ENVIRONMENT**

**Abstract.** Technogenic radioactive contamination of the external environment has a radiation effect on flora and fauna and humans. Radionuclides entering the biosphere become a source of external, contact and internal radiation in a variety of combinations. The electron paramagnetic resonance dosimetry is a technique that allows a retrospective assessment of an individual dose to be made. A reconnaissance and radioecological survey of environmental objects was carried out using analytical methods, which made it possible to determine the quantitative content of toxic components, priority pollutants and radioactive isotopes. The objects of study are the Bokeyordinsky and Zhanibeksky districts of the West Kazakhstan region (WKR), adjacent to the Kapustin Yar test site. The values of the volumetric activity of natural and technogenic radionuclides in soil samples, drinking water and bio substrates (teeth, samples of human peripheral blood) from settlements of the surveyed areas were studied. Measurements of gamma radiation showed that along the perimeter of the polygon and in nearby settlements, the radiation level is in the range of 0.06–0.14  $\mu\text{Sv/h}$ . An insignificant excess of the level of radioactivity persists near the fall of missiles in the Bokeyordin region. The indicators of the general morbidity of the adult population of maternal and child mortality in the indicated regions were also studied. It was found in the inhabitants of the Bokeyordinsky district with a reliability of  $p = 95\%$  in the studied teeth, beta and gamma activity is less than the natural level and indicates that the content of radionuclides in the studied teeth is not higher than their natural level. A noticeable excess of the activity of radionuclides  $\text{K}^{40}$  and  $\text{Ra}^{226}$  is noted among residents of Zhanibeksky district. In the surveyed districts of the region, there is an unsatisfactory state of health of children and women, especially of fertile age, a high level of primary morbidity, maternal mortality; there is a tendency for the growth of eco-dependent human diseases (previously unrecorded forms of oncological diseases, congenital malformations, diseases of the hematopoietic and nervous systems). The conclusions can be used to implement measures to improve the ecological state of the region and the health of the population.

**Key words:** radionuclides, radioactivity, bio substrate, polygon, ecology, eco-dependent diseases

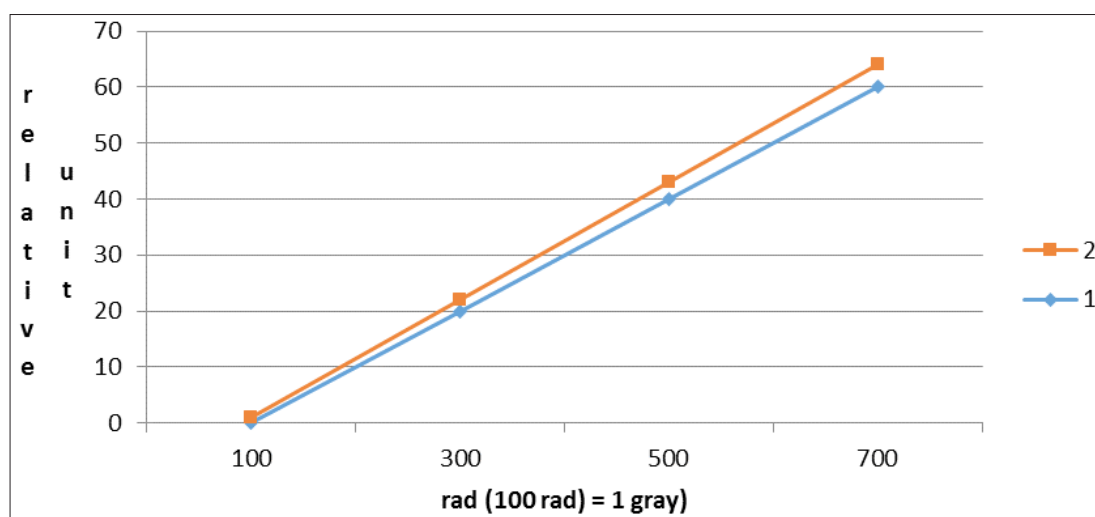
**Introduction.** The influence of one of the components that determine the intensity of the ecological situation of prolonged ionizing radiation on the body, in general, has been sufficiently studied. Technogenic radioactive contamination of the external environment has a radiation effect on flora and fauna, including humans [1,2,3]. Anthropogenic disturbance of the earth's crust is accompanied by the redistribution and concentration of natural radionuclides. Radionuclides entering the biosphere become a source of external, contact and internal radiation in a variety of combinations [4,5,6]. EPR dosimetry is a technique that allows a retrospective assessment of an individual dose to be made. The electron paramagnetic resonance (EPR) method is based on the resonant absorption of a microwave (microwave) field by a sample containing unpaired electrons (free radicals, paramagnetic ions, hydrogen and oxygen atoms, etc.), placed in a magnetic field of a certain value. The value of tooth enamel for EPR dosimetry is due to the fact that when it is irradiated, free radicals ( $\text{CO}^2$ ) arise, the lifetime of which at +25 degrees is 107; the concentration of these free radicals is proportional to the absorbed dose up to certain values.

**Materials and methods.** We have studied the indicators of the general morbidity of the adult population

in two districts of the West Kazakhstan region, adjacent to the Kapustin Yar landfill: Bokeyordinsky and Zhanibeksky. The total morbidity, maternal and child mortality rates were taken from the annual reports of medical institutions and data from the WKR Department of Health. The main indicators of dental morbidity (prevalence, intensity of caries) are also presented by the statistical data of the regional dental clinic.

In these settlements, 30 people were examined in indicator groups to determine the radiation doses. Individual radiation doses were studied in samples of extracted teeth from residents living near the Kapustin Yar test site for 10 and more than 30 years using EPR dosimetry. The basics of EPR dosimetry were described in [7,8]. To determine the absorbed dose by the EPR method, the EPR spectrum of the original enamel was recorded, then 4-5 irradiation with known doses was carried out on a calibrated gamma source, then the EPR spectra were recorded. The EPR spectra were measured using an upgraded IRES-1001 spectrometer (2014) operating in the 3 cm wavelength range. Measurements of the beta and gamma activity of tooth powder were carried out on the Progress complex (2013), designed to measure beta and gamma emitting nuclides in counting samples by the spectrometric method. The activity of the radionuclide in the sample used was determined by processing the obtained spectrogram using a special program that allows identifying radionuclides and determining the activity of the corresponding radionuclides in the sample.

**Research results.** EPR dosimetry results. In our experiment, the doses of additional gamma radiation were 150, 350, 550, 750 rad (100 rad = 1 gray). The EPR spectra of an unirradiated sample and a sample irradiated with the indicated doses were recorded. Further, the dependence of the intensity of the EPR signal of the tooth enamel on the dose of the received radiation was built. As an illustration, the figure shows the dependence of the amplitude of the EPR signal of the enamel of the teeth of two regions (curve 1 - Bokeyordinsky, curve 2 - Zhanibeksky). Determination of the absorbed dose is described in materials and methods. The actual values are shown in figure 1



line 1 - Bokeyordinsky district, line 2 - Zhanibeksky district

Figure 1 - Relative dose values depending on the amplitude of the EPR signal of tooth enamel.

From figure 1 it follows that the relative values of the doses received, depending on the amplitude of the EPR signal of the enamel of the teeth of the two regions, practically do not differ. Noteworthy is the fact that the dose from 25-30 rad and more, found in residents of the surveyed regions, on average, exceeds the average dose for similar territories [9,10,11,12]. To determine the activity of radionuclides in the hard tissues of teeth, we carried out measurements of beta and gamma activity in the radiological laboratory of the Scientific and Practical Center for Sanitary and Epidemiological Expertise and Monitoring, Alma-Ata, Kazakhstan. The results are shown in Table 1.2.

Table 1 - Activity of radionuclides in hard tissues of teeth of residents of Bokeyorda region of WKR

Radionuclide	Activity Bq \ kg raw sample	Absolute activity value Bq / kg	Confidence test ( $P \geq; \leq 0,95$ )
Cs <sup>137</sup>	Less than 49	14.0 ±35	= 0,5
K <sup>40</sup>	Less than 3.2 e + 0.2	0.1 ±318	≠ 0,5
Ra <sup>226</sup>	Less than 95	19.6 ±75	≥0,5

Sampling date: 01.08.2018

Table 2 - Activity of radionuclides in hard tissues of teeth of residents of Zhanibek district

Radionuclide	Activity Bq \ kg raw sample	Absolute activity value Bq / kg	Confidence test ( $P \geq; \leq 0,95$ )
<sup>137</sup> Cs	Less than 32	12.0 ±32	≥ 0,5
<sup>40</sup> K	Less than 6.6 e +0.2	314.0 ±346	≤ 0,5
<sup>226</sup> Ra	Less than 12 e +0.2	40.0 ±76	≥ 0,5

Sampling date: 02.08.2018

As follows from the data of tables 1 and 2 of the inhabitants of the Bokeyorda region with a reliability of  $p = 95\%$  in the studied teeth, the beta and gamma activity are less than the natural level and indicates that the content of radionuclides in the studied teeth is not higher than their natural level. In turn, a noticeable excess of the activity of radionuclides  $K^{40}$  and  $Ra^{226}$  is noted among residents of Zhanibeksky district.

Analysis of the incidence of the population of the surveyed areas. The negative impact of the landfill is noted. As a result, the so-called eco-morbidity and mortality from individual causes are increasing. The study of the morbidity structure of the population showed a significant dependence on the state of the environment (eco-diseases - circulatory systems, respiratory cancer, congenital malformations, neuropsychic pathology), which is confirmed by the literature data [13]. Infant mortality rates are one of the most important indicators of the health of the population, primarily of pregnant women, young mothers and their children. We have studied and calculated infant mortality rates in cities and districts of WKR for 2017-2018 (Table 3).

Table 3 - Dynamics of the decrease in infant mortality in the West Kazakhstan region for 2015 – 2018 years

№	Years	Indicator	Absolute decrease	Pace diminishing
1	2015 Year	14.9	-10	6.2
2	2016 Year	10.8	-4.1	27.5
3	2017 Year	10,5	-0.3	0.2
4	2018 Year	9.5	-1	9.5

This table gives the characteristics of infant mortality and the trend of the annual decrease in this indicator. The highest rate of decline was in 2015 and amounted to 27.5%. It can also be seen that the infant mortality rate in 2015 is the highest in Taipak District (21.1% - the landfill area), and the lowest in Syrym District (12.3% - in a remote area). It is especially necessary to note the ranking of the infant mortality rate in the Bokeyorda region: 2015 year - 17.5%; 2016 year - 4.8%; 2017 year - 11.3%; 2018 year - 6.6%. Such leaps can be explained by environmental problems, unskilled medical care and other reasons. Thus, the conducted research on the analysis of infant mortality showed that from 2015 to 2018 years there is an annual trend towards a decrease in infant mortality both in the region and in the surveyed districts. These results are confirmed by the literature data. The results of the study carried out by E.U. Kuandykov et al. [14,15,16,17,18] indicate a high frequency of perinatal pathology in children born to pregnant women from the risk group by birth to children with congenital malformations and hereditary pathology.

**The discussion of the results.** A comparative analysis of literature data shows the presence of similar effects in areas with increased background radiation of natural and technogenic origin [18-25]. This study was aimed at assessing the ecological scenario in a semi-arid region located in northeastern Brazil. We measured the concentration of metals, alpha and beta radiation in water, as well as the concentration of radon in the room and gamma emitters (U, K and Th). In our studies, we also analyzed the drinking and ground waters of the surveyed areas [16]. The results, as noted by the authors of this study, emphasize the role of high background radioactivity can help explain the exacerbation of cancer incidence in such areas. In work [9,10,11,12,15], similar to our work, several methods of presenting the results of gamma-spectrometric measurements of environmental samples for calculating doses are presented and discussed. It has been shown that the primary measurement results, modified according to the quantification limit, can lead to an underestimation of the annual dose. On the other hand, the best estimates lead to an overestimation of the annual dose. Annual doses, calculated from measurements obtained in accordance with an EC-recommended procedure that does not deal with uncertainties, fluctuate between underestimated and overestimated depending on the frequency of measurements exceeding the detection limit. As the authors note, the average value based on the results of primary measurements is about 80%. The mean value obtained by Bayesian hindsight by 85% and treatment according to the EC recommendation underestimates the value of the annual radiation doses by 89% at Zhanibek district.

**Conclusion.** 1. In residents of the Bokeyorda region, with a reliability of  $p = 95\%$ , the beta and gamma

activity in the studied teeth samples is less than the natural level and indicates that the content of radionuclides in the studied teeth samples is not higher than their natural level.

2. A noticeable excess of the activity of radionuclides  $K^{40}$  and  $Ra^{226}$  is noted among residents of the Zhanibeksky district.

3. In the region, there is an unsatisfactory state of health of children and women, especially of fertile age, a high level of primary morbidity, maternal mortality, there is a tendency for an increase in eco-dependent human diseases (previously unrecorded forms of cancer, congenital malformations, diseases of the hematopoietic and nervous systems). The conclusions can be used to implement measures to improve the ecological state of the region and the health of the population.

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### **АДАМ ТІСІНІҢ ЭМАЛІН ҚОРШАҒАН ОРТАНЫҢ РАДИАЦИЯЛЫҚ ЛАСТАНУЫ САЛДАРЫН БАҒАЛАУҒА ТЕСТ РЕТІНДЕ ПАЙДАЛАНУ**

**Аннотация.** Қоршаған ортаның антропогендік ластануы радиацияның өсімдіктер мен жануарлар әлеміне, соның ішінде адамдарға әсерін тигізеді [1]. Электронды парамагниттік резонанс негізіндегі дозиметрия – бұл жеке дозаларды ретроспективті бағалауға мүмкіндік беретін әдіс. Жұмыста Батыс Қазақстан облысының Жәнібек және Бөкейорда аудандарына іргелес Капустин Ярға аудандары зерттелді. Гамма-сәулеленуді өлшеу полигонның периметрі бойынша және жақын орналасқан елді мекендерде радиация деңгейі 0,06-0,14 мЗв/сағ шегінде екенін көрсетті. Радиоактивтілік деңгейінің шамалы артуы Бөкей Ордасы ауданындағы зымырандардың құлауына жақын жерде сақталады. Сондай-ақ, осы аудандардағы ересек тұрғындардың ана мен бала өліміне қатысты жалпы сырқаттанушылық көрсеткіштері зерттелді. Облыстың тексерілген аудандарында балалар мен әйелдердің, әсіресе фертильді жастағы, денсаулығының қанағаттанғысыз жай-күйі, бастапқы сырқаттанушылықтың, ана өлімінің жоғары деңгейі байқалады; адамның экологияға тәуелді ауруларының өсу үрдісі байқалады (бұрын тіркелмейтін, ТБК, қан өндіру және жүйке жүйесі аурулары). Алынған нәтижелерді өңірдің экологиялық жай-күйін анықтауға және халықтың денсаулығын жақсарту жөніндегі іс-шараларды іске асыру үшін пайдаланылуға болады.

**Түйінді сөздер:** радионуклидтер, радиоактивтік, биосубстрат, полигон, экологияға тәуелді аурулар.

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### **ЭМАЛЬ ЗУБОВ ЧЕЛОВЕКА КАК ТЕСТ ДЛЯ ОЦЕНКИ ПОСЛЕДСТВИЙ РАДИАЦИОННОГО ЗАГРЯЗНЕНИЯ СРЕДЫ ОБИТАНИЯ**

**Аннотация.** Техногенное радиоактивное загрязнение внешней среды оказывает радиационное воздействие на растительный и животный мир, в том числе и человека. Радионуклиды, поступающие в биосферу, становятся источником внешнего, контактного и внутреннего облучения в самых различных сочетаниях. Дозиметрия на основе ЭПР является методом, которая позволяет сделать ретроспективную оценку индивидуальной дозы. Проведено рекогносцировочное и радиоэкологическое обследование объектов окружающей среды с использованием аналитических методик, что позволило определить количественное содержание токсичных компонентов, приоритетных загрязнителей и радиоактивных изотопов. Объектами исследования являются районы Западно-Казахстанской области (ЗКО) Бокейординский и Жанибекский, прилегающие к полигону Капустин Яр. Изучены значения объемной активно-



сти природных и техногенных радионуклидов в пробах почвы, питьевой воды и биосубстратах (зубы, образцы периферической крови человека) из населенных пунктов обследованных районов. Измерения гамма-излучений показали, что по периметру территории полигона и в близлежащих населенных пунктах уровень радиации находится в пределах 0.06–0.14 мкЗв/ч. Незначительное превышение уровня радиоактивности сохраняется вблизи падения ракет в Бокейординском районе. Изучены также показатели общей заболеваемости взрослого населения материнской и детской смертности указанных районов. Установленные у жителей Бокейординского района с достоверностью  $p=95\%$  в исследованных зубах бета и гамма-активность меньше естественного уровня и свидетельствует о том, что содержание радионуклидов в исследованных зубах не выше их естественного уровня. Заметное превышение активности радионуклидов  $K^{40}$  и  $Ra^{226}$  отмечается у жителей Жанибекского района. В обследованных районах области отмечается неудовлетворительное состояние здоровья детей и женщин, особенно фертильного возраста, высокий уровень первичной заболеваемости, материнской смертности; отмечается тенденция роста экзозависимых болезней человека (ранее не регистрируемые формы онкозаболеваний, ВПР, болезней кроветворной, нервной систем). Выводы могут быть использованы для реализации мероприятий по улучшению экологического состояния региона и здоровья населения.

**Ключевые слова:** радионуклиды, радиоактивность, биосубстрат, полигон, экология, экзозависимые болезни.

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