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DISTRIBUTION AND MIGRATION OF NATURAL AND ARTIFICIAL RADIONUCLIDES IN BIOGEOCENOSES OF ABSHERON (on the example of Sabunchu region of Baku)

[1]M.A. Abdullayev, [1]S.R. Khudaverdiyeva
[1]Institute of Radiation Problems of ANAS
mahmud.su@mail.ru

Abstract: In recent work the results of radioecological research of the territory of Sabunchu region of Baku are presented. As a result of dosimetric investigation it is revealed that the maximum values of exposition dose power exist in the territory of the former Iodine plant in the settlement of Ramana (up to 11,0 μR/hour). It is established that in all soil samples prevails ^{40}K (239-524 Bq/kg).

Keywords: Ecosystems, radionuclides, migration, accumulation coefficients, natural radiation background

1. Introduction

Absheron peninsula is located on the west coast of Caspian Sea, against the easternmost tip of Greater Caucasus of Azerbaijan Republic. Its width - 30 km juts out into the sea on 60 km. Absheron from the North and from the South is adjoined by two lowlands – Caspian and Kura-Araks. Along the flat shores of the northern and northeast coast of Absheron sandy sea beaches are stretching on dash strip. Because of fluctuation of Caspian Sea level and the strong winds transferring coastal sand, the coastline continuously changes its sizes and outlines. Absheron's east coast have islands Absheron archipelago, among them two rather larger – Pirallahy and Chilov, further to the east Oil Stones (the legendary city on piles) rise over water. The surface of the soil of Absheron is put by friable sedimentary deposits: limestones, clays and sandstones.

Modern climate of Absheron is dry, subtropical Mediterranean type. Winters are often snowless, without frost, sunny days. Summer – dry and hot. The average annual amount of precipitation is insignificant (110-250 mm) and it is the share mainly of the beginning of spring and the end of fall. Because of a drying-up summer heat the natural vegetation is developed poorly.

In the southern part of Absheron the city of Baku – the capital of Azerbaijan Republic, large industrial, cultural and scientific center, large seaport – one of the largest cities of the CIS is located. Today city line of Baku includes the extensive territory, the area more than 2 thousand km^2 which represents the compact city, with about 3 million populations and divided into 12 administrative regions. The largest of them is the Sabunchu area. All of them are the centers of oil production and are rich with gas fields. In the early twentieth century, the Absheron peninsula came in the first place in the world on oil production – 11 million t. (1901). The ecosystems of the Sabunchu area, along with other regions of Baku, more than 200 years is under indefatigable anthropogenous loading.

In Sabunchu region in addition to the oil and gas fields, there are summer resorts and vacation villages: Pirshagha, Bilgah, Buzovna, Nardaran, etc. Besides, in the area on big sites coal waste of nowadays defunct Ramana iodine plant settled down. The natural (natural) radiation background over coal waste is slightly higher, than in other places. Now this waste is buried by employees of the Ministry of Emergency Situations of Azerbaijan in burial grounds. After such procedures, the ecological situation in Absheron is in an unsuccessful, critical condition. On scales of industrial production Absheron is the largest industrial region of

Azerbaijan Republic. Over 70% of gross output of the industrial production, about 60% of the general oil production on land, all oil processing, almost all petrochemistry, over 80% of mechanical engineering and the metal working, about 30% of the developed electric power, over 75% of forest and woodworking, more than 40% of food, 50% of light industry, 70% of the industry of construction materials of all republic fall to its share.

Now the environment of Absheron demands fixed ecological, including radio ecological attention. Absheron peninsula needs urgent restoration of stability of its ecosystems [Ecological Atlas (Azerbaijan Republic), 2010].

Ecological stability of the biosphere of Absheron is influenced negatively by violations in exploitation of natural recourses of the area and placement without the ecological capacity of industrial and production objects. On Absheron over 150 mineral deposits are operated, around of which all environment is sharply broken. About 16 thousand hectares of land are polluted with oil and its products and with waste of the chemical industry – 2196 hectares [See Ecological Atlas (Azerbaijan Republic), 2010].

In the territory of Absheron there are about 200 large and small reservoirs, a part of which dries during summer season. They are supplied with reservoir waters of wellbore, sewage of the enterprises and settlements. Water of these reservoirs are highly mineralized and eutrophicated and they contain dozens of harmful chemicals and radionuclides. Today more than 50% territory of Baku isn't provided with a sewer network. Every day more than 70 thousand m^3 of sewage from nearby settlements are dumped to the lake Beyuk-Shor. The lake Bulbula has turned into an open hole plum of sewer waters of two large inhabited massifs: Sabunchu and Surakhani areas.

Special ecological danger on Absheron is constituted by solid industrial and household waste. These wastes are constantly processed on dumps without due supervision, storage and utilization. Over the past 30 years on a city dump about 20 million tons of waste was formed. The industrial enterprises and transport release into Absheron's atmosphere annually more than 2 million m^3 of gaseous toxic substances.

Natural radiation background of Absheron hesitates within 3-6 μR/hour [See Ecological Atlas (Azerbaijan Republic), 2010]. But, as a result of production violations in some places, radioactivity may exceed the admissible radiation background several times. These are oil production sites with sediment box, territories defunct iodine plant in the settlement of Ramana and the settlement of New Surakhana. Pollution by radionuclides and products of their disintegration represent health hazard for the population.

Since 1970, under the leadership of academician Jalal Aliyev we have been engaged in studying distribution and migration of natural and artificial radionuclides in biogeocenoses of Azerbaijan (Aliyev, Abdullayev, 1983; Aliyev, etc., 1988; Abdullayev, Aliyev, 1998; Abdullaev, Aliev, 1987). These works proceed to the present.

The main objective of the work was the study of degree of radiation pollution and behavior of natural and artificial radionuclides in biogeocenoses of the Sabunchu region of Baku.

2. Materials and methods

For this purpose, expeditions to the studied area were organized for soil and plants sampling (Fig).

The soil and plant samples were selected both with arable, and from virgin grounds. While taking soil samples, comparative – geographical method was applied. The samples were taken by the laying of the soil cuts. Plant samples were selected not far from soil cuts. The selected soil and plant samples were dried up at room temperature in shadow. After the corresponding cameral processing, concentrations of natural and artificial radionuclides in them

were determined by gamma-spectrometer method. The gamma-spectrometer analysis of the selected samples was carried out on radiospectrometer with HPGe –semiconductor detector (Canberra, the USA) on standard method.

3. Results and their discussion

At the beginning of the work we measured in sampling points the exposure dose rate of the ground atmosphere (at the height of 1,0 m over an earth surface). Radiation monitoring data are provided in table 1. As a result of dosimetric inspection it is revealed that the maximum values of exposition dose rate exist in the territory of the former iodine plant in the settlement of Ramana (11,0 μR/hour).

Fig. The map of the Sabunchu region of Baku (Figures specified sampling places)

The soil's and plant's samples were selected both with arable, and from virgin grounds. At a capture of soil samples applied a comparative – geographical method. Samples were taken by the laying of the soil cuts. Plant's samples were selected not far from soil cuts. The selected soil's and plant's samples dried up at the room temperature in a shadow. After the corresponding cameral processings in them by a gamma-spectrometer method were determined concentrations of natural and artificial radionuclides. The gamma-spectrometer analysis of the selected samples carried out on a radiospectrometer with HPGe – the semiconductor detector (Canberra, the USA) by a standard method.

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Table 1. The soil sampling points and their characteristic

NN of sample	Settlement	Characteristic of soil	Coordinates of an average point	Level of gamma radiation dose, μR/h
			Width, longitude	
1	Pirshaghi Settl.	Gray-brown, arable, settlement Pirshaghi, soil section 50	N40^{0}31.861 E49^{0}52.300	2,5
2	Kurdakhana settl.	Gray-brown, virgin, settlement of Kyurdakhana, soil section 51	N40^{0}32.888 E49^{0}54.300	2,3
3	Bilgah Settl.	Gray-brown, virgin, settlement Bilgyakh, soil section 52	N40^{0}34.663 E50^{0}03.708	2,3
4	Nardaran Settl.	Gray-brown, virgin, settlement of Nardaran, soil section 53	N40^{0}33.983 E49^{0}56.380	2,5
5	Ramana Settl. (in the settlement center)	Gray-brown, virgin, settlement of Ramana, soil section of KR-1	N40^{0}26.678 E49^{0}57.920	5
6	Ramana (territory of the former, defunct iodine plant)	Gray-brown, virgin, settlement of Ramana, soil section of KR-2	N40^{0}26.684 E49^{0}57.842	11,0

As it is seen from the results of our researches, concentration of ^{40}K in soils of the Sabunchu area varies within 239-524 Bq/kg, with average value of 349 Bq/kg. The maximum concentration of ^{40}K is found in coal mine 50, on arable gray-brown soils of the Scientific-Research Institute of Agriculture in the settlement Pirshagha. Obviously, it is connected with long-term insertion of mineral fertilizers into the soil, including potash. Average concentration of ^{226}Ra in soils of the area is 27,7 Bq/kg (24,0-36,4 Bq/kg) and of which fluctuation is less, than the fluctuation of the ^{40}K. The content of ^{228}Ra in soil varies from 14,8 to 36,6 and averaging 24,3 Bq/kg. The greatest content of this radionuclide is observed in the gray-brown virgin soil in the settlement Bilgyah (soil section 52). Concentration of the ^{137}Cs changes from 1,0 to 3,8 Bq/kg, and average value is equal to 2,2 Bq/kg. The greatest content of this radionuclide is observed in the gray-brown soil at the settlement Ramana (KR-2 soil section). Content of ^{90}Sr in soils varies from 0,6 to 2,4 Bq/kg, averaging 1,4 Bq/kg (tab. 2). Last we have identified calculated based on constantly.

Table 2. Concentration of natural and artificial radionuclides in soils of the Sabunchi region of Baku

Soil, site and section number	Depth, cm	**Radionuclides, Bq/kg**					**$A_{eff.}$, Bq/kg**
		^{40}K	**^{226}Ra**	**^{228}Ra**	**^{137}Cs**	**^{90}Sr**	
Gray-brown, arable, settlement Pirshagha, soil section 50	0-24	432	20.4	22.8	1.1	0.7	87.0
	24-33	540	21.1	28.7	2.7	1.7	32.2
	33-40	556	28.9	34.2	2.9	1.8	34.2
	40-62	568	25.5	31.4	2.5	1.6	114.9
Average on a profile	**0-62**	**524**	**24.0**	**29.2**	**2.3**	**1.5**	**67.1**
Gray-brown, virgin, settlement of Kyurdakhana, soil section 51	0-18	585	31.6	35.6	1.6	1.0	31.5
	18-29	354	23.7	38.6	4.3	2.7	86.4
	29-43	274	26.4	8.2	1.5	0.9	30.2
	43-48	282	27.3	6.9	1.2	0.8	24.1
Average on a profile	**0-48**	**374**	**27.2**	**22.3**	**2.2**	**1.4**	**43.1**
Gray-brown, virgin, settlement Bilgyah, soil section 52	0-10	366	22.7	35.4	2.7	1.7	100.2
	10-20	378	25.3	34.4	2.3	1.4	102.5
	20-30	308	26.6	37.4	2.7	1.7	101.8
	30-40	322	24.8	39.1	2.6	1.6	103.4
Average on a profile	**0-40**	**344**	**24.8**	**36.6**	**2.6**	**1.6**	**101.2**
Gray-brown, virgin, settlement of Nardaran, soil section 53	0-10	385	26.7	35.3	2.8	1.8	105.7
	10-26	308	22.5	18.5	0.6	0.4	72.9
	26-38	282	31.9	23.2	0.7	0.4	86.3
	38-46	325	30.2	21.7	0.7	0.4	86.2
Average on a profile	**0-46**	**350**	**27.8**	**24.7**	**1.2**	**0.8**	**87.8**
Gray-brown, virgin, settlement of Ramana, soil section KR-1	0-15	217	35.0	14.9	0.7	0.4	73.0
	15-30	256	44.2	13.8	0.4	0.3	84.0
	30-42	245	30.0	15.7	1.8	1.1	71.4
Average on a profile	**0-42**	**239**	**36.4**	**14.8**	**1.0**	**0.6**	**76.1**
Gray-brown, virgin, settlement of Ramana, soil section KR-2	0-5	255	11.9	19.8	2.1	1.3	59.5
	5-15	256	34.5	12.8	1.7	1.1	73.0
	15-22	283	31.9	21.2	7.7	4.8	83.7
Average on a profile	**0-22**	**265**	**26.1**	**17.9**	**3.8**	**2.4**	**68.6**
Limits of fluctuations of indicators		**239-524**	**24.0-36.4**	**14.8-36.6**	**1.0-3.8**	**0.6-2.4**	**43.1-101.2**
Average		**349**	**27.7**	**24.3**	**2.2**	**1.4**	**74.0**

Note: ^{90}Sr determined by calculation (^{137}Cs:^{90}Sr=1.6).

Observed relationship ^{137}Cs:^{90}Sr=1.6 (this attitude is justified for many regions of the world). This value is measured in fallout in different areas and for a long time, is fairly constant and is approximately 1.6 (Sources and influence of ionizing radiation, 1978). The value of the

activity of ^{90}Sr in soils of the Oryol region of the Russian Federation was calculated in similar way (Andriyashina, etc., 2012).

The comparison of our data with the similar indicators in the 80-90s of the XX century revealed the relative stability in relation to the contents of natural radionuclides in soils that cannot be attributed to radionuclide ^{137}Cs. For the last 20-30 years, the content of ^{137}Cs in soils of Absheron has significantly been decreased. The reason for the favorable change of the situation - is, on the one hand, the reduction of artificial radionuclides in the composition of atmospheric fallings-out, and on the other hand - the removal of radionuclides from plants, radioactive decay and other.

Consideration of the data in table 2 also shows that the total radioactivity of the soil of Sabunchu district of Baku, due to natural and man-made radionuclides mainly depends on the content of the ^{40}K.

The study of migration of radionuclides in the soil profile shows that these indicators are complex, independent from each other in nature. It is known from literature that usually in the upper layers of soils it is observed the maximum content of artificial, but in the lower - maximum content of natural radionuclides (Kuznetsov and others, 1986). But in our research it is not observed similar pattern, as in the soils of Imishli and Saatli districts of Azerbaijan (Abdullayev and others, 2012; Abdullayev, 2012) and other regions of our Republic (Aliyev, Abdullayev, 1996; Aliyev and others, 1986).

Consideration of the data in table 2 also showed that the specific effective activity ($A_{eff.}$) of radionuclides for all soil cuts does not exceed 370 Bq/kg, which corresponds to the normative documents of the permitted levels of radioactivity of natural components and currently, we can say that the radiation situation of the studied Sabunchu district of Baku city is abundance (radiation safety Norms, 2009; the Law of the Azerbaijan Republic. 1997).

Table 3 provides data on the content of natural and artificial radionuclides in plant samples growing on soils of Sabunchu district of Baku city. High concentration of the radionuclides in plants is observed at ^{40}K. The lowest concentration of radionuclides in plants is observed at the ^{137}Cs.

On the content of ^{40}K plants can be placed in the following descending range: burs > sage ethiopian > sorghum > wormwood > red pigweed > licorice > milkweed > lucerne.

On the content of ^{226}Ra plants can be placed in the following descending range: red pigweed > camel thorn > wormwood > sorghum > sage ethiopian > milkweed > licorice > lucerne.

On the content of ^{228}Ra plants can be placed in the following descending range: spurge > red pigweed > sorghum > sage ethiopian > lucerne > camel thorn > licorice > wormwood.

On the content of ^{137}Cs plants can be placed in the following descending range: burs > milkweed > licorice = sorghum > sage ethiopian > lucerne = red pigweed = wormwood.

On the effective activity ($A_{eff.} = 0{,}085A^{40}K+A^{226}Ra+1{,}31A^{228}Ra$) plants can be placed in the following descending range: burs > sage ethiopian > red pigweed > sorghum > milkweed > wormwood > licorice > lucerne.

As it is seen from table 3, the accumulation of radionuclides by individual plants has a different, selective nature. The differences observed in the concentrations of radionuclides can be explained with the differences of the soils of separate natural and artificial radionuclides, as well as various specific features of plants.

Currently the territories of former iodine factories in Ramana and Surakhani settlements have been cleaned up from radioactive waste and works are carried out on improvement and landscaping of areas. Within the selection of species of plants for green plantation in such areas is extremely necessary to consider the results of our research.

Table 3. Concentration and coefficients of accumulation of natural and artificial radionuclides in the plant samples, which have been selected from the Sabunchu region of Baku.

Sam-ple No	Plants, place of sampling	^{40}K		^{226}Ra		^{228}Ra		^{137}Cs		$A_{eff.}$, Bq/kg
		Con-centra-tion, Bq/kg	Accu-mula-tion Coef-ficients (AC), $n \cdot 10^{-2}$	Con-centra-tion, Bq/kg	Accu-mula-tion Coef-ficients (AC), $n \cdot 10^{-2}$	Con-centra-tion, Bq/kg	Accu-mula-tion Coef-ficients (AC), $n \cdot 10^{-2}$	Con-centra-tion, Bq/kg	Accu-mula-tion Coef-ficients (AC), $n \cdot 10^{-2}$	
1.	Lucerne *(Medicago sativa)*, territory of the Agriculture Research Institute	234	44	34.8	145	25.2	86	0.6	26	87.7
2.	Wormwood (*Artemisia absinthium*), settlement of Kyurdakhana	326	87	45.4	166	19.9	89	0.6	27	99.2
3	Sorghum (*Sorghum bicolor L.*), settlement Pirshagha	373	71	44.8	186	27.4	93	0.8	33	112.4
4.	Camel thorn (*Alhagi Pseudoalhagi*)-1, settlement of Kyurdakhana	575	153	48.1	173	21.0	94	2.2	100	124.5
5.	Redpigweed (*Chenopodium rubrum*), Nardaran	306	114	54.6	196	28.2	114	0.6	50	117.6
6.	Spurge *(Euporbia sp.)*, Nardaran	256	73	42.4	152	29.2	118	1,3	107	102.4
7.	Licorice (*Glycyrrhiza glabra L.*), Nardaran	277	79	40.0	143	20.8	84	0.8	68	89.0
8.	Sage Ethiopian *(Salvia aethiopis*), settlement Bilgyakh	507	147	43.4	175	26.3	71	0.7	28	120.9
The range of fluctuations of Indicators		**234-575**	**44-153**	**34.8-54.6**	**143-196**	**19.9-29.2**	**71-118**	**0.6-2.2**	**26-107**	**87.7-124.5**

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РАСПРЕДЕЛЕНИЕ И МИГРАЦИЯ ЕСТЕСТВЕННЫХ И ИСКУССТВЕННЫХ РАДИОНУКЛИДОВ В БИОГЕОЦЕНОЗАХ АБШЕРОНСКОГО ПОЛУОСТРОВА (на примере Сабунчинского района г.Баку)

М.А. Абдуллаев, С.Р. Худавердиева

Резюме: В данной работе представлены результаты радиоэкологических исследований территории Сабунчинского района г.Баку. В результате дозиметрического обследования обнаружено, что максимальные значения мощности экспозиционной дозы существуют на территории бывшего йодового завода в пос. Рамана (11,0 мкР/час). Установлено, что во всех образцах почв преобладает ^{40}К (239-524 Бк/кг).

Ключевые слова: Экосистем, радионуклиды, миграция, коэффициенты накопления.

TƏBİİ VƏ SÜNİ RADİONUKLİDLƏRİN ABŞERON YARIMADASI BİOGEOSENOZLARINDA YAYILMASI VƏ MİQRASİYASI
(Bakı şəhəri Sabunçu rayonu timsalında)

M.A. Abdullayev, S.R. Xudaverdiyeva

Xülasə:Tədqiqat işində Bakı şəhəri Sabunçu rayonunun radioekoloji tədqiqatlarının nəticələri təqdim olunur. Dozimetrik ölçmələr nəticəsində γ-şüalanmanın ekspozisiya dozasının maksimal göstəricilərinin Ramana qəsəbəsində, keçmiş Yod zavodunun ərazisində aşkar olunduğu (11,0 mkR/saat) müəyyən olunmuşdur. Müəyyən olunmuşdur ki, bütün götürülən torpaq nümunələrində ^{40}K radionuklidi (239-524 Bk/kq) üstünlük təşkil edir.

***Açar sözlər*:** Ekosistem, radionuklidlər, miqrasiya, toplanma əmsallar.