RADIOECOLOGICAL STUDY OF OIL FIELDS ON ABSHERON PENINSULA

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Introduction

Over 150 years oil production is developed on Absheron Peninsula in Azerbaijan. This has resulted in a variety of ecological problems, such as contamination of water, soil and air with natural radioactive elements and oil, formation of great number of oil-field water lakes and swamps etc. Oil-field water is rich with chlorine ion and dissolves some radionuclide containing compounds such as compounds of radium in oil-bearing strata. Being pumped out together with oil and then separated from it, oil-field water is discharged by channels to artificial lakes. Due to precipitation and accumulation processes Ra^{226}, Ra^{228} isotopes and their decay products are found in large amounts in soil, water and sediments in oil production areas [1].

This results in high gamma radiation level in some places in oil production fields. Coprecipitation with Ca and Ba and concentration in scales and sludge on the old equipment (well heads, pipe walls, drains, spigots, separation tanks) turns it into dangerous sources of radiation.

Contamination of soil, water, air and equipment with radionuclides causes additional exposure of workers to radiation in the oil production areas. Spreading of radon and contaminated dust particles by winds threatens settlements around oil fields.

Radioecological study of oil production fields, revealing and remediation of contaminated areas are urgent problems. In the present work we studied ionizing radiation background at one of the oil production fields on Absheron Peninsula and calculated its mean value using a statistical approach. Radionuclide composition of soil, water and solid waste samples from places with elevated radiation level is analyzed.

Experimental Procedure

To study ionizing radiation background, and to locate places with high radiation level pedestrian gamma-radiation survey was performed. Using gamma dosimeters we measured exposure rate in 20993 points in the area. With this purpose parallel routes were selected. Distance between measurement points along the routes was 10 m.

Distance between routes was 20 m. When measuring exposure rate, detector of dosimeter touched the surface and the mean value of 5 readings was taken as the measurement. While moving between measurement points, operators held detectors at 10 cm distance from the surface and checked the dosimeter reading. This allowed revealing contamination spots located between measurement points along the routes.

Geographical coordinates of the measurement points were determined by a GPS device with the purpose of putting the results on a map and easily finding them in the future.

Exposure rate measurements were performed by gamma dosimeters with NaI scintillation detectors. The dosimeters were inspected at the beginning and end of each working day with the same standard check source. Detectors of the instruments were placed at the same distance from the source and readings were recorded. Then the mean value of readings from all dosimeters was calculated. A particular dosimeter was considered accurate if its reading differs from the mean value not more than 5%.

Samples taken from the studied area were analyzed for radionuclide composition by gamma-spectroscopy. We used a spectrometer with NaI(Tl) detector. Soil and solid waste samples were grinded, homogenized and dried. Analyses were performed using standard Marinelli vessels.

To attain radioactive equilibrium samples were stored in hermetically closed Marinelli vessels for 1 month before being analyzed. For water samples we used ion-exchange technique to accumulate radionuclides from large amount of sample.
The dried ion-exchange resin was stored in hermetically closed Marinelli vessel for 1 month before being analyzed. A spectrum processing software was used to correct self-absorption in the sample.

Results and Discussion

During the gamma-survey of the territory of oil production area, measurements of exposure rate (ER) at 20993 points were performed. In 570 points ER value was larger than 30 *∝R/h*. The minimal and maximal values of ER are found to be 2 *∝R/h* and 825 *∝R/h*. Places near channels, around lakes of oil-field water, around separators, areas with wastes of clogged up with scale pipes are typical places with high radiation level.

From the ER measurement results for 20993 points we calculated the mean radiation background level for the oil production area. We assumed random distribution of contamination in the area means random distribution of ER values. Then we can apply Gaussian distribution to calculate the mean radiation background level.

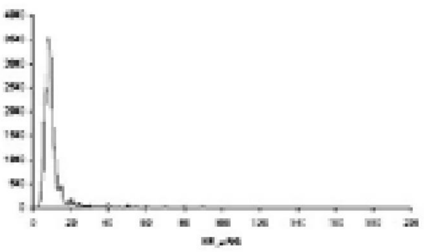

Fig 1. Plot of distribution of exposure rate values in the studied area.

In Fig.1 the plot of number of points with certain ER value N versus that ER values is shown for ER values range 0–200 *∝R/h*.

As it is seen from the Fig.1, mainly ER values were lower than 20 *∝R/h*. The graph has practically a Gaussian shape and only some small deviations are observed. These deviations are related to high ER values, which are rare. The numbers of points with high ER values are few and they do not follow statistical distribution.

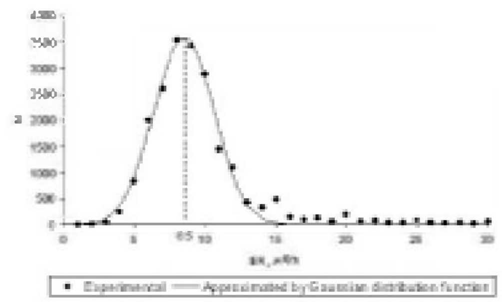

Fig 2. Determination of mean radiation background level by statistical method.

We are interested in the range of 0–20 *∝R/h*. In Fig.2 the range of 0-30 *∝R/h* is expanded. We approximated the experimental plot with Gaussian distribution function:

$$N(x) = Ae^{-\frac{(x-\propto)^2}{2\sigma^2}}$$

The solid line shown in the graph represents this Gaussian function with $\propto$=8.5, σ=2.13 and A=3600.

The maximum of Gaussian function is at 8.5 *∝R/h* and this is the mean radiation background level for the studied oil-production area.

Background level for the region where the studied area is located is 5.5 *∝R/h* (excluding the studied area). Radiation background level in the studied area is raised by 3 *∝R/h* due to contaminations in oil-production process.

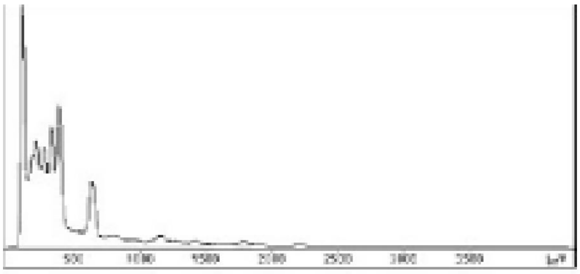

Fig 3. Gamma-radiation spectra of soil sample.

In Fig.3 a gamma-radiation spectrum acquired from the soil sample taken from the studied area is shown.

Gamma-peaks of natural radionuclides are observed on the spectrum. Using peaks of Pb-214 and Bi-214 we calculated the activity of Ra-226.

Activity of Th-232 was determined through Ac-228 and Tl-208. K-40 activity is determined using its own peak at 1461 keV.

Results of radionuclide analyses of different soil and solid waste samples together with exposure rate values at the sampling points are presented in Table 1. Effective activity of samples is calculated by the following formula [2]:

$$A_{eff} = A_{Ra226} + 1.31A_{Th232} + 0.085A_{K40}$$

Table 1. Exposure rate values at the sampling points

ER at the sampling point *∝R/h*	**Specific Activity,** *Bq/kg*			
	K-40	**Ra-226**	**Ra-228**	A_{eff}
210	1416 ± 406	6526 ± 686	1018± 128	7980 ± 707
150	1021 ± 245	3699 ± 285	1861 ± 153	6223 ± 349
9	315 ± 60	35.4 ± 4.2	25.6 ± 4.4	95 ± 12
150	2383 ± 896	11490 ± 1226	278 ± 81	12056 ± 1233
87	439 ± 123	2511 ± 189	52 ± 11	2617 ± 190
50	-	63 ± 12	17.3 ± 7.2	88 ± 16
11	224 ± 46	38.5 ± 5.5	18.6 ± 3.9	82 ± 8
10	112 ± 33	27.3 ± 4.6	10.2 ± 3.3	50 ± 7
160	1394 ± 257	50.4 ± 9.8	55.6 ± 10.4	242 ± 27
230	1502 ± 267	6254 ± 459	112 ± 18	6529 ± 460
43	346 ± 97	1189 ± 93	18.2 ± 7.2	1242 ± 94
5	128 ± 26	17.5 ± 2.8	9.9 ± 2.2	41 ± 5
5	226 ± 47	24.9 ± 4.5	17.1 ± 3.9	67 ± 8
10	138 ± 59	35.8 ± 8.9	36.6 ± 9.0	95 ± 16

As it is seen from the table in general ER value is higher in the places with higher effective activity of soil or waste, but because of different sizes and shapes of contaminated spots, deviations from this rule are observed. Thus, in large spots with relatively low mean effective activity ER can be higher that in small spots with high mean effective activity.

Mean radiation background level for the studied oil-production area is raised in comparison with the surrounding area, but it is not high. Nevertheless, presence of spots with elevated ER threatens workers in places near these spots.

References

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