# RADIATION MONITORING OF SYR DARYA RIVER (II)

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The article contains the results obtained during the radiation monitoring of Syr-Darya River, which was conducted within the frames of international collaboration of Kazakhstan, Kyrgyzstan, Tajikistan, Uzbekistan, and USA. The data on the nature of radionuclide distribution of uranium and thorium rows in bottom and soil is presented. Reasons of formation of the observed dependence of the obtained results on the distance from the source are discussed.

## INTRODUCTION

In compliance with international agreement of the scientists of Central Asia, Kazakhstan, and USA /1/, we are conducting a joint work on studying and monitoring the environment in the basins of Syr-Darya and Amu Darya rivers.

During three expeditions the participating countries (Kazakhstan, Kyrgyzstan, Tajikistan, and Uzbekistan) in 15 control sites on their territory has conducted field researches and has obtained samples of the elements of the environment. Laboratory researches were carried out in Kazakhstan and Uzbekistan.

Soon after beginning of work, the first results were published in the reports and international conference materials /2-4/. During the work /5/ we presented the detailed analysis of water salinity and alpha- and beta- activities of samples of the environment along Syr-Darya river. It was found that salinity and alpha- and beta- activity of water have regular and same nature depending on the distance from the source. Alpha- and beta-activity of bottom and costal soil have the same and regular nature, however absolutely different from what we observed in the water samples. In one of the works /5/ we proposed reasons of formation of such patterns.

In the current work, data analysis of radionuclide composition of bottom and costal soil samples along Syr-Darya River is presented.

## EXPERIMENT TECHNIQUES

Radionuclide composition was determined in the same samples, which were used to determine alpha- and beta-activity. We are reminding of locations of sampling sites on the geographical map on Figure 1.

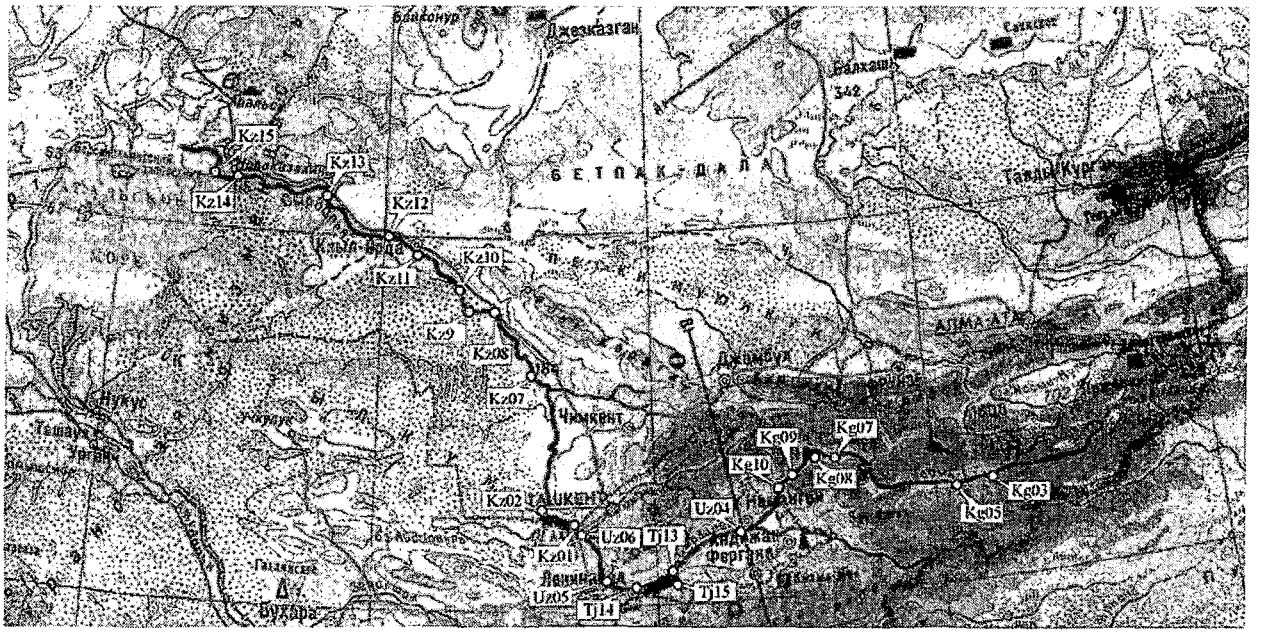


**Fig. 1.** Geographical map of Syr-Darya river pool with sites of sampling indicated

Gamma-spectra were measured by means of germanium semi-conducting detector Selena in volumetric geometry. Samples of soil and bottom were placed in Marinelli jar with the sizes of D=85 mm and 105 mm and H=60 mm and 80 mm. Weight of samples in the jar was usually 0,3 – 0,5 kg. Nuclides of thorium and uranium radioactive rows and $^{40}K$ were determined by gamma-spectrometry. Exposition was usually 9-18 hours. Weight of samples, exposition time, and background conditions of detector caused statistical error range in determining specific activities, which is equal to 5-20%.

Analysis results are expressed in Becquerel in one weight unit of dry sample (Bq/kg).

## RESULT ANALYSIS

Same as in the work /5/ we analyzed average seasonal results for each sampling site. In most of the sites three seasonal samplings were done. Unfortunately, technical difficulties did not allow us to select samples in all the planned sites. In several locations some of the seasonal samplings were omitted.

Table 1 shows specific activity of nuclides, which are in the radionuclide rows of uranium and thorium rows. They are in radioactive balance between each other and identified in the samples of costal soil.

**Table 1.** Activity of radionuclides of uranium and thorium rows in soil samples.

| Sample site | Distance from source, km | Nuclides of thorium row | | | | | | Nuclides of uranium row | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Bi212 | Pb212 | Tl208,×2.78 | Ac228 | $A^{Th}_{eff}$ | $\Delta A^{Th}_{eff}$ | Pb214 | Bi214 | Ra206, ×0.6 | $A^{U}_{eff}$ | $\Delta A^{U}_{eff}$ |
| Kg03 | 250 | 58 | 54 | 42 | 41 | 49 | 7 | 35 | 33 | 31 | 33 | 1 |
| Kg05 | 350 | 37 | 38 | 33 | 28 | 36 | 4 | 26 | 22 | 24 | 24 | 1 |
| Kg07 | 600 | 37 | 40 | 36 | 32 | 38 | 3 | 28 | 23 | 28 | 26 | 2 |
| Kg08 | 650 | 55 | 49 | 42 | 41 | 49 | 5 | 35 | 30 | 33 | 33 | 2 |
| Kg09 | 700 | 48 | 46 | 39 | 37 | 44 | 5 | 38 | 31 | 33 | 34 | 3 |
| Kg10 | 750 | 39 | 33 | 31 | 29 | 34 | 4 | 29 | 24 | 28 | 27 | 2 |
| Uz04 | 800 | 40 | 33 | 34 | 27 | 36 | 5 | 27 | 23 | 20 | 23 | 2 |
| Tj13 | 1000 | 43 | 33 | 58 | 28 | 45 | 11 | 29 | 26 | 30 | 28 | 2 |
| Tj15 | 1150 | 45 | 46 | 31 | 35 | 41 | 6 | 46 | 39 | 43 | 43 | 2 |
| Tj14 | 1100 | 56 | 60 | 53 | 50 | 56 | 3 | 38 | 37 | 42 | 39 | 2 |
| Uz5 | 1200 | 38 | 29 | 25 | 23 | 31 | 6 | 26 | 23 | 25 | 25 | 1 |
| Uz6 | 1300 | 34 | 27 | 31 | 22 | 31 | 4 | 24 | 19 | 19 | 21 | 2 |
| KZ1 | 1350 | | | | | | | | | | | |
| KZ2 | 1450 | 27 | 34 | 28 | 26 | 30 | 3 | 26 | 23 | 22 | 24 | 2 |
| KZ7 | 1750 | 45 | 48 | 31 | 35 | 41 | 7 | 33 | 30 | 34 | 32 | 2 |
| KZ8 | 1850 | 51 | 41 | 33 | 32 | 42 | 7 | 32 | 28 | 30 | 30 | 1 |
| KZ9 | 1950 | 41 | 44 | 36 | 33 | 40 | 4 | 32 | 27 | 34 | 31 | 3 |
| KZ10 | 2050 | 47 | 35 | 28 | 28 | 37 | 8 | 28 | 25 | 23 | 25 | 2 |
| KZ11 | 2150 | 42 | 34 | 28 | 29 | 35 | 5 | 26 | 27 | 30 | 28 | 2 |
| KZ12 | 2250 | 39 | 37 | 31 | 29 | 36 | 4 | 28 | 25 | 24 | 26 | 2 |
| KZ13 | 2350 | 51 | 37 | 31 | 30 | 40 | 8 | 30 | 27 | 32 | 30 | 2 |
| KZ14 | 2500 | 38 | 30 | 25 | 23 | 31 | 6 | 26 | 21 | 22 | 23 | 2 |
| KZ15 | 2700 | 36 | 32 | 28 | 26 | 32 | 4 | 26 | 24 | 22 | 24 | 1 |

For the nuclides of each radioactive row we can find effective activity of nuclides, which are in balance:

$$A^{Th}{}_{eff} = \frac{1}{4}\left(A_{Pb\,212} + A_{Bi\,212} + 2{,}78\,A_{Tl\,208} + A_{Ac\,228}\right)$$

$$A^{U}{}_{eff} = \frac{1}{3}\left(A_{Pb214} + A_{Bi214} + 0{,}6A_{Ra226}\right)$$

For the samples of costal soil, $A^{Th}{}_{eff}$ is calculated without taking into consideration data on $^{208}$Tl.

Only these effective activities were further analyzed. Figure 2 shows these values for nuclides of thorium and uranium rows depending on the distance from the sampling sites and from the source.

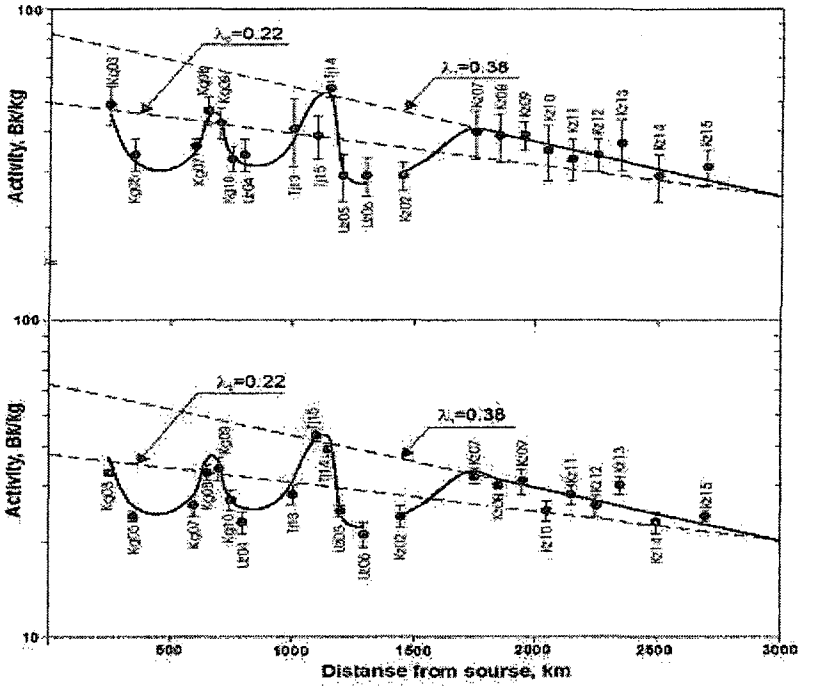


**Fig. 2.** Distribution of specific effective activity of radionuclides of thorium (above) and uranium (below) radioactive rows in the soil samples along the river.

Activities of nuclides of thorium row is 1,3 times higher than the activity of uranium row along the river and dependence of distribution of nuclide activity along the river is the same. The figure shows the same curve. This curve with its shape is similar to the dependence of total beta-activity of soil (see /5/, where we saw exponential dependence). In /5/ we showed that if the river source is the source of the observed activity, then the activity of rocks along the river will decrease according to exponential law. As a whole, it turned out this way, except for three areas of the river, where rock activity, deviating from the exponential dependence, was decreasing. According to our assumption, these areas of the river have smaller sorption abilities. Here active rocks, which are carried away by the river, stay for shorter period of time than in other areas.

Coefficient of decrease of total beta-activity was determined as following: $\xi = 0{,}15$ (1/thousand km). Figure 2 shows two exponential dependences. One dependence with decrease coefficient of $\lambda = 0{,}22$ (1/thousand km) is "relic" with the source at the river source. Other dependence with coefficient of $\lambda = 0{,}38$ (1/thousand km) is man-caused (presumably) with the source on Tadjik territory.

It should be noted that "relic" decrease constant of total beta-activity does not coincide with effective gamma-activity of (0,15 and 0,22). Reasons of this discrepancy will be discussed later.

Average seasonal and effective activities of nuclides in soil samples are presented in Table 2.

**Table. 2.** Activity of radionuclides of uranium and thorium rows in bottom samples

| Sample site | Distance from source, km | *Nuclides of thorium row* | | | | | Nuclides of uranium row | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Bi212 | Pb212 | Ac228 | $A^{Th}_{eff}$ | $\Delta A^{Th}_{eff}$ | Pb214 | Bi214 | Ra206, ×0.6 | $A^{U}_{eff}$ | $\Delta A^{U}_{eff}$ |
| Uz04 | 800 | 18 | 18 | 15 | 17 | 1 | 15 | 14 | 14 | 14 | 1 |
| Tj13 | 1000 | 36 | 39 | 30 | 35 | 3 | 30 | 27 | 28 | 28 | 1 |
| Tj15 | 1150 | 52 | 46 | 42 | 47 | 4 | 51 | 46 | 44 | 47 | 3 |
| Tj14 | 1100 | 44 | 40 | 34 | 39 | 4 | 40 | 42 | 42 | 41 | 1 |
| Uz5 | 1200 | 22 | 32 | 18 | 24 | 5 | 16 | 15 | 21 | 17 | 2 |
| Uz6 | 1300 | 20 | 22 | 16 | 19 | 2 | 17 | 15 | 19 | 17 | 1 |
| KZ1 | 1350 | 55 | 61 | 44 | 53 | 6 | 35 | 35 | 40 | 37 | 2 |
| KZ2 | 1450 | 29 | 30 | 24 | 28 | 2 | 24 | 21 | 20 | 22 | 2 |
| KZ7 | 1750 | 36 | 38 | 29 | 34 | 4 | 27 | 24 | 19 | 23 | 3 |
| KZ8 | 1850 | 31 | 34 | 24 | 30 | 4 | 25 | 21 | 25 | 24 | 2 |
| KZ9 | 1950 | 33 | 36 | 27 | 32 | 3 | 25 | 22 | 21 | 23 | 2 |
| KZ10 | 2050 | 36 | 40 | 33 | 36 | 2 | 27 | 24 | 27 | 26 | 1 |
| KZ11 | 2150 | 49 | 50 | 37 | 45 | 6 | 35 | 30 | 30 | 32 | 2 |
| KZ12 | 2250 | 29 | 31 | 23 | 28 | 3 | 23 | 18 | 20 | 20 | 2 |
| KZ13 | 2350 | 32 | 38 | 27 | 32 | 4 | 25 | 24 | 27 | 25 | 1 |
| KZ14 | 2500 | 39 | 47 | 32 | 39 | 5 | 30 | 26 | 25 | 27 | 2 |
| KZ15 | 2700 | 28 | 34 | 24 | 29 | 4 | 22 | 19 | 18 | 20 | 2 |

Same as in soil samples here activities of nuclides of thorium row exceed the activity of uranium row nuclides by 1,3 times. Figure 3 shows effective specific activities of nuclides of both radioactive rows, which were found in bottom samples.

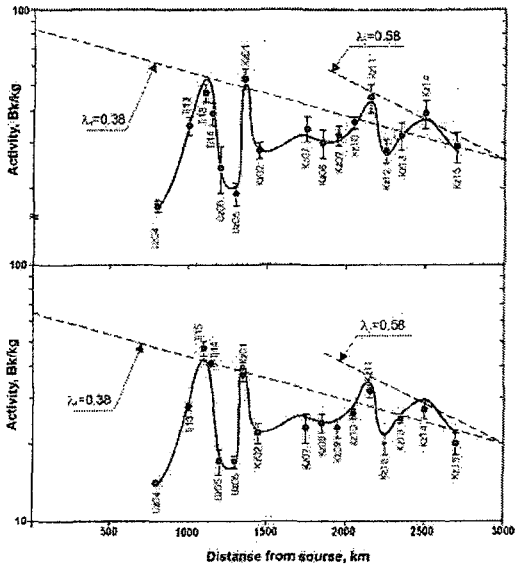


**Fig. 3**. Distribution of specific effective activity of radionuclides of thorium (above) and uranium (below) radioactive rows in bottom samples along the river.

Here, the absence of sampling sites on the first 800 km allows seeing "relic" pattern. Same as on the Figure 2, we see Tadjik source of activity with $\lambda$ = 0,38 (1/thousand km). Site location Kz-01 (absent in soil samples) is not the source of activity, because activity in this location does not exceed the value calculated by exponential law for Tadjik source with decrease coefficient of $\lambda$ = 0,38 (1/thousand km). In contrast to figure 2, we see new exponential decrease of activity in site location Kz-11 with decrease coefficient of $\lambda$ = 0,58 (1/thousand km). Activity, which was found in soil samples in site location Kz-11, shows that this source is under ground.

## CONCLUSION

We analyzed results of three season environment monitoring along Syr Darya River and got results on the radionuclide distribution in soil and bottom samples. These results, in general, correlate with the results of total alpha- and beta- activities, presented in work /5/.

For obtaining these results it was necessary to use two-dimensional system of averaging: averaging by season and averaging of activity of radionuclides, which are in balance.

Obtained dependences indicate additional sources of heavy radionuclide, which have man-caused nature. This work was carried out in collaboration with Cooperative Monitoring Center at Sandia National Laboratories, USA and financed by the Department of Energy of USA.

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# APPLICATION OF THE REACTOR RADIATION AT THE DEFINITION OF ECOLOGICAL CONDITIONS OF ENVIRONMENT

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The work aims at investigation of spectroscopic characteristics of the reactor and source $Co^{60}$ irradiated industrial silica glasses. The purpose of this investigation is the determination of the growth kinetics of radiation defects, their stability, dependence on radiation mode, irradiation conditions and the possible use of glass as the detector of gamma and neutron fluence in compound fields of reactors and for definition of ecological conditions of environment.

The optical registering capabilities (the absorption, luminescence, infrared and Raman spectra were measured before and after irradiation) of some types of silica glasses were studied have been chosen.

There are a lot of reports [1-4] about solid state based ionizing radiation detectors. For instance in [1,2] Al, Si, Be oxides based thermoluminescence detectors, photoluminescence [3] - made from glasses for gamma-rays registration, in [4] - activation and track detectors for neutron registration etc are discussed. However, majority of them has defects, namely, radiation sensitivity, ability to detect only up to 10 Gy, difficulty in information receiving etc.

The work is aimed at investigation of spectroscopic characteristics of the on the reactor and the gamma- source irradiated solid states oxides. The purpose of this investigation is the determination of the radiation damage growth kinetics, stability, dependence on radiation dose, irradiation conditions, for studied ecological investigations of environment.

As the investigation objects the silica glasses of I-IV types were selected. Some spectroscopic methods were used as the investigation methods. The photoluminescence and the absorption spectra of the samples were measured in appropriate spectrophotometers. The samples were irradiated at different doses in the WWR-SM reactor and by $Co^{60}$ source.

The photoluminescence spectra in UV region are shown in Fig.1 to illustrate the effect of gamma-radiation on the silica glasses of type II. The operating diapason of $Co^{60}$ radiation ($D_\gamma = 10^0 - 10^5$ Gy) was found where a linear slope of the wavelength 396 nm photoluminescence intensity was observed in the silica glasses of types I and II.

The influence of dose gamma-radiation power ($A_1$), irradiation temperature ($A_2$), time of storage ($A_3$) on the intensity change of 396 nm peak in type II glass is represented in Table 1.