RADIATION MONITORING OF SYR-DARYA RIVER

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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 salinity of water, alfa- and beta-activity of water, bottom, water plants, and soil was obtained. Dependence of the obtained results on the distance form the source is discussed.

Introduction

The major life-providing arteries for the great region of Central Asia are Syr-Darya and Amu Darya rivers. There are many countries next to the pools of these rivers: Tajikistan, Afghanistan, Turkmenistan, Uzbekistan, Kyrgyzstan, and Kazakhstan. There is a great concern caused by the shortage of supply of fresh water, severe epidemiological situation, and radiation conditions along of the pools of these rivers. Such conditions have developed as a result of intensive economic and industrial activities, and also of geological and geochemical features of this region.

One of the most serious aspects of this problem is the weak scrutiny level of influence of large deposits of natural uranium and consequences of technological and industrial activities.

Since November, 2000 Scientifics of four of the listed countries (Kazakhstan, Kyrgyzstan, Tajikistan, and Uzbekistan) have come to an agreement carrying out the teamwork on studying and monitoring the environment in the pools of Syr-Darya and Amu Darya rivers [1]. Collaborator of these works is Cooperative Monitoring Center at Sandia National Laboratories, USA.

During three expeditions each country in 15 control sites on their territory has conducted field researches and has obtained the samples of elements of the environment. Laboratory researches were carried out in Kazakhstan and Uzbekistan. The first results were obtained in [2, 3] and later in [4].Currently, the analysis of the data on salinity of water and alpha- and beta- activities of samples along Syr-Darya River is presented.

Experiment Techniques

Locations of sampling sites were chosen uniformly along the length of river. Additionally, some sites were organized in the areas of borders (Uz04, Tj14, Uz06, Kz01) and places were traces of technological activity of humans were expected (Tj14, Uz04, Kz08, Kz09, Kz10, Kz14). Site locations are shown on the geographical map on Figure 1.

Samples were selected according to the standardized system decided by the participants [1].

The volume of each sample of water was 5 liters, the weight of bottom and coastal soil was 1 kg, and the weight of seaweed and vegetation in a wet condition was also 1 kg. Samples were dried out and only after additional processing were analyzed. The salinity of water was determined on sites by “Hydrolab” and in laboratory conditions after evaporation, when they were dry.

The total alfa- and beta-activities were measured on the automatic devices NRR-610, the main recording elements of which are the flowing gas and scintillation counters.

The results of the analysis are expressed as specific activity for water – Bq/L, for soil, bottom, and plants in wet condition in Bq/kg.

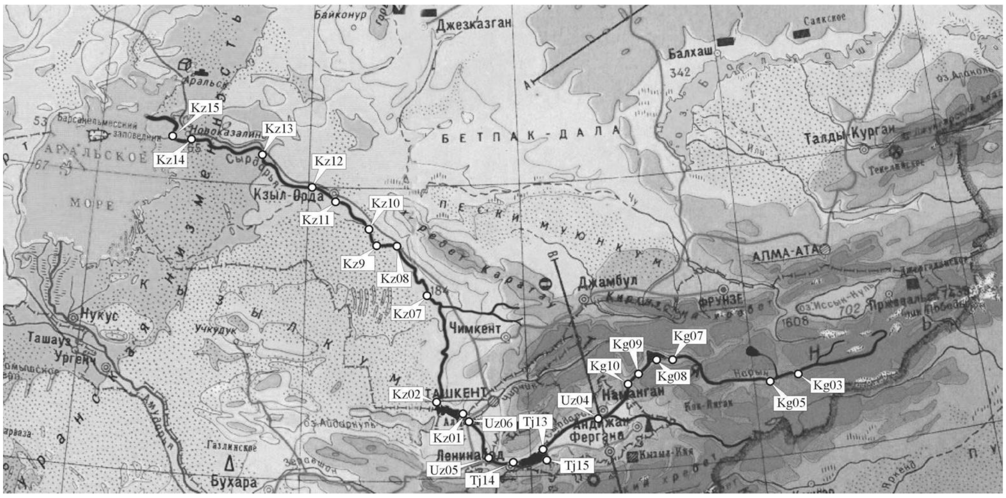

Figure 1.. Geographical map of Syr-Darya River pool with sites of sampling indicated.

Analysis of Results

Total of three expeditions for sampling were conducted – two summer expeditions and one spring expedition. For each sampling site we had three measurements for each type of environment. Average values for each sample site (average seasonal values) are presented in Table 1. Deviations from the average values and averages from each sample sites with average seasonal data are shown in table 1 and on the figures.

The measured salinity and alfa- and beta-activities are shown on figure 2. From the figure it is clear that all three characteristics, depending on the distance from the source, are the identical character. This means that the activity of water is caused by soluble salts in water. The salinity increases and grows exponentially on a high mountainous site (H>800 m) and on a flat site (H<800 m), depending on the distance from the source. On the site from KG08 to Uz04, Tj13 the salinity and activity sharply increases by 4.3 times.

Exponential character of the dependence is obvious, if to assume that salinity of water is caused by salinity of soil, from which salt gets into the river (through springs, underground drains, with thawed snow, etc.)

In fact, the salinity increase on the site of the river Δl at the distance from the starting point l is proportional to the length of the site and salinity of the surrounding area. $S_{soil}(l)$:

$$\Delta S_{water} = C_1 \cdot S_{soil}(l) \cdot \Delta l$$

However, since under our assumptions $S_{soil} = C_2 \cdot S_{water}$, we can write the equation:

$$\Delta S_{water} = \gamma \cdot S_{water} \cdot \Delta l$$

The solution of this equation is the exponential dependence:

$$S(l) = S_0 \exp(\gamma \cdot l) + const$$

Sharp increase of the dependence on the height change from 1200 m to 800 m is caused by sharp change of salinity in the surrounding area.

Table 1. Salinity and activity of water, soil, bottom and water plants

Sample site	Distance from source, km	Salinity, g/l	Activity water, Bq/l		Activity Soil, Bq/kg		Activity Bottom, Bq/kg		Activity Aqutic plant, Bq/kg	
			β	α	β	α	β	α	β	α
Kg03	250	0,22	0,046	0,02	660	550				
Kg05	350	0,25	0,048	0,02	560	380				
Kg07	600	0,20	0,059	0,04	630	340				
Kg08	650	0,24	0,048	0,03	760	560				
Kg09	700	0,29	0,059	0,04	750	460				
Kg10	750	0,36	0,064	0,07	440	420				
Uz04	800	0,87	0,24	0,11	470	300	440	300	95	15
Tj13	1000	0,96	0,26	0,16	500	310	450	270	120	10
Tj15	1100	1,31	0,28	0,09	610	410	550	400	190	40
Tj14	1150	0,93	0,29	0,20	600	370	540	430		
Uz05	1200	1,13	0,34	0,25	470	220	460	410	100	50
Uz06	1300	1,14	0,34	0,19	490	250	490	360	90	20
Kz01	1350	1,39	0,35	0,29	650	440	690	560	165	45
Kz02	1450	1,42	0,32	0,19	630	270	490	280		
Kz07	1750	1,31	0,34	0,22	600	360	490	360	165	50
Kz08	1850	1,26	0,34	0,15	570	350	590	280	180	20
Kz09	1950	1,35	0,40	0,22	600	580	540	380	115	10
Kz10	2050	1,09	0,26	0,16	570	430	520	320	145	30
Kz11	2150	1,31	0,37	0,32	540	330	530	510	140	80
Kz12	2250	1,35	0,34	0,29	520	370	570	420	155	35
Kz13	2350	1,33	0,34	0,29	510	520	550	270	160	50
Kz14	2500	1,40	0,38	0,24	480	290	570	300	100	30
Kz15	2700	1,48	0,43	0,19	520	370	450	320	170	25
Average Deviation		18%	22%	40%	12%	30%	10%	30%	35%	43%

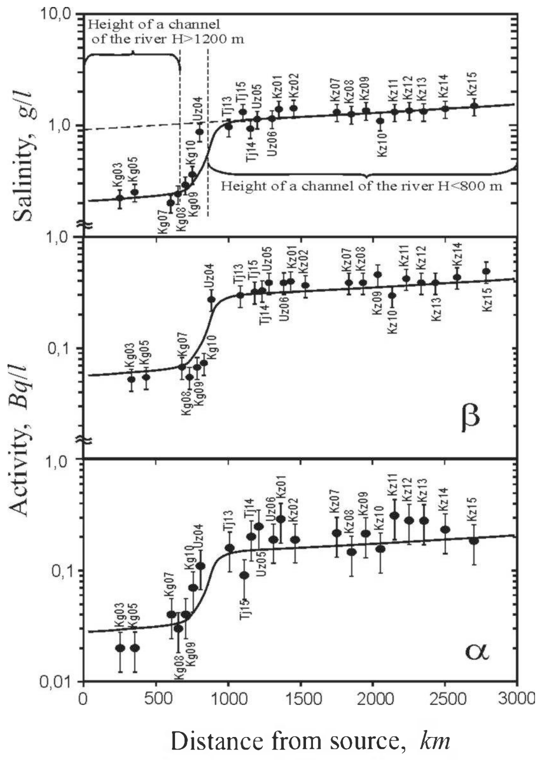

Figure 2. Dependence of salinity and alfa- and beta-activities of water on the distance from source.

From figure 2 we obtained the parameters of dependence for salinity:

$$S[g/l] = 0,9\exp(\gamma \cdot l),$$

and for activity:

$$A_\beta[Bq/kg] = 0,25\exp(\gamma \cdot l),$$

where γ = 0,16 (1/1000 km).

From these two equations we can find the specific β - activity of salts soluble in the water. It is constant along all length of the river and $260\,Bq/kg$ of dry salt.

The specific activity of bottom and soil is shown on figure 3. The values of the activity of bottom and soil match on all length of the river. On the values of β-activity, the dispersion of which is insignificant, it is possible to represent the curve of dependence of activity on the distance from the source. We transferred this curve, with coefficient=0,6, into the area of α-activity (since the deviations of α-activity values are large, and it is impossible to determine the curve).

The figure shows that, in overall, the character of dependence of α-activity does not contradict with the character of dependence of β-activity.

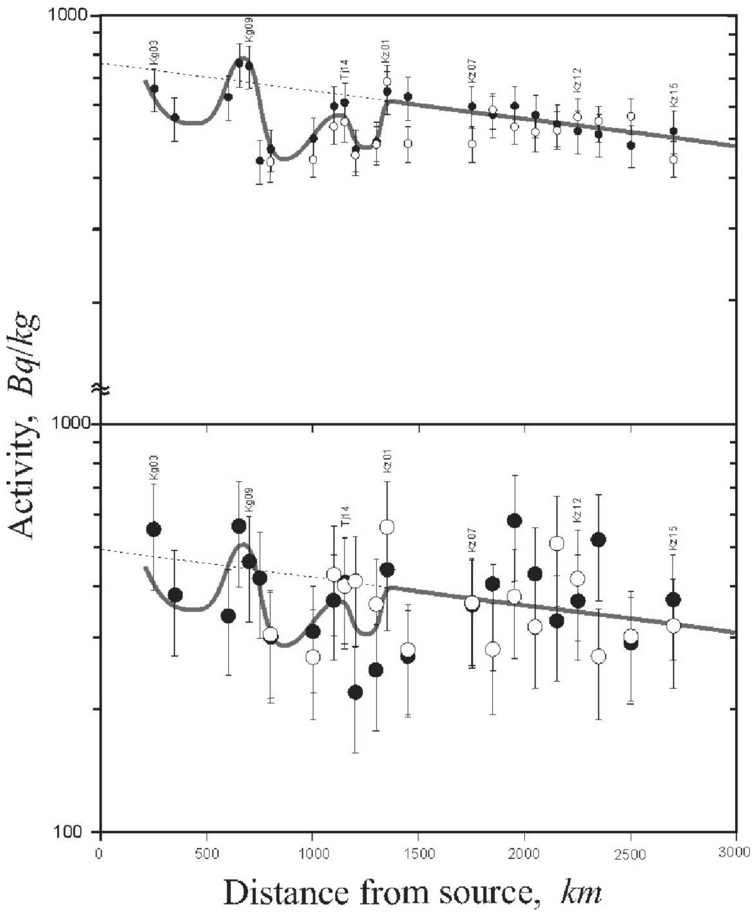

Figure 3. Activity of bottom (white dots) and soil (black dots) depending on distance from source. (the top part – beta-activity, the bottom part – alpha – activity)

On the first half of the river β-activity of soil and bottom sharply changes but, then, on the second half it turns into regular exponential dependence. Note that if we extrapolate the exponential dependence into the first half of the river, we will see that maximum activity of the first half corresponds to this exponent.

Since the character of activity of soil and bottom is totally different in comparison to the change of salinity and activity of water, we can conclude that activity of soil and bottom is caused by insoluble rocks.

Exponentially decreasing dependence is possible if we assume that the source of active rocks is in the pool of river source and carried further by water stream on all length of the river. In fact, in this assumption the change of activity of the rocks on the site of the river Δl, at the distance l from the source is proportional to the activity on this site and to the length of the site:

$$\Delta A_{S,B} = -\xi \cdot A_{S,B}(l) \cdot \Delta l$$

Solution to this equation is exponential dependence. $A_{S,B}(l) = A^{0}{}_{S,B} \cdot \exp(-\xi\, l) + const$

In this equation constant can be relic activity of rocks before mountain formation, and it is much smaller than the activity $A^{0}{}_{S,B}$ of open high-mountainous sites of source rocks. From the figure, it is easy to obtain the constants of this dependence:

$A^{0}{}_{S,B}$ = 760 Bq/kg, ξ = 0,15 (1/1000 km.)

River-beds of the sites, where rock activity decreases and deviates from exponential dependence, have small sorption ability. Carried by river, active rocks get stuck here less than in other places.

The fact that there is no increase in activity of soil and bottom where Naryn and Kara-Darya merge, means that there is insignificant contribution of active rocks from Kara-Darya source.

Samples of plants were selected only in several places. On one hand, it is because of technical reasons. On the other, it is because of absence of plants on some sites.

Poor given data and great deviations do not allow to find any dependence of activity of vegetation along the river. However, we are including the intervals of plant activity in order to have an idea about the range of values. It can be found on figure 4, where curves of alfa- and beta-activities of all researched samples are shown, taking into account error of measurement.

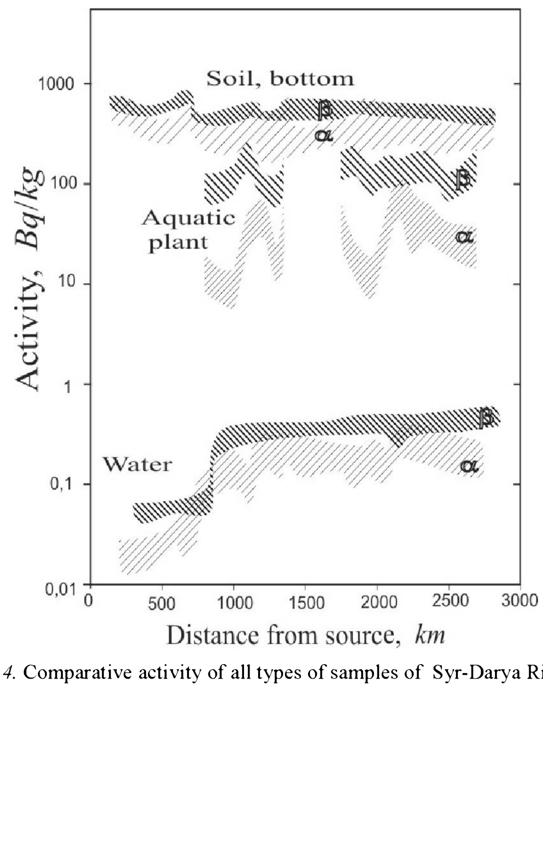

Figure 4. Comparative activity of all types of samples of Syr-Darya River.

Conclusion

We had an opportunity to get only few samples from each site, that's why we had to analyze just average seasonal values. A few samples determined great average deviations. These circumstances did not allow us to determine seasonal changes of characteristics of the investigated samples and trace technological and industrial activities by alfa- and beta-activities. We saw results of general character and suggested formation models of these changes.

However, these results, in our opinion, are interesting and give a general idea about radiation background along Syr-Darya and Narin Rivers. Detailed changes of background (because of seasons and technological changes) can be obtained with systematic and longer monitoring. 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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