SAND REPORT
SAND2002-2916
Unlimited Release
Printed September 2002

The Navruz Project: Monitoring for Radionuclides and Metals in Central Asia Transboundary Rivers

End of Year One Reports

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Albuquerque, New Mexico 87185 and Livermore, California 94550

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under Contract DE-AC04-94AL85000.

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Abstract

The Navruz Project is a cooperative, transboundary, river monitoring project involving rivers and institutions in Kazakhstan, Kyrgyzstan, Tajikistan, and Uzbekistan facilitated by Sandia National Laboratories in the U.S. The Navruz Project focuses on waterborne radionuclides and metals because of their importance to public health and nuclear materials proliferation concerns in the region. Data obtained in this project are shared among all participating countries and the public through an internet web site and are available for use in further studies and in regional transboundary water resource management efforts. Overall, the project addresses three main goals: to help increase capabilities in Central Asian nations for sustainable water resources management; to provide a scientific basis for supporting nuclear transparency and non-proliferation in the region; and to help reduce the threat of conflict in Central Asia over water resources, proliferation concerns, or other factors.

The Navruz project has a duration of three years. This document contains the reports from each of the participating institutions following the first year of data collection. While a majority of samples from the Navruz project are within normal limits, a preliminary anaylsis does indicate a high concentration of selenium in the Kazakhstan samples. Uzbekistan samples contain high uranium and thorium concentrations, as well as elevated leves of chromium, antimony and cesium. Additionally, elevated concentrations of radioactive isotopes have been deteced at one Tajikistan sampling location. Further anaylsis will be published in a subsequent report.

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Acronyms & Abbreviations

Bq/kg	Becqerels per kilogram
DL	Detection Limit
IAEA	International Atomic Energy Agency
INP NNC RK	Institute of Nuclear Physics, Kazakstan
g/t	grams per ton
LNPAM	laboratory of nuclear-physical analysis methods
mBq/l	milli Becquerqels per liter
mkg/g	microkilograms per gram
NAA	Neutron activation analysis
XRF/XRFA	X-ray-fluorescent analysis

Executive Summary

The experiment described in this report, named Navruz (meaning "new beginning"), monitors basic water quality parameters, radionuclides and metals in the Syrdarya and Amudarya rivers and their major tributaries. These rivers are crucial for domestic, agricultural and industrial use throughout Central Asia.

Participating countries, the Central Asian states of Kazakhstan, Uzbekistan, Kyrgyzstan and Tajikistan, are collecting water, bottom sediment, vegetation, and soil samples from a total of 60 stations along the rivers. These samples are then sent to laboratories in Kazakhstan, Uzbekistan, and the United States for analysis. Samples are also being collected at two locations along the Rio Grande in central New Mexico.

Data from this project are being posted on an Internet site as they become available for use by the participants, scientists, and the public worldwide. The web address is: www.cmc.sandia.gov/Central/centralasia.html. The complete Sampling and Analysis Plan is also available at this address.

The Navruz experiment is aimed at serving three main objectives:

- Understanding the severity and location of heavy metal, radionuclide,m and other contaminates in the major rivers of Central Asia
- Facilitating the development of scientific methodology for cooperation and understanding of transboundary resource issues. This is a precursor to cooperative, transboundary, natural resource management.
- Facilitating regional scientific cooperation and collaboration in these newly independent republics of the former Soviet Union. This helps improve regional relationships and promote cooperation on difficult issues that would enhance security and stability in Central Asia.

The following is a report from the Institute of Nuclear Physics (INP), the Kazakhstan partner in this project, for the first year of data collection. This report contains the results of analytical investigations, obtained by the INP NNC RK during the first year of the Project realization. Also presented is a preliminary interpretation of these results. Final conclusions based on analysis of environmental data within all four states will be presented by the end of the second year.

The Navruz Project: Monitoing for Radionuclides and Metals in Central Asia Transbounday Rivers End of Year One Report

Kazakhstan

1. Introduction

The purpose of the international project "Navruz" is increasing nuclear transparency of the Central Asian states of Kazakhstan, Uzbekistan, Kyrgyzstan and Tajikistan. Funding for the two-year project is through Sandia National Laboratories and the United States Department of Energy. The project representative on behalf of Kazakhstan is the Institute of Nuclear Physics, NNC.

The focus of the project is radiation and ecological monitoring of the Amudarya and Syrdarya rivers, whose water belongs to all the enumerated participant countries. Contamination of these rivers is a result of water pollution and radioactive contamination from uranium mining, industry, and other activities, and poses a threat to the environment and the health and safety of those living nearby.

Each country determined 10-15 sampling locations. Twice in a year, in the spring and in the autumn, at each of the locations field investigations and sampling of environmental objects (water, soil, bottom sediments, and vegetation) for further laboratory investigation are conducted. Controlled parameters of the studied objects are natural and artificial radionuclides (^{226}Ra, ^{228}Th, ^{210}Pb, ^{137}Cs, ^{90}Sr, ^{239}Pu, ^{241}Am and etc.) and toxic dopes (U, Pb, Se, Sb, As, Be and etc.). The analysis is conducted by two organizations: The Institute of Nuclear Physics NNC RK (Kazakhstan, c. Almaty) and the Institute of Nuclear Physics SA UR (Uzbekistan, c. Tashkent).

2. Sampling Locations

The Institute of Nuclear Physics NNC, as a result of thorough consideration of all geographical, geological, industrial and economical aspects related to Syrdarya river and its environment, as well as discussion of specific geological matters with specialists on uranium exploring and mining (Industrial corporation "Volkovgeologiya") has offered the following 15 sampling locations, for inclusion to the radiation monitoring project Navruz.

1. Syrdarya river, below junction with Keles river, abuilding bridge via Chardara reservoir.
2. Syrdarya river, 1 km below Chardara reservoir dam.
   Sites 1 and 2 measure the impact of economic and technogenic human activity on the environment (site 2) and provide a comparison with the impact of natural factors (site 1). Site 2 will also provide initial information for comparison with all other sites.
3. Keles inflow, Saryagash town (upper).
4. Keles inflow, Saryagash town (lower).

Sites 3 and 4 will measure the environmental conditions in this resort zone (mineral water springs).

5. Badam inflow, Shymkent town (higher), Sairam village.
6. Junction Badam and Arys inflows, Shymkent town (lower).
   Sites 5 and 6 measure the influence of the industrial center at Chymkent.
7. Syrdarya river, opposite Turkestan town, Baltakol village
   Site 7 measures the influence of agriculture activity and the status of the Turkestan canal.
8. Syrdarya river, Shieli town (upper), Tomenaryk village.
9. Syrdarya river, Shieli town (opposite), Bulanbaybauy village.
10. Syrdarya river, Shieli town (lower), Zhuantobe village.
    Sites 8,9, and 10 will measure the effect of several uranium deposits.
11. Syrdarya river, Kyzylorda town (upper), Tasbuget village.
12. Syrdarya river, Kyzylorda town (lower), Terenozek village.
    Sites 11 and 12 will measure the impact of industrial activities in Kyzyl-Orda town.
13. Syrdarya river, Dzhusaly town.
    Site 13 will measure the joint influence of the towns Terenozek, Dzhalagat and Dzhusaly on the Karaozek tributary.
14. Syrdarya river, Kazalinsk town (upper), Baikozha village.
    Site 14 will measure the influence of activities at the Bajkonur space center.
15. Syrdarya river, Kazalinsk town (lower), Karlan village.
    Site 15 will provide a control on the total influence of all areas/sites and all activities related to Syrdarya River (in comparison with Site 2).

The proposed sampling locations were adopted at the project work meeting in the city of Tashkent (August 2000). In this meeting the main objects and top-priority tasks of the Project were viewed and approved.

This report presents the results of analytical investigations, obtained by INP NNC RK during the first year of the Project. Also presented is a preliminary interpretation of these results. Final conclusions will be presented by the end of the second year.

3. Methods and facilities

The methods used for the analysis of samples include gamma-spectrometric radionuclide analysis and activation and X-ray-fluorescent elemental analysis. The following is a short description of these methods.

3.1 Radionuclide analysis

The determination of radionuclide compounds was made by gamma spectrometry, which measures gamma radiation in investigated samples. The measurements were conducted using three types of detectors with different parameters and semiconductor detectors. Detector characteristics are given in Table 1. The measurement time of each sample ranges from 3 to 30 hours.

Table 1:Characteristics of spectrometric equipment used for analysis

Detector type and model	Relative registration efficiency, %	Energy resolution on 1332 keV line
Coaxial GEM-2018 "PRTEC"	20	1.7
Wide-range GX-1520 "CANBERRA"	15	1.9
Planar "CANBERRA" BE-2020	15	1.5

Wide-range and planar detectors have thin intake windows made of soft low gamma radiation absorbing material (beryllium and all-carbon composite respectively). This feature allows efficient determination of radionuclides on their relative soft gamma lines, for example, ^{210}Pb on 46.5keV line and ^{234}Th on 63.3keV line.

The soil and bottom sediments samples were dried and homogenized by milling to 150-200 microns in a ball mill, and the milled sample is then quartered to obtain analytical sub samples with a 200gr mass. Prior to measuring, the sub samples are placed in 70mm Petri cups with a bottom made of polyethylene film of 100 microns thickness. Water samples are evaporated to obtain dry radicals or strong brine and packed in 25 ml fluoroplastic with a bottom thickness of 100 microns. All of the samples for analysis are placed directly on the detector intake window. The measured specters are treated by a software package for gamma spectrometric analysis, which was developed by the laboratory members and has been successfully used and tested during last several years. This software package uses a treatment program of complex gamma and X-ray specters, using an algorithm based on the nonlinear method of the smallest squares and the analytical description of the line apparatus form. This method, at present, assures the smallest possible fault during determination of the full uptake peak area and consequently, maximum sensitivity in analysis. Another feature of the software package allows the calculation of gamma radiation registration total efficiency depending on geometrical sizes, detector sample material, and absorbents possible between them. After determination of evaporated water sample activities, amendments were introduced to the results, taking the concentration degree into account.

Activities of radionuclides from three natural families – uranium, thorium and actinouranium – activities of the natural radionuclide ^{40}K, and the artificial radionuclides ^{137}Cs, and ^{241}Am, have been calculated (accounting for global fall-outs after nuclear tests and Chernobyl accident). The characteristics of determinate nuclides are presented in Table 2. As seen in the table, some of the nuclides had more than one sufficiently intense gamma line. In these cases, calculations were based on a weight-average activity value – the weight of each value included in the calculation was the reverse activity value of fault squares of activity determination.

Table 2: Characteristics of determinate nuclides and used gamma lines

Radionuclide	Family	Energy, keV	Quantum yield, %
^{234}Th	^{238}U – ^{206}Pb	63.29	4.8
^{226}Ra	^{238}U – ^{206}Pb	186.211	3.59
^{214}Pb	^{238}U – ^{206}Pb	241.997 295.224 351.932	7.43 19.3 37.6
^{214}Bi	^{238}U – ^{206}Pb	609.312 1120.287 1238.11	46.1 15.1 5.79
^{210}Pb	^{238}U – ^{206}Pb	46.539	4.25
^{228}Ac	^{232}Th – ^{208}Pb	338.32 911.204 968.971	11.27 25.8 15.8
^{224}Ra	^{232}Th – ^{208}Pb	240.986	4.1
^{212}Pb	^{232}Th – ^{208}Pb	238.632	43.3
^{212}Bi	^{232}Th – ^{208}Pb	727.33	6.58
^{208}Tl	^{232}Th – ^{208}Pb	583.191	30.42*
^{235}U	^{235}U – ^{207}Pb	163.33 185.72 205.31	5.08 57.2 5.01
^{227}Th	^{235}U – ^{207}Pb	235.97	11.65
^{223}Ra	^{235}U – ^{207}Pb	269.46	13.6
^{219}Rn	^{235}U – ^{207}Pb	271.23 401.81	9.90 6.64
^{211}Pb	^{235}U – ^{207}Pb	404.85 832.01	3.83 3.80
^{211}Bi	^{235}U – ^{207}Pb	351.06	12.76
^{40}K	-	1460.75	10.67
^{137}Cs	-	661.657	85.1
^{241}Am	-	59.541	35.9

*- value of ^{208}Tl quantum yield is given by taking into account 36% branch for convenient comparison of its activity with parent nuclide and daughter nuclide.

During the analysis of obtained results, each of natural radionuclide families was divided into several subfamilies, inside of which determinate nuclides should be in the state of equilibrium even at natural and man-caused redistribution, conditioned by physical-chemical processes in soil and water. This equilibrium is conditioned by little period of half-decay, not exceeding several months or years. Examples of such groups are: ^{214}Pb and ^{214}Bi from uranium family; ^{212}Pb, ^{212}Bi and ^{208}Tl from thorium family; and ^{227}Th, ^{223}Ra, ^{219}Rn, ^{211}Pb and ^{211}Bi from actinouranium family. Activity parity of each of the radionuclide subfamilies should indicate on the one hand the correctness of the analysis, and on the other hand, provide a more objective bases for comparison, for example of two progenitors of different subfamilies from the sight of their equilibrium.

3.2 Neutron activation analysis

Elemental analysis of bottom sediments samples and water samples was conducted by neutron activation analysis (NAA). Preliminary preparation of bottom sediment samples and water consisted of drying and abrasion of dry samples in a porcelain mortar. After quartering the prepared sample, analytical sub samples of 0.2 gr were selected. For NAA the selected sub samples were packed in double polyethylene packets and an aluminum container and irradiated in the nuclear reactor. Nichrome comparators for determination of neutron fluence and specter at irradiation were placed in the same container. Irradiation of samples was conducted in the WWR-K reactor's central channel heat rating of reactor made up 300kVt, at that the neutron flux on the spot of irradiation made up n 10^{12} neutron cm^{-2} s^{-1}. The irradiated samples, after a 4 day "cooling" and repacking period, were delivered for measuring.

Measurements were conducted on semiconducting gamma-spectrometers of LNPAM (laboratory of nuclear-physical analysis methods) with a germanium detector GEM-20180 (certificate on State control #4-016/0-415 dated 26.01.99). During the first measurement the values of Na, K, Ca, As, Br, Cd, Sb, La, Sm, Au, and U were determined. The second reading was conducted in 30-32 days. During the second measurement the values for Sc, Cr, Co, Fe, Zn, Se, Rb, Cs, Ba, Eu, Tb, Yb, Hf, Ta, Hg, and Th were determined. Measured simultaneously with work samples there were nichrom comparators and standard samples: SGD-1a, Sl-1, TM-2a, GXR-1, GXR-5, irradiated in the same container. Calculation of the element concentration was fulfilled on the measured activities of analytical isotopes, nuclear-physical parameters (activation section, half-decay period, quantum yield of gamma-radiation) and flow data and neutrons specter, calculated from results of comparators measurements.

3.3 X-ray fluorescent analysis

The X-ray-fluorescent analysis method (XRFA) was one of the methods use to characterize elemental compounds. During the analysis of soil, bottom sediments and dry water remainders samples after evaporation, XRFA with isotope excitation was used. As an excitation source the isotope 109Cd with activity of approximately 3mCi was used. To detect X-rays from the analyzed elements and back scattering radiation of the excitation source, a Si(Li) detector with an active surface of $80mm^2$ and resolution 180eV at 5,9keV was used. An intake detector window was made of beryllium with thickness of 25 micron. At the indicated characteristics of spectrometric cluster and 30-minute exposure, the method allows simultaneous determination of approximately 15 elements with sensitivity from hundreds and tens to units and portions of μg/gr. Most of the elements were analyzed on K-series characteristic X-ray radiation lines, except lead, which was determined on L-series lines. Analysis samples passed standard preparation, including drying and homogenization and were placed in 10ml. ditches with bottom of polyethylene of 100-micron thickness. The ditches for analysis were disposed on a special holder containing the excitation source. The holder construction assured protection from direct source radiation and minimized distance between sample and detector intake window. A special program, developed by the laboratory members, treated the selected specters. For calculation of the matrix effect, a back scattering radiation of excitation source was used. For the calculation of selective absorption by elements with significant concentrations (approximately 10000mkg/gr. and higher) special amendments were introduced. The correctness of the analysis tested many times on IAEA comparison samples during several last years.

4. Results

A potentiometric analysis (standard methods) was conducted to determine the minor and major elements in the samples of water collected in Kazakhstan during the 1st (autumn) and 2nd (spring) sampling expeditions. The results are presented in tables 3 and 4, respectively. Comparison of the data indicated a higher concentration of water components in the winter than in the spring. The greatest water mineralization corresponds to Sites 3 and 4 (Sary-Agach resort).

X-ray-fluorescent analysis was used analyze the bottom sediment and soil samples selected on Kazakhstan territory (1st and 2nd expeditions), Uzbekistan (1st expedition), Kyrgyzstan (1st expedition) and Tajikistan (1st expedition). The results are presented in tables 5-9, respectively. A comparison of the obtained values with values of "average concentrations for sediment rocks" indicates high concentrations of calcium in all of the studied samples of soil and sediments.

Neutron-activation analysis was used to determine compound of micro-dopes (and definite micro-dopes) in samples of water, bottom sediments, soil and vegetation, selected on Kazakhstan territory during the 1st expedition. The results are presented in tables10-12, respectively. The obtained data indicated a very high content of selenium in all studied objects. The concentration of this element in water arouses concern, as it exceeds health sanitary standards of maximal tolerant concentration (MTC-1mkg/l) for drinking water by 1.5-4 times. In some water samples high concentrations of other elements are present:

- Site 13 – Fe (940 mkg/l), Ag (0,713mkg/l), Th (0.13 mkg/l);
- Site 4 – Hg (0.4 mkg/l);
- Sites 5 and 6 –Re (0.7-1.4 mkg/l).

The largest concentration of micro-dopes in bottom sediments corresponds to Site 1, which can be attributed to their import with water from neighboring countries. Also, one can note a significant concentration of As in bottom sediments and soil in the proximity of the industrial center of Shymkent town (Sites 4 and 5).

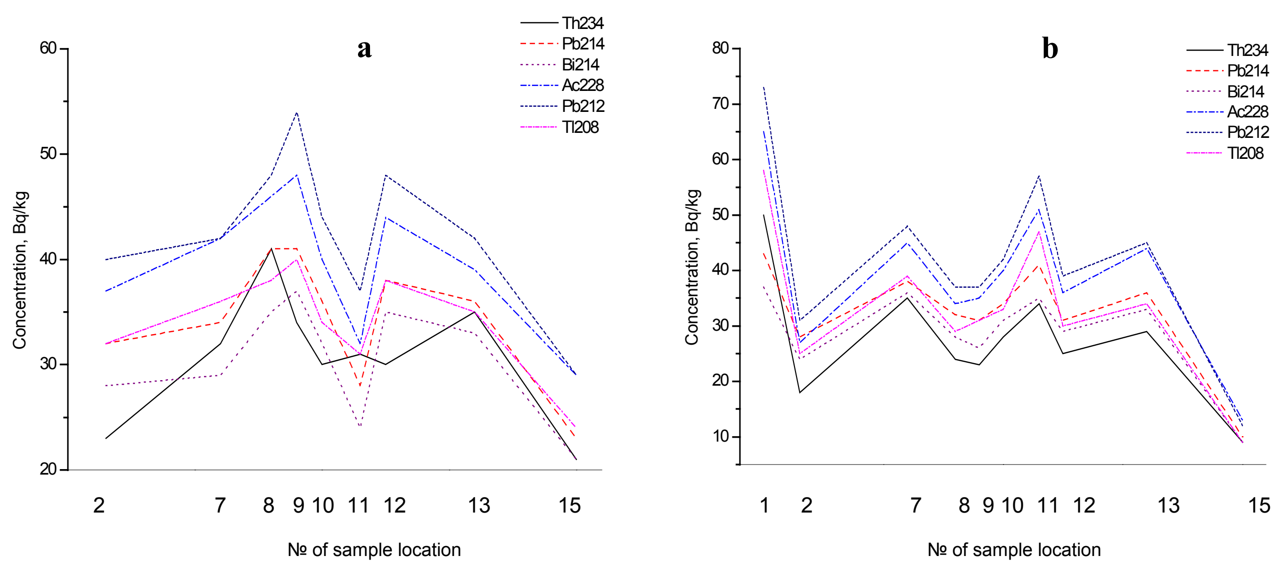

Figure 1. Distribution of natural radionuclides (238U and 232Th families) along the Syrdarya river bed (a-soil, b-bottom sediments)

The results of a radionuclide analysis of environmental samples selected from the first sampling expedition are presented in tables13-22. Included in this analysis are the following samples: Kazakhstan (water, soil, bottom sediments), Uzbekistan (soil, bottom sediments), Kyrgyzstan (water, soil, and bottom sediments), Tajikistan (soil and bottom sediments).

A graphic structure of natural radionuclide distribution in soil and bottom sediments along Syrdarya riverbed on Kazakhstan territory is presented in Figure 1. The largest concentration of natural radionuclides in bottom sediments corresponds to the eastern part of the Chardara reservoir (point 1). A probable explanation for this concentration is the hydro-geological and landscape properties of this location, which contributes to the redistribution of radionuclides from water to bottom sediments. Uranium deposits and industrial engineering's effect in headstreams of Syrdarya River (Uzbekistan, Tajikistan, Kyrgyzstan) also could be taken into account. There are increased concentrations of all natural radionuclides the point 9 (soil) and points 10, 11 (bottom sediments) – uranium deposits near Shieli town.

Radionuclide compound comparison of bottom sediments in the vicinity (upstream and downstream) of the big towns of Saryagash (points 3 and 4) and Kyzylorda (points 11 and 12) indicates a significant decrease of radionuclide content level (30-50%) in downstream waters. One can assume that the technical facilities on the river in these towns serve as distinctive barriers for the further distribution of radionuclides.

In Uzbekistan the highest content of natural radionuclides in soil and bottom sediments was detected in samples from sites 7 and 8. In these samples, the concentration of the radionuclides of the ^{238}U and ^{232}Th families frequently exceeded 100Bq/kg.

In Kyrgyzstan the highest content of natural radionuclides of ^{238}U and ^{232}Th families in soil was detected at sampling location 1. The highest content of ^{137}Cs artificial radionuclides in soil was detected at location 5 (38Bq/kg).

The highest concentration of natural radionuclides (up to 100Bq/kg) in ^{238}U and ^{232}Th families is found in Tajikistan soil samples from sampling locations 3, 4,5 and 14. In this country we can also note the highest contamination by artificial ^{137}Cs radionuclide (average content in soil – 6.7 Bq/kg).

In addition to the enumerated analytical investigations, an analysis of definite soil, bottom sediments and water samples by mass-spectroscopy, as well as AES-ICP and ICP-MC was conducted. The results of the anlysis and their interpretation, in combination with the other data analysis, will be presented in the final report, after completion of the second year of work on the project.

5. Conclusion

The first results of analytical investigations obtained from the International project "Navruz" allowed for a preliminary evaluation of the radiation and ecological situation in specific regions of the participating countries. This preliminary evaluation reveals a number of peculiarities in the distribution of radionuclides in the watershed of the Syrdarya and Amudarya rivers.

The results reveal a high concentration of selenium in the entire investigated region. The content of this element in the Syrdarya river water notably exceeds the norm for the maximum allowable concentration for drinking water.

Radionuclide analysis data revealed the most contaminated areas by natural radionuclides in each participant country.

The remainder of the Project will further reveal the radiation situation dynamics in the Syrdarya and Amudarya rivers watersheds.

Table 3: Determination of macro- and microcomponents in water, Kazakhstan

Sample code	Ca^{2+}, mg/l	Mg^{2+}, mg/l	Na^{+}, mg/l	Cl^{+}, mg/l	HCO_3, mg/l	SO_4^{2-}, mg/l
KZ-01WD	137.88	59.34	80.7	3.12	73.20	501.21
KZ-02WD	143.49	74.42	119.0	2.76	87.84	623.01
KZ-03WD	219.64	109.44	276.0	3.30	82.96	1106.94
KZ-04WD	179.16	84.63	180.0	2.36	73.20	863.33
KZ-05WD	85.77	43.78	70.8	3.40	92.72	244.43
KZ-06WD	80.56	43.78	69.7	3.40	112.24	263.36
KZ-07WD	143.49	59.83	111.0	3.05	117.12	595.85
KZ-08WD	148.25	46.69	123.0	3.15	97.60	656.75
KZ-09WD	146.69	71.50	122.0	3.76	92.72	626.30
KZ-10WD	149.10	74.42	127.0	3.48	97.60	667.45
KZ-11WD	151.5	79.28	136.0	4.21	97.60	707.78
KZ-12WD	131.86	78.80	124.0	4.24	92.72	629.6
KZ-13WD	149.1	79.77	131.0	3.9	73.20	684.74
KZ-14WD	161.12	83.17	141.0	4.38	82.96	747.28
KZ-15WD	149.10	79.28	128.0	4.18	73.20	699.55
Average	145.11	71.20	129.3	3.51	89.79	641.17
CO-18	146.29	9.73	414.0	715.0		388.46
CO-18 attest.	146.0	9.5	424.0	687.0		390.0
CO-20	29.66	15.56	108.0	120.0		172.83
CO-020 attest.	29.00	15.0	112.0	123.0		196.0

Elements determination fulfiled on GOST (all-Union State Standard) 23268.5-78; GOST 26449.1-85; GOST 23268.3-78

Table 4: Determination of macro- and microcomponents in water , Kazakhstan

Sample code	Ca^{2+}, mg/l	Mg^{2+}, mg/l	K^{+}, mg/l	Na^{+}, mg/l	Cl^{+}, mg/l	HCO_3, mg/l	SO_4^{2-}, mg/l
Kz-01WD	164.33	97.28	5.25	226.0	1.91	24.4	859.21
Kz-02WD1	124.25	63.23	5.19	130.0	2.58	24.4	562.11
Kz-02WD2	128.26	62.02	5.27	136.0	2.48	30.5	568.69
Kz-03WD	192.38	89.98	3.44	296.0	1.29	36.6	996.65
Kz-04WD	152.30	48.64	2.88	166.0	1.83	36.6	684.74
Kz-05WD	72.14	51.07	2.60	65.7	2.42	61.00	232.09
Kz-06WD	72.14	36.48	2.03	57.4	2.50	42.7	181.06
Kz-07WD	112.22	60.80	5.03	103.0	1.51	42.7	513.55
Kz-08WD	120.24	36.48	5.38	119.0	2.62	36.6	522.61
Kz-09WD	120.24	55.94	5.20	118.0	1.60	26.84	528.37
Kz-10WD1	108.22	58.37	5.25	103.0	1.88	42.7	511.91
Kz-10WD2	112.22	58.37	5.17	107.0	2.26	48.8	516.84
Kz-011WD	112.22	55.94	5.55	98.7	1.84	30.5	509.44
Kz-012WD	104.21	60.80	5.04	112.0	2.35	42.7	508.61
Kz-013WD	112.22	68.10	5.55	128.0	1.92	36.6	564.58
Kz-014WD	116.23	68.10	5.77	129.0	2.01	30.5	590.91
Kz-015WD	120.24	75.39	6.02	133.0	2.72	61.0	628.77
Average	120	62	4.7	131.0	2	38.5	558
St. 026	66.13	29.18	19.1	35.5	57.5		274.10
St. 026 (At. cont.)	66.5	29.0	20.0	34.5	559.0		279.50

Elements determination fulfiled on GOST 26449.1-85; 23368.5-78; 23268.3-78; 26449.1-85.

Table 5: XRF analysis of bottom sediment, soil, and vegetation samples, Kazakhstan

Sample	Ca, %	Ti, %	Mn, %	Fe, %	Cu, g/t	Zn, g/t	As, g/t	Rb, g/t	Sr, g/t	Y_, g/t	Zr, g/t	Nb, g/t	Mo, g/t	Ba, g/t	Pb, g/t
KZ-01 B	7.1 ± 0.2	0.42 ± 0.04	0.06 ± 0.01	3.43 ± 0.02	< 24	106 ± 13	< 30	91 ± 3	340 ± 4	18 ± 2	113 ± 2	11.9 ± 1.3	< 1.4	499 ± 28	< 12
KZ-02 B 1	6.9 ± 0.1	0.44 ± 0.03	0.03 ± 0.01	2.01 ± 0.01	< 17	40 ± 9	< 21	68 ± 2	194 ± 2	12 ± 2	173 ± 2	8.6 ± 0.9	1.3 ± 0.7	612 ± 26	< 9
KZ-02 B 2	6.9 ± 0.1	0.44 ± 0.03	0.02 ± 0.01	1.98 ± 0.01	< 17	41 ± 9	< 22	68 ± 2	195 ± 3	11 ± 2	148 ± 2	7.9 ± 0.9	1.2 ± 0.7	607 ± 26	< 9
KZ-03 B	5.4 ± 0.1	0.37 ± 0.03	0.03 ± 0.01	1.84 ± 0.01	< 15	46 ± 8	< 20	79 ± 2	326 ± 3	13 ± 1	170 ± 2	9.7 ± 0.9	1.7 ± 0.6	758 ± 25	< 8
KZ-04 B	5.4 ± 0.2	0.40 ± 0.04	0.04 ± 0.01	2.02 ± 0.02	< 22	50 ± 11	< 28	64 ± 2	267 ± 3	18 ± 2	242 ± 3	11.8 ± 1.2	< 1.4	597 ± 28	< 10
KZ-05 B	9.6 ± 0.2	0.49 ± 0.05	0.04 ± 0.01	2.18 ± 0.02	< 26	67 ± 13	< 33	60 ± 3	294 ± 4	14 ± 2	134 ± 3	8.8 ± 1.3	1.7 ± 0.9	513 ± 28	< 12
KZ-06 B	11.0 ± 0.2	0.39 ± 0.04	0.03 ± 0.01	1.59 ± 0.01	< 19	62 ± 10	< 24	51 ± 2	319 ± 3	11 ± 2	153 ± 2	7.0 ± 1.0	1.6 ± 0.7	417 ± 26	< 10
KZ-07 B	6.4 ± 0.2	0.35 ± 0.03	0.04 ± 0.01	2.20 ± 0.02	< 19	66 ± 10	< 24	69 ± 2	286 ± 3	16 ± 2	154 ± 2	9.5 ± 1.1	1.1 ± 0.7	578 ± 28	< 10
KZ-08 B	7.1 ± 0.1	0.45 ± 0.03	0.03 ± 0.01	2.03 ± 0.01	< 18	45 ± 9	< 23	68 ± 2	203 ± 3	14 ± 2	243 ± 3	9.5 ± 1.0	1.6 ± 0.7	572 ± 27	< 9
KZ-09 B	6.4 ± 0.2	0.36 ± 0.03	0.03 ± 0.01	1.89 ± 0.01	< 19	51 ± 10	< 24	72 ± 2	206 ± 3	13 ± 2	145 ± 2	8.7 ± 1.0	< 1.1	600 ± 28	< 9
KZ-10 B	6.6 ± 0.1	0.37 ± 0.03	0.04 ± 0.01	2.11 ± 0.01	< 17	50 ± 9	< 21	72 ± 2	228 ± 3	15 ± 2	174 ± 2	9.8 ± 0.9	1.7 ± 0.7	593 ± 25	< 8
KZ-10 B 1	6.3 ± 0.1	0.38 ± 0.03	0.04 ± 0.01	2.08 ± 0.01	< 18	50 ± 9	< 22	72 ± 2	226 ± 3	14 ± 2	169 ± 2	9.5 ± 1.0	1.6 ± 0.7	612 ± 26	< 9
KZ-11 B	8.3 ± 0.1	0.53 ± 0.02	0.03 ± 0.00	2.63 ± 0.01	< 10	68 ± 5	< 13	74 ± 1	281 ± 1	18 ± 1	155 ± 1	11.1 ± 0.5	1.4 ± 0.4	530 ± 10	< 5
KZ-12 B	6.5 ± 0.2	0.38 ± 0.04	0.03 ± 0.01	1.87 ± 0.01	< 22	47 ± 11	< 28	67 ± 2	210 ± 3	12 ± 2	146 ± 2	10.2 ± 1.2	< 1.3	588 ± 28	< 10
KZ-13 B	6.6 ± 0.1	0.39 ± 0.03	0.04 ± 0.01	2.11 ± 0.01	< 18	57 ± 9	< 22	70 ± 2	272 ± 3	15 ± 2	169 ± 2	10.2 ± 1.0	1.3 ± 0.7	591 ± 26	< 9
KZ-14 B	1.1 ± 0.1	0.18 ± 0.04	0.01 ± 0.01	0.74 ± 0.01	< 18	17 ± 9	< 23	31 ± 2	78 ± 2	4 ± 1	84 ± 2	4.4 ± 0.9	< 1.0	210 ± 20	< 8
Average	6.7 ± 0.1	0.4 ± 0.03	0.03 ± 0.01	2.0 ± 0.01	< 19	54 ± 10	< 24	67 ± 2	245 ± 3	14 ± 2	161 ± 2	9.3 ± 1	1.4 ± 0.9	555 ± 25	< 9

Sample	Ca, %	Ti, %	Mn, %	Fe, %	Cu, g/t	Zn, g/t	As, g/t	Rb, g/t	Sr, g/t	Y_, g/t	Zr, g/t	Nb, g/t	Mo, g/t	Ba, g/t	Pb, g/t
KZ-02 S	7.6 ± 0.2	0.44 ± 0.03	0.04 ± 0.01	2.06 ± 0.01	< 19	53 ± 10	< 24	77 ± 2	204 ± 3	14 ± 2	158 ± 2	9.8 ± 1.0	1.8 ± 0.7	645 ± 28	< 9
KZ-02 S1	6.2 ± 0.1	0.40 ± 0.03	0.03 ± 0.01	1.92 ± 0.01	< 18	47 ± 9	< 23	69 ± 2	189 ± 3	13 ± 2	163 ± 2	9.1 ± 1.0	1.2 ± 0.7	620 ± 27	< 9
KZ-02 S2	6.5 ± 0.1	0.42 ± 0.03	0.03 ± 0.01	1.97 ± 0.01	< 18	48 ± 9	< 23	70 ± 2	192 ± 3	14 ± 2	163 ± 2	9.1 ± 1.0	1.2 ± 0.7	627 ± 27	< 9
KZ-03 S	5.9 ± 0.1	0.49 ± 0.03	0.05 ± 0.01	2.16 ± 0.01	< 18	49 ± 9	< 23	81 ± 2	256 ± 3	18 ± 2	284 ± 3	11.8 ± 1.1	1.8 ± 0.8	772 ± 30	< 9
KZ-04 S	4.6 ± 0.1	0.38 ± 0.03	0.05 ± 0.01	2.27 ± 0.01	< 18	63 ± 9	< 22	76 ± 2	227 ± 3	18 ± 2	224 ± 3	10.9 ± 1.0	1.5 ± 0.7	622 ± 27	< 9
KZ—05 S	6.6 ± 0.1	0.36 ± 0.03	0.05 ± 0.01	2.51 ± 0.02	< 18	93 ± 10	< 22	70 ± 2	208 ± 3	18 ± 2	150 ± 2	10.3 ± 1.0	1.8 ± 0.7	466 ± 24	26 ± 6
KZ-06 S	8.8 ± 0.2	0.36 ± 0.04	0.03 ± 0.01	1.62 ± 0.01	< 19	53 ± 10	< 24	51 ± 2	247 ± 3	13 ± 2	159 ± 2	8.0 ± 1.0	1.8 ± 0.7	392 ± 25	< 9
KZ-07 S	8.0 ± 0.2	0.43 ± 0.03	0.04 ± 0.01	2.41 ± 0.02	< 19	73 ± 10	< 24	73 ± 2	309 ± 3	17 ± 2	164 ± 2	10.1 ± 1.1	1.7 ± 0.8	574 ± 28	< 10
KZ-08 S	7.6 ± 0.2	0.46 ± 0.03	0.05 ± 0.01	2.72 ± 0.02	< 20	77 ± 10	< 25	79 ± 2	362 ± 4	19 ± 2	155 ± 2	11.4 ± 1.1	1.6 ± 0.8	611 ± 28	< 10
KZ-09 S	6.6 ± 0.2	0.44 ± 0.05	0.04 ± 0.01	2.36 ± 0.02	< 26	75 ± 13	< 32	67 ± 3	312 ± 4	17 ± 2	151 ± 3	10.4 ± 1.3	< 1.4	569 ± 29	< 12
KZ-10 S1	6.0 ± 0.1	0.36 ± 0.03	0.04 ± 0.01	2.44 ± 0.02	< 19	74 ± 10	< 24	72 ± 2	397 ± 4	15 ± 2	132 ± 2	9.8 ± 1.0	2.8 ± 0.7	560 ± 27	30 ± 7
KZ-10 S2	6.0 ± 0.2	0.36 ± 0.03	0.04 ± 0.01	2.38 ± 0.02	< 19	82 ± 10	< 25	72 ± 2	392 ± 4	15 ± 2	135 ± 2	9.6 ± 1.1	2.6 ± 0.8	563 ± 28	32 ± 7
KZ-11 S	7.0 ± 0.2	0.44 ± 0.05	0.04 ± 0.01	2.38 ± 0.02	< 25	74 ± 13	< 31	68 ± 3	288 ± 3	16 ± 2	149 ± 3	10.4 ± 1.3	1.5 ± 0.9	534 ± 28	< 11
KZ-12 S	7.0 ± 0.2	0.45 ± 0.05	0.05 ± 0.01	2.73 ± 0.02	< 28	104 ± 14	< 35	71 ± 3	452 ± 4	16 ± 3	113 ± 3	9.6 ± 1.3	2.1 ± 0.9	480 ± 28	53 ± 9
KZ-13 S	6.7 ± 0.2	0.39 ± 0.04	0.04 ± 0.01	2.33 ± 0.02	< 23	73 ± 12	< 30	61 ± 2	461 ± 4	14 ± 2	116 ± 3	9.8 ± 1.2	< 1.3	393 ± 26	< 11
KZ-15 S	3.0 ± 0.1	0.33 ± 0.04	0.02 ± 0.01	1.77 ± 0.01	< 20	40 ± 10	< 25	50 ± 2	157 ± 2	12 ± 2	144 ± 2	8.4 ± 1.1	< 1.2	345 ± 23	< 9
Average	6.5 ± 0.16	0.4 ± 0.04	0.04 ± 0.01	2.25 ± 0.02	< 20	67 ± 11	< 26	69 ± 2	291 ± 3	16 ± 2	160 ± 2	9.9 ± 1.1	1.7 ± 0.9	548 ± 27	16 ± 9
KZ-06 V	11.5 ± 0.2	0.52 ± 0.05	0.04 ± 0.01	2.06 ± 0.02	< 25	75 ± 13	< 32	51 ± 2	472 ± 4	14 ± 2	153 ± 3	8.9 ± 1.3	< 1.5	427 ± 27	< 12
Av. conc. for sediments	2.5	0.45	0.07	3.33	57	80	6.6	200	450	30	200	20	2.0	800	-

Table 6: XRF analysis of bottom sediment and soil samples, Kazakhstan

Sample	Ca, %	Ti, %	Mn, %	Fe, %	Cu, g/t	Zn, g/t	As, g/t	Rb, g/t	Sr, g/t	Y, g/t	Zr, g/t	Nb, g/t	Mo, g/t	Ba, g/t	Pb, g/t
kz01b01r	6.0 ± 0.3	0.26 ± 0.07	0.05 ± 0.02	2.61 ± 0.03	< 42	62 ± 22	< 56	78 ± 5	244 ± 6	19 ± 4	176 ± 5	10.9 ± 2.3	< 2.4	605 ± 46	< 21
kz02b01r	4.9 ± 0.3	0.17 ± 0.07	0.04 ± 0.02	1.62 ± 0.03	< 38	< 29	< 53	70 ± 4	202 ± 5	8 ± 4	102 ± 4	7.4 ± 2.0	< 2.1	688 ± 46	< 19
kz03b01r	5.8 ± 0.3	0.26 ± 0.07	0.03 ± 0.02	2.01 ± 0.03	< 39	42 ± 20	< 53	77 ± 4	311 ± 6	16 ± 4	238 ± 5	10.3 ± 2.1	< 2.3	780 ± 48	< 19
kz04b01r	6.0 ± 0.3	0.32 ± 0.08	0.04 ± 0.02	1.91 ± 0.03	< 40	32 ± 21	< 54	72 ± 4	263 ± 6	19 ± 4	233 ± 5	11.4 ± 2.2	< 2.4	680 ± 47	< 20
kz05b01r	9.0 ± 0.4	0.15 ± 0.08	0.04 ± 0.02	2.42 ± 0.03	< 42	55 ± 22	< 58	63 ± 4	267 ± 6	16 ± 4	148 ± 5	9.7 ± 2.2	< 2.4	539 ± 44	< 21
kz06b01r	9.8 ± 0.4	0.17 ± 0.08	0.04 ± 0.02	2.08 ± 0.03	< 42	94 ± 23	< 59	59 ± 4	388 ± 7	16 ± 4	201 ± 5	8.7 ± 2.3	< 2.4	428 ± 41	< 21
kz07b01r	6.1 ± 0.3	0.19 ± 0.08	< 0.02	1.85 ± 0.03	< 39	35 ± 20	< 53	70 ± 4	197 ± 5	12 ± 4	162 ± 4	8.3 ± 2.0	< 2.2	607 ± 44	< 19
kz08b01r	7.1 ± 0.3	0.25 ± 0.08	< 0.03	2.04 ± 0.03	< 41	36 ± 21	< 56	69 ± 4	219 ± 6	15 ± 4	174 ± 5	9.8 ± 2.2	< 2.3	633 ± 46	< 20
kz09b01r	7.2 ± 0.3	0.24 ± 0.08	0.03 ± 0.02	2.06 ± 0.03	< 41	35 ± 21	< 55	71 ± 4	210 ± 5	14 ± 4	182 ± 5	9.1 ± 2.1	< 2.3	621 ± 45	< 20
kz10b01r	6.9 ± 0.3	0.24 ± 0.08	0.04 ± 0.02	2.08 ± 0.03	< 41	41 ± 21	< 55	70 ± 4	235 ± 6	17 ± 4	155 ± 5	10.9 ± 2.2	< 2.3	610 ± 45	< 20
kz11b01r	7.4 ± 0.4	0.22 ± 0.08	0.04 ± 0.02	2.68 ± 0.03	< 42	58 ± 22	< 57	76 ± 5	307 ± 7	16 ± 4	134 ± 5	10.6 ± 2.3	< 2.4	572 ± 46	< 20
kz12b01r	6.3 ± 0.3	0.15 ± 0.07	0.03 ± 0.02	1.69 ± 0.03	< 39	< 30	< 53	74 ± 4	206 ± 5	12 ± 4	102 ± 4	7.6 ± 2.0	< 2.1	656 ± 45	< 19
kz13b01r	5.5 ± 0.3	0.16 ± 0.07	< 0.02	1.50 ± 0.02	< 38	< 29	< 51	74 ± 4	185 ± 5	12 ± 4	136 ± 4	7.2 ± 1.9	< 2.1	652 ± 44	< 18
kz14b01r	7.1 ± 0.3	0.32 ± 0.08	0.04 ± 0.02	2.31 ± 0.03	< 40	42 ± 21	< 54	68 ± 4	271 ± 6	16 ± 4	188 ± 5	10.4 ± 2.2	2.9 ± 1.6	522 ± 43	< 20
kz15b01r	6.0 ± 0.3	0.18 ± 0.08	0.03 ± 0.02	1.84 ± 0.03	< 40	37 ± 21	< 54	76 ± 4	219 ± 5	13 ± 4	110 ± 4	8.9 ± 2.1	< 2.2	642 ± 45	< 19
Average	6.7 ± 0.3	0.22 ± 0.08	0.03 ± 0.02	2.05 ± 0.03	< 40	44 ± 23	< 55	71 ± 4	248 ± 6	15 ± 4	163 ± 5	9.4 ± 2.1	2.3 ± 2.2	616 ± 45	< 20

kz02s01r	6.9 ± 0.3	0.26 ± 0.08	0.04 ± 0.02	2.17 ± 0.03	< 41	45 ± 21	< 55	72 ± 4	217 ± 6	17 ± 4	195 ± 5	9.4 ± 2.2	< 2.3	639 ± 46	< 20
kz03s01r	4.7 ± 0.3	0.33 ± 0.07	0.03 ± 0.02	2.06 ± 0.03	< 39	40 ± 20	< 53	76 ± 4	246 ± 6	17 ± 4	274 ± 5	10.9 ± 2.2	2.5 ± 1.6	740 ± 48	< 19
kz04s01r	4.4 ± 0.3	0.29 ± 0.07	0.05 ± 0.02	2.45 ± 0.03	< 38	61 ± 20	< 51	77 ± 4	262 ± 6	18 ± 4	171 ± 5	11.9 ± 2.1	< 2.2	544 ± 42	< 18
kz05s01r	6.3 ± 0.3	0.23 ± 0.07	0.05 ± 0.02	2.72 ± 0.03	< 40	74 ± 21	< 54	77 ± 4	203 ± 5	18 ± 4	148 ± 5	10.5 ± 2.2	< 2.3	427 ± 40	24 ± 13
kz06s01r	8.2 ± 0.3	0.19 ± 0.08	0.03 ± 0.02	1.83 ± 0.03	< 41	125 ± 23	< 56	58 ± 4	257 ± 6	13 ± 4	190 ± 5	8.8 ± 2.2	< 2.4	512 ± 42	29 ± 14
kz07s01r	7.0 ± 0.3	0.22 ± 0.08	0.03 ± 0.02	2.08 ± 0.03	< 40	44 ± 21	< 55	69 ± 4	268 ± 6	15 ± 4	154 ± 5	10.1 ± 2.2	< 2.3	575 ± 44	< 19
kz08s01r	6.1 ± 0.3	0.23 ± 0.07	0.03 ± 0.02	2.38 ± 0.03	< 40	58 ± 21	< 55	68 ± 4	381 ± 7	14 ± 4	141 ± 5	9.2 ± 2.2	< 2.3	534 ± 43	< 20
kz09s01r	6.6 ± 0.3	0.23 ± 0.07	0.04 ± 0.02	2.62 ± 0.03	< 40	65 ± 22	< 55	74 ± 5	309 ± 7	17 ± 4	143 ± 5	11.7 ± 2.3	< 2.3	515 ± 43	< 20
kz10s01r	6.8 ± 0.3	0.22 ± 0.08	0.03 ± 0.02	2.10 ± 0.03	< 41	41 ± 21	< 56	71 ± 4	260 ± 6	17 ± 4	163 ± 5	9.3 ± 2.2	< 2.3	567 ± 44	< 20
kz11s01r	6.6 ± 0.3	0.23 ± 0.07	0.04 ± 0.02	2.15 ± 0.03	< 40	82 ± 21	< 54	60 ± 4	491 ± 8	13 ± 4	118 ± 5	8.6 ± 2.1	< 2.2	465 ± 40	< 20
kz12s01r	6.1 ± 0.3	0.19 ± 0.07	0.04 ± 0.02	2.38 ± 0.03	< 41	51 ± 21	< 55	75 ± 4	264 ± 6	17 ± 4	130 ± 4	10.1 ± 2.2	< 2.3	571 ± 44	< 20
kz13s01r	6.7 ± 0.3	0.25 ± 0.07	0.04 ± 0.02	2.83 ± 0.03	< 42	64 ± 22	< 57	76 ± 5	352 ± 7	19 ± 4	121 ± 5	10.2 ± 2.2	< 2.3	539 ± 44	< 20
kz14s01r	6.0 ± 0.3	0.20 ± 0.08	0.03 ± 0.02	1.95 ± 0.03	< 40	38 ± 20	< 53	68 ± 4	245 ± 6	15 ± 4	153 ± 5	9.8 ± 2.1	< 2.3	569 ± 43	< 19
kz15s01r	6.4 ± 0.3	0.23 ± 0.08	0.03 ± 0.02	2.09 ± 0.03	< 41	38 ± 21	< 54	71 ± 4	252 ± 6	13 ± 4	165 ± 5	9.8 ± 2.1	< 2.3	596 ± 44	< 20
Average	6.3 ± 0.3	0.24 ± 0.07	0.04 ± 0.02	2.27 ± 0.03	< 40	59 ± 21	< 55	71 ± 4	286 ± 6	16 ± 4	162 ± 5	9.8 ± 2	2.3 ± 2.2	557 ± 43	21 ± 19

Table 7: XRF analysis of bottom sediment and soil samples, Uzbekistan

Sample	Ca, %	Ti, %	Mn, %	Fe, %	Cu, g/t	Zn, g/t	As, g/t	Rb, g/t	Sr, g/t	Y_, g/t	Zr, g/t	Nb, g/t	Mo, g/t	Ba, g/t	Pb, g/t
UZ-01 B	8.6 ± 0.3	0.75 ± 0.06	0.04 ± 0.01	3.05 ± 0.02	< 30	55 ± 15	< 40	60 ± 3	274 ± 4	24 ± 3	349 ± 4	11.3 ± 1.6	2.7 ± 1.2	417 ± 28	< 14
UZ-02 B	7.8 ± 0.3	0.55 ± 0.05	0.03 ± 0.01	3.08 ± 0.02	< 29	66 ± 15	< 39	70 ± 3	254 ± 4	18 ± 3	180 ± 3	9.7 ± 1.6	< 1.6	385 ± 27	< 14
UZ-03 B	5.3 ± 0.2	0.46 ± 0.05	0.03 ± 0.01	2.92 ± 0.02	< 28	61 ± 14	< 36	68 ± 3	221 ± 4	20 ± 3	185 ± 3	11.5 ± 1.5	< 1.6	359 ± 25	< 13
UZ-04 B	7.8 ± 0.2	0.50 ± 0.05	0.03 ± 0.01	2.11 ± 0.02	< 27	54 ± 14	< 37	72 ± 3	191 ± 4	13 ± 3	139 ± 3	8.7 ± 1.4	< 1.5	758 ± 33	< 13
UZ-05 B	12.6 ± 0.2	0.49 ± 0.06	< 0.02	1.75 ± 0.02	< 27	77 ± 14	< 37	49 ± 3	507 ± 5	8 ± 2	92 ± 3	5.7 ± 1.4	3.4 ± 1.0	533 ± 29	< 14
UZ-06 B	7.0 ± 0.2	0.47 ± 0.05	0.02 ± 0.01	1.92 ± 0.02	< 27	47 ± 14	< 36	76 ± 3	193 ± 3	11 ± 3	116 ± 3	8.5 ± 1.4	< 1.5	681 ± 31	< 13
UZ-07 B	2.8 ± 0.2	0.40 ± 0.05	0.06 ± 0.01	2.38 ± 0.02	< 27	70 ± 14	< 36	181 ± 4	122 ± 3	24 ± 3	242 ± 3	23.8 ± 1.7	3.0 ± 1.1	747 ± 32	24 ± 9
UZ-08 B	2.8 ± 0.2	0.42 ± 0.05	0.06 ± 0.01	2.70 ± 0.02	< 27	117 ± 15	< 37	157 ± 4	173 ± 3	24 ± 3	212 ± 3	20.9 ± 1.7	2.6 ± 1.1	808 ± 34	46 ± 10
UZ-09 B	8.5 ± 0.2	0.39 ± 0.05	0.96 ± 0.02	2.49 ± 0.02	< 28	106 ± 15	< 37	76 ± 3	233 ± 4	15 ± 3	116 ± 3	8.5 ± 1.5	2.7 ± 1.1	577 ± 31	< 14
UZ-10 B	7.7 ± 0.3	0.50 ± 0.05	0.13 ± 0.01	2.88 ± 0.02	< 29	169 ± 17	< 41	92 ± 3	266 ± 4	14 ± 3	140 ± 3	11.3 ± 1.5	< 1.6	1102 ± 40	31 ± 10
UZ-11 B	6.6 ± 0.2	0.42 ± 0.05	0.03 ± 0.01	2.38 ± 0.02	59 ± 19	91 ± 14	< 36	74 ± 3	212 ± 4	10 ± 2	136 ± 3	10.1 ± 1.4	< 1.5	851 ± 34	< 13
UZ-12 B	7.2 ± 0.2	0.44 ± 0.05	< 0.02	1.70 ± 0.02	< 26	45 ± 13	< 35	106 ± 3	231 ± 4	9 ± 3	91 ± 3	8.5 ± 1.4	< 1.4	833 ± 34	< 13
Average	7.06 ± 0.2	0.48 ± 0.05	0.14 ± 0.01	2.45 ± 0.02	30 ± 27	80 ± 15	< 37	90 ± 3	240 ± 4	16 ±2	167 ± 3	12 ± 1.5	2.1 ± 1.4	670 ± 32	19 ± 13
Sample	**Ca, %**	**Ti, %**	**Mn, %**	**Fe, %**	**Cu, g/t**	**Zn, g/t**	**As, g/t**	**Rb, g/t**	**Sr, g/t**	**Y_, g/t**	**Zr, g/t**	**Nb, g/t**	**Mo, g/t**	**Ba, g/t**	**Pb, g/t**
UZ-01 S	6.1 ± 0.2	0.55 ± 0.05	0.03 ± 0.01	2.43 ± 0.02	< 27	45 ± 14	< 36	48 ± 3	247 ± 4	21 ± 3	388 ± 4	8.8 ± 1.5	2.5 ± 1.2	351 ± 25	< 13
UZ-02 S	8.1 ± 0.2	0.66 ± 0.06	0.03 ± 0.01	2.53 ± 0.02	< 28	49 ± 15	< 38	56 ± 3	241 ± 4	18 ± 3	271 ± 4	7.8 ± 1.5	1.9 ± 1.1	411 ± 27	< 14
UZ-03 S	5.3 ± 0.2	0.40 ± 0.05	0.02 ± 0.01	1.78 ± 0.02	< 25	49 ± 13	< 34	58 ± 3	195 ± 3	10 ± 2	109 ± 3	6.4 ± 1.3	< 1.4	483 ± 26	< 12
UZ-04 S	8.8 ± 0.3	0.59 ± 0.06	0.02 ± 0.01	2.42 ± 0.02	< 29	62 ± 15	< 39	76 ± 3	231 ± 4	16 ± 3	172 ± 3	9.4 ± 1.5	< 1.6	822 ± 36	< 14
UZ-05 S	9.1 ± 0.2	0.54 ± 0.06	0.03 ± 0.01	2.15 ± 0.02	< 27	74 ± 15	< 37	62 ± 3	220 ± 4	13 ± 3	159 ± 3	8.6 ± 1.4	2.1 ± 1.0	696 ± 32	19 ± 9
UZ-06 S	6.8 ± 0.2	0.46 ± 0.05	0.03 ± 0.01	1.99 ± 0.02	< 26	86 ± 14	< 35	77 ± 3	196 ± 3	12 ± 2	105 ± 3	7.8 ± 1.3	< 1.4	698 ± 31	17 ± 9
UZ-07 S	2.4 ± 0.2	0.42 ± 0.05	0.07 ± 0.01	2.89 ± 0.02	< 27	150 ± 15	< 37	160 ± 4	145 ± 3	26 ± 3	223 ± 3	21.1 ± 1.7	5.4 ± 1.1	666 ± 31	73 ± 10
UZ-08 S	2.0 ± 0.2	0.40 ± 0.05	0.04 ± 0.01	2.68 ± 0.02	< 27	191 ± 16	< 37	177 ± 4	176 ± 3	26 ± 3	230 ± 3	19.9 ± 1.6	3.8 ± 1.1	868 ± 34	62 ± 10
UZ-09 S	8.1 ± 0.2	0.47 ± 0.05	0.02 ± 0.01	2.33 ± 0.02	< 28	111 ± 15	< 38	116 ± 3	239 ± 4	20 ± 3	170 ± 3	13.9 ± 1.6	< 1.6	764 ± 34	27 ± 10
UZ-10 S	6.3 ± 0.2	0.44 ± 0.05	0.04 ± 0.01	2.50 ± 0.02	< 27	93 ± 15	< 37	89 ± 3	228 ± 4	13 ± 3	116 ± 3	10.4 ± 1.4	< 1.5	696 ± 32	< 14
UZ-11 S	7.6 ± 0.2	0.49 ± 0.05	0.04 ± 0.01	2.45 ± 0.02	< 28	74 ± 14	< 37	78 ± 3	210 ± 4	15 ± 3	149 ± 3	10.3 ± 1.5	1.9 ± 1.0	580 ± 30	< 13
UZ-12 S	7.7 ± 0.2	0.51 ± 0.05	0.03 ± 0.01	2.04 ± 0.02	< 27	62 ± 14	< 37	102 ± 3	231 ± 4	14 ± 3	133 ± 3	11.4 ± 1.5	1.6 ± 1.0	785 ± 34	< 13
Average	6.5 ± 0.2	0.5 ± 0.05	0.03 ± 0.01	2.35 ± 0.02	< 27	87 ± 15	< 37	92 ± 3	213 ± 4	17 ± 3	185 ± 3	11 ± 1.5	2.2 ± 1.3	652 ± 31	24 ± 12
WSO	< 0.2	0.20 ± 0.04	0.04 ± 0.01	3.22 ± 0.02	< 22	52 ± 11	< 29	66 ± 3	218 ± 4	20 ± 3	167 ± 3	12.7 ± 1.5	< 1.5	274 ± 22	< 11
Av. conc. for sed.	2.5	0.45	0.07	3.33	57	80	6.6	200	450	30	200	20	2.0	800	-

Table 8: XRF analysis of bottom sediment and soil samples, Kyrgyzstan

Sample	Ca, %	Ti, %	Mn, %	Fe, %	Cu, g/t	Zn, g/t	Pb, g/t	As, g/t	Rb, g/t	Sr, g/t	Y_, g/t	Zr, g/t	Nb, g/t	Mo, g/t	Ba, g/t
kg0100b	7.1 ± 0.4	0.41 ± 0.07	0.04 ± 0.02	3.57 ± 0.04	< 44	50 ± 23	< 21	< 59	112 ± 5	331 ± 7	30 ± 5	243 ± 6	14.8 ± 2.5	2.7 ± 1.7	761 ± 51
kg0200b	11.0 ± 0.4	0.39 ± 0.08	< 0.03	2.73 ± 0.03	< 42	< 32	< 20	< 56	104 ± 5	129 ± 5	16 ± 4	175 ± 5	13.9 ± 2.3	< 2.4	536 ± 44
kg0300b	10.0 ± 0.4	0.41 ± 0.07	0.04 ± 0.02	3.27 ± 0.03	< 42	44 ± 22	< 20	< 56	87 ± 5	369 ± 7	25 ± 4	257 ± 6	12.1 ± 2.4	< 2.5	681 ± 48
kg0400b	10.6 ± 0.4	0.40 ± 0.08	0.04 ± 0.02	3.25 ± 0.03	< 43	37 ± 22	< 21	< 58	42 ± 4	228 ± 6	17 ± 4	132 ± 4	9.5 ± 2.2	< 2.3	484 ± 43
kg0500b	8.6 ± 0.4	0.38 ± 0.08	0.06 ± 0.02	3.53 ± 0.04	< 44	53 ± 23	< 21	< 59	78 ± 5	237 ± 6	22 ± 4	191 ± 5	11.4 ± 2.4	< 2.5	508 ± 45
kg0601b	3.4 ± 0.3	0.38 ± 0.06	0.03 ± 0.02	2.96 ± 0.03	< 38	57 ± 20	< 19	< 51	122 ± 5	118 ± 4	29 ± 4	195 ± 5	14.8 ± 2.2	< 2.2	544 ± 41
kg0701b	9.4 ± 0.4	0.29 ± 0.08	0.04 ± 0.02	2.85 ± 0.03	< 43	49 ± 22	< 21	< 58	82 ± 5	227 ± 6	19 ± 4	187 ± 5	11.6 ± 2.3	< 2.5	626 ± 47
kg0801b	11.7 ± 0.4	0.32 ± 0.08	0.04 ± 0.02	3.26 ± 0.04	< 47	< 36	< 22	< 62	108 ± 6	443 ± 8	17 ± 5	129 ± 5	10.0 ± 2.4	< 2.5	1310 ± 67
kg0901b	7.4 ± 0.4	0.41 ± 0.07	0.04 ± 0.02	4.17 ± 0.04	< 47	99 ± 25	< 22	< 60	112 ± 5	219 ± 6	22 ± 5	159 ± 5	11.3 ± 2.4	< 2.4	632 ± 48
kg1001b	5.4 ± 0.3	0.31 ± 0.06	0.03 ± 0.01	1.90 ± 0.02	< 34	60 ± 18	20 ± 11	< 45	62 ± 4	170 ± 4	16 ± 3	140 ± 4	8.6 ± 1.8	< 1.9	417 ± 34
kg1101b	8.7 ± 0.4	0.40 ± 0.08	0.05 ± 0.02	3.52 ± 0.04	< 45	68 ± 24	< 21	< 59	77 ± 5	149 ± 5	17 ± 4	160 ± 5	9.9 ± 2.3	< 2.5	728 ± 51
kg1201b	8.4 ± 0.4	0.47 ± 0.07	0.04 ± 0.02	4.07 ± 0.04	< 46	40 ± 24	< 22	< 60	66 ± 5	159 ± 5	17 ± 4	189 ± 5	9.8 ± 2.3	< 2.5	1124 ± 61
kg1301b	7.6 ± 0.3	0.30 ± 0.08	0.03 ± 0.02	2.27 ± 0.03	< 40	79 ± 21	< 19	< 53	89 ± 5	132 ± 5	13 ± 4	119 ± 4	7.0 ± 2.0	< 2.2	624 ± 45
kg1401b	6.0 ± 0.3	0.45 ± 0.07	0.04 ± 0.02	3.38 ± 0.04	< 42	71 ± 23	< 21	< 57	86 ± 5	178 ± 5	23 ± 4	207 ± 5	12.4 ± 2.3	< 2.4	551 ± 44
kg1501b	5.3 ± 0.3	0.36 ± 0.07	0.06 ± 0.02	3.49 ± 0.04	50 ± 30	403 ± 29	33 ± 14	< 56	76 ± 5	131 ± 5	18 ± 4	138 ± 4	9.8 ± 2.2	< 2.3	693 ± 49
Average	8.4 ± 0.36	0.37 ± 0.07	0.04 ± 0.02	3.21 ± 0.03	43 ± 42	85 ± 23	22 ± 20	< 56	89 ± 5	215 ± 6	20 ± 4	175 ± 5	11.1 ± 2.2	2.4 ± 2.3	681 ± 48

Sample	Ca, %	Ti, %	Mn, %	Fe, %	Cu, g/t	Zn, g/t	Pb, g/t	As, g/t	Rb, g/t	Sr, g/t	Y_, g/t	Zr, g/t	Nb, g/t	Mo, g/t	Ba, g/t
kg1101s	9.7 ± 0.4	0.48 ± 0.07	0.05 ± 0.02	4.45 ± 0.04	< 49	< 38	< 22	< 63	58 ± 5	166 ± 5	24 ± 4	195 ± 5	8.6 ± 2.4	< 2.6	839 ± 55
kg1201s	8.9 ± 0.4	0.39 ± 0.08	0.05 ± 0.02	3.54 ± 0.04	< 45	69 ± 24	< 21	< 59	73 ± 5	165 ± 5	19 ± 4	210 ± 5	9.6 ± 2.3	2.8 ± 1.7	791 ± 52
kg1301s	6.8 ± 0.3	0.33 ± 0.07	0.03 ± 0.02	3.53 ± 0.03	< 44	< 33	< 20	< 56	69 ± 4	119 ± 4	11 ± 4	78 ± 4	5.1 ± 2.0	< 2.2	456 ± 41
kg1401s	8.2 ± 0.4	0.43 ± 0.08	0.03 ± 0.02	2.80 ± 0.03	< 43	< 33	< 21	< 57	89 ± 5	156 ± 5	16 ± 4	215 ± 5	9.3 ± 2.2	< 2.4	737 ± 49
kg1501s	6.5 ± 0.4	0.36 ± 0.06	0.03 ± 0.02	4.60 ± 0.04	< 47	< 36	< 21	< 60	47 ± 4	127 ± 5	16 ± 4	79 ± 4	8.0 ± 2.2	< 2.3	390 ± 40
Average	8.0 ± 0.4	0.39 ± 0.07	0.04 ± 0.02	3.78 ± 0.03	< 46	42 ± 33	< 21	< 59	67 ± 4.6	146 ± 5	17 ± 4	155 ± 4.6	8.1 ± 2.2	2.5 ± 2.2	642.6 ± 47.4

Table 9: XRF analysis of bottom sediment and soil samples, Tajikistan

Sample	Ca, %	Ti, %	Mn, %	Fe, %	Cu, g/t	Zn, g/t	Pb, g/t	As, g/t	Rb, g/t	Sr, g/t	Y_, g/t	Zr, g/t	Nb, g/t	Mo, g/t	Ba, g/t
tj0200b	3.5 ± 0.3	0.22 ± 0.07	0.03 ± 0.02	2.30 ± 0.03	< 37	72 ± 20	< 19	< 51	106 ± 5	184 ± 5	13 ± 4	95 ± 4	7.6 ± 2.0	< 2.1	622 ± 44
tj0300b	3.9 ± 0.3	0.26 ± 0.07	0.03 ± 0.02	2.24 ± 0.03	< 38	42 ± 19	< 18	< 50	108 ± 5	223 ± 5	10 ± 4	86 ± 4	7.2 ± 1.9	< 2.0	724 ± 46
tj0400b	4.1 ± 0.3	0.28 ± 0.07	0.04 ± 0.02	2.62 ± 0.03	< 39	69 ± 21	< 19	< 53	91 ± 5	198 ± 5	18 ± 4	159 ± 4	10.6 ± 2.1	< 2.2	521 ± 42
tj0500b	8.0 ± 0.4	0.33 ± 0.08	0.04 ± 0.02	2.91 ± 0.03	< 41	66 ± 22	< 20	< 56	98 ± 5	256 ± 6	19 ± 4	157 ± 5	10.2 ± 2.3	< 2.4	507 ± 43
tj0600b	3.5 ± 0.3	0.27 ± 0.07	0.03 ± 0.02	1.96 ± 0.03	< 37	48 ± 19	< 18	< 51	70 ± 4	149 ± 5	15 ± 4	296 ± 5	7.9 ± 2.0	2.4 ± 1.6	528 ± 41
tj0700b	7.5 ± 0.3	0.20 ± 0.08	0.03 ± 0.02	2.17 ± 0.03	< 40	< 31	< 19	< 54	46 ± 4	213 ± 5	13 ± 4	87 ± 4	5.6 ± 2.0	< 2.1	388 ± 38
tj0900b	11.1 ± 0.4	0.19 ± 0.08	0.03 ± 0.02	1.89 ± 0.03	< 39	34 ± 20	< 19	< 53	55 ± 4	410 ± 7	12 ± 4	125 ± 5	5.8 ± 2.1	< 2.3	375 ± 38
tj1000b	7.9 ± 0.4	0.27 ± 0.08	0.04 ± 0.02	2.67 ± 0.03	< 42	42 ± 22	< 20	< 56	39 ± 4	290 ± 6	13 ± 4	136 ± 5	6.5 ± 2.0	< 2.3	299 ± 35
tj1300b	6.9 ± 0.3	0.30 ± 0.08	0.04 ± 0.02	2.48 ± 0.03	< 42	47 ± 22	< 21	< 57	73 ± 5	231 ± 6	17 ± 4	287 ± 6	11.6 ± 2.3	2.6 ± 1.7	950 ± 55
tj1400b	11.7 ± 0.4	0.24 ± 0.08	0.05 ± 0.02	2.89 ± 0.03	< 43	108 ± 24	84 ± 16	< 59	84 ± 5	497 ± 8	16 ± 4	155 ± 5	10.0 ± 2.4	< 2.5	809 ± 54
tj1500b	7.9 ± 0.3	0.23 ± 0.08	0.03 ± 0.02	2.32 ± 0.03	< 42	61 ± 22	< 20	< 57	77 ± 5	306 ± 6	14 ± 4	105 ± 4	9.3 ± 2.2	< 2.3	958 ± 55
Average	6.9 ± 0.3	0.25 ± 0.07	0.03 ± 0.02	2.48 ± 0.03	<40	59 ± 21	25 ± 19	<54	77 ± 4.6	269 ± 5.8	14.5 ± 4	153 ± 4.6	8.3 ± 2.1	2.3 ± 2.1	607 ± 44.6

Sample	**Ca, %**	**Ti, %**	**Mn, %**	**Fe, %**	**Cu, g/t**	**Zn, g/t**	**Pb, g/t**	**As, g/t**	**Rb, g/t**	**Sr, g/t**	**Y_, g/t**	**Zr, g/t**	**Nb, g/t**	**Mo, g/t**	**Ba, g/t**
tj0200s	8.1 ± 0.3	0.28 ± 0.07	0.04 ± 0.02	2.85 ± 0.03	< 43	154 ± 24	39 ± 14	< 56	111 ± 5	195 ± 5	19 ± 4	152 ± 5	9.9 ± 2.2	< 2.3	633 ± 46
tj0300s	4.3 ± 0.3	0.30 ± 0.07	0.04 ± 0.02	2.72 ± 0.03	< 40	134 ± 22	67 ± 14	< 54	110 ± 5	212 ± 5	17 ± 4	184 ± 5	10.0 ± 2.2	< 2.3	741 ± 48
tj0400s	5.0 ± 0.3	0.33 ± 0.07	0.03 ± 0.02	2.37 ± 0.03	< 39	47 ± 21	< 20	< 53	102 ± 5	196 ± 5	18 ± 4	260 ± 5	8.7 ± 2.2	< 2.4	714 ± 47
tj0500s	0.9 ± 0.2	0.38 ± 0.07	0.02 ± 0.02	2.60 ± 0.03	< 38	44 ± 20	< 19	< 52	94 ± 5	152 ± 5	33 ± 4	701 ± 8	10.6 ± 2.3	4.0 ± 1.9	553 ± 42
tj0600s	4.3 ± 0.3	0.18 ± 0.07	0.04 ± 0.02	1.71 ± 0.03	< 37	37 ± 19	< 18	< 51	73 ± 4	179 ± 5	11 ± 3	122 ± 4	6.0 ± 1.9	< 2.1	526 ± 41
tj0700s	9.3 ± 0.4	0.31 ± 0.08	0.05 ± 0.02	2.86 ± 0.03	< 43	36 ± 22	< 20	< 56	56 ± 4	339 ± 7	18 ± 4	146 ± 5	7.7 ± 2.2	< 2.4	357 ± 38
tj0900s	7.7 ± 0.4	0.31 ± 0.07	0.05 ± 0.02	3.35 ± 0.04	< 43	50 ± 22	< 21	< 58	86 ± 5	222 ± 6	21 ± 4	183 ± 5	9.8 ± 2.3	< 2.5	437 ± 41
tj1000s	10.4 ± 0.4	0.38 ± 0.08	0.04 ± 0.02	3.00 ± 0.03	< 44	51 ± 23	< 21	< 59	50 ± 4	272 ± 6	19 ± 4	176 ± 5	7.6 ± 2.3	< 2.5	343 ± 38
tj1300s	8.4 ± 0.4	0.35 ± 0.08	0.04 ± 0.02	2.74 ± 0.03	< 43	59 ± 23	< 21	< 59	79 ± 5	240 ± 6	17 ± 4	182 ± 5	9.0 ± 2.3	< 2.5	803 ± 52
tj1400s	7.7 ± 0.3	0.30 ± 0.07	0.05 ± 0.02	2.82 ± 0.03	< 42	126 ± 23	41 ± 14	< 55	95 ± 5	317 ± 7	16 ± 4	157 ± 5	12.2 ± 2.3	< 2.4	1046 ± 57
tj1500s	8.5 ± 0.4	0.34 ± 0.07	0.04 ± 0.02	3.30 ± 0.04	< 43	85 ± 23	< 21	< 57	98 ± 5	287 ± 6	19 ± 4	135 ± 5	12.8 ± 2.4	< 2.4	1041 ± 58
Average	6.7 ± 0.3	0.31 ± 0.07	0.04 ± 0.02	2.75 ± 0.03	< 41	75 ± 22	28 ± 18	< 55	86.7± 4.7	237 ± 6	19 ± 4	218 ± 5	9.4 ± 2.2	2.5 ± 2.3	654 ± 46

Table 10: Activation analysis of water samples, Kazakhstan

	Na	K		Cr	Fe	Co	Zn	As	Se	Br	Rb	Mo	Ag		Cd		Sb
kodobr	mg/L	mg/L	er%	mkg/L	mkg/L	mkg/L	mkg/L	mkg/L	mkg/L	mkg/L	mkg/L	mkg/L	mkg/L	er%	mkg/L	er%	mkg/L
kz-01W	71.5	0.05	100	60.5	505	0.28	17.1	1.5	1.85	8.0	1.32	3.48	0.034	32	0.4	100	0.48
kz-02W	80.3	0.06	100	41.7	88	0.20	6.3	1.7	1.61	11.0	0.87	4.18	0.036	26	0.7	100	0.59
kz-03W	214.8	13.25	48	186.5	262	0.37	10.0	1.2	3.95	37.0	1.38	3.22	<0.028	100	2.8	83	0.50
kz-04W	152.1	0.69	100	241.6	307	0.38	7.9	1.1	3.11	23.6	5.68	2.09	0.032	55	1.8	88	0.36
kz-05W	43.3	1.92	83	87.6	160	0.23	25.4	1.8	2.36	7.0	2.57	1.99	0.017	39	0.2	100	0.65
kz-06W	58.5	0.91	100	68.7	211	0.24	7.2	2	2.78	16.5	2.36	1.56	<0.01	100	1.2	81	0.77
kz-07W	84.3	4.82	69	98.3	259	0.25	5.7	1.3	1.44	8.6	2.25	3.55	0.022	59	0.4	100	0.64
kz-08W	102.4	0.08	100	64.8	422	0.20	4.8	1.1	1.53	7.1	3.03	4.52	<0.008	100	0.5	100	0.60
kz-09W	92.9	5.45	70	22.0	119	0.17	7.4	0.7	1.44	12.2	1.20	3.46	0.025	68	0.5	100	0.55
kz-10W	98.8	4.80	79	25.4	224	0.26	7.8	1.1	1.62	10.5	1.31	4.66	<0.007	100	0.4	100	0.63
kz-11W	103	6.90	60	23.0	299	0.30	5.3	1.2	1.64	12.9	1.09	4.73	<0.008	100	1.5	60	0.70
kz-12W	97.1	2.28	100	29.6	440	0.36	7.5	0.9	1.49	10.5	1.68	4.22	0.107	13	2.8	38	0.59
kz-13W	112.3	6.64	68	38.2	943	0.46	33.9	1.8	1.69	9.1	2.16	4.40	0.713	3	1.2	73	0.77
kz-15W	124.8	11.07	43	21.3	105	0.24	7.7	1	1.66	7.9	0.86	4.27	0.043	33	0.5	100	0.73
Average	102.6	4.2	80	72	310	0.28	11	1.3	2.0	13	1.98	3.6	0.08	59	1.06	87	0.6

	Cs	Ba	La	Ce	Nd	Sm	Eu	Tb	Yb	Hf	Re	Au	Hg		Th	U
kodobr	mkg/L	mkg/L	mkg/L	mkg/L	mkg/L	mkg/L	mkg/L	Mkg/L	mkg/L	mkg/L	mkg/L	mkg/L	mkg/L	er%	mkg/L	mkg/L
kz-01W	0.18	45.87	0.96	5.21	0.70	1.32	0.021	0.001	0.015	0.040	0.12	0.0154	0.083	25	0.059	16.6
kz-02W	0.15	64.05	0.98	5.69	6.15	1.44	0.003	0.006	0.012	0.028	0.14	0.0290	0.037	35	0.007	18.1
kz-03W	0.19	41.77	1.07	6.66	0.00	1.54	0.149	0.003	0.030	0.121	0.06	0.0283	0.025	50	0.080	19.8
kz-04W	0.57	40.68	1.14	7.36	9.14	1.50	0.025	0.004	0.023	0.053	0.02	0.0513	0.378	17	0.065	17.7
kz-05W	0.29	46.05	0.77	3.79	2.20	0.90	0.013	0.003	0.000	0.034	0.73	0.0104	0.036	30	0.064	11.1
kz-06W	0.27	54.03	0.77	3.22	4.29	0.73	0.019	0.003	0.015	0.034	1.43	0.0114	0.022	35	0.056	9.1
kz-07W	0.28	48.59	1.06	5.68	5.19	1.49	0.031	0.003	0.030	0.030	0.19	0.0192	0.040	35	0.042	18.8
kz-08W	0.33	37.92	1.28	7.05	3.79	1.64	0.008	0.002	0.066	0.032	0.21	0.0179	0.014	50	0.054	20.1
kz-09W	0.18	44.22	1.15	6.11	9.90	1.60	0.027	0.007	0.018	0.067	0.20	0.0189	0.015	58	0.023	20.0
kz-10W	0.18	38.69	1.25	6.70	9.88	1.69	0.018	0.000	0.019	0.047	0.16	0.0097	0.013	39	0.066	20.0
kz-11W	0.18	50.98	1.35	6.75	8.98	1.71	0.008	0.002	0.003	0.099	0.26	0.0208	0.014	38	0.064	21.0
kz-12W	0.24	50.14	1.30	6.91	0.00	1.78	0.030	0.006	0.040	0.061	0.19	0.0141	0.018	37	0.114	21.3
kz-13W	0.18	33.45	1.57	7.84	7.95	1.91	0.057	0.006	0.055	0.077	0.20	0.0185	0.112	25	0.126	23.1
kz-15W	0.15	45.05	1.56	8.00	3.20	1.98	0.023	0.003	0.000	0.046	0.15	0.0418	0.115	25	0.017	24.6
Average	0.24	45.8	1.16	6.2	5.1	1.5	0.03	0.003	0.023	0.05	0.29	0.02	0.07	36	0.06	18.7

Table 11: Activation analysis of bottom sediments, Kazakhstan

	Na	Sc	Cr	Fe	Co	Ni	Zn	As	Se	Br	Rb	Sr	Cd		Sb	Cs	Ba
kodobr	**mg/g**	**mkg/g**	**mkg/g**	**mg/g**	**mkg/g**	**mkg/g**	**mkg/g**	**Mkg/g**	**mkg/g**	**mkg/g**	**mkg/g**	**mg/g**	**mkg/g**	**er%**	**mkg/g**	**mkg/g**	**mkg/g**
KZ-01 Sd	4.77	15.5	100	41.5	16.9	26.6	155	7.80	2.25	4.85	146	457	0.55	100	1.55	9.0	569
KZ-02 Sd	9.00	8.1	65	23	8.0	11.7	67	7.70	3.15	2.35	130	429	0.50	100	1.20	4.5	774
KZ-03 Sd	9.51	7.1	77	20.1	7.4	12.9	57	4.30	1.66	0.35	105	244	0.40	100	0.80	2.9	545
KZ-04 Sd	8.61	10.1	84	26.2	9.9	19.7	83	6.55	3.09	1.85	113	387	0.30	100	1.35	4.6	622
KZ-05 Sd	4.29	8.7	66	26.3	10.0	13.2	88	11.05	2.44	2.50	97	394	0.35	100	1.90	4.4	487
KZ-06 Sd	5.37	6.8	75	18	6.9	11.0	81	4.60	1.96	2.80	76	430	0.20	100	1.00	2.9	403
KZ-07 Sd	7.97	10.3	86	27.3	11.1	17.1	93	6.35	1.87	2.65	107	387	1.20	90	0.90	4.7	549
KZ-08 Sd	8.50	8.3	82	23.7	8.8	14.0	65	3.80	3.34	0.55	105	259	0.15	100	0.85	3.3	536
KZ-09 Sd	8.77	8.2	67	22.4	9.0	17.2	68	4.75	1.68	1.10	114	286	0.15	100	0.90	3.9	566
KZ-10 Sd	8.61	9.7	81	25.9	10.2	15.8	79	4.15	2.24	0.80	113	313	0.40	100	1.00	4.7	558
KZ-11 Sd	7.44	11.7	81	30.6	12.5	20.6	100	7.30	2.46	1.40	117	354	0.50	100	1.10	5.9	542
KZ-12 Sd	8.64	8.8	63	23.4	9.5	16.5	74	5.50	2.17	1.05	114	311	0.25	100	0.90	4.3	594
KZ-13 Sd	9.59	10.1	72	26.2	10.7	20.6	83	6.20	2.16	2.35	118	409	0.75	100	1.05	5.1	619
KZ-15 Sd	3.19	3.1	63	8.9	3.6	5.1	31	1.95	1.55	0.65	53	116	0.10	100	0.40	1.7	263
Average	7.45	9.0	76	25	9.6	15.9	80	5.86	2.29	1.8	108	341	0.41	99	1.06	4.42	545
Av. conc. for sediments	6.60	10.0	100	33.3	20.0	95.0	80.0	6.60	0.60	6.00	200	450	0.30		2.00	12.0	800

	La	Ce	Nd	Sm	Eu	Tb	Yb	Hf	Ta	Hg		Th	U
kodobr	**mkg/g**	**mkg/g**	**mkg/g**	**mkg/g**	**mkg/g**	**Mkg/g**	**mkg/g**	**mkg/g**	**mkg/g**	**mkg/g**	**er%**	**mkg/g**	**mkg/g**
KZ-01 Sd	7.80	61.1	28.6	2.90	1.22	0.74	1.70	4.5	0.9	0.035	91	15.6	3.55
KZ-02 Sd	7.70	51.2	26.3	2.45	1.15	0.63	1.49	8.59	0.9	0.017	95	14.0	2.10
KZ-03 Sd	4.30	33.7	18.9	1.70	0.83	0.46	1.05	5.45	0.7	0.002	100	8.1	1.20
KZ-04 Sd	6.55	62.3	29.7	2.75	1.33	0.80	1.95	10.52	1	0.01	91	14.6	2.05
KZ-05 Sd	11.05	44.1	18.9	2.00	1.03	0.57	1.34	5.99	0.7	0.008	94	10.3	1.60
KZ-06 Sd	4.60	38.2	19.9	2.00	0.85	0.57	1.39	6.32	0.7	0.014	99	8.5	1.65
KZ-07 Sd	6.35	49.8	26.4	2.35	1.05	0.65	1.61	6.53	0.9	0.007	91	11.5	2.30
KZ-08 Sd	3.80	43.3	20.0	2.15	1.01	0.63	1.60	10.6	0.9	0.003	100	9.5	1.70
KZ-09 Sd	4.75	45.0	21.7	2.20	0.94	0.63	1.53	5.84	0.8	0	100	9.6	1.65
KZ-10 Sd	4.15	47.0	21.2	2.30	1.04	0.65	1.84	7.8	0.9	0.004	100	12.0	2.00
KZ-11 Sd	7.30	53.4	23.9	2.70	1.18	0.76	1.72	6.07	0.9	0.004	100	13.3	2.30
KZ-12 Sd	5.50	45.1	24.3	2.25	1.01	0.63	1.46	5.55	0.8	0.003	100	11.6	1.60
KZ-13 Sd	6.20	50.7	20.5	2.55	1.12	0.75	1.79	7.8	1	0.014	95	13.2	2.05
KZ-15 Sd	1.95	17.8	8.5	0.90	0.46	0.26	0.73	5.79	0.4	0.001	100	3.3	0.70
Average	5.86	45.9	22.1	2.23	1.02	0.62	1.51	6.95	0.82	0.009	97	11.1	1.89
Av. conc. for sediments	40.0	50.0	23.0	6.5	1.00	0.30	3.00	6.00	3.5	0.400		11.0	3.2

Table 12: Activation analysis of soils and vegetation, Kazakhstan

	Na	Sc	Cr	Fe	Co	Ni	Zn	As	Se	Br	Rb	Sr	Cd		Sb	Cs	Ba
kodobr	mg/g	mkg/g	mkg/g	mg/g	mkg/g	mkg/g	mkg/g	mkg/g	mkg/g	mkg/g	mkg/g	mg/g	mkg/g	er%	mkg/g	mkg/g	mkg/g
KZ-02 S	12.24	9.3	87.1	26.1	9.7	17.6	81	5.20	2.12	0.30	119.1	281	0.25	100	1.15	3.95	660
KZ-03 S	10.46	9.8	69.6	26.8	9.4	15.6	84	7.50	2.2	1.80	124.0	333	0.15	100	1.30	4.73	769
KZ-04 S	8.49	11.5	96.3	30.1	11.5	16.3	102	8.85	2	2.75	125.5	327	0.15	100	1.30	5.72	656
KZ-05 S	4.86	10.6	98.6	30.4	12.3	20.0	133	11.80	2.28	3.80	108.2	295	0.55	98	2.45	5.81	449
KZ-06 S	6.59	8.3	120.7	20.8	8.3	13.5	72	4.20	1.7	2.10	84.8	378	0.25	100	0.80	3.19	394
KZ-07 S	8.12	10.5	84.0	27.8	11.2	20.2	99	6.00	1.9	2.85	111.7	403	0.35	100	1.05	5.20	579
KZ-08 S	11.49	12.8	91.0	33.5	13.8	20.2	114	6.85	2.22	5.90	124.2	473	1.60	96	1.25	6.56	559
KZ-09 S	8.71	11.7	83.7	30.8	12.4	20.3	110	7.20	2.46	4.65	114.1	440	1.10	91	1.05	5.88	598
KZ-10 S	11.43	11.7	91.9	30.9	12.5	22.2	122	6.05	2.3	6.95	119.6	556	0.45	100	2.05	6.03	588
KZ-11 S	14.76	11.2	155.0	29.8	12.0	21.1	106	5.35	2.49	5.65	117.8	391	0.55	93	1.05	5.67	550
KZ-12 S	8.20	11.4	86.5	33.5	13.0	27.3	144	7.25	2.21	11.25	117.5	608	1.15	95	8.40	6.13	547
KZ-13 S	25.13	10.1	73.6	26.2	10.8	15.8	96	6.15	1.54	9.85	92.8	572	0.40	100	1.05	5.34	468
KZ-15 S	4.88	8.9	99.7	22.9	9.0	13.6	72	3.90	1.85	1.00	91.1	223	0.30	100	0.70	4.29	418
Average	10.4	10.6	95	28.4	11.2	18.8	103	6.64	2.1	4.53	112	406	0.56	98	1.82	5.27	557
kzV-06	6.06	8.5	150.7	22.7	9.5	16.3	91	6.30	1.92	8.20	76.8	570	0.45	100	0.90	3.80	429
Av. conc. for sed.	6.60	10.0	100	33.3	20.0	95.0	80.0	6.60	0.60	6.00	200	450	0.30		2.00	12.0	800

	La	Ce	Nd	Sm	Eu	Tb	Yb	Hf	Ta	Hg		Th	U
kodobr	**mkg/g**	**mkg/g**	**mkg/g**	**mkg/g**	**mkg/g**	**mkg/g**	**mkg/g**	**mkg/g**	**mkg/g**	**mkg/g**	**er%**	**mkg/g**	**mkg/g**
KZ-02 S	5.20	52.7	27.36	2.80	1.19	0.664	1.518	8.02	1	0	100	13.06	1.90
KZ-03 S	7.50	66.07	30.93	3.10	1.393	0.834	1.786	10.93	1.1	0.008	96	15.63	2.45
KZ-04 S	8.85	64.66	35.18	3.10	1.362	0.855	2.027	9.3	1.8	0.005	100	15.04	2.15
KZ-05 S	11.80	49.92	29.04	2.55	1.102	0.671	1.603	5.82	0.8	0.005	100	11.70	1.90
KZ-06 S	4.20	46.26	20.67	2.25	1.05	0.558	1.362	6.71	0.8	0	100	9.42	1.70
KZ-07 S	6.00	51.36	22.19	2.50	1.124	0.723	1.711	6.4	0.9	0	100	12.06	2.45
KZ-08 S	6.85	56.36	24.61	2.65	1.183	0.716	1.665	6.99	1	0.012	97	13.87	2.80
KZ-09 S	7.20	53.32	23.3	2.65	1.187	0.762	1.669	6.3	0.9	0	100	12.73	2.45
KZ-10 S	6.05	50.98	24.05	2.55	1.116	0.705	1.729	6.22	0.9	0.009	92	12.35	2.00
KZ-11 S	5.35	51.78	22.68	2.55	1.106	0.686	1.711	6.38	0.9	0.02	97	12.00	2.40
KZ-12 S	7.25	48.6	21.13	2.35	1.026	0.649	1.536	4.84	0.8	0.006	99	11.93	1.85
KZ-13 S	6.15	42.7	19.34	2.35	0.952	0.575	1.273	4.81	0.7	0.007	73	10.45	2.30
KZ-15 S	3.90	41.07	19.4	2.15	0.993	0.614	1.371	6.05	0.8	0	100	9.24	1.40
Average	6.64	52	24.6	2.58	1.137	0.693	1.612	6.83	0.95	0.006	96	12.27	2.13
KzV-06	6.30	39.87	23.48	2.25	0.858	0.542	1.086	5.8	0.7	0.012	96	8.95	2.10
Av. conc. for sediments	40.0	50.0	23.0	6.5	1.00	0.30	3.00	6.00	3.5	0.400		11.0	3.2

Table 13: Radionuclide analysis of water samples, Kazakhstan (mBq/l)

Probe code	**Th-234**	**Ra-226**	**Pb-214**	**Bi-214**	**Pb-210**	**Ac-228**	**Ra-224**	**Pb-212**	**Bi-212**	**Tl-208**	**U-235**	**Th-227**	**Rn-219**	**Ra-223**	**Pb-211**	**K-40**	**Cs-137**	**Am-241**
KZ-01WD	55 ± 29	< 121	< 18	< 33.2	< 31	< 42	< 119	< 12	< 203	< 43	< 12	< 38	< 55	< 54	< 199	< 515	< 14.0	< 4.1
KZ-02WD	150 ± 15	< 49	24 ± 5	38 ± 11	< 12	25 ± 11	< 48	12 ± 4	< 70	17 ± 11	15 ± 4	< 15	< 21	< 23	< 66	< 214	< 4.9	< 1.6
KZ-03WD	170 ± 27	< 94	17 ± 8	39 ± 17	< 24	< 30	< 86	16 ± 6	< 116	35 ± 21	17 ± 6	< 26	< 35	< 40	< 127	< 397	< 7.6	< 3.0
KZ-04WD	93 ± 25	< 91	24 ± 10	40 ± 19	< 23	< 31	< 97	21 ± 7	< 118	< 35	11 ± 6	< 27	< 43	< 43	< 134	< 419	< 8.9	< 3.1
KZ-05WD	76 ± 14	< 58	33 ± 6	39 ± 12	< 13	< 19	< 54	10 ± 4	< 78	< 21	10 ± 4	< 17	< 24	< 28	< 83	< 252	< 5.2	< 1.8
KZ-06WD	62 ± 16	< 63	19 ± 7	20 ± 13	< 15	< 23	< 64	10 ± 5	< 100	31 ± 17	7 ± 5	< 20	< 28	< 31	< 100	< 300	< 6.9	< 2.3
KZ-07WD	81 ± 16	< 60	26 ± 7	34 ± 13	< 14	< 22	< 60	9 ± 4	< 83	< 20	9 ± 4	< 19	< 27	< 30	< 88	< 269	< 5.6	< 2.0
KZ-08WD	190 ± 25	< 81	16 ± 7	< 20	< 20	< 25	< 72	16 ± 5	< 110	< 26	18 ± 5	< 20	< 29	< 35	< 103	< 314	< 7.1	< 2.5
KZ-09WD	196 ± 39	< 130	18 ± 12	< 36	< 31	< 42	< 129	16 ± 9	< 155	< 42	18 ± 9	< 34	< 49	< 51	< 179	< 548	< 13.5	< 4.2
KZ-10WD	174 ± 30	< 98	< 13	< 27	< 21	< 33	< 91	19 ± 7	< 121	< 30	19 ± 7	< 29	< 41	< 43	< 117	< 411	< 9.0	< 3.0
KZ-11WD	184 ± 40	< 138	< 18	40 ± 27	< 34	< 43	< 120	17 ± 9	< 167	< 50	17 ± 9	< 37	< 55	< 56	< 188	< 560	< 11.6	< 4.3
KZ-12WD	177 ± 30	< 101	< 13	< 28	< 23	34 ± 22	< 87	12 ± 6	< 140	< 30	17 ± 7	< 25	< 40	< 37	< 127	< 420	< 8.9	< 3.3
KZ-13WD	194 ± 25	< 84	27 ± 8	34 ± 15	< 21	< 28	< 74	13 ± 6	< 111	< 28	19 ± 6	< 22	< 34	< 37	< 118	< 351	< 7.4	< 3.1
KZ-14WD	217 ± 24	< 71	12 ± 6	< 18	< 16	< 24	< 60	12 ± 5	< 94	< 23	19 ± 5	< 21	< 29	< 31	< 92	< 297	< 6.3	< 2.4
Average	144 ± 25	< 88	19 ± 5	32 ± 9	< 21	< 30	< 82	14 ± 6	< 119	< 30	15 ± 6	< 25	< 36	< 39	< 123	< 376	< 8.3	< 3

Table 14: Radionuclide content (Bq/kg) of soil samples, Kazakhstan

probe code	Th-234	Ra-226	Pb-214	Bi-214	Pb-210	Ac-228	Ra-224	Pb-212	Bi-212	Tl-208	U-235	Th-227	Ra-223	Rn-219	Pb-211	K-40	Cs-137	Am-241
Kz-02s	23 ± 4	39 ± 20	32 ± 2	28 ± 3	43 ± 5	37 ± 3	35 ± 7	40 ± 2	39 ± 8	32 ± 3	2.3 ± 1.4	3.1 ± 1.5	< 4	< 3	< 9	600 ± 30	3.0 ± 0.6	< 0.5
Kz-03s	33 ± 4	50 ± 20	39 ± 2	33 ± 2	49 ± 5	53 ± 3	56 ± 7	57 ± 2	51 ± 9	44 ± 3	1.9 ± 1.2	4.1 ± 1.7	< 4	< 4	< 9	740 ± 30	1.4 ± 0.5	< 0.6
Kz-04s	30 ± 5	42 ± 27	38 ± 2	33 ± 3	72 ± 7	49 ± 4	53 ± 9	53 ± 2	58 ± 12	43 ± 4	3.6 ± 1.6	4.2 ± 2.1	< 6	< 4	< 10	680 ± 40	4.3 ± 0.9	< 0.7
Kz-05s	27 ± 2	48 ± 12	33 ± 1	28 ± 2	76 ± 4	41 ± 2	43 ± 4	43 ± 1	38 ± 5	35 ± 2	1.9 ± 0.7	2.4 ± 1.0	< 3	2.3 ± 1.4	< 6	560 ± 20	5.5 ± 0.4	< 0.3
Kz-06s	23 ± 7	< 60	27 ± 3	25 ± 5	42 ± 9	27 ± 5	34 ± 14	31 ± 3	< 20	25 ± 5	< 3.5	< 4.6	< 8	< 7	< 20	470 ± 60	< 1.6	< 1.0
Kz-07s	32 ± 8	< 70	34 ± 3	29 ± 5	50 ± 10	42 ± 6	58 ± 17	42 ± 3	34 ± 18	36 ± 7	< 4.1	< 5.2	< 9	< 7	< 20	510 ± 60	< 1.8	< 1.2
Kz-08s	41 ± 5	54 ± 27	41 ± 2	35 ± 3	43 ± 6	46 ± 3	43 ± 9	48 ± 2	46 ± 11	38 ± 4	< 2.4	3.2 ± 2.1	< 5	< 5	< 12	610 ± 40	1.7 ± 0.7	< 0.7
Kz-09s	34 ± 7	< 60	41 ± 3	37 ± 5	48 ± 9	48 ± 5	52 ± 14	54 ± 3	46 ± 17	40 ± 6	< 3.6	< 4.5	< 8	< 7	< 17	580 ± 60	2.4 ± 1.1	< 1.0
Kz-10s	30 ± 3	43 ± 17	36 ± 2	32 ± 2	50 ± 4	40 ± 3	42 ± 6	44 ± 2	45 ± 8	34 ± 3	2.0 ± 1.0	2.6 ± 1.3	< 4	< 3	< 8	650 ± 30	3.0 ± 0.6	< 0.5
Kz-11s	31 ± 4	40 ± 23	28 ± 2	24 ± 3	36 ± 5	32 ± 3	36 ± 8	37 ± 2	36 ± 10	31 ± 3	2.9 ± 1.4	< 2.6	< 4	< 4	< 10	420 ± 40	< 0.8	< 0.6
Kz-12s	30 ± 4	62 ± 25	38 ± 2	35 ± 3	61 ± 6	44 ± 3	47 ± 9	48 ± 2	35 ± 3	38 ± 4	< 2.2	< 2.9	< 5	< 4	< 12	640 ± 40	5.1 ± 1.0	< 0.6
Kz-13s	35 ± 8	< 70	36 ± 3	33 ± 6	56 ± 10	39 ± 6	34 ± 16	42 ± 3	43 ± 20	35 ± 7	< 4.3	< 5.5	< 10	< 8	< 20	560 ± 80	3.3 ± 1.5	< 1.1
Kz-15s	21 ± 4	34 ± 20	23 ± 1	21 ± 2	43 ± 5	29 ± 3	28 ± 7	29 ± 1	30 ± 8	24 ± 3	< 1.9	< 2.4	< 4	< 4	< 10	430 ± 40	4.0 ± 0.7	< 0.5
Average	30 ± 5	46 ± 21	34 ± 2	30 ± 3	51 ± 7	41 ± 4	43 ± 10	44 ± 2	42 ± 11	35 ± 4	2.4 ± 1.2	3.3 ± 1.6	< 6	< 5	< 13	580 ± 40	3.4 ± 0.8	< 0.7

Table 15: Radionuclide content (Bq/kg) of bottom sediment samples, Kazakhstan

№ probe	Th-234	Ra-226	Pb-214	Bi-214	Pb-210	Ac-228	Ra-224	Pb-212	Bi-212	Tl-208	U-235	Th-227	Ra-223	Rn-219	Pb-211	K-40	Cs-137	Am-241
Kz-01b	50 ± 4	63 ± 20	43 ± 1	37 ± 2	72 ± 5	65 ± 3	75 ± 7	73 ± 2	64 ± 8	58 ± 3	3. 3 ± 1. 2	5.4 ± 1.5	< 4	< 3	< 9	730 ± 30	3. 6 ± 0. 6	< 0. 5
Kz-02b	18 ± 4	35 ± 10	28 ± 2	24 ± 3	25 ± 4	27 ± 3	30 ± 8	31 ± 2	26 ± 4	25 ± 3	2. 0 ± 1. 0	3.0 ± 1.0	< 3	< 2	< 5	590 ± 30	0. 4 ± 0. 2	< 0. 3
Kz-03b	31 ± 4	38 ± 20	34 ± 1	30 ± 2	39 ± 5	48 ± 3	51 ± 8	50 ± 2	44 ± 9	40 ± 3	2. 1 ± 1. 3	3.5 ± 1.7	< 4	< 4	< 10	800 ± 30	1. 1 ± 0. 5	< 0. 6
Kz-04b	33 ± 5	56 ± 30	40 ± 2	35 ± 3	42 ± 6	47 ± 3	47 ± 9	52 ± 2	50 ± 10	43 ± 4	< 2. 3	< 3	< 5	< 4	< 10	610 ± 30	1. 3 ± 0. 6	< 0. 7
Kz-05b	31 ± 3	52 ± 15	35 ± 1	31 ± 2	40 ± 3	37 ± 2	40 ± 5	39 ± 1	36 ± 6	32 ± 2	1. 7 ± 0. 9	2.6 ± 1.1	< 3	< 3	< 7	550 ± 20	0. 9 ± 0. 3	< 0. 4
Kz-06b	23 ± 2	39 ± 11	27 ± 1	23 ± 1	34 ± 2	30 ± 1	31 ± 4	32 ± 1	30 ± 4	25 ± 2	1. 7 ± 0. 6	2.8 ± 0.9	< 2	< 2	< 5	460 ± 20	2. 3 ± 0. 3	< 0. 3
Kz-07b	35 ± 5	50 ± 25	38 ± 2	36 ± 3	43 ± 5	45 ± 3	46 ± 9	48 ± 2	50 ± 10	39 ± 4	2. 8 ± 1. 5	< 3	< 5	< 3	< 10	580 ± 40	< 0. 9	< 0. 6
Kz-08b	24 ± 4	34 ± 20	32 ± 2	28 ± 2	30 ± 4	34 ± 3	36 ± 7	37 ± 1	25 ± 8	29 ± 3	< 1. 8	2.9 ± 1.6	< 4	< 3	< 10	560 ± 30	< 0. 6	< 0. 6
Kz-09b	23 ± 6	65 ± 35	31 ± 2	26 ± 4	26 ± 7	35 ± 4	45 ± 10	37 ± 2	49 ± 17	31 ± 5	< 3. 2	< 4. 3	< 7	< 6	< 20	630 ± 50	< 1. 3	< 1
Kz-10b	28 ± 5	45 ± 25	34 ± 2	31 ± 3	33 ± 5	40 ± 3	43 ± 9	42 ± 2	40 ± 10	33 ± 4	< 2. 5	3.5 ± 2.0	< 5	< 4	< 10	620 ± 30	< 0. 8	< 0. 6
Kz-11b	34 ± 5	47 ± 27	41 ± 2	35 ± 3	37 ± 5	51 ± 4	58 ± 10	57 ± 2	50 ± 10	47 ± 4	2. 9 ± 1. 6	3.3 ± 2.0	< 5	< 5	< 12	580 ± 40	1. 3 ± 0. 6	< 0. 7
Kz-12b	25 ± 3	44 ± 14	31 ± 1	29 ± 2	30 ± 3	36 ± 2	41 ± 5	39 ± 1	37 ± 6	30 ± 2	1. 4 ± 0. 8	2.7 ± 1.1	< 3	< 3	< 6	600 ± 30	< 0. 4	< 0. 4
Kz-13b	29 ± 4	38 ± 20	36 ± 2	33 ± 3	37 ± 5	44 ± 3	48 ± 8	45 ± 2	42 ± 9	34 ± 3	< 1. 9	3.6 ± 1.7	< 5	< 4	< 10	570 ± 40	< 0. 7	< 0. 6
Kz-15b	9 ± 5	< 42	10 ± 2	9 ± 3	17 ± 6	13 ± 3	< 13	12 ± 2	< 18	9 ± 3	< 2. 6	< 3. 4	< 6	< 6	< 16	330 ± 60	< 1. 1	< 0. 8
Average	28 ± 4	46 ± 20	33 ± 2	29 ± 3	36 ± 5	40 ± 3	43 ± 7	42 ± 2	40 ± 8	34 ± 3	2.3 ± 1.1	3.4 ± 0.9	< 4	< 4	< 10	590 ± 30	1.0 ± 0.5	< 0.6

Table 16: Radionuclide analysis of soil samples, Uzbekistan (Bq/kg)

Probe	**Th-234**	**Ra-226**	**Pb-214**	**Bi-214**	**Pb-210**	**Ac-228**	**Ra-224**	**Pb-212**	**Bi-212**	**Tl-208**	**U-235**	**Th-227**	**Rn-219**	**Ra-223**	**Pb-211**	**Cs-137**	**K-40**	**Am-241**
UZ0100S	38.9 ± 10.0	< 87	55.9 ± 4.4	50.8 ± 7.7	45 ± 12	64.0 ± 8.2	73 ± 22	66.2 ± 4.4	71 ± 28	62 ± 10	< 5.3	< 7.4	< 10	< 13	< 31	< 2.1	425 ± 70	< 1.3
UZ0200S	29.7 ± 4.7	47 ± 27	39.8 ± 2.0	34.8 ± 3.4	33.0 ± 5.7	44.6 ± 3.6	54 ± 10	49.8 ± 2.0	52 ± 13	40.3 ± 4.4	2.6 ± 1.6	< 3.5	< 5.0	< 5.5	< 13	< 0.9	478 ± 37	< 0.6
UZ0300S	21.0 ± 7.3	< 62	27.1 ± 3.1	22.5 ± 5.5	29.8 ± 9.6	28.0 ± 5.8	24 ± 15	29.3 ± 2.9	41 ± 22	25.0 ± 6.6	< 3.9	< 5.8	< 8.0	< 10	< 24	2.3 ± 1.4	529 ± 72	< 1.0
UZ0400S	25.5 ± 1.9	45 ± 12	35.4 ± 0.8	30.5 ± 1.5	38.2 ± 2.6	39.7 ± 1.6	39.9 ± 4.3	41.5 ± 0.8	37.5 ± 5.2	34.6 ± 1.8	2.0 ± 0.7	2.0 ± 1.0	< 2.1	< 2.5	< 5.7	1.9 ± 0.3	649 ± 19	< 0.3
UZ0500S	27.6 ± 4.1	15.0 ± 8.2	36.7 ± 1.8	32.2 ± 3.1	35.0 ± 5.3	34.0 ± 3.1	45.6 ± 8.9	36.9 ± 1.6	37 ± 11	29.9 ± 3.7	2.4 ± 0.8	3.7 ± 2.1	< 4.5	< 4.9	< 12	1.8 ± 0.7	518 ± 36	< 0.6
UZ0600S	20.9 ± 7.7	< 68	28.6 ± 3.1	23.8 ± 5.4	31 ± 10	34.1 ± 6.0	37 ± 17	38.8 ± 3.2	38 ± 22	32.7 ± 7.1	< 4.0	< 6.3	< 8.3	< 9.1	< 26	< 1.4	746 ± 79	< 1.1
UZ0700S	136.2 ± 9.2	269 ± 53	170.0±4.0	147.1± 6.6	216 ± 13	112.7 ± 5.8	115 ± 16	120.4 ± 3.2	107 ± 19	99.6 ± 7.0	7.6 ± 2.9	11.6 ± 3.9	8.1 ± 5.3	< 9.4	< 21	4.7 ± 1.2	1195 ± 57	< 1.1
UZ0800S	63 ± 15	< 130	72.0 ± 6.0	62 ± 10	100 ± 21	118 ± 13	130 ± 34	126.2 ± 7.1	115 ± 42	100 ± 15	< 7.7	< 11	< 16	< 18	< 39	< 3.5	1249±125	< 2.2
UZ0900S	40.7 ± 5.0	29.7 ± 9.4	47.8 ± 1.9	42.6 ± 3.4	54.9 ± 6.4	80.6 ± 4.1	90 ± 11	83.3 ± 2.3	80 ± 13	67.3 ± 4.8	4.7 ± 0.9	4.2 ± 2.4	< 4.7	< 5.9	< 14	3.7 ± 0.9	974 ± 43	< 0.7
UZ1000S	34 ± 12	< 30	47.6 ± 4.9	41.6 ± 8.7	83 ± 18	65.8 ± 10.0	72 ± 27	63.7 ± 5.1	62 ± 33	52 ± 11	5.0 ± 1.8	< 8.9	< 12	< 14	< 38	< 2.7	842 ± 107	< 1.5
UZ1100S	31 ± 11	< 34	40.6 ± 4.9	32.0 ± 8.5	58 ± 16	60 ± 10	59 ± 27	61.3 ± 5.3	80 ± 37	51 ± 12	3.5 ± 1.9	< 8.7	< 12	< 16	< 42	< 3.6	637 ± 104	< 1.4
UZ1200S	33 ± 11	< 31	35.5 ± 4.2	30.9 ± 7.5	38 ± 13	59.9 ± 9.2	56 ± 24	60.4 ± 4.8	54 ± 31	48 ± 11	< 2.5	< 8.5	< 11	< 13	< 34	< 2.1	855 ± 105	< 1.5
Average	42 ± 8	34 ± 9	53 ± 3	46 ± 6	64 ± 11	62 ± 7	66 ± 17	65 ± 3.6	65 ± 23	54 ± 8	3.97 ± 1.5	1.8 ± 0.8	< 8.4	< 10	< 25	2.88±0.9	758 ± 71	< 1.1

Table 17: Radionuclide analysis of bottom sediment samples, Uzbekistan (Bq/kg)

Probe	**Th-234**	**Ra-226**	**Pb-214**	**Bi-214**	**Pb-210**	**Ac-228**	**Ra-224**	**Pb-212**	**Bi-212**	**Tl-208**
UZ-01 B	34.0 ± 9.2	< 84	51.0 ± 4.1	46.2 ± 6.9	44 ± 12	66.7 ± 7.8	59 ± 20	66.7 ± 4.2	66 ± 26	56.4 ± 9.1
UZ-02 B	22.5 ± 9.0	< 88	36.6 ± 4.2	35.1 ± 7.5	42 ± 13	45.8 ± 8.2	37 ± 21	52.3 ± 4.4	64 ± 30	40.9 ± 9.8
UZ-03 B	31.9 ± 7.8	< 71	39.9 ± 3.4	39.8 ± 6.3	42 ± 10	53.6 ± 6.7	55 ± 18	58.0 ± 3.6	53 ± 22	44.1 ± 8.0
UZ-04 B	20.5 ± 1.8	41 ± 11	29.2 ± 0.8	25.2 ± 1.4	30.5 ± 2.5	31.7 ± 1.5	36.9 ± 4.1	34.1 ± 0.8	33.0 ± 5.0	29.0 ± 1.8
UZ-05 B	56.5 ± 4.1	46 ± 23	35.8 ± 1.5	32.3 ± 2.6	31.0 ± 4.1	46.6 ± 2.9	36.4 ± 7.2	31.5 ± 1.3	27.5 ± 8.5	27.6 ± 3.0
UZ-06 B	19.8 ± 1.8	37 ± 11	27.6 ± 0.7	24.0 ± 1.3	27.5 ± 2.4	28.9 ± 1.4	30.5 ± 3.8	31.7 ± 0.7	31.6 ± 4.6	26.4 ± 1.6
UZ-07 B	89 ± 13	157 ± 76	105.6 ± 5.5	97.2 ± 9.4	111 ± 17	120.6 ± 9.9	123 ± 27	121.8 ± 5.4	127 ± 33	99 ± 12
UZ-08 B	75.1 ± 4.4	110 ± 25	85.2 ± 1.8	75.8 ± 3.0	109.0 ± 5.9	116.2 ± 3.5	132.3 ± 9.4	122.2 ± 1.9	117 ± 11	102.9 ± 4.1
UZ-08 B	76.7 ± 3.4	114 ± 19	87.1 ± 1.4	75.5 ± 2.3	104.1 ± 4.5	119.4 ± 2.7	128.5 ± 7.2	121.6 ± 1.5	120.5 ± 8.7	99.9 ± 3.1
UZ-09 B	83.2 ± 6.0	158 ± 38	87.8 ± 2.6	78.7 ± 4.4	153.0 ± 8.6	221.1 ± 6.5	135 ± 14	132.2 ± 2.9	139 ± 18	105.8 ± 6.1
UZ-09 B	84.4 ± 7.3	132 ± 46	91.8 ± 3.2	84.3 ± 5.4	147 ± 10	222.2 ± 7.8	144 ± 17	140.6 ± 3.5	133 ± 21	118.3 ± 7.7
UZ-10 B	29 ± 11	< 99	39.0 ± 4.6	32.2 ± 7.9	62 ± 16	65.0 ± 9.9	70 ± 25	59.6 ± 5.0	59 ± 33	49 ± 11
UZ-11 B	35.1 ± 3.8	53 ± 22	40.3 ± 1.5	34.8 ± 2.6	45.9 ± 5.0	57.8 ± 3.1	66.4 ± 8.5	62.2 ± 1.7	56 ± 10	48.4 ± 3.6
UZ-11 B	33.6 ± 4.6	46 ± 27	41.7 ± 1.9	37.8 ± 3.3	49.2 ± 6.2	60.8 ± 3.9	64 ± 10	62.4 ± 2.1	62 ± 13	48.2 ± 4.4
UZ-12 B	23 ± 10	< 97	31.6 ± 4.3	26.7 ± 7.5	31 ± 13	50.4 ± 9.3	35 ± 23	51.6 ± 4.8	< 43	42 ± 11
Average	48 ± 7	78 ± 21	55 ± 3	50 ± 5	69 ± 9	87 ± 6	77 ± 14	76 ± 3	75 ± 16	62 ± 6

Probe	**U-235**	**Th-227**	**Ra-223**	**Rn-219**	**Pb-211**	**K-40**	**Am-241**	**Cs-137**
UZ-01 B	< 4.8	< 7.0	< 10	< 9.9	< 27	462 ± 67	< 1.2	< 2.2
UZ-02 B	< 5.2	< 7.6	< 12	< 11	< 34	501 ± 85	< 1.3	< 2.5
UZ-03 B	< 4.2	< 6.5	< 9.9	< 8.6	< 23	588 ± 70	< 1.0	< 2.0
UZ-04 B	< 1.0	1.9 ± 1.0	< 2.3	< 2.0	< 5.7	630 ± 19	< 0.3	1.3 ± 0.3
UZ-05 B	3.8 ± 1.3	< 2.4	< 4.4	< 3.5	< 9.9	420 ± 28	< 0.4	1.3 ± 0.6
UZ-06 B	1.4 ± 0.6	< 1.4	< 2.2	< 1.9	< 5.4	616 ± 18	< 0.2	< 0.4
UZ-07 B	6.7 ± 4.4	9.6 ± 6.2	< 15	< 12	< 34	1365 ± 101	< 1.7	3.4 ± 1.9
UZ-08 B	5.3 ± 1.4	6.1 ± 2.0	< 5.0	4.4 ± 2.8	< 11	1321 ± 35	< 0.6	2.7 ± 0.6
UZ-08 B	4.7 ± 1.1	5.9 ± 1.5	4.0 ± 2.6	< 3.2	< 8.3	1316 ± 27	< 0.4	2.8 ± 0.5
UZ-09 B	6.3 ± 2.2	5.1 ± 2.9	< 7.7	< 6.4	< 16	623 ± 38	< 0.7	2.6 ± 0.9
UZ-09 B	4.9 ± 2.6	5.8 ± 3.5	< 9.7	< 7.2	< 21	632 ± 46	< 0.9	2.7 ± 1.1
UZ-10 B	< 5.7	< 8.8	< 15	< 12	< 36	694 ± 100	< 1.4	< 3.0
UZ-11 B	< 2.0	3.1 ± 1.9	< 4.6	< 3.9	< 10	759 ± 34	< 0.5	1.0 ± 0.6
UZ-11 B	2.7 ± 1.6	< 3.5	< 5.7	< 4.5	< 13	774 ± 42	< 0.6	< 1.0
UZ-12 B	< 5.9	< 8.8	< 13	< 11	< 36	832 ± 110	< 1.5	< 2.6
Average	4 ± 2	6 ± 3	< 8	< 7	< 20	770 ± 55	< 0.8	2 ± 1

Table 18: Radionuclide analysis of soil samples, Kyrgyzstan

	Th234	**Ra226**	**Pb214**	**Bi214**	**Pb210**	**Ac228**	**Pb212**	**Bi212**	**Tl208**	**K40**	**Cs137**
kodobr	**Bq/kg**	**Bq/kg**	**Bq/kg**	**Bq/kg**	**Bq/kg**	**Bq/kg**	**Bq/kg**	**Bq/kg**	**Bq/kg**	**Bq/kg**	**Bq/kg**
kg0100s	63 ± 31	49 ± 2	53 ± 2	51 ± 3	< DL	70 ± 3	75 ± 2	73 ± 9	82 ± 7	910 ± 30	< DL
kg0200s	< DL	26 ± 1	25 ± 2	25 ± 3	< DL	48 ± 3	50 ± 2	55 ± 10	48 ± 6	800 ± 30	1.0 ± 0.6
kg0300s	38 ± 24	36 ± 2	38 ± 2	38 ± 3	< DL	58 ± 3	62 ± 2	64 ± 11	43 ± 8	750 ± 30	3.8 ± 0.7
kg0400s	< DL	25 ± 2	28 ± 2	21 ± 2	< DL	30 ± 2	34 ± 2	42 ± 8	31 ± 6	320 ± 20	< DL
kg0500s	58 ± 13	35 ± 1	37 ± 1	32 ± 2	< DL	45 ± 1	50 ± 1	46 ± 5	50 ± 3	710 ± 20	37.9 ± 0.7
kg0601s	< DL	34 ± 2	36 ± 2	31 ± 3	< DL	78 ± 3	76 ± 2	68 ± 9	73 ± 7	1240 ± 40	3.3 ± 0.7
kg0701s	61 ± 12	38 ± 1	41 ± 1	34 ± 1	52 ± 36	47 ± 1	55 ± 1	50 ± 4	55 ± 3	750 ± 10	3.2 ± 0.2
kg0801s	30 ± 13	38 ± 1	43 ± 1	32 ± 1	< DL	46 ± 1	49 ± 1	48 ± 4	42 ± 3	950 ± 10	1.7 ± 0.3
kg0901s	51 ± 24	45 ± 1	50 ± 2	46 ± 3	< DL	58 ± 3	62 ± 2	58 ± 9	65 ± 5	970± 30	1.3 ± 0.4
kg1001s	19 ± 12	38 ± 1	42 ± 1	38 ± 1	< DL	43 ± 1	44 ± 1	44 ± 4	45 ± 3	470 ± 10	2.5 ± 0.2
kg1101s	32 ± 20	45 ± 1	49 ± 2	42 ± 3	< DL	31 ± 2	33 ± 2	27 ± 7	30 ± 5	570 ± 20	3.0 ± 0.6
kg1201s	23 ± 6	21 ± 1	25 ± 1	16 ± 2	46 ± 6	22 ± 2	22 ± 4	15 ± 5	23 ± 3	430 ± 20	3.2 ± 0.4
kg1301s	36 ± 20	25 ± 2	30 ± 2	28 ± 2	< DL	39 ± 2	39 ± 2	38 ± 8	26 ± 6	810 ± 20	0.9 ± 0.4
kg1401s	11 ± 4	28 ± 1	32 ± 2	20 ± 5	74 ± 10	27 ± 2	28 ± 7	28 ± 6	36 ± 5	450 ± 20	3.7 ± 0.5
kg1501s	14 ± 5	12 ± 1	13 ± 1	8 ± 1	16 ± 5	16 ± 1	19 ± 4	8 ± 4	18 ± 3	390 ± 20	2.1 ± 0.4
Average	36 ± 15	33 ± 1	36 ± 2	31 ± 2	47 ± 14	44 ± 2	47 ± 2	44 ± 7	44 ± 5	700 ± 20	4.5 ± 0.4

Table 19: Radionuclide analysis of bottom sediment samples, Kyrgyzstan

	Th234	**Ra226**	**Pb214**	**Bi214**	**Pb210**	**Ac228**	**Pb212**	**Bi212**	**Tl208**	**K40**	**Cs137**
kodobr	**Bq/kg**	**Bq/kg**	**Bq/kg**	**Bq/kg**	**Bq/kg**	**Bq/kg**	**Bq/kg**	**Bq/kg**	**Bq/kg**	**Bq/kg**	**Bq/kg**
kg1101b	45 ± 11	26 ± 1	26 ± 1	22 ± 1	< DL	23 ± 1	28 ± 1	30 ± 4	31 ± 3	550 ± 10	1.4 ± 0.2
kg1201b	43 ± 12	33 ± 1	36 ± 1	34 ± 1	< DL	27 ± 1	33 ± 1	46 ± 4	38 ± 3	700 ± 10	1.3 ± 0.2
kg1301b	13 ± 4	15± 1	20 ± 1	10 ± 2	< DL	11 ± 1	13 ± 5	17 ± 4	10 ± 6	400 ± 20	1.2 ± 0.3
kg1401b	< DL	27± 1	33 ± 2	24 ± 2	< DL	32 ± 2	36 ± 1	30 ± 8	26 ± 5	820 ± 20	0.8 ± 0.4
kg1501b	28 ± 7	36 ± 1	42 ± 2	25 ± 3	40 ± 7	44 ± 2	48± 7	46 ± 7	38 ± 5	550 ± 20	1.3 ± 0.4
Average	26 ± 7	27 ± 1	31 ± 1	23 ± 2	40 ± 7	28 ± 2	32 ± 3	33 ± 6	29 ± 4	610 ± 20	1.2 ± 0.3

* DL – Detection Limit

Table 20: Radionuclide analysis of water samples, Kyrgyzstan

	Th234	**Ra226**	**Pb214**	**Bi214**	**Pb210**	**Ac228**	**Pb212**	**Bi212**	**Tl208**	**K40**	**Cs137**
kodobr	**mBq/l**	**mBq/l**	**mBq/l**	**mBq/l**	**mBq/l**	**mBq/l**	**MBq/l**	**mBq/l**	**mBq/l**	**mBq/l**	**mBq/l**
kg0100wd	< DL	< DL	< DL	< DL	< DL	1.1 ± 0.7	< DL	< DL	< DL	< DL	< DL
kg0200wd	< DL	3.8 ± 0.6	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL
kg0300wd	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL
kg0400wd	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL
kg0500wd	14 ± 7	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL	67 ± 15	< DL
kg0601wd	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL
kg0701wd	< DL	< DL	0.6 ± 0.4	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL
kg0801wd	10 ± 5	2.4 ± 0.5	< DL	< DL	< DL	< DL	< DL	< DL	< DL	82 ± 10	< DL
kg0901wd	9 ± 5	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL	35 ± 12	< DL
kg1001wd	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL
kg1101wd	< DL	< DL	< DL	1.9 ± 0.8	< DL	< DL	< DL	< DL	< DL	< DL	< DL
kg1201wd	1.3 ± 0.9	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL
kg1301wd	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL
kg1401wd	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL
kg1501wd	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL

Table 21: Radionuclide analysis of soil samples, Tajikistan

	Th234	**Ra226**	**Pb214**	**Bi214**	**Pb210**	**Ac228**	**Pb212**	**Bi212**	**Tl208**	**K40**	**Cs137**
kodobr	**Bq/kg**	**Bq/kg**	**Bq/kg**	**Bq/kg**	**Bq/kg**	**Bq/kg**	**Bq/kg**	**Bq/kg**	**Bq/kg**	**Bq/kg**	**Bq/kg**
tj0200s	37 ± 7	44 ± 1	51 ± 2	32 ± 3	< DL	57 ± 2	64 ± 6	77 ± 8	50 ± 6	620 ± 20	3 ± 0.5
tj0300s	72 ± 18	54 ± 1	62 ± 1	49 ± 1	< DL	92 ± 2	103 ± 1	95 ± 6	91 ± 3	890 ± 10	12.8 ± 0.5
tj0400s	65 ± 14	59 ± 1	66 ± 1	55 ± 2	< DL	102 ± 2	108 ± 1	98 ± 5	98 ± 4	870 ± 10	3 ± 0.3
tj0500s	66 ± 8	78 ± 1	90 ± 2	70 ± 3	82± 10	108 ± 3	107 ± 9	120 ± 9	90 ± 7	610 ± 20	< DL
tj0600s	< DL	31 ± 1	37 ± 2	26 ± 2	< DL	47 ± 2	42 ± 2	44 ± 7	49 ± 5	690 ± 20	1.7 ± 0.4
tj0700s	< DL	33 ± 1	39 ± 2	37 ± 2	< DL	40 ± 2	39 ± 2	37 ± 7	33 ± 5	540 ± 20	3.6 ± 0.5
tj0900s	< DL	37 ± 2	42 ± 2	36 ± 3	< DL	47 ± 2	49 ± 1	56 ± 7	51 ± 5	790 ± 20	2.6 ± 0.4
tj1000s	52 ± 25	33 ± 1	35 ± 2	40 ± 2	< DL	38 ± 2	42 ± 2	43 ± 8	43 ± 5	450 ± 20	10.1 ± 0.8
tj1300s	74 ± 17	41 ± 1	45 ± 2	34 ± 3	< DL	34 ± 2	47 ± 2	54 ± 8	40 ± 6	640 ± 30	14.6 ± 0.8
tj1400s	48 ± 16	70 ± 1	79 ± 2	68 ± 2	< DL	98 ± 2	106 ± 1	112 ± 7	98 ± 5	770 ± 20	5.7 ± 0.4
tj1500s	86 ± 30	60 ± 2	67 ± 3	47 ± 4	< DL	57 ± 3	61 ± 2	72 ± 10	57 ± 6	740 ± 30	9.6 ± 0.8
Average	62 ± 17	49 ± 1	56 ± 2	45 ± 2		66 ± 2	70 ± 2	74 ± 7	64 ± 5	690 ± 20	6.7 ± 0.5

Table 22: Radionuclide analysis of bottom sediment samples, Tajikistan

	Th234	**Ra226**	**Pb214**	**Bi214**	**Pb210**	**Ac228**	**Pb212**	**Bi212**	**Tl208**	**K40**	**Cs137**
kodobr	**Bq/kg**	**Bq/kg**	**Bq/kg**	**Bq/kg**	**Bq/kg**	**Bq/kg**	**Bq/kg**	**Bq/kg**	**Bq/kg**	**Bq/kg**	**Bq/kg**
tj0200b	52 ± 28	52 ± 2	62 ± 2	50 ± 3	< DL	120 ± 4	131 ± 3	132 ± 11	121 ± 8	930 ± 30	3.8 ± 0.5
tj0300b	< DL	45 ± 2	46 ± 2	33 ± 3	< DL	62 ± 2	69 ± 2	67 ± 9	53 ± 6	1100 ± 30	1.7 ± 0.5
tj0400b	< DL	47 ± 1	52± 2	50 ± 2	< DL	65 ± 3	77 ± 2	73 ± 8	65 ± 6	790 ± 20	5.5 ± 0.6
tj0500b	49 ± 16	45 ± 1	48 ± 1	42 ± 2	< DL	64 ± 2	65 ± 1	73 ± 6	56 ± 4	840 ± 20	4.6 ± 0.4
tj0600b	13 ± 4	15 ± 1	19 ± 1	9 ± 2	44± 6	21 ± 1	22 ± 4	15 ± 4	22 ± 3	350 ± 20	3.5 ± 0.4
tj0700b	16 ± 10	31 ± 1	33 ± 1	30 ± 1	< DL	34 ± 1	39 ± 1	47 ± 4	33 ± 2	420 ± 10	0.4 ± 0.1
tj0900b	24 ± 16	30 ± 1	32 ± 1	28 ± 2	< DL	43 ± 2	42 ± 1	40 ± 5	33 ± 3	590 ± 10	1.6 ± 0.2
tj1000b	< DL	30 ± 1	32 ± 2	30 ± 2	< DL	30 ± 2	34 ± 1	21 ± 7	26 ± 5	330 ± 20	0.6 ± 0.4
tj1300b	42 ± 16	49 ± 1	56 ± 1	48 ± 1	< DL	54 ± 2	57 ± 1	61 ± 5	65 ± 3	650 ± 10	2.1 ± 0.2
tj1400b	140 ± 17	57 ± 1	64 ± 1	54 ± 2	< DL	59 ± 2	59 ± 1	66 ± 5	65 ± 4	720 ± 10	4.7 ± 0.3
tj1500b	41 ± 7	44 ± 1	49 ± 2	32 ± 3	52 ± 9	39 ± 2	40 ± 5	48 ± 6	39 ± 4	460 ± 20	1.1 ± 0.3
Average	47 ± 14	40 ± 1	45 ± 1	37 ± 1	-	54 ± 2	58 ± 2	58 ± 6	53 ± 4	650 ± 20	2.7 ± 0.3

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Uzbekistan

1. Introduction

The experiment, named NAVRUZ (meaning “new beginning”), monitors basic water quality parameters, radionuclides and metals in the Syrdarya and the Amudarya rivers, and their major tributaries. These rivers are crucial for domestic, agricultural and industrial use throughout Central Asia.

This experiment is aimed at serving three main objectives:

- Understanding of the severity and location of heavy metal, radionuclide and other contaminates in the major rivers of Central Asia
- Facilitating the development of scientific methodology for cooperation and understanding of transboundary resource issues. This is a precursor to cooperative, transboundary natural resource management.
- Facilitating regional scientific cooperation and collaboration in these newly independent republics of the former Soviet Union. This helps improve regional relationships and promote cooperation on difficult issues that would enhance security and stability in Central Asia.

Participating countries, the Central Asian states of Kazakhstan, Uzbekistan, Kyrgyzstan and Tajikistan, are collecting water, bottom sediment, vegetation and soil samples from a total of 60 stations along the rivers. These samples are then sent to laboratories in Kazakhstan, Uzbekistan and the United States for analysis.

The project partner in Uzbekistan is the Institute of Nuclear Physics in Tashkent. Photographs of the Institute Director and the Project Manager are included as figures 1 and 2.

Figure 2. Project Manager B.S.Yuldashev

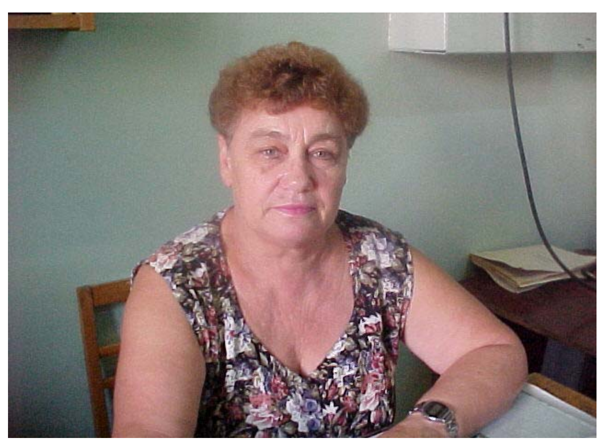

Figure 3. Project Supervisor R.I. Radyuk

2. Sampling Locations

Five major watersheds have been identified for sample collection sites in Uzbekistan. Each watershed is presented below with their corresponding sites for a total of 15 sites.

Amudarya River (Tuyamuyun, Kyzyldzhar and Kipchak – in Lower Amudarya)
This site selection is due to the availability of various industrial activities including uranium mining. Water sampling will be conducted in the watershed of the Amudarya River. The uses of this river's resources are multiple: irrigation, hydropower plants, industrial purposes, and as a water supply. The water system is polluted from the dumping of agriculture wastewater (mainly from Turkmenistan), and drainage waters from the cities of Termez and Nukus.

Sampling sites at Amudarya river will be located at existing meteorological stations.
Site 1: Kyzyldzhar village, Karakalpakstan, 1 km above the terminating range of the Amudarya River (the nearest town is Kungrad).
Site 2: Kipchak town, Karakalpakstan, 0.5 km above the town.
Site 3: Tuyamuyun site, 8 km below the dam (Khorezm region).

Syrdarya River (Chinaz, Bekabad and Karadarya)
The water uses of this river resource include, irrigation, industrial purposes, and a water supply. There are many industrial activities in this watershed and their resultant sewage effluent has an impact on water resources. Among these enterprises are Chirchik-"Elektrokhimprom," the Altyaryk oil processing factory, fiber crops plants, sewage disposals and the factories of Angren, Almalyk, Gazalkent, Chirchik, Tashkent, and Chinaz.

Sampling sites at Syrdarya river will be at existing meteorological stations

Site 4: Karadarya River, Namangan region, 20 km southwest from Namangan, at Kol' village. The meteorological post is below the merging point of Karadarya and Naryn rivers with Syrdarya River.
Site 5: Bekabad, Tashkent region, 0.9 km below the dump of drainage waters of "Vodokanal" enterprise.
Site 6: Chinaz town, Tashkent region, 3.5 km SSW from Chinaz.

Akhangaran River (Tuyabuguz, Angren, Yangiabad)
The basin of the Akhangaran River is a tributary of Syrdarya River. Sampling sites at the Akhangaran River will be located at existing meteorological stations.
Site 7: Yangiabad town, Tashkent region, 5.5 km below Dukant village.
Site 8: Angren town, Tashkent region, 5.5 km below the Angren dam.
Site 9: Tuyabuguz, Tashkent region, Soldatskoe village, 0.5 km above the outfall of the Akhangaran River.

Chirchik River (Gazalkent, Kibraj, Zangiota)
The Chirchik River basin, one of Syrdarya River’s tributaries, receives effluent from industrial and private sewage and drainage waters. Sampling sites at the Chirchik river will be located at existing meteorological stations.
Site 10: Gazalkent town, Tashkent region, 3.5 km below the town.
Site 11: Kibraj village, Tashkent region, 3 km below the UZKTZhM enterprise sewage effluent.
Site 12: Tashkent City, Tashkent region, 3 km below the sewage effluent from the Segeli KSM plant.

Zaravshan River (Ravatkhodzha, Kattakurgan, Navoi)
The Zarafshan River is related to the Amudarya river basin. Sampling sites at the Zarafshan river will be on existing meteorological stations. (Note: Sampling from Zarafshan river sites will not be done in the present stage of the Navruz experiment. In the future, if the monitoring experiment is extended, these sites will be included in the sampling.)
Site 13: Ravatkhodzha, Samarkand region, 3.7 km below the outfall of the Taligulyan dump.
Site 14: Kattakurgan, Samarkand region, 0.8 km below the outfall of the Chegonak collector.
Site 15: Navoi City, Navoi region, 0.8 km below the sewage effluent from “NavoiAzot” enterprise.

Figure 4. Sampling Locations

Data from this project are being posted on an Internet site as they become available for use by the participants, scientists, and the public worldwide. The web address is: www.cmc.sandia.gov/Central/centralasia.html. The complete Sampling and Analysis Plan is also available at the above address.

Figure 5. Water sampling on Chirchik River

Figure 6. Sampling of bottom sediment. Syr-Darya, Chinaz

Figure 7. Chemical determination HYDROLAB. parameters using Chirchik River

3. Hydrolab Field Data Collection Log

ame: Radyuk R.I., Vdovina E.D.	Project Name: Navruz
erial number:	Institution: Institute of Nuclear Physics, Uzbekistan

Ec= Electrical Conductivity measured in microSimtns per cm

ORP= Oxidation Reduction Potencial measured in millivolts DO% =Dissolved Oxygen, % of total saturation

Hydrolab Measurements

GPS Lattitude/ Longitude	Date/Time	Pressure, mm.	Temp.(^{0}C)	DO %	DO (mg/l)	EC	Salinity (g/l)	TDS (mg/l)	Depth	pH	ORP (mV)	Color
$42^0\ 22^1 37$ $59^0 35^1 23$	09.11.00 02:19:30	770.0	3.15	93.3	11.70	1941	1.04	1.242	1.1	8.22	321	turbid
$42^0 13^1 48$ $60^0 06^1 60$	09.11.00 12:30:11	770.1	2.16	95.8	12.35	1799	0.96	1.152	1.1	8.19	329	turbid
$41^0 12^1 98$ $61^0 20^1 18$	09.11.00 08:43.55	769.5	4.61	91.8	11.08	1790	0.95	1.146	0.9	8.15	342	turbid
$40^0 50^1 62$ $71^0 06^1 06$	02.11.00 11:15:57	738.6	12.66	92.0	9.19	795.8	0.41	-5093	0.5	8.05	374	no trans-parent
$40^0 13^1 73$ $69^0 14^1 91$	17.10.00 10:45:00	746.8	12.80	105.6	10.45	221.9	1.19	1.420	0.9	7.81	388	transpa-rent
$40^0 54^1 16$ $68^0 41^1 85$	24.10.00 11:30:00	744.4	12.96	100.1	9.89	1798	0.96	1.151	0.8	8.05	344	turbid
$40^0 59^1 46$ $69^0 17^1 64$	19.10.00 10:09:38	675.3	9.42	91.3	9.84	188.9	0.09	-1209	0.1	8.00	365	turbid
$40^0 58^1 04$ $70^0 03^1 19$	19.10.00 11:23:31	696.8	11.18	92.8	9.54	218.4	0.10	-1398	0	7.97	363	turbid
$40^0 23^1 16$ $69^0 15^1 22$	17.10.00 02:09:58	738.9	16.8	100.4	9.29	686.7	0.35	-4395	0.6	8.31	359	turbid
$41^0 22^1 56$ $69^0 31^1 71$	11.10.00 10:35:00	706.2	12.55	93.9	9.4	220.4	0.10	-1410	0.2	7.91	416	transpa-rent
$41^0 22^1 56$ $69^0 31^1 70$	10.10.00 14:48:47	716.3	20.5	133.1	11.28	384.6	0.19	-2962	0.3	8.54	355	-”-”-”-
$41^0 24^1 42$ $69^0 23^1 65$	10.10.00 12:15:42	723.5	17.4	143.1	12.9	492.0	0.25	-3148	0.4	8.79	336	-”-”-”-

Flow Meter Discharge

Point collection	Velocity m/s autumn	Discharge m^3/s autumn	Velocity m/s spring	Discharge m^3/s spring
Uz-01	0.15	4.29	0.06	3.06
Uz-02	0.26	79.0	0.47	119
Uz-03	0.25	89.0	0.44	116
Uz-04	0.32	248.0	0.55	195
Uz-05	0,13	51.3	0.05	19.5
Uz-06	0.27	114.0	0.27	286
Uz-07	0.63	3.21	1.8	9.87
Uz-08	0.68	30.2	0.43	17.5
Uz-09	0.20	2.66	1.03	10.4
Uz-10	1.06	113.0	1.42	21.4
Uz-11	0.21	2.48	0.49	24.9
Uz-12	0.03	0.33	0.43	22.9
Uz-13	-	-	1.87	23.5
Uz-14	-	-	0.87	18.0
Uz-15	-	-	0.18	10.4

Figure 8. Flow discharge measurements using FLOWMETER. Chirchik River.

4. Preliminary Results:

For sampling methodology, please consult the sampling and analysis plan located on the project's web page.

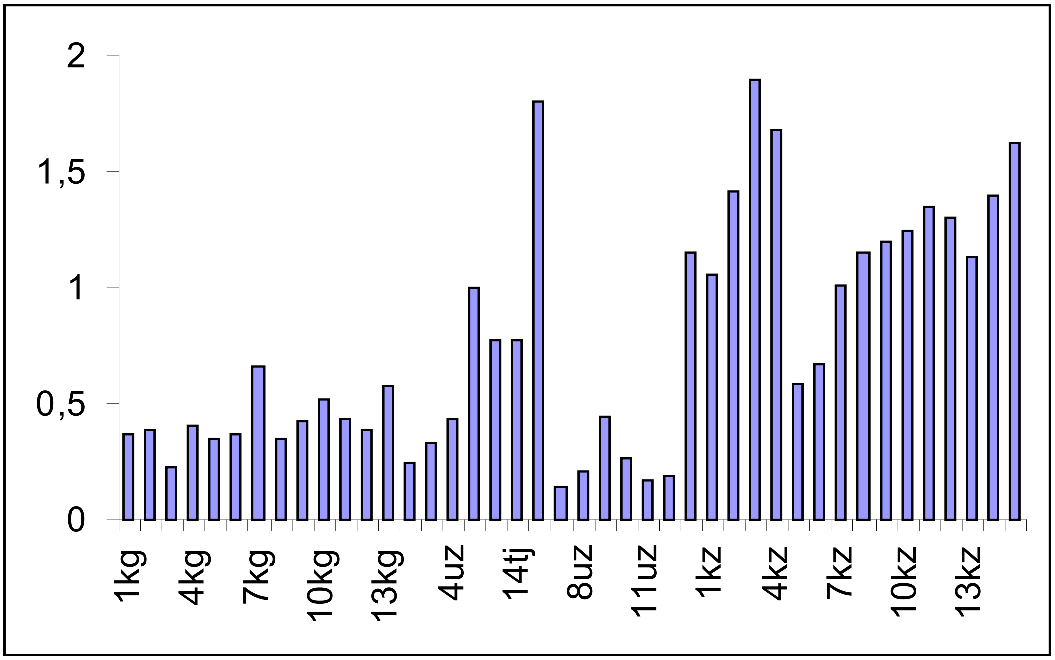

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Figure 9. Flow discharge measurements using FLOWMETER. Chirchik River.

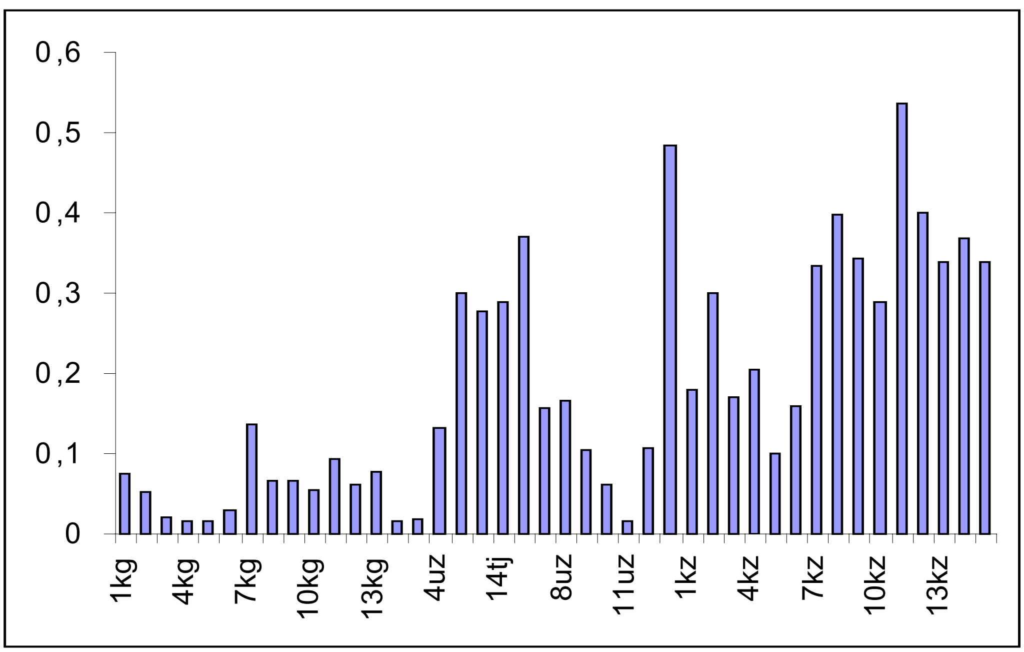


Figure 10. Water Specific beta-activity, Syr Darya River

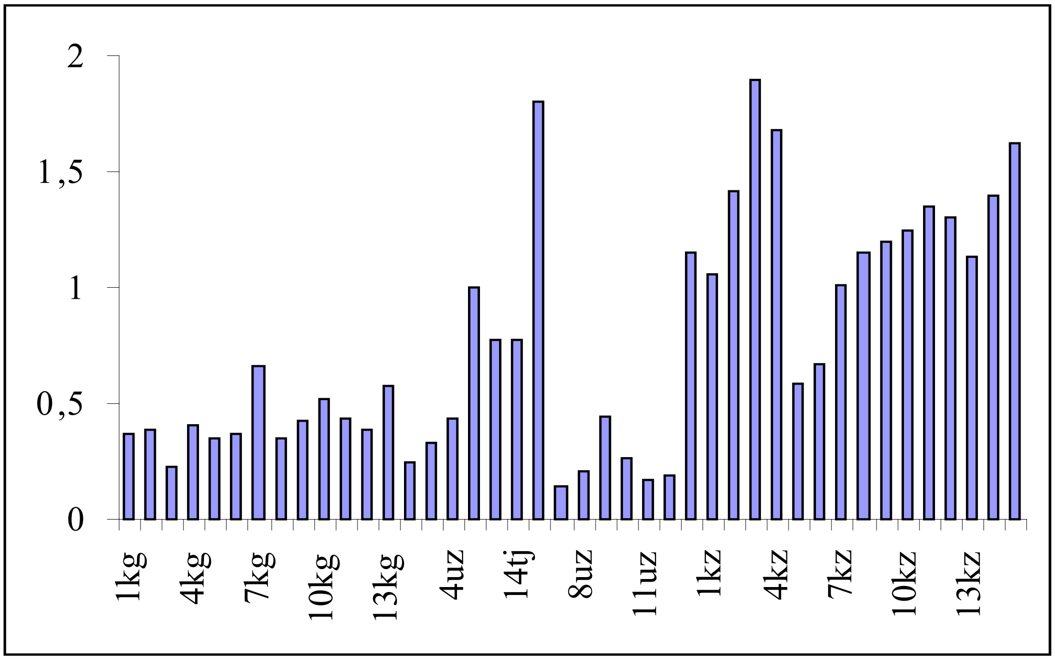


Figure 11. Salt Concentration, Syr Darya River

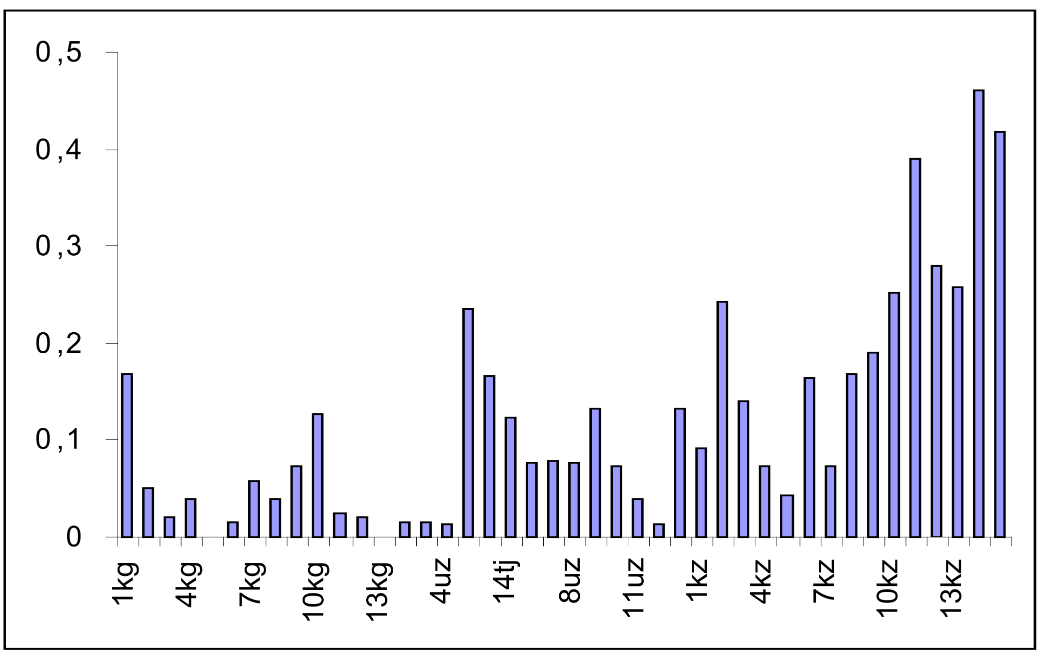


Figure 12. Water Specific alpha activity, Syr Darya River

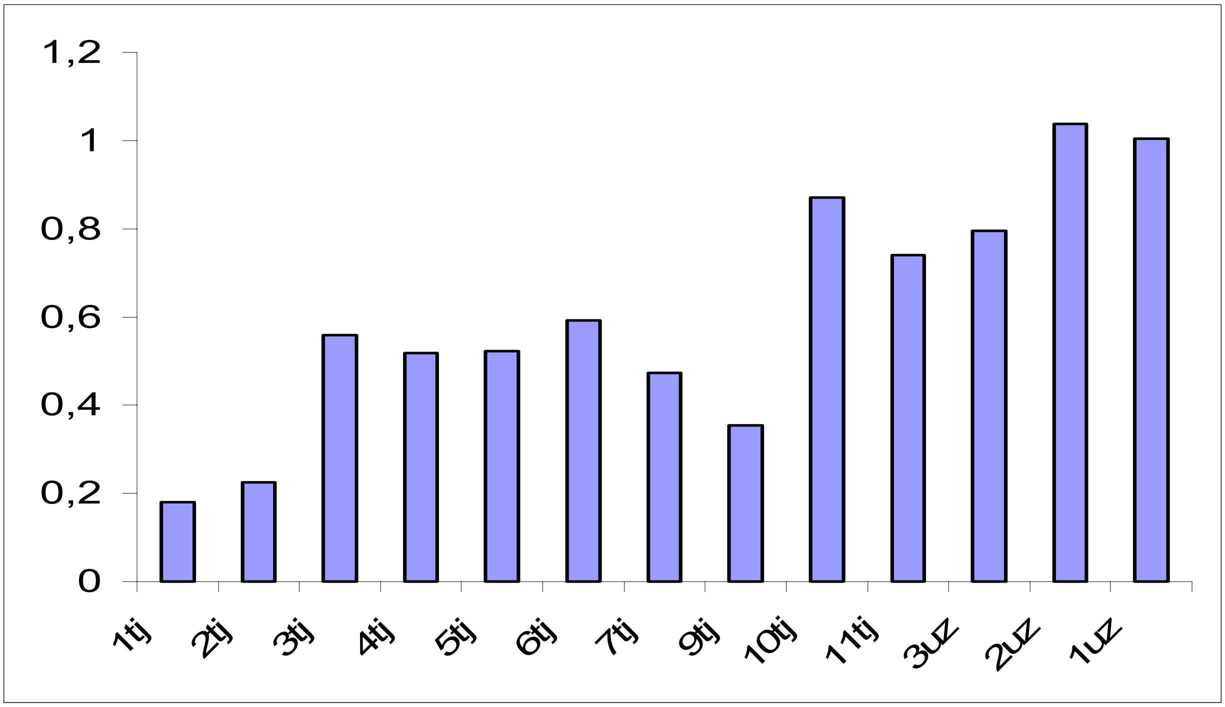


Figure 13. Salt Concentration, Amu Darya River

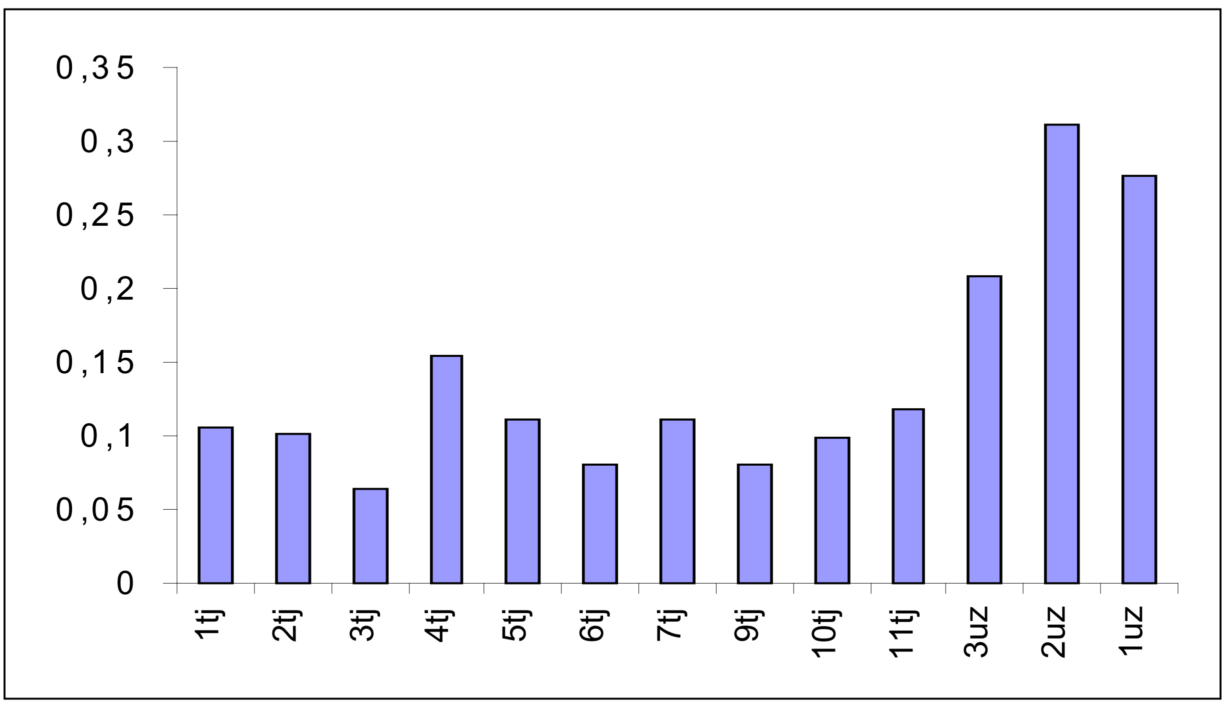


Figure 14. Water specific beta-activity, Amu Darya River

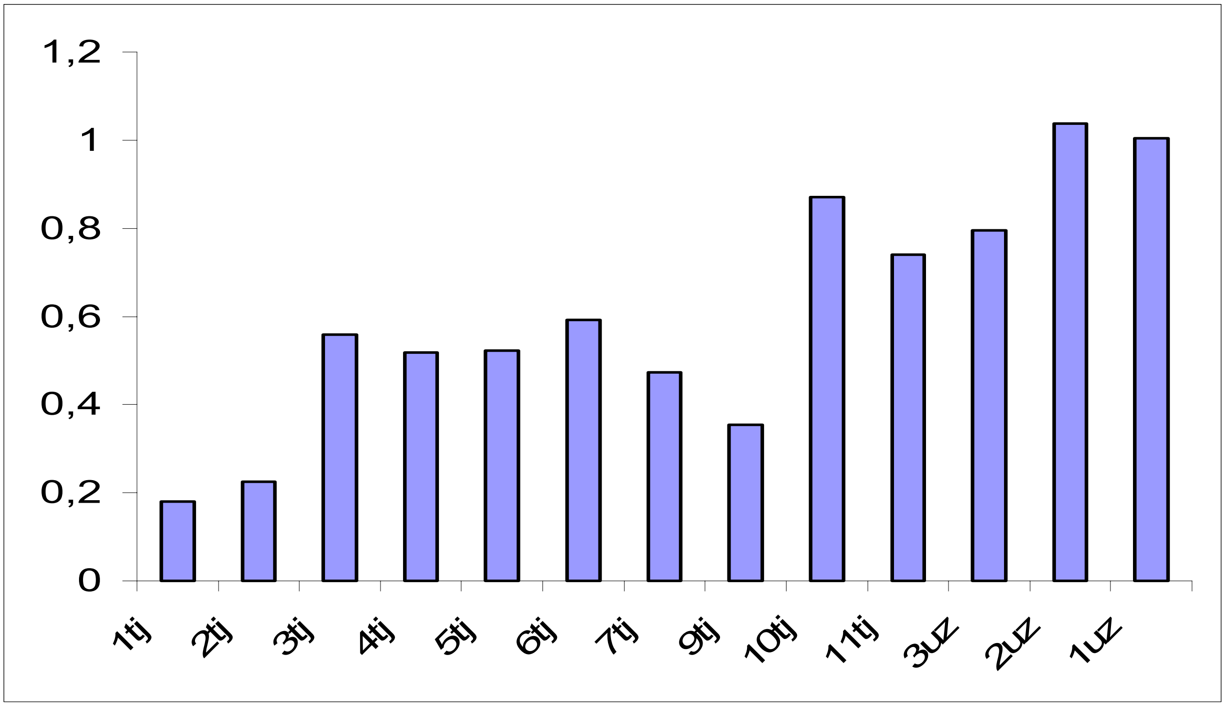


Figure 15. Salt Concentration, Amu Darya River

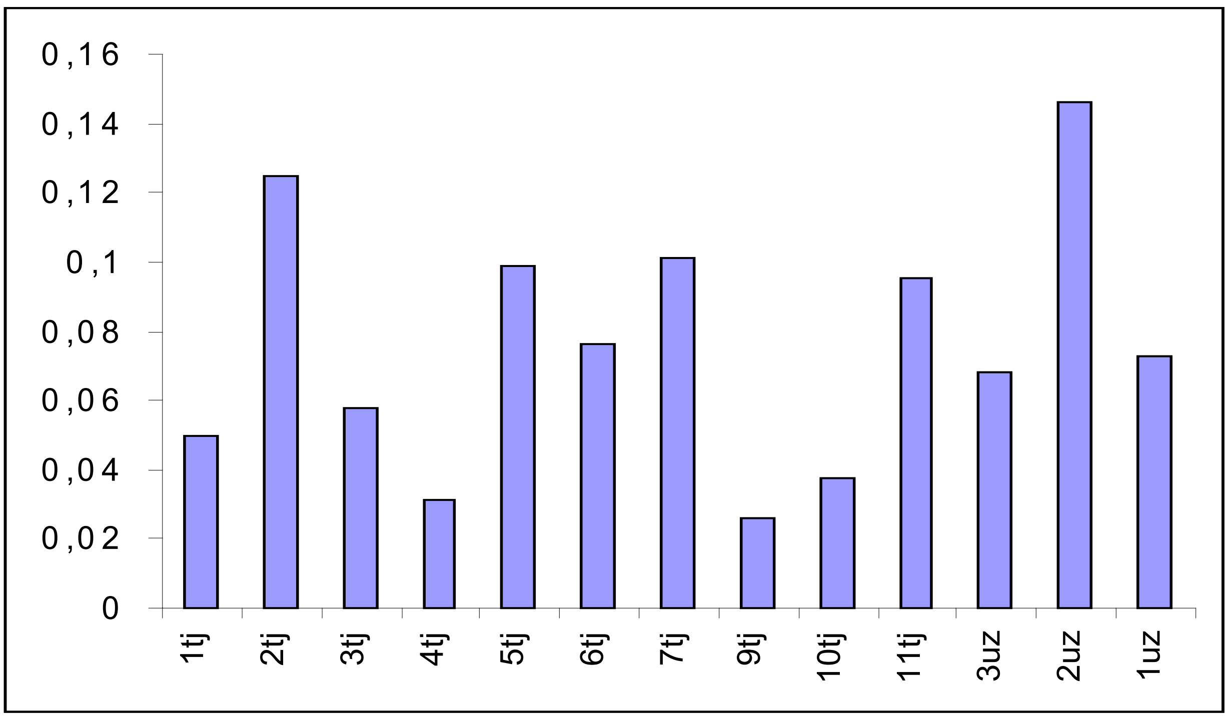


Figure 16. Water specific alpha-activity, Amu Darya River

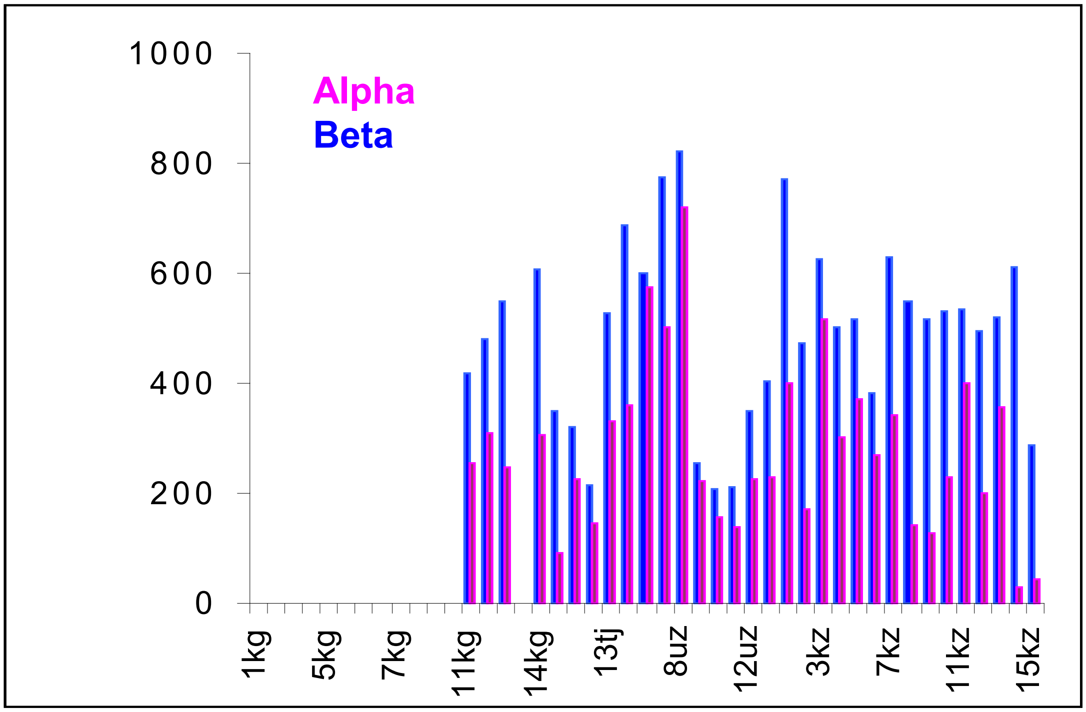


Figure 17. Bottom Sediment specific activity, Syr Darya River, Bq/kg

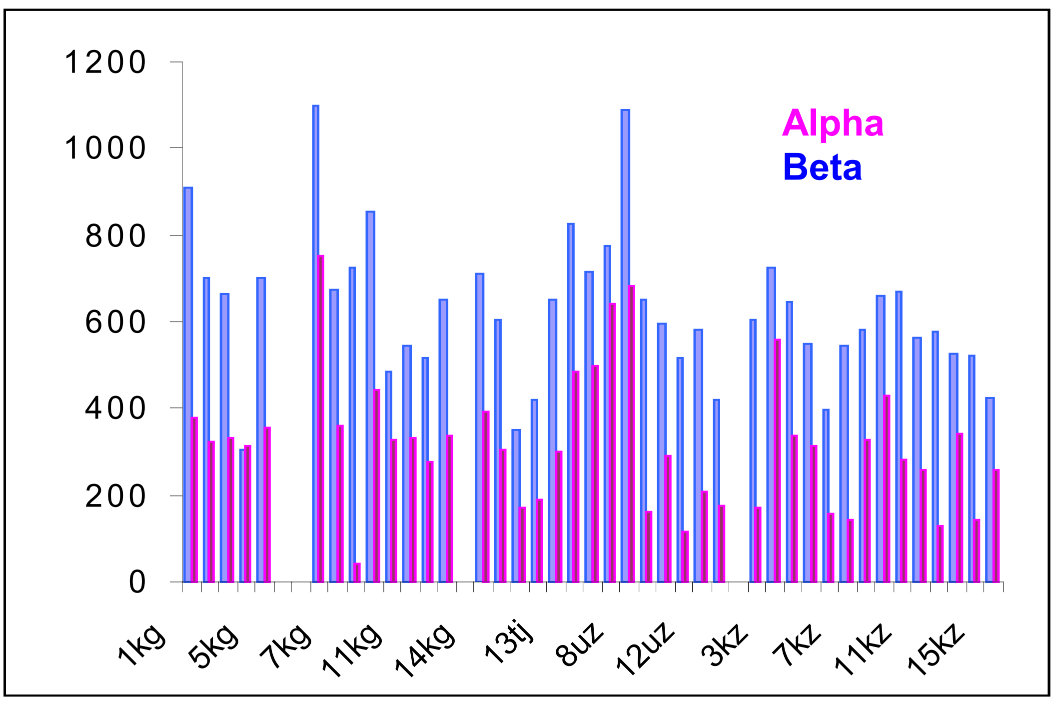


Figure 18. Soil specific activity, Syr Darya River, Bq/kg

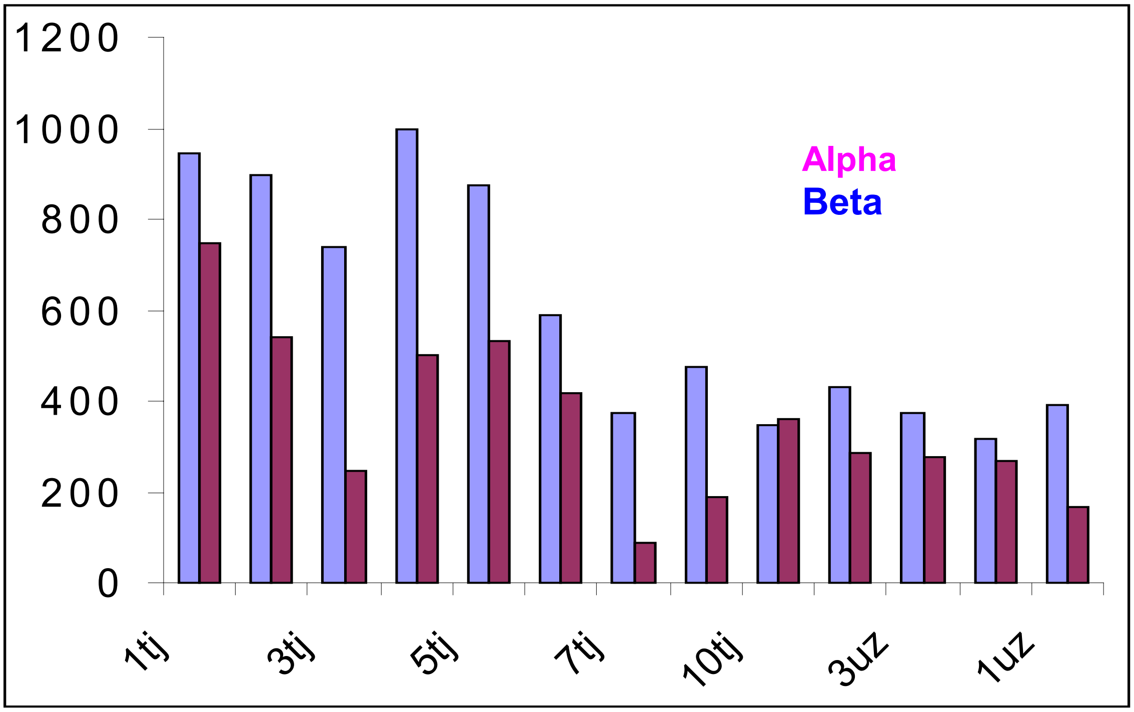


Figure 19. Bottom sediments specific activity, Amu Darya River, Bq/kg

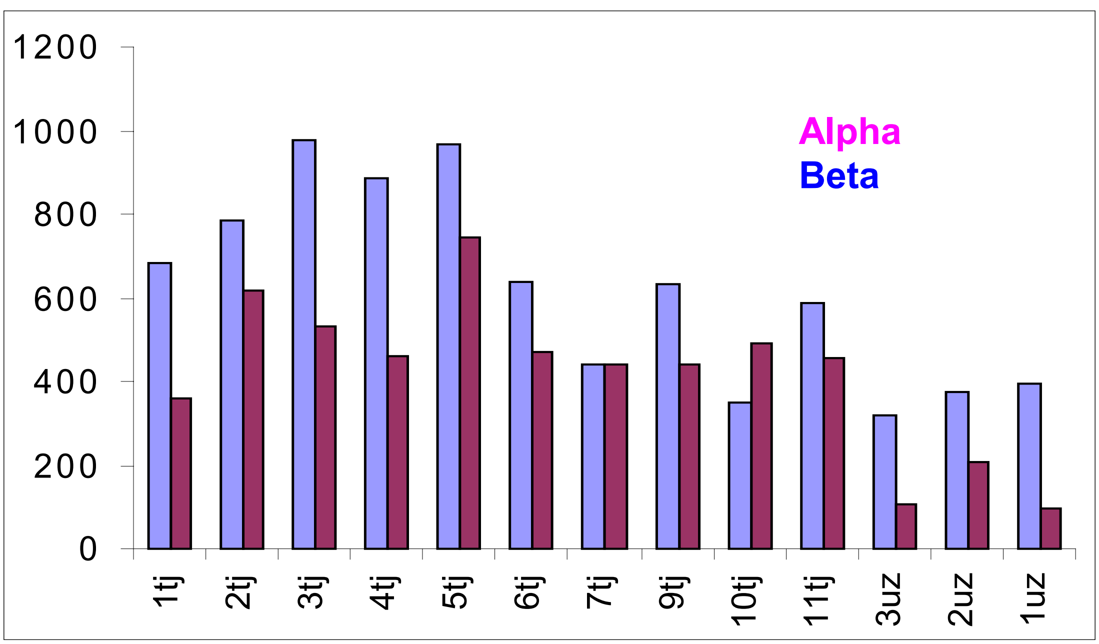


Figure 20. Soil specific activity, Amu Darya River, Bq/kg

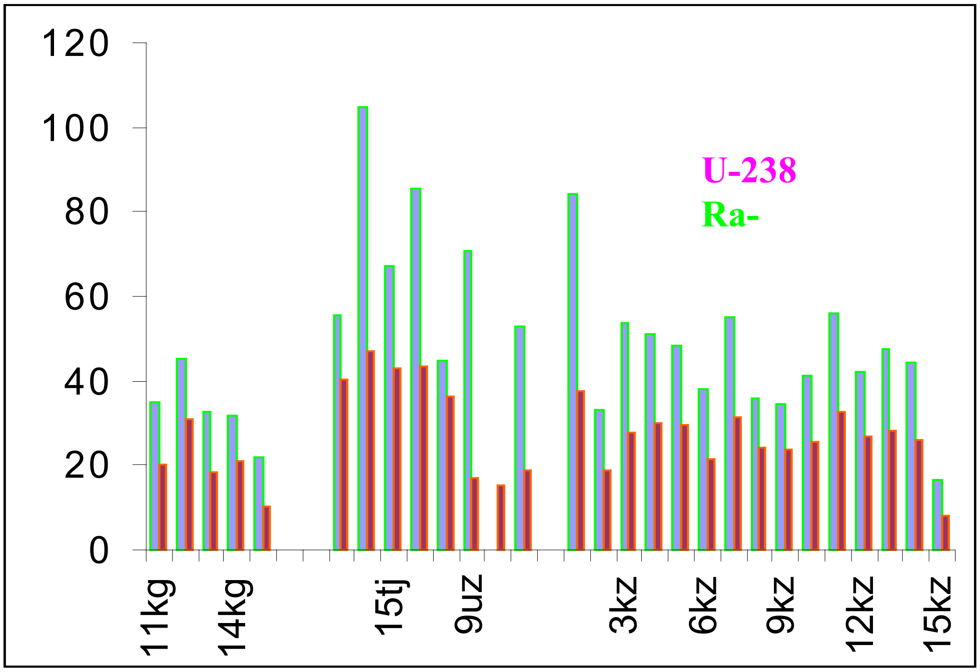


Figure 21. U238 and Ra226 in bottom sediments, Syr Darya River, Bq/kg

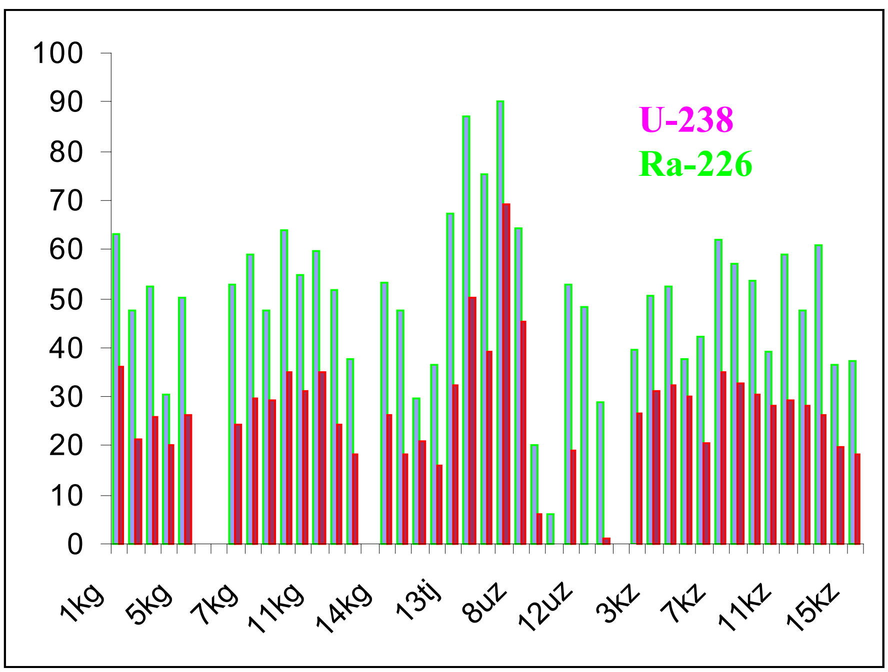


Figure 22. U238 and Ra226 in soil, Syr Darya River, Bq/kg

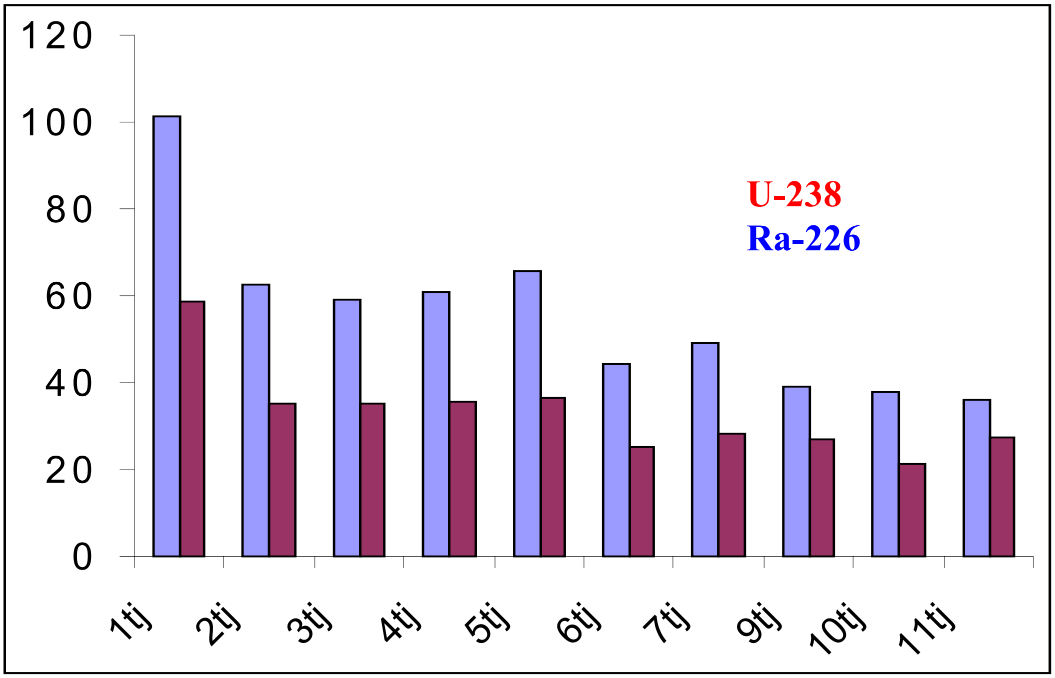


Figure 23. U238 and Ra226 in bottom sediments, Amu Darya River, Bq/kg

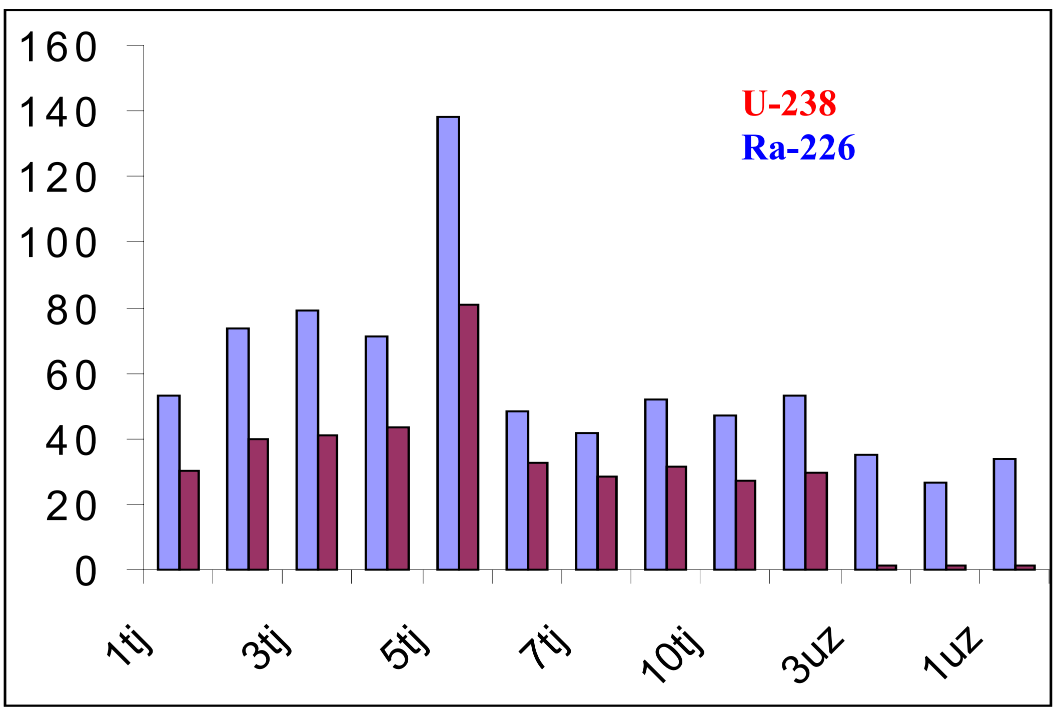


Figure 24. U238 and Ra226 in bottom sediments, Amu Darya River, Bq/kg

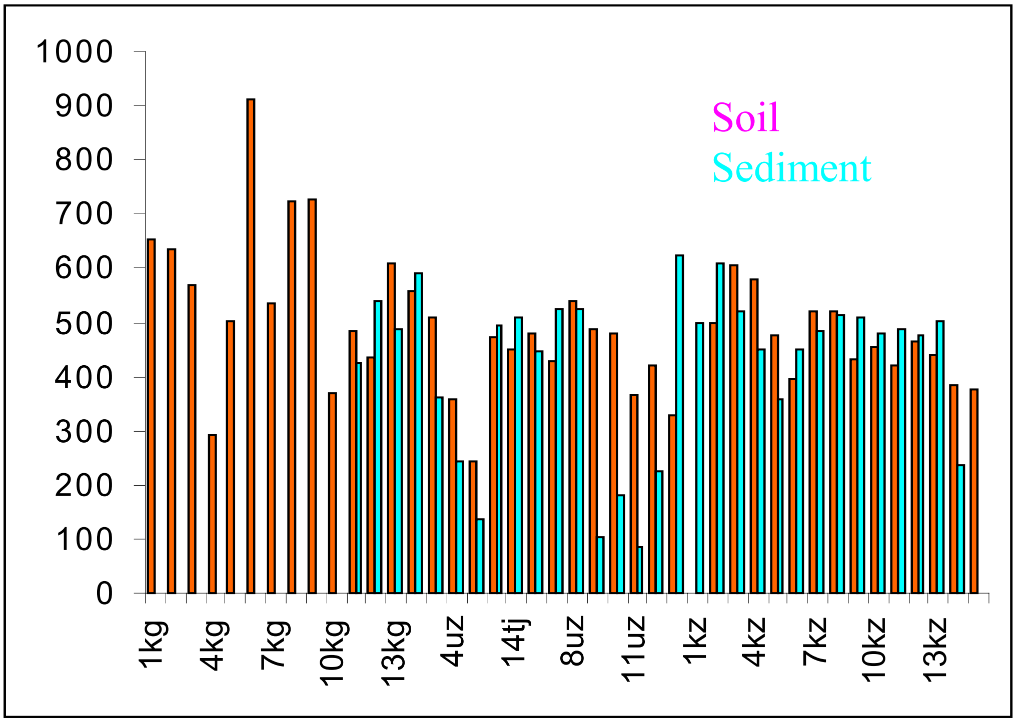


Figure 25. K40 in bottom sediment and soil, Syr Darya River, Bq/kg

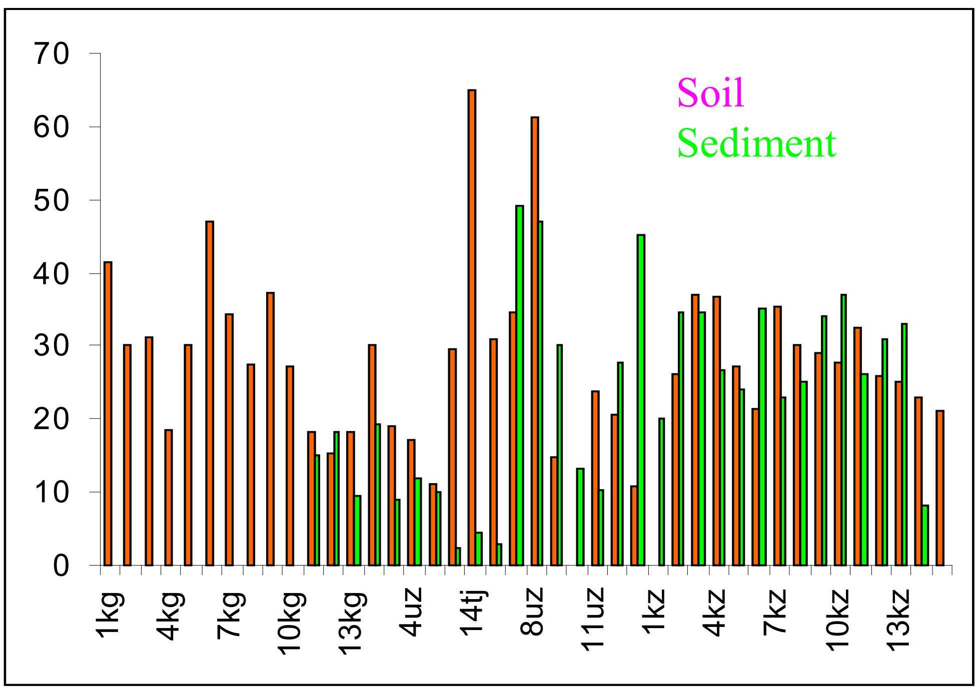


Figure 26. Th232 in bottom sediment and soil, Syr Darya River, Bq/kg

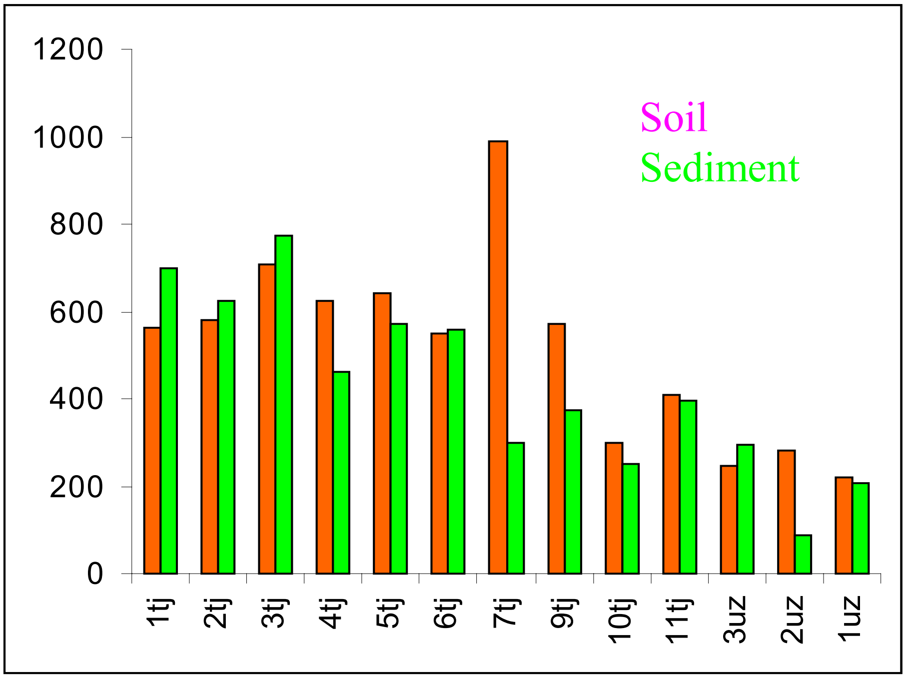


Figure 27. K40 in bottom sediment and soil, Amy Darya River, Bq/kg

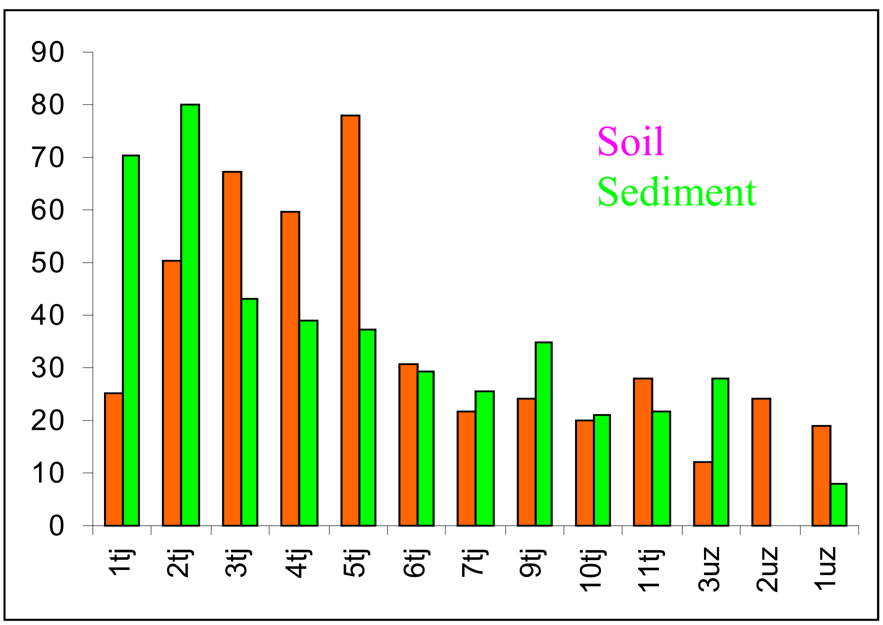


Figure 28. Th232 in bottom sediment and soil, Amu Darya River, Bq/kg

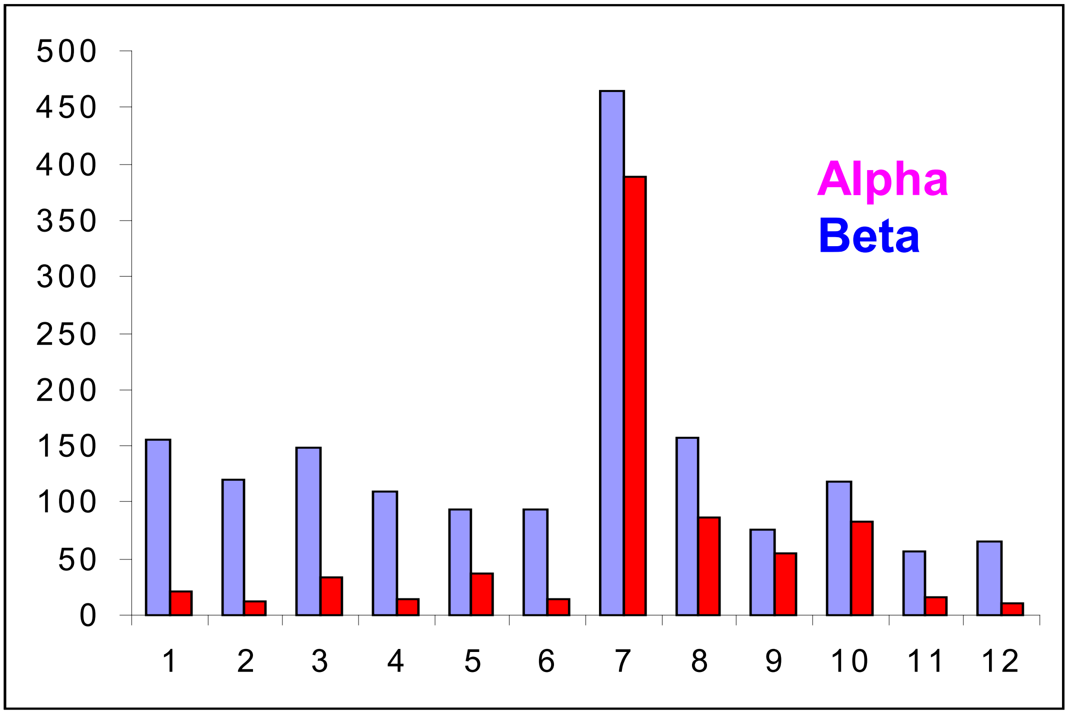


Figure 29. Radioactivity of Uzbekistan vegetation, Bq/kg

UZB	Sediment, g/L	KAZ	Sediment, g/L	KRG	Sediment, g/L
Uz 01	0.0088	Kz 01	0.1164	Kg 01	0.0005
Uz 02	0.1462	Kz 02	0.0152	Kg 02	0.0005
Uz 03	0.2229	Kz 03	0.1818	Kg 03	0.0010
Uz 04	0.0806	Kz 04	0.1978	Kg 04	0.0011
Uz 05	0.0005	Kz 05	0.0300	Kg 05	0.0007
Uz 06	0.1463	Kz 06	0.0500	Kg 06	0.0011
Uz 07	0.9986	Kz 07	0.0762	Kg 07	0.0020
Uz 08	1.2610	Kz 08	0.0718	Kg 08	0.0085
Uz 09	0.0106	Kz 09	0.0928	Kg 09	0.0006
Uz 10	0.0049	Kz 10	0.1216	Kg 10	0.0011
Uz 11	0.0048	Kz 11	0.3380	Kg 11	0.0014
Uz 12	0.0017	Kz 12	0.2686	Kg 12	0.0010
Uz 13	-	Kz 13	0.3180	Kg 13	0.0024
Uz 14	-	Kz 14	0.1812	Kg 14	0.0045
Uz 15	-	Kz 15	0.0528	Kg 15	0.0025

Figure 30. Content of Sediment

Figure 31. Alpha and beta radioactivity measurements using NRR-610. Analyst E.D. Vdovina

Figure 32. Sampling expedition, V.S. Vasilieva, A. Rakhimbayev, E.D. Vdovina, O.A. Smolkova

Figure 33. Water sample preparation. Analyst S.I. Yatsenko

Element	Nuclide	γ-energy. keV	T1/2	LOD mg/kg
Ag	110m-Ag	658	250 h	0.01
Au	198-Au	411	2.69 h	0.001
Ba	133-Ba	496.3	11.8 d	50
Br	82-Br	777	1.47 h	0.1
Ca	47-Sc	160	3.43 d	250
Cl	38-Cl	1642	37.2 min	100
Co	60-Co	1173	5.27 y	0.01
Cr	51-Cr	320	27.2 d	0.08
Cs	134-Cs	796	2.06 y	0.01
Cu	64-Cu	511	12.8 h	1
Eu	152-Eu	1408	13.6 y	0.01
Fe	59-Fe	1098	44.5 d	10
Hg	203-Hg	278	46.6 h	0.01
I	128-I	443	25.4 h	0.1
La	140-La	1595	40.2 h	0.01
Mn	56-Mn	845	2.58 h	0.05
Na	24-Na	1369	15 h	5
Sb	124-Sb	1696	60 h	0.01
Sc	46-Sc	889	84 d	0.001
Se	75-Se	265	120 d	0.05
Sr	85-Sr	514	64.8 d	50
Th	233-Pa	312	27 d	0.1
U	230-Np	228	2.35 h	0.02
Zn	65-Zn	1115	244 d	5

Figure 34. Activation analysis of samples

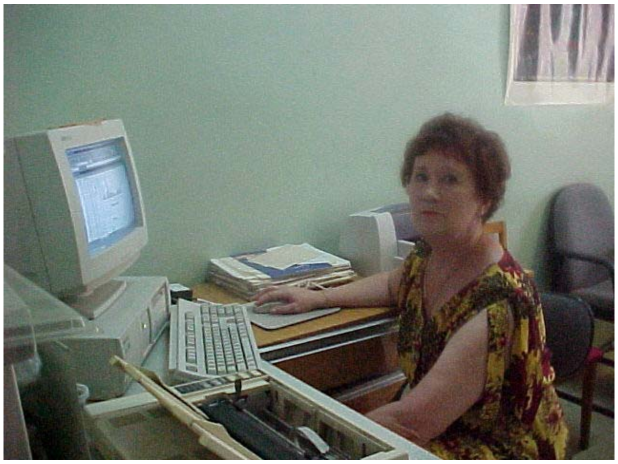
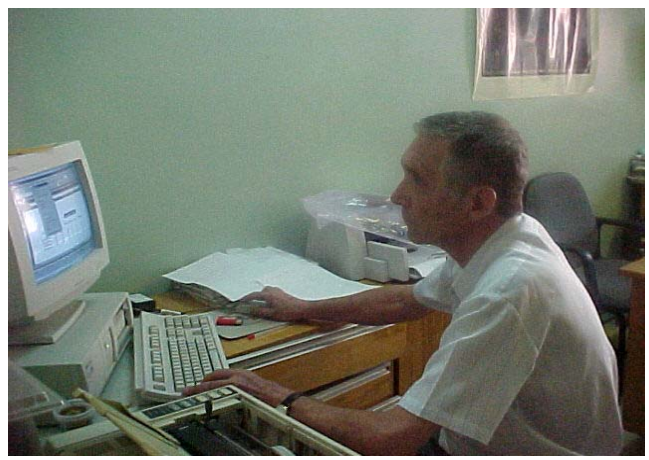


Figure 35. Neutron Activation analyst L.I. Zhuk

Figure 36. Neutron Activation analyst A.A. Kist



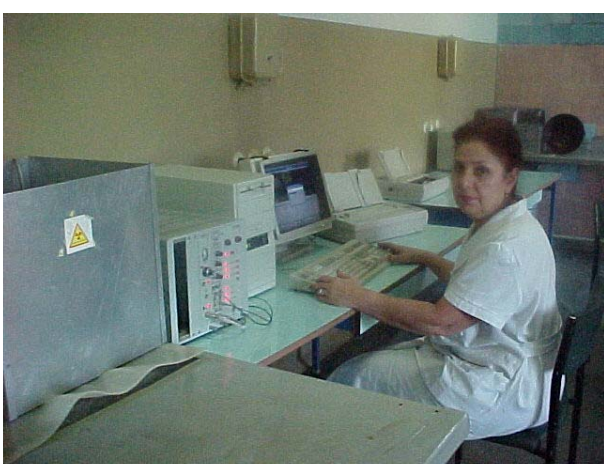


Figure 37. Neutron Activation analyst E.A. Danilova

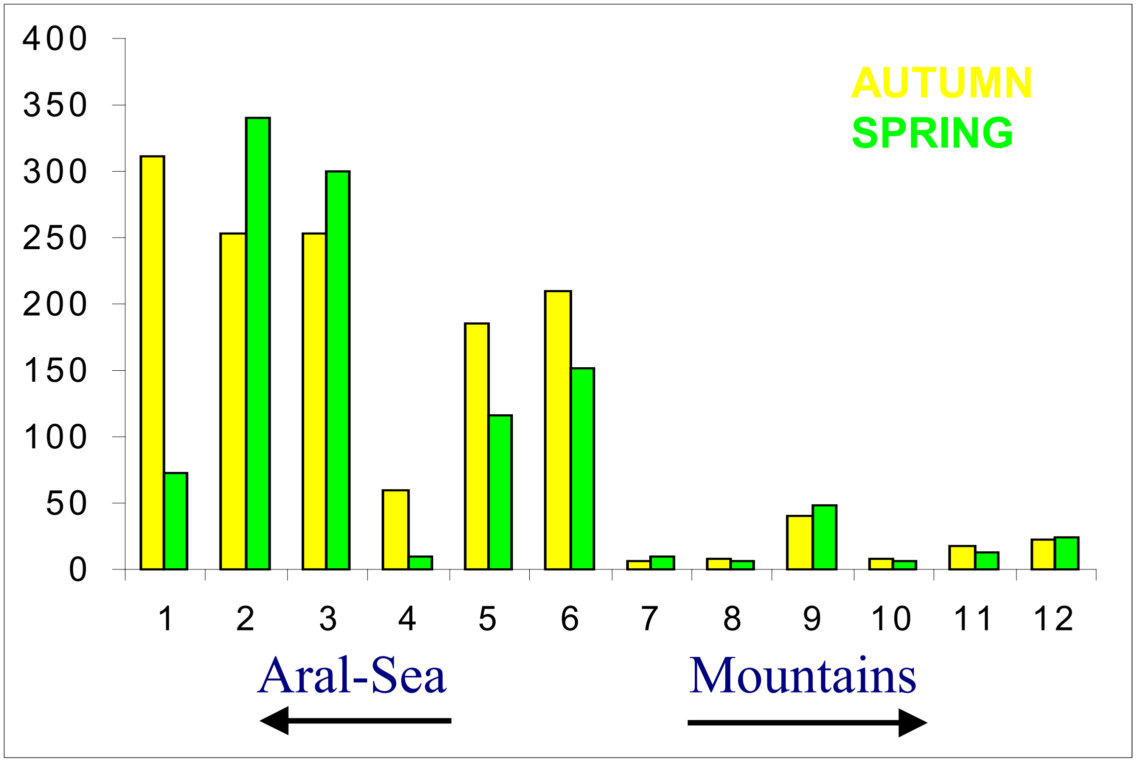


Figure 38. Water dissolved Na., Syr Darya River, mg/L

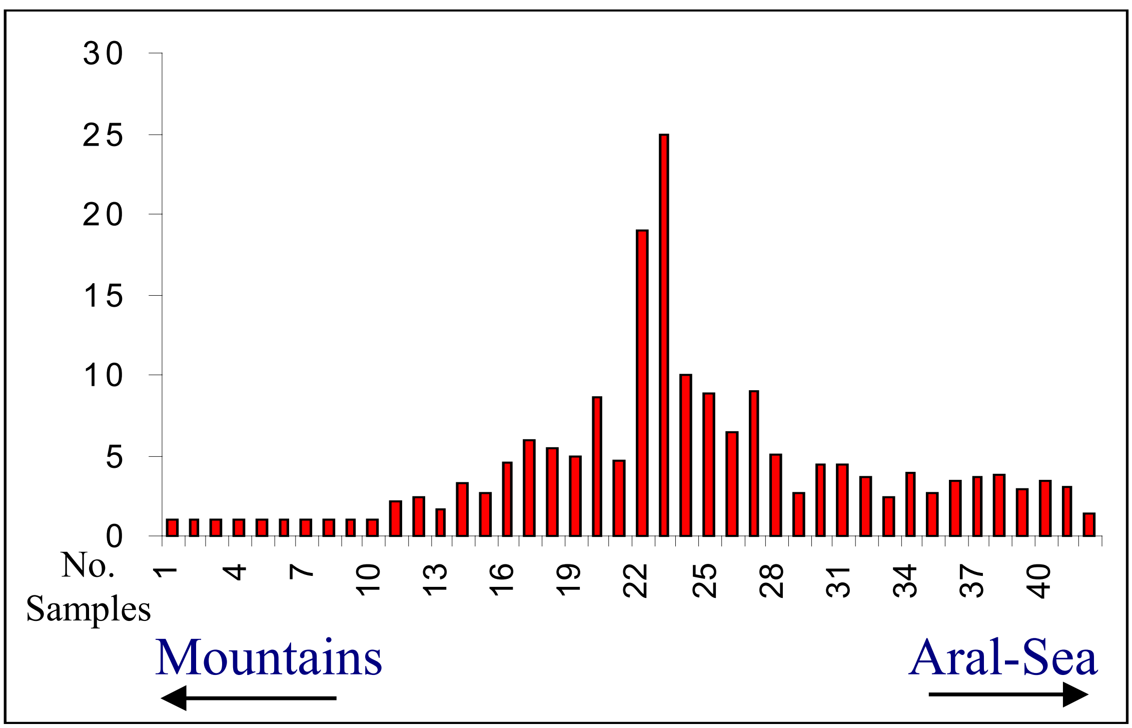


Figure 39. Th concentrations in bottom sediment, SyrDarya, Autum, mg.kg

5. Preliminary Conclusion:

Besides high uranium and thorium concentrations, in some cases significantly elevates levels of chromium, antimony and cesium have been detected. The Navruz experiment is continuing.

Figure 40. Deputy Director, Uzbekistan Institute of Nuclear Physics, U.S. Salikhbayev

Acknowledgement:

The Institute of Nuclear Physics, Uzbekistan would like to extend its cordial thanks to the CMC and DoE for arranging, supporting and supervising this extremely important experiment for Central Asia.

Tajikistan

1. Introduction

Water and life are inseparably linked. Once considered an infinitely renewable and abundant resource, today water defines and establishes human, social, and economic boundaries in almost all parts of the world.

Considering the important role water plays on the planet and in order to focus attention of the world community on issues related to water resource utilization strategies, the year 2003 has been declared to be the "International Year of Freshwater" by the 54th U.N. General Assembly, in response to a proposal by the President of Tajikistan E. Sh. Rakhmonov.

In countries that currently have adequate freshwater reserves, requirements with regard to water system pollution are being tightened, while in developing countries, the demand for freshwater is increasing constantly owing to the rapid growth of agriculture and industry and the development of urban centers.

Considering the potential effects of global warming and climate changes on the Earth, future availability of freshwater seems more doubtful than at any previous time.

This challenge of nature is forcing people to unite and find possibilities for working together to find specific solutions to the problem.

The problem of sound utilization of water resources to support the population of Central Asia is one of the constant subjects of discussion at the majority of regional forums. The scope of problems discussed at these forums, ranging from jurisprudence to agronomy, confirms the importance of the water utilization problem.

An important feature of rivers in our region is that they cross national boundaries. This imposes a particular responsibility for preserving their purity and utilizing them soundly, and in turn produces an insistent need to work out legal norms and international agreements regarding the joint utilization of water, taking account of the interests of all regional governments. The resolution of this problem must utilize international experience, and must involve the participation of various government and social agencies. The tragedy of the Aral sea also compels us to pursue this goal.

The Cooperative Monitoring Center of the Sandia National Laboratory and the Center for Nonproliferation Studies at the Monterey Institute for International Studies have developed a proposal for the joint conduct of an experiment to perform radioecological monitoring in Central Asia, involving scientists from countries of the Central Asian region.

Understanding that the solution of the problem is only possible on the basis of precise scientific data and with the utilization of international experience, the scientists of Tajikistan take great pleasure in agreeing to participate in the proposed experiment.

The basic goal of the experiment has been defined by us as follows: "The experiment to jointly monitor radionuclides in Central Asian regional water systems will increase the level of mutual trust among regional governments, who are preparing to sign a Nuclear-Weapons-Free Zone Agreement. In addition, it will serve as an example to the entire world community of another scientifically based approach to establishing transparent observance of conditions related to the Agreement on Nonproliferation of Nuclear Weapons. In the Central Asian region, water is life, and any international cooperation between nations on this real, first-order issue that affects this life-essential resource will serve to benefit all countries of the region."

Samples of water from various bodies of water in the region are very revealing from an information point of view and are sensitive to various industrial effects. A decision was made to take samples twice yearly for water, associated vegetation, bottom sediment, and adjacent soil at a number of specified points in the Syrdarya and Amudarya river basins. The data obtained in the course of radiation monitoring of water systems must be accessible for use in future research in countries of the region, in particular, those related to the problem of the Aral sea and other ecologically troubled areas.

It was decided to perform the experiment using the largest analytical laboratories at scientific-research centers of the participating countries. At the same time, exchanges of data and samples is anticipated, in the spirit of cooperation.

In response to a proposal by a group of Tajikistan scientists, "NAVRUZ" was adopted as the abbreviated name of the experiment. The Navruz holiday is one of the springtime reawakening of nature and is a holiday common to all peoples inhabiting the Central Asian region.

Colleagues from the International Center for the Study of Cosmic Rays at the Physicotechnical Institute of the Academy of Sciences and from the radiochemical laboratory of the Ministry of Emergency Situations were engaged in the experiment on behalf of the Republic of Tajikistan.

2. Description of sampling locations

"Moverounnakhr is the richest country in the Islamic world...." "Sogd is the most fertile of Allah's countries. It has the best fruit; all dwellings have gardens, cisterns, and running water; it is rare for a street or house to not have a canal with running water. Moreover, the people here are the most kind, generous, enlightened, and hospitable." The 10th century Arab traveler al-Istarkhi described the Central Asian region in this way."

Tajikistan is one of the most water-producing territories in the Central Asian region. The overall area of Tajikistan is 14.31 million hectares, which comprises only 11.2% of the area of Central Asia. Around 9.4 million hectares of the country's territory is situated at an altitude of 2000 m and higher above sea level. It is in this mountainous territory, which comprises only about 7.5% of the area of Central Asia, that more than 65% of the water resources of the Aral Sea basin are created. In accordance with scientific analyses, the dynamic water resources in Tajikistan comprise about 60 km^3 per year, of which about 8 km^3 are due to subsurface water that is formed directly in the runoff zone owing to the infiltration of atmospheric precipitation into strata of ecologically clean pebble–sand rock strata, while the rest, approximately 52 km^3, trace their origin directly to atmospheric precipitation and melted snow and glaciers.

The rivers of Tajikistan, basically, find their source high in the mountains and are fed first by melted water from seasonal snows and rain water (at altitudes of up to 3000 m) in March–June, and afterward, by melted water from high-mountain snow and glaciers, in July–August. At this time, [when] the afternoon air temperature in the mountains rises above zero by one degree, the average thickness of melted water is 5.5 mm. Rivers, which collect the rain and melted water from large and small drainage areas in the mountainous relief and at various altitudes, are most often characterized by mixed supplies: glacial–snow or snow–glacial. The fraction of rain water in the annual flow in rivers is small, as is the purely glacial fraction. In terms of river water supply, the year is divided into 3 periods. The first is the low water period, when the supply from snow and glaciers is very small or is absent altogether and rivers are fed by subsurface water (November–December). The second is a high-water snow and rain period (March–June), where the high-water snow period may start in February in years when winters are mild or humid. The third is the snow–glacier flood period (July–October).

The surface water created in the republic is of 1st and 2nd class purity. The concentration of contaminants in water does not attain high levels and, as a rule, does not exceed 10 MAC. For example, during the high-water period, the salinity of water in the Kafirnigan river near the city of Kafirnigan is 0.1 g/L, while during the low-water period, when the fraction of subsurface supply is more significant, this level rises to 0.2 g/L. On the whole, salinity of river water in the central and southern territory of Tajikistan (the Zarafshan, Kafirnigan, Vakhsh, and Pyandzh rivers) is between 0.1–0.4 g/L, while in Northern Tajikistan, the average salinity of the Syrdarya river above the Kayrakkum reservoir and below it is between 1.15–1.07 g/L.

The largest subwatershed area for one of the largest rivers of Central Asia - the Amudarya river - is found within the republic, and it comprises 199,350 thousand km^2. There are more than a thousand glaciers in its water basin, including the Fedchenko glacier, many snowfields, and permanent snow cover. Its flow comprises 79 km^3/yr, which is 3 times larger than the annual average flow of the Syrdarya or Don rivers, and its water content is not less than that of the Dnepr. Most of the rivers in the Amudaryinsk basin are fed by glacier–snow water. The same is true for its primary tributaries, the Pyandzh and Vakhsh, and most of the other tributaries of these rivers. The Kafirnigan, Kyzylsu, Yakhsu, and some others are fed by snow–glacier water. The Amudarya is formed by the confluence of the Pyandzh and Vakhsh rivers. Somewhat to the west, at the Aivadzh settlement, the Kafirnigan river joins the Amudarya while still within Tajikistan.

In the north of the republic, the second longest river in Central Asia - the Syrdarya - flows from east to west. Basically, this river is also fed by snow–glacier water. There are about 750 glaciers in the Naryn river basin, which is the main component of the Syrdarya. Of these, more than 500 are located on the northern slopes of the Alai and Turkestan mountain ridges, and more than 100 on the southwest slopes of the Fergan mountain ridge. The area of the mountainous basin zone is 150,100 km^2 and at the exit of the Fergan valley, it is 142,000 km^2. Within the republic of Tajikistan, the Syrdarya is fed primarily by its left bank tributaries, the Isfara, Isfana, Aksu, and Khodzha-kirgan rivers. Of the tributaries of the Syrdarya within Tajikistan, the one with the largest water capacity is the Isfara river, which has a maximum flow of up to 42 m^3/sec in June–August and a minimum flow of 3–5 m^3/sec; the one with the smallest flow is the Isfana river, with a flood flow of 1.4-1.6 m^3/sec (in March–April), resulting from rain and snow melt, and a minimum flow of 0.5 m^3/sec the rest of the year. Of intermediate water capacity and identical in terms of supply to the Isfara river are the Khodzha-bakirgansai and Aksu rivers, which are characterized by a maximum flow of 23 and 14 m^3/sec, respectively, and a minimum flow of 5.2 and 4.0 m^3/sec. The waters of these rivers are almost completely employed for irrigation and only small flows, made up of runoff from fields, reach the main arteries via surface flow and apparently, for the most part, via subsurface flow. In addition, during the flood and rainy periods, the Syrdarya is fed by a number of small ravines and from the right bank below the Kayrakkum reservoir.

In the central part of Tajikistan, known as "Kukhistan," a large portion of water enters the Zeravshan river system. But since there is neither a surface nor subsurface outflow from the Zeravshan to the Amudarya, the Zeravshan can be considered an independent, sufficiently local hydrogeological object and will not be examined by us in the course of the NAVRUS experiment.

In selecting monitoring sites, particular attention was devoted to densely populated locations and industrially developed areas (both present and former).

Maps showing the monitoring sites and photographs taken at those sites are presented in Appendix 1**.**

From the industrial point of view, among the areas with the greatest industrial load within Tajikistan is the Vakhsh river basin. The Southern Tajik Territorial Industrial Complex is located here, which includes such large facilities and the Yavansk Electrochemical and Vakhshsk Nitrogen Fertilizer plants. The Vakhsh river is also the primary source of electrical power in Tajikistan. The Perepadnyi, Tsentralnyi, Golovnyi, and Nurek hydroelectric stations are situated

on this river. Nurek, Kurgan-tyube and Sarband should be noted among the largest cities. The basin of another tributary of the Amudarya, the Kafirnigan river, is also under a great industrial load. Mining facilities are located here, along with large cities such as Dushanbe, Kofaringon, and Gissar, which have various industries.
The territory of the Syrdarya basin is a major industrial and mining region in northern Tajikistan. The cities of Khudzhant, Chkalovsk, Isfara, Kanibadam, and Kayrakkum are home to developed industries. The Syrdarya river is regulated by two reservoirs within the republic, the Kayrakkum (since 1956) and the Farkhad (since 1947).

Weather data from hydrometeorological stations (HMS) are presented in Appendix 2 for several recent years for the sampling areas.

3. Experiment preparation and conduct

Unfortunately, our participation in the experiment began on a sour note when the device to be used for determining the qualitative characteristics of water, the Hydrolab, was received in an inoperative state.

The problem centered around the failure of a normal screen to appear when the device was turned on. Instead, only a series of bouncing lines could be seen, similar to what is seen on a television set that has defective line frequency synchronization. Our efforts to repair the device by ourselves did not meet with success. It was necessary to send the device to the fabricating plant for repair or replacement.

Here, we encountered another complication. The device had been sent to us via the United States Embassy as humanitarian aid, so that we did not have the funding documents required by the Customs authorities for processing when shipping the device.

In overcoming all of these problems, we were aided only by the interest expressed in the experiment by government agencies of the Republic of Tajikistan, by the Sandia National Laboratory, by Mr. Dennis Reisenweaver, who is a colleague at the International Atomic Energy Agency, and, of course, by colleagues at the Hydrolab corporation and most of all by Mr. Cooper Petterson. We received the repaired device at the end of May 2001, so our first expedition (October–November 2000) was undertaken without this remarkable tool.

4. Technical developments.

Samples of water, bottom sediment, aquatic vegetation, and soil adjacent to the shore were taken for analytic laboratory analysis. The water quality was determined at the sampling site using the Hydrolab device.

Samples were taken at places where bridges crossed rivers. A floating contrivance based on a procured inflatable rubber boat was assembled at the Physicotechnical Institute to permit taking integrated measurements.

River flow rates were measured using a pitot tube that was built at the Phyicotechnical Institute. River depths were measured using measurement poles.

A water-pressure vacuum pump was developed at the Institute in order to filter water samples under vacuum at the sampling sites. The vacuum in the apparatus is created by a water column in a vertical tube that is filled with water. The tube is connected to a receiver. This development permitted a sharp (approximately 10-fold) acceleration in the water sample filtration process and allowed filtration to be performed under strictly defined vacuum conditions.

A description and photographs related to these technical developments are presented in Appendix 3.

5. Preliminary results

Preliminary experiment results were assessed in September 2001 at the regular working seminar at Bishkek. At this seminar, our group's proposal to hold the 2003 seminar in Dushanbe at the same time as the conference on problems of clean water utilization, with the presentation of a series of papers on the Navruz experiment at the conference, was accepted.

Of the direct results, noteworthy are the detection of two spots of radioactive contamination of bottom sediment within the territories of Uzbekistan and Kazakhstan (the Syrdarya river basin) and elevated concentrations of industrially produced radioactive isotopes in the Varzov river in Tajikistan. The contamination of the Syrdarya river is related to the processing of uranium-containing materials. No such contamination has been found within Tajikistan, but investigations must be continued in connection with the presence of possible sources of contamination in Tajikistan itself, and in the tributaries of the Syrdarya within Kyrgyzstan. The cause of the contamination of the Varzob river with industrially produced isotopes remains to be identified in subsequent investigations.

In the summer - during July and August 2001 - flow rates were measured at eight sites on the Varzob, Elok, and Kafirnigan rivers above their confluence, on the Kafirnigan river in the vicinity of the railroad bridge in the city of Shaartuz, on the Yakhsu and Kyzylsu rivers above their confluence and on the Kyzylsu river after its confluence with the Yakhsu in the vicinity of the city of Vose, and on the Isfara river at mid-channel.

The physical and chemical properties of water were measured at all fifteen observation sites. For the "Chiluchor chashma" spring, it was determined that in terms of oxidation–reduction potential, the sources are divided into three different types, given that all other measured parameters (temperature, conductivity, salinity, quantity of insoluble particles and pH) are equal.

The dispersion of parameter values among the observation sites was as follows:

- for conductivity, from 0.12 mS/cm at mid-channel in the Varzob, to 5.83 mS/cm in the Kyzylsu below its confluence with the Yakhsu;
- for pH, from 7.24 at the "Chiluchor chashma," to 8.38 in the Yakhsu above its confluence with the Kyzylsu;
- for oxidation–reduction potential, from 230.2 mV for the Yakhsu above its confluence with the Kyzylsu, up to 429.2 mV at mid-channel in the Varzob;

- for dissolved salts, from 0.05 g/L at mid-channel in the Varzob, up to 3.22 g/L in the Kyzylsu river above its confluence with the Yakhsu;
- for fine solids (< 50 μm), from 0.08 g/L at mid-channel in the Varzob. to 3.73 g/L in the Kyzylsu after its confluence with the Yakhsu;
- for dissolved oxygen, from 6.51 mg/L in the Kyzylsu river, to 10.19 mg/L in the Yakhsu river above their confluence.

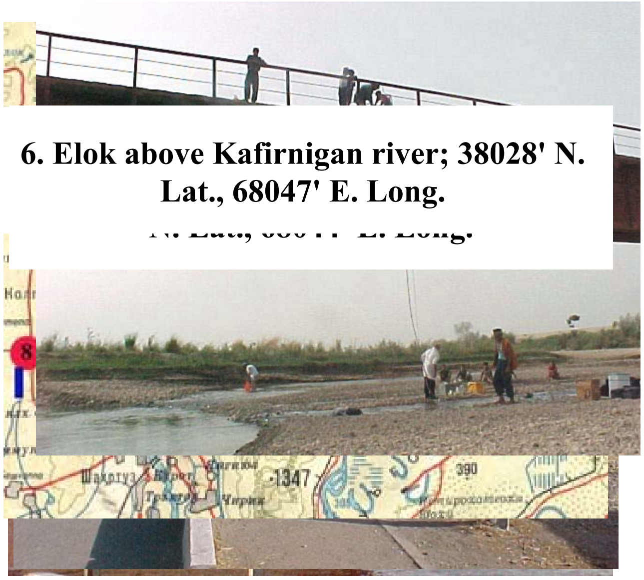
Samples are at present being analyzed for radionuclides and toxic heavy metals.

A plan for continuing investigations has been prepared for submission to the International Science and Technology Center (ISTC).

Appendix 1. Observation Sites

1. Varzob river above Dushanbe (near 'Tekstilshchik' sanatorium); 38042' N. Lat., 68047' E. Long.

3. Kafirnigan river above the confluence with the Elok and Varzob rivers; 38030' N. Lat., 68047' E. Long.



6. Elok above Kafirnigan river; 38028' N. Lat., 68047' E. Long.

5. Kafirnigan river in Shaartuz (railroad bridge); 37015' N. Lat., 68009' E. Long.

8. Natural boundary of the spring [*Chiluchor chashma*]; (The *Chiluchor chasma* was taken to be the background section for the entire experiment)

9. Vakhsh river below Nurek City (highway bridge); 38023' N. Lat., 69018' E. Long.

10. Yekhsu upstream of confluence with Kyzylsu (highway bridge in Vose); 37048' N. Lat., 69039' E. Long.

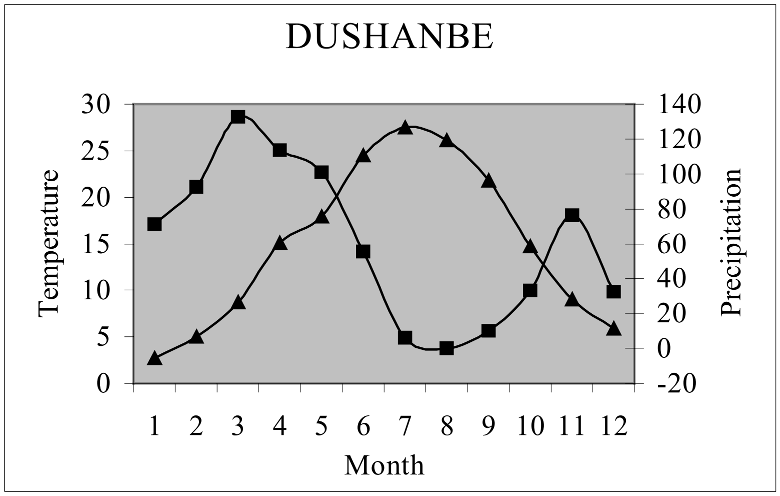
12. Kyzylsu river below the confluence with the Yekhsu (about 500 m below the confluence); 37046' N. Lat., 69033' E. Long.

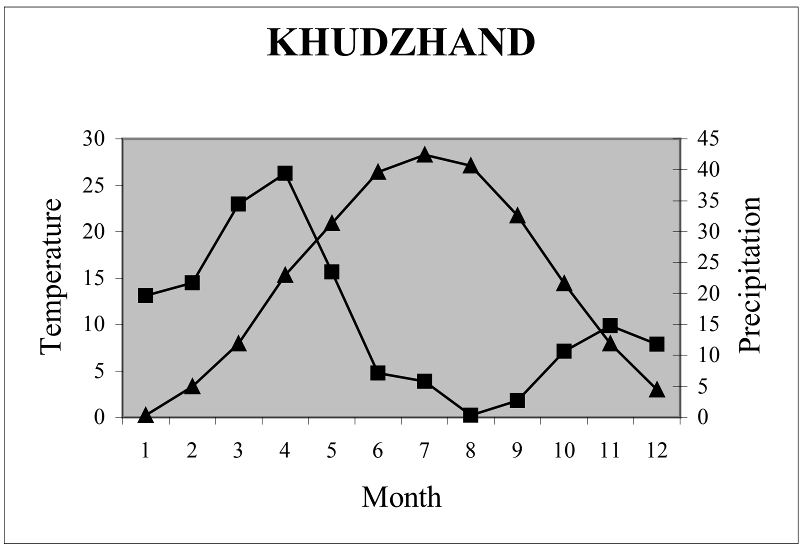
13. Syrdarya above Kayrakkum reservoir (Bulok settlement); 40033' N. Lat., 70032' E. Long.

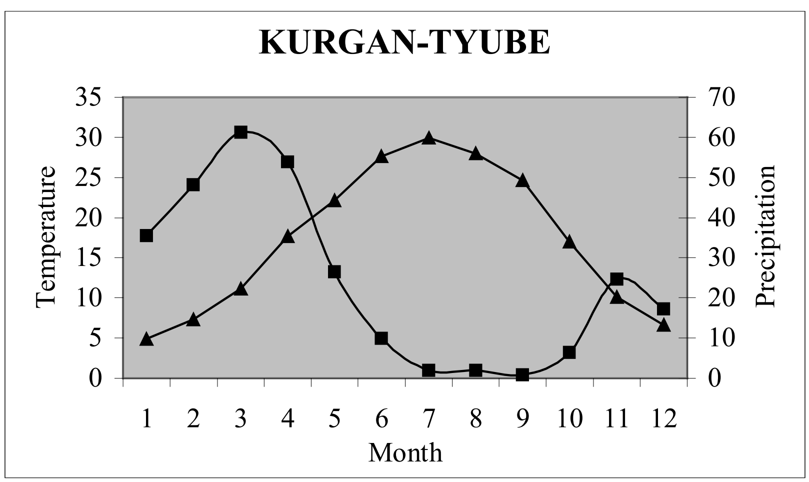
14. Syrdaya below Khudzhand (lower city bridge) 40017' N. Lat., 69037' E. Long.

15. Isfara river (between Rabat and Nefteabad) 40033' N. Lat., 70033' E. Long.

Appendix 2: Average HMS[1] Data







[1] Translator's note: Hydrometeorological Station.

Appendix 3. "Floating laboratory" for the ship Narvuz

A "floating laboratory" has been assembled at the S. U. Umarov Physicotechnical Institute of the Academy of Sciences of the Republic of Tajikistan to permit on-site water sampling and testing and measurement of current speeds in deep rivers.

The foundation of the "laboratory" is an inflatable rubber boat. A removable wooden framework has been mounted on the boat. The required equipment is mounted on the framework using rigid brackets. In this case, the equipment is the "Hydrolab," which measures temperature, the quantity of dissolved oxygen in the water, conductivity, salinity, quantity of solid particles, acidity (pH) and oxidation–reduction potential of the water in the river, and a pitot tube for measuring river current speeds at a depth of 50 cm, calculated by measuring the difference between the static and dynamic water flow pressure at a specified depth.

The construction is very simple, yet creates comfortable working conditions, making tasks more pleasant to perform.

The first photograph shows almost the entire "creative" group (the photographer is absent) beside their creation within their Institute. The second photo shows the "floating laboratory" assembled at a work site (the Kafirnigan river). The third photo shows everything in readiness to start work.

The Pitot Tube

This device is used widely to measure speeds of both liquid and gas flows. The pitot tube is, for example, a basic instrument for measuring aircraft air speeds.

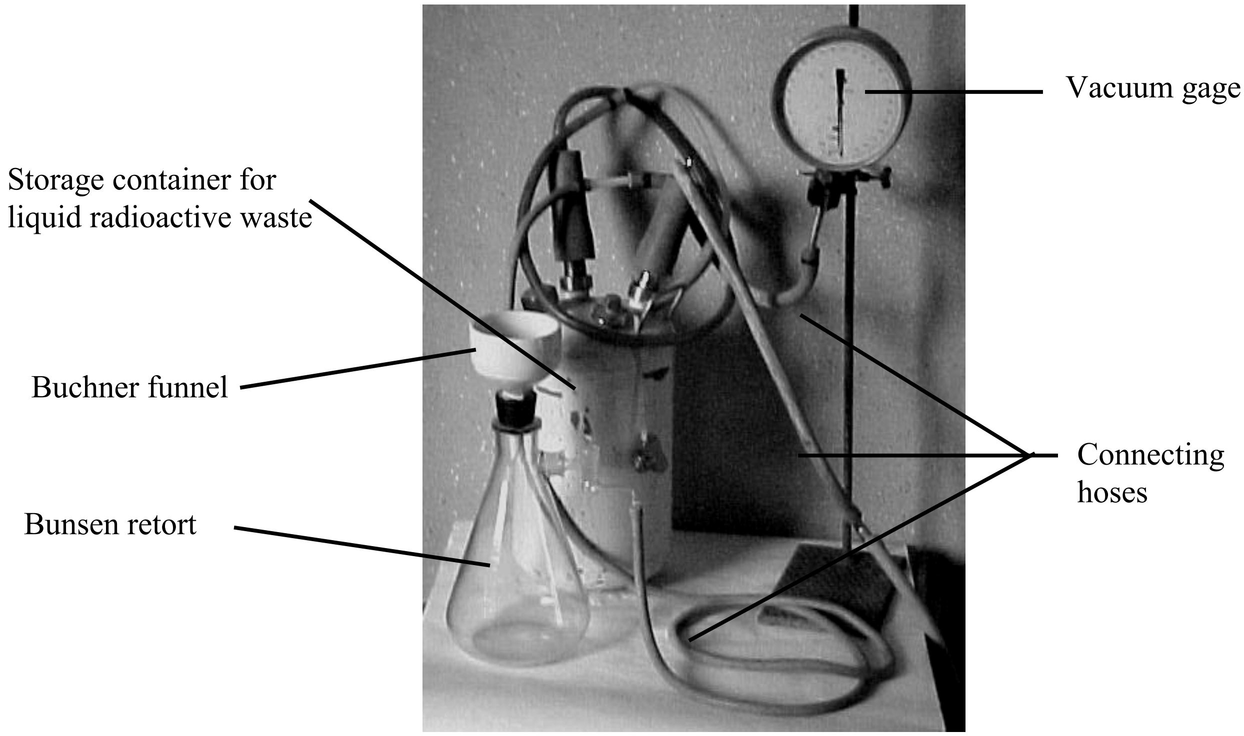
The operating principle is based on the measurement of the difference between the static (p_0) and dynamic (p) pressures. Over a rather broad range of flow speeds, using Bernoulli's law for incompressible fluids, we have $V = A \checkmark (p - p_0)$

The device itself is shown in the first photograph. Two glass tubes are attached to a broad ruler. They are connected by a piece of rubber tubing at the bottom. The resulting U-shaped tube is filled halfway with water. The upper ends of the glass tubes are connected using vacuum hoses to metal tubes used for measuring pressure. The straight tube measures the static pressure, while the tube bent at a right angle measures the dynamic pressure. The lower ends of the metal tubes are at exactly the same level.

The described device was used by us to measure representative samples. A sample was taken at 5 to 10 points along the section of a river, proportional to the current flow rate at the sampling points.

We were also able to calibrate the device (to obtain values for the coefficient A) downstream of the Nurek and Kayrakkum reservoirs. Thus, using this device we were able to meaure the flows of shallow rivers (up to 2 m deep). Those measurements are shown in the two following photographs, which were taken on the Varzob and Kyzylsu rivers.

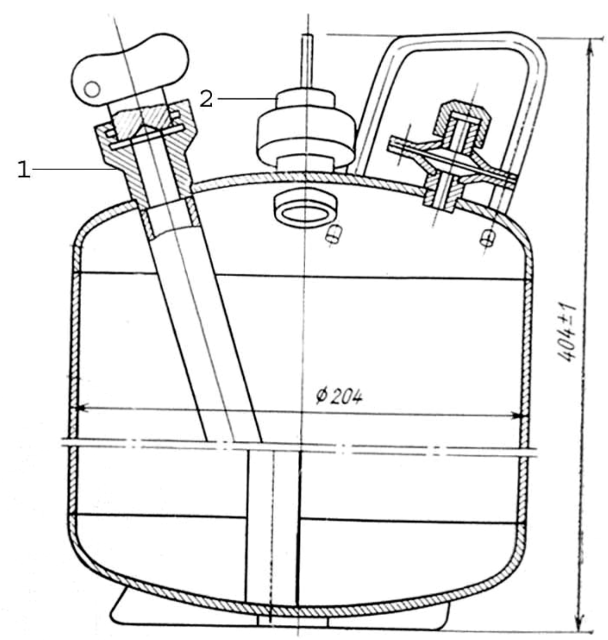
Field apparatus for filtering water using vacuum.



As a rule, the rivers of Central Asia contain much sand and silt. Thus, ordinary filtration of samples may take a very long time. The process is significantly accelerated via vacuum filtration. We assembled a simple apparatus that allowed us to implement this process under field conditions.
An overall view of the apparatus is shown in the first photograph. A diagram of a standard SZhO-10 radioactive waste collector is shown in the figure.

In our case, the convenience of this container consists in its excellent pressure-tightness. When the filter opening is shut tight, the container becomes completely pressure-tight.

If the pouring fitting of a water-filled container is connected to a vertically submerged tube, then a rarefied environment occurs above the water plane, and the degree of rarefaction will depend on the length of this tube. Thus, for a 5-m long tube, the rarefaction is exactly a half atmosphere. In this manner, the only thing that remains to be done is



SZhO- 10
1 - pouring fitting reaches the bottom
2 - filling fitting on lid

to connect the filling fitting to the Bunsen retort or to any other vessel from which air can be pumped.

Such an assembled "pump" is shown in the next photograph.. This apparatus was so convenient to use that both "bosses" and ordinary workers used it with pleasure.

Kyrgyzstan

Kyrgyzstan is a country of high mountains. Average land elevation is 2,750 meters, with the highest point reaching 7,439 meters in elevation. More than 94% of Kyrgyzstan's area is higher than 1,000 meters above sea level. The enormous ranges of absolute heights, the complex relief, the lengthy geological evolution of the country, and other factors are responsible for the diversity of natural conditions and the wealth of natural resources. All the natural zones typical of the northern hemisphere, with the exception of tropical zone, are found in Kyrgyzstan.

The natural features of Kyrgyzstan are defined by massive mountain ranges and broad closed and semiclosed intermontane basins that vary dramatically in terms of landscape and economic use. The highest part of Kyrgyzstan is located on the country's eastern margin. There, in the mountains bordering China, are the highest points of the entire Tyan-Shan mountain system—Pobeda [Victory] Peak (7,439 m) and Khan-Tengri (6,995 m). From there, the ranges fan out to the west and southwest, creating distinct, parallel chains that run for up to 300–400 km, mainly in a latitudinal direction. Elevations drop (to 1,000–2,000 m from 7,000 m) in that direction.

Vast intermontane basins and valleys, one of which is the Srednenaryn, are of great significance in the relief of Tyan-Shan. Those depressions, which are megasynclines (intermontane troughs), are sloped, mildly undulating or flat alluvial–proluvial plains.

The mountain relief, in combination with other factors, exerts a substantial influence on economic activities and on the specialization of individual sectors of the economy. Most fully developed are the piedmont plains and low-mountain and medium-high–mountain intermontane basins. The greatest difficulties are encountered in the development of high-mountain areas—Kichi-Naryn and other areas that are distinguished by dry natural conditions.

The diversity of the climate of Kyrgyzstan—particularly its continentality and aridness—stems from the comparatively southern location of the country, its remoteness from any oceans, the fact that it neighbors vast deserts, the degree of geomorphic contrast, and the fact that most of the republic is orographically closed off. The Naryn Basin is a closed, medium-high–mountain, intermontane basin with a markedly continental climate.

The seasonal contrast of climatic conditions is appreciable in terms of temperature fluctuations. Summer everywhere is dry and hot, especially in the submontane valleys of the Fergana region. Winter is rather cold, particularly in the mountains and the intermontane basins, and temperatures reach an absolute low of −53.6°C in upper Naryn.

Precipitation is unevenly distributed across Kyrgyzstan. More than anywhere else, precipitation falls in the Fergana Region, Chu, and Talas valleys in the spring months (as much as 1,500–2,000 mm). In the Naryn Basin, the greatest amount of rainfall is in the warm season (200–400 mm).

Kyrgyzstan has a markedly ramified hydrographic network. Some 90% of the rivers and streams have a length of up to 10 km. Most of the rivers of Kyrgyzstan (78.4% of the area of the republic) are in the Aral Sea Basin. The most important water artery is the Naryn River. The average annual discharge of the river at its mouth is 429 cu m/s. Kyrgyzstan's water resources are widely used in the national economy, particularly for irrigation and power engineering.

Kara-Kul', Tash-Kumyr, Mailu-Suu, and other industrial population centers are located in the Naryn River Basin. Numerous tributaries pollute the Naryn River with the industrial waste of Kok-Yangak, Uzgen, and Kara-Su and other pollutants.

The greatest danger in terms of contaminating the entire length of the Syrdarya with toxic radioactive waste is posed by the Mailu-Suu River, which flows across the Kyrgyz Republic and the Republic of Uzbekistan. Tailings ponds and dumps that have a high concentration of uranium and are located on the erosional and avalanche slopes along the river have been formed in that region as a result of the processing of uranium ore.

Various components participate in the recharge of mountain rivers—namely, glacial–snowmelt recharge (0–60% of annual runoff), seasonal snowmelt recharge (70–10% [sic]), recharge from precipitation (about 2–6%), and recharge from groundwater (30–40%).

Hydrographic characteristics of rivers
(inside the republic)

Main rivers	First-order tributaries	Length, km	Area of basin, sq km	Gradient, %
Naryn		535	58400	3
	Chong-Naryn	132	5710	7
	Kichi-Naryn	144	3870	1
	Chychkan	78	1290	54

Hydrogeological structures characterizing sampling points

Sampling point code	Location of sampling point	Hydrogeological structures characterizing sampling points	Type of river recharge
Kg-01	The tributary Kichi-Naryn before confluence with Chong-Naryn river	N–unseparated Neogene and Pliocene – intricately interbanded conglomerates, gritstone, sandstone, and, less commonly, sandy-argillaceous and marlaceous rock (with bands of gypsum and salt)	Glacial–snow melt
Kg-02	The tributary Chong-Naryn before confluence with Kichi-Naryn river	P-Є – Precambrian– primarily metamorphic and effusive formations; gneisses, marble, heavily marmorized limestone and sandstone, effusive rock	Glacial–snow melt
Kg-03	Naryn river after confluence of tributaries Chong-Naryn and Kichi-Naryn	N^3_2-Q– Upper Pliocene/Lower Quaternary– intricately interbanded conglomerates, sandstone and sandy-argillaceous rock with a preponderance of conglomerates N – unseparated Neogene and Pliocene and intricately interbanded conglomerates, gritstone, sandstone, and, less commonly, sandy-argillaceous and marlaceous rock (with bands of gypsum and salt) PZ_2 - Middle Paleozoic – primarily terrigenous, metamorphic, and effusive formations; sandstone, conglomerates, gritstone, aleurolites, shales, phyllites, quartzites, and, less commonly, limestone, marble, and effusive rock	Glacial–snow melt
Kg-04	Tributary At-Bashy before confluence into Naryn river	N – unseparated Neogene and Pliocene– intricately interbanded conglomerates, gritstone, sandstone, and, less commonly, sandy-argillaceous and marlaceous rock (with bands of gypsum and salt) PZ_2-Middle Paleozoic – primarily terrigenous, metamorphic, and effusive formations; sandstone, conglomerates, gritstone, aleurolites, shales, phyllites, quartzites, and, less commonly, limestone, marble, and effusive rock	Glacial–snow melt
Kg-05	Naryn river after confluence of tributary At-Bashy	αQ_{IV} - Lower Quaternary alluvial – modern pebble beds, sandy-gravelly rock and sand, and, less commonly, loams and clays N – unseparated Neogene and Pliocene– intricately interbanded conglomerates, gritstone, sandstone, and, less commonly, sandy-argillaceous and marlaceous rock (with bands of gypsum and salt)	Glacial–snow melt

Sampling point code	Location of sampling point	Hydrogeological structures characterizing sampling points	Type of river recharge
Kg-06	Chychkan river before confluence in Toktogul water pool.	pQ_{III} - Lower Quaternary alluvial–proluvial – modern boulder–pebble beds, pebble beds, and, less commonly, sandy-argillaceous rock and loams N^3_2-Q_1 – Upper Pliocene/Lower Quaternary– intricately interbanded conglomerates and sandstone	Glacial–snow melt
Kg-07	Naryn river before confluence in Toktogul water pool (hydropost Uch-Terek).	P-Є – Precambrian– primarily metamorphic and effusive formations; gneisses, marble, heavily marmorized limestone and sandstone, effusive rock γPZ - rock of intrusive formations: granite - porphyries and quartz porphyries, granodiorites and diorites	Glacial–snow melt
Kg-08	Toktogul water pool	N – unseparated Neogene and Pliocene– intricately interbanded conglomerates, gritstone, sandstone, and, less commonly, sandy-argillaceous and marlaceous rock (with bands of gypsum and salt) αQ_{IV} - Lower Quaternary alluvial – modern pebble beds, sandy-gravelly rock and sand, and, less commonly, loams and clays	Glacial–snow melt
Kg-09	Naryn river after Toktogul water pool (region of Kara-Kul town)	N – unseparated Neogene and Pliocene– intricately interbanded conglomerates, gritstone, sandstone, and, less commonly, sandy-argillaceous and marlaceous rock (with bands of gypsum and salt) αQ_{IV} - Lower Quaternary alluvial – modern pebble beds, sandy-gravelly rock and sand, and, less commonly, loams and clays	Glacial–snow melt
Kg-10	Naryn river, south-east part of the town Tashkumyr	N – unseparated Neogene and Pliocene– intricately interbanded conglomerates, gritstone, sandstone, and, less commonly, sandy-argillaceous and marlaceous rock (with bands of gypsum and salt) αQ_{IV} - Lower Quaternary alluvial – modern pebble beds, sandy-gravelly rock and sand, and, less commonly, loams and clays	Glacial–snow melt
Kg-11	Mailuu-Su river, on the bridge. Boundary with Uzbekistan	N – unseparated Neogene and Pliocene– intricately interbanded conglomerates, gritstone, sandstone, and, less commonly, sandy-argillaceous and marlaceous rock (with bands of gypsum and salt)	Glacial–snow melt
Kg-12	Mailuu-Su river at departure from Mailuu-Su town.	N – unseparated Neogene and Pliocene– intricately interbanded conglomerates, gritstone, sandstone, and, less commonly, sandy-argillaceous and marlaceous rock (with bands of gypsum and salt)	Glacial–snow melt

Sampling point code	Location of sampling point	Hydrogeological structures characterizing sampling points	Type of river recharge
Kg-13	Mailuu-Su river near to Transformer factory.	N – unseparated Neogene and Pliocene– intricately interbanded conglomerates, gritstone, sandstone, and, less commonly, sandy-argillaceous and marlaceous rock (with bands of gypsum and salt) P - Paleogene-clay marls and limestone with bands of gypsum and salt, and above in sequence sandy-argillaceous layers	Glacial–snow melt
Kg-14	Right tributary of Mailuu-Su river.	PZ_2 - Middle Paleozoic – primarily terrigenous, metamorphic, and effusive formations; sandstone, conglomerates, gritstone, aleurolites, shales, phyllites, quartzites, and, less commonly, limestone, marble, and effusive rock P-Є – Precambrian– primarily metamorphic and effusive formations; gneisses, marble, heavily marmorized limestone and sandstone, effusive rock	Glacial–snow melt
Kg-15	Mailuu-Su river 200 meters from the tributary	PZ_2 - Middle Paleozoic – primarily terrigenous, metamorphic, and effusive formations; sandstone, conglomerates, gritstone, aleurolites, shales, phyllites, quartzites, and, less commonly, limestone, marble, and effusive rock	Glacial–snow melt

Distribution:

1	MS 1373	David Barber, 5324
1	MS 1373	Amir Mohagheghi, 5324
1	MS 1373	Howard Passell, 5324
1	MS 1373	Adriane Littlefield, 5324
10	MS 1373	CMC Library, 5341
1	MS 9018	Central Tech Files, 8945-1
2	MS 0899	Technical Library, 9616
1	MS 0612	Review & Approval Desk 9612 for DOE/OSTI