Heavy metals in the waters of Tajikistan's Rivers

D.A.Abdushukurov

Institute of Water Problem, Hydropower and Ecology of the Academy of Sciences of Republic of Tajikistan.
Institute of Water Problem, 14A, Ayni str., Dushabe, 734042, Tajikistan
E-mail: abdushukurov.dj@gmail.com

Abstract: Results of calculations of the limiting health hazard indicator of water for 35 sampling points on the main rivers of Tajikistan were represented. Water samples were analyzed by means of neutron activation analysis.It is shown that the water in all mountain rivers of Tajikistan is clean. In the north of Tajikistan, almost all the rivers are polluted. Pollution caused by anthropogenic factors.

Key words: ecology, hydrochemistry,water quality, rivers of Tajikistan.

Introduction

Dissolved metals in the water are most dangerous pollutants in water usage.During the simple water purification usuallywater precipitationused,this can sharply reduce the number of suspensions, respectively sedimentary metals in suspension, after the water is chlorinated, which allows to clear water from microorganisms, viruses and other pathogens. At the same time to reducing the dissolved metal fraction needed complex physical and chemical cleaning methods. These methods usually are not available in the rural areas.

Hygiene rulesHR 2.1.5.1315-03 of Russia (Hygienic rules)determined the maximum permissible concentration (MPC) of chemicals, including metals in waters for drinking, cultural and community usage. The HR regulatedMPC of chemical substances, including metals in waters, and indicatesdangerclasses of substance. At the presence of several metals in waters the limiting health hazard indicator of water (LHHIW) representing the sum of the ratio of concentration of metals to their MPCrecommended used.

Currentarticle is dedicated to the processing of a database on the hydrochemistry of waters, namely the content of metals in the dissolved fraction of water sampled in 35 points in the main rivers of Tajikistan. Analysis obtained data, calculation of the LHHIW index and the definition of ecologically dangerous rivers of Tajikistan.

Research Methods

Scientists of Tajikistan, in cooperation with scientists from Kazakhstan, Uzbekistan and Kyrgyzstan, over the 10 years took part in a large international experiment "Navruz". During the experiment sampling of soil, sediment and waterwas carried out. Water was sampling on 35 points, almost on all main rivers of Tajikistan. In 15 points sampling was carried out twice in a year: in autumn and spring, for 5 years, selectionother points wereoccasionally in different seasons. In our studies we tried to select only the points on which the sampling was carried out in one (spring) season. In autumn in the rivers increases the portion of underground waters and, accordingly, the amount of dissolved metals. If the elemental composition of the bottom sediments and the surrounding soils not strongly depend on the season of sampling, but the elemental composition of watersin rivers strongly depends on the selection of the season. Unfortunately, we did only treatment to available data and could not influence for the sampling process.

Forimplementation of elemental analysis of samples the prepared samples were sent for neutron activation analysis (NAA) to the Institute of Nuclear Physics of Uzbekistan (UzINP), and 10% of the samples were sent to the Institute of Nuclear Physics of the Republic of Kazakhstan (KzINP) (BarberD.S., et al., 2003),(YuldashevB.S., et al.,2005).

During the analyzes in UzINP, in water samples were determined concentration of 22 elements: As, Au, Ba, Ca, Ce, Co, Cr, Cs, Eu, Fe, Hf, La, Lu, Mn, Na, Rb, Sb, Sc, Sm, Tb, Th, U, Yb and Zn. In the KzINP 30 elements were determined.In addition to the ones mentioned above: Br, Mo, Nd, Ni, Se, Sr, Ta, and Zr. Elements such as: Ca, Fe, Mn, Na classified as macro elements, and other as a trace elements.

Name of the sampling points and theirs geographical coordinates given in Table 1and shown in Figure 1.

Results and Discussion

In the selected samples concentrations of dissolved metals in the waterwere measured. Among the elements were detected metals from hazard 1class: As, and 2classes: Ba, Co, Mo, Na, Ni, Sb, Sr, Se and U.

At presence in the waters of several metals from 1 and 2 hazard class the limiting health hazard indicator of water (LHHIW) presenting the sum of the ratio concentration of metals to their MPC for several metalsused (Hygienic rules).

$$\text{LHHIW} = \sum_{i=1}^{j} Ci/\,MPCi \leq 1$$

Where Ci- is concentration of the i-element and MPCi-maximum permissible concentration of metalsin the drinking water. The number of defined elements (j) is equal to 6 for analyzes carried out on the UzINP and 10 for analyzes on the KzINP. For pure water value of the index LHHIWmust be less or equal to one.

In the table 2 are collected the calculated value of the ratio Ci/MPCi for different metals in the main rivers of Tajikistan.

Unfortunately, only forthe lower reaches of the Syr Darya and Isfara River have been identified 10 toxicants, for the other river only 6. This was due to the different capabilities of analytical laboratories.

The value of the index LHHIWis greater than one only for 4 sampling points; it is the Syr Darya in the entrance and exit of Tajikistan, in the lower reaches of Isfara and Zaravshan Rivers, Figure 2.

Syr Darya isTransit Riverfor Tajikistan, andflows through its territory, only about 180 km. It was early noted that the value of LHHIW at the entrance to the Tajikistan is higher thanin its output (Abdushukurov D.A., et al., 2014a) and it is associated with a positive effect on water quality in the river of Kairakum reservoir. Large reservoirs have a positive effect to water quality in rivers, suspended matters almost completely precipitated. At the same time, in a static state of the water of reservoirs the various biochemical and geochemical reactions take place, as result the precipitation of heavy metals in water occur.

Significant contamination of water in the lower reaches of the Zaravshan River has an anthropogenic origin. Generally the pollution caused by presence the dissolved in waterantimony. In the Yagnob River inflow of Zeravshan big Anzob Dressing Mining Plant (ADMP) for the production of mercury-antimony concentrates take place. In the plant technogenic accident was occur, so it was broken slurry pipeline for transportation liquid wastes, and a large part of the wastesof plant flow into the water of river. Despite for the significant removal sampling point from the ADMP (150 km), the concentration of antimony in the waters of Zaravshan was large (more than 2 MPC's). Fig. 3 shows the distribution of antimony dissolved in water in the tributaries of the Zaravshan river. Unfortunately, in the tributaries Yagnob and Fondarya in which the ADMP located sampling has not been made.

A similar pattern is observed for the bottom sediments (Fig. 4), where it was identified geochemical anomaly (with concentration of antimony /average abundanceof antimony in the Earth crust = 154)(Abdushukurov et. al., 2014b). Such a large concentration of antimony can be formed only by man-made path, when the flotation tailings flow in the water of river on ADMP.

In all sampling points of Zeravshan, both in bottom sediments and surrounding soils observed repeatedly overstating the antimony content above the average abundance of antimony in the Earth crustvalues (0.2 µg / g) [5]. In the bottom sediments concentration of antimony is larger than in the surrounding soils.

The water was dirty, also in the lower reaches of Isfara river on the border with Uzbekistan, LHHIW greater than 1. In general, pollution caused by the presence of three elements: Na, Se and U. Brackish water in the lower reaches, due to the influence of drainage water from agricultural fields. Also, there is an increased concentration of selenium and uranium.

In our works on geochemistry Kairakum reservoir [6] we were faced with an increased concentration of selenium in soil and sediment in the north of Tajikistan. Most likely, in the northern Sogd region on the throughout the high concentrations of selenium observed.

In general, the water was clean in theMountain Rivers of Tajikistan. The concentration of dissolved metals increases as move to the mouths of rivers. The difference in LHHIW mainly depends to geological and geochemical characteristics of the river basins. Rivers are polluted in the Sogd (Northern) region, in basin of which located the mining and metal processing enterprises.

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Table 1

The geographical coordinates of the sampling points.

Shown: code sampling points, rivers or human settlements,

location of the sampling points and the geographical coordinates by GPS.

№	Code	Rivers	Location of sampling points	Latitude	Longitude
1	TJ-25	Sioma	Inflow of Varzob	38,9683	68,7596
2	TJ-28	Tagob	Inflow of Varzob	38,8471	68,8485
3	TJ-29	Obi Chappa	Inflow of Varzob	38,7899	68,8267

4	TJ-30	Odjuk	Inflow of Varzob	38,7532	68,8154
5	TJ-01	Varzob 1	18 km above Dushanbe	38,7112	68,7920
6	TJ-02	Varzob 2	9 km belowDushanbe	38,5247	68,7718
7	TJ-67	Sarbo	1 km above confluence withSardai Miona	38,7276	69,3270
8	TJ-66	Sardai Miena	1 km above confluence with Sarbo	38,7286	69,3220
9	TJ-03	Kafirnigan 1	1 km above confluence with Varzob	38,4935	68,7847
10	TJ-04	Kafirnigan 2	3 km below confluence with Elok	38,4569	68,7364
11	TJ-05	Kafirnigan 3	Railway bridge of Shartuz	37,2513	68,1526
12	TJ-06	Elok	1 km above confluence with Kafirnigan	38,4790	68,7867
13	TJ-08	Vahsh 1	Settlement Chosada	38,4876	69,52232
14	TJ-07	Vahsh 2	Railway bridge Jilikul	37,5532	68,5271
15	TJ-09	Gunt	Outskirts of Horog	37,4898	71,5330
16	TJ-10	Pyanj 1	Bridge of Tem settlement	37,5374	71,4971
17	TJ-11	Pyanj 2	Bridge near Nigniy Pynj settlement	37,1975	68,6097
18	TJ-31	Syr Darya 1	Kishak Bulok	40,5556	70,5430
19	TJ-13	Syr Darya 2	Western outskirts of Hojent	40,2908	69,6200
20	TJ-14	Isfara 1	Border with Kirgizstan	39,8587	70,5432
21	TJ-15	Isfara 2	Rabot settlement (above Fergan chanel)	40,3120	70,5572
22	TJ-68	Saburgan	Inflow of Karatag	38,6833	68,3734
23	TJ-69	Karatag 1	500 mabove confluence with Saburgan	38,6847	68,3677
24	TJ-58	Karatag 2	KishlakBatosh	38,5807	68,3230
25	TJ-70	Rogova	Inflow of Honako	38,6498	68,5726
26	TJ-71	Honako 1	1 km above Rogova, kishak Dutaka	38,6515	68,5768
27	TJ-59	Honako 2	Kishlak Hirmanak	38,5815	68,5559
28	TJ-74	Shahristan 1	Beginning of Shahristan pass	39,5664	68,5919
29	TJ-72	Shahristan 2	Beginning of Shahristan pass	39,5754	68,5951
30	TJ-73	Shahristan 3	Shahristan pass, on Shahristan side	39,5763	68,5785
31	TJ-75	Shahristan 4	End of Shahristan pass, on Ayni side	39,4586	68,5464
32	TJ80	Oburdon	Inflow of Zeravshan (Matcha)	39,4127	69,0921
33	TJ89	Tomin	Inflow of Zeravshan (Matcha)	39,3867	68,6448
34	TJ45	Magiyn	Inflow of Zeravshan	39,4896	67,7174
35	TJ44	Zeravshan	Border with Uzbekistan	39,4993	67,5183

Table 2

The ratio of the concentration of elements 1 and 2 hazard classes to their MPCs and the sum of ratios (LHHIW) for rivers in Tajikistan

Rivers	As	Ba	Co	Mo	Na	Ni	Sb	Sr	Se	U	SUM
Sioma	0,278	0,003	0,003	nd	0,005	nd	0,060	nd	nd	0,032	0,38
Tagob	0,060	0,031	0,001	nd	0,008	nd	0,112	nd	nd	0,024	0,24
Obi Chappa	0,183	0,003	0,002	nd	0,008	nd	0,454	nd	nd	0,159	0,8
Odjuk	0,061	nd	0,001	nd	0,007	nd	0,030	nd	nd	0,132	0,23
Varzob 1	0,178	0,052	0,002	nd	0,006	nd	0,032	nd	nd	0,037	0,31
Varzob 2	0,171	0,136	0,002	nd	0,007	nd	0,056	nd	nd	0,038	0,41
Sarbo	0,281	0,041	0,003	nd	0,006	nd	0,028	nd	nd	0,018	0,37
Sardai Miena	0,141	0,031	0,001	nd	0,005	nd	0,056	nd	nd	0,015	0,25
Kafirnigan 1	0,208	0,059	0,002	nd	0,009	nd	0,052	nd	nd	0,031	0,36
Kafirnigan 2	0,157	0,063	0,002	nd	0,025	nd	0,044	nd	nd	0,026	0,32
Kafirnigan 3	0,134	0,008	0,001	nd	0,135	nd	0,376	nd	nd	0,018	0,67
Elok	0,071	0,196	0,001	nd	0,064	nd	0,030	nd	nd	0,023	0,38
Vahsh 1	0,065	0,070	0,001	nd	0,065	nd	0,044	nd	nd	0,010	0,26
Vahsh 2	0,112	0,117	0,001	nd	0,350	nd	0,056	nd	nd	0,023	0,66
Gunt	0,062	0,013	0,001	nd	0,033	nd	0,014	nd	nd	0,048	0,17
Pyanj 1	0,081	0,025	0,001	nd	0,027	nd	0,034	nd	nd	0,043	0,21
Pyanj 2	0,133	0,052	0,001	nd	0,261	nd	0,044	nd	nd	0,020	0,51
Syr Darya 1	0,163	0,038	0,002	0,071	0,583	0,004	0,068	0,371	0,213	0,201	1,74
Syr Darya 2	0,135	0,123	0,001	0,064	0,404	nd	0,050	0,340	0,170	0,193	1,48
Isfara 1	0,029	0,068	0,000	nd	0,019	nd	0,024	nd	nd	0,020	0,16
Isfara 2	0,074	0,077	0,001	nd	0,397	nd	0,060	nd	0,520	0,114	1,25
Saburgan	0,026	0,060	0,000	nd	0,014	nd	0,034	nd	nd	0,005	0,14
Karatag 1	0,023	0,024	0,000	nd	0,006	nd	0,010	nd	nd	0,015	0,08
Karatag 2	0,047	0,023	0,000	nd	0,014	nd	0,024	nd	nd	0,019	0,13
Rogova	0,077	0,032	0,001	nd	0,009	nd	0,006	nd	nd	0,011	0,14
Honako 1	0,066	0,042	0,001	nd	0,007	nd	0,020	nd	nd	0,015	0,15
Honako 2	0,094	0,027	0,001	nd	0,014	nd	0,012	nd	nd	0,017	0,17
Shahristan 1	0,030	0,008	0,000	nd	0,012	nd	0,026	nd	nd	0,005	0,09
Shahristan 2	nd	0,049	0,000	nd	0,013	nd	0,028	nd	nd	0,005	0,1
Shahristan 3	0,050	0,021	0,001	nd	0,012	nd	0,014	nd	nd	0,004	0,1
Shahristan 4	0,043	0,013	0,000	nd	0,000	nd	0,236	nd	nd	0,001	0,3
Oburdon	0,007	0,008	0,000	nd	0,003	nd	0,013	nd	nd	0,003	0,03
Tomin	0,054	0,068	0,001	nd	0,004	nd	0,042	nd	nd	0,010	0,19
Magiyn	0,394	0,163	0,004	nd	0,004	nd	0,220	nd	nd	0,016	0,8
Zeravshan	0,096	0,013	0,001	nd	0,006	nd	2,060	nd	nd	0,011	2,19

nd- no data.

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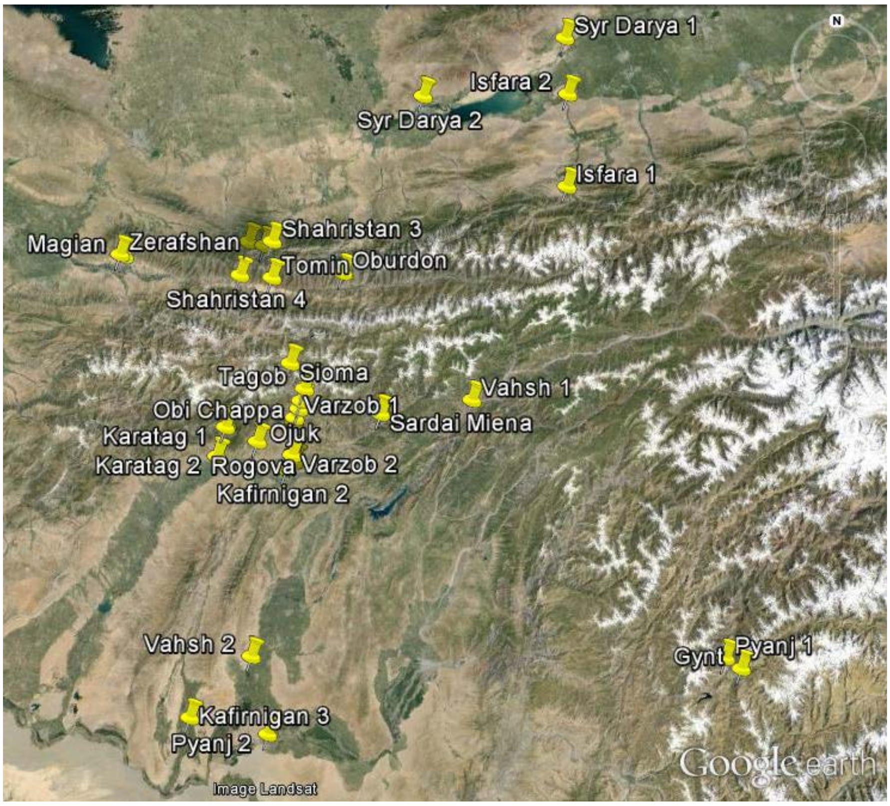

Fig. 1. Sampling points on the rivers shown on the Google Earth map

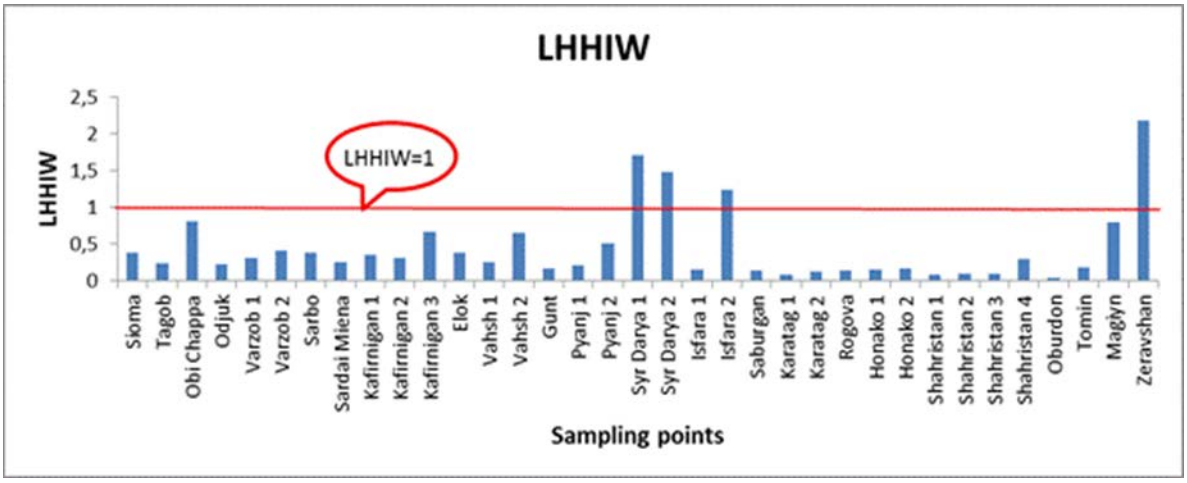

Fig. 2. Limiting health hazard indicator of water for the rivers of Tajikistan

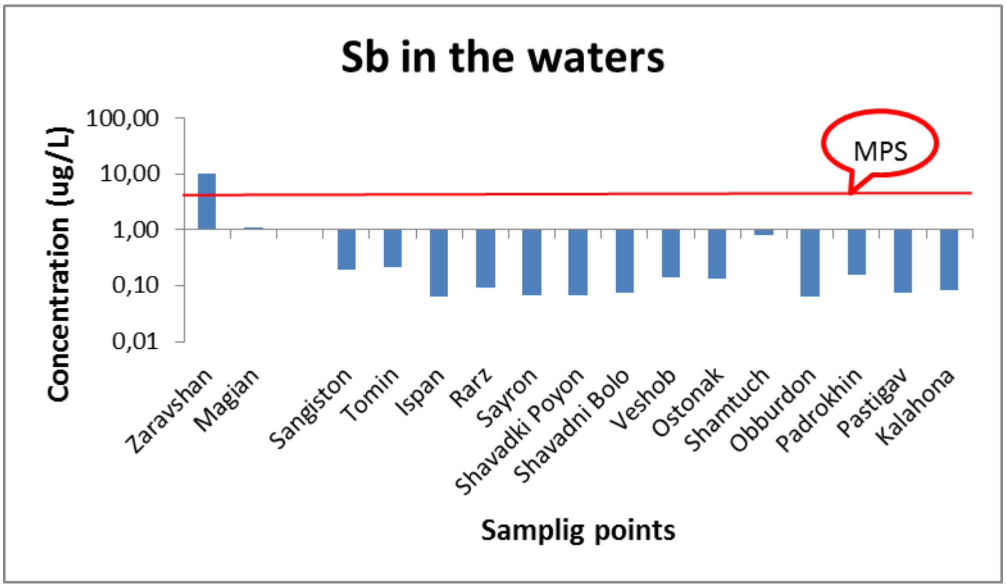

Fig. 3. Distribution of antimony dissolved in water in the tributaries of the Zeravshan River

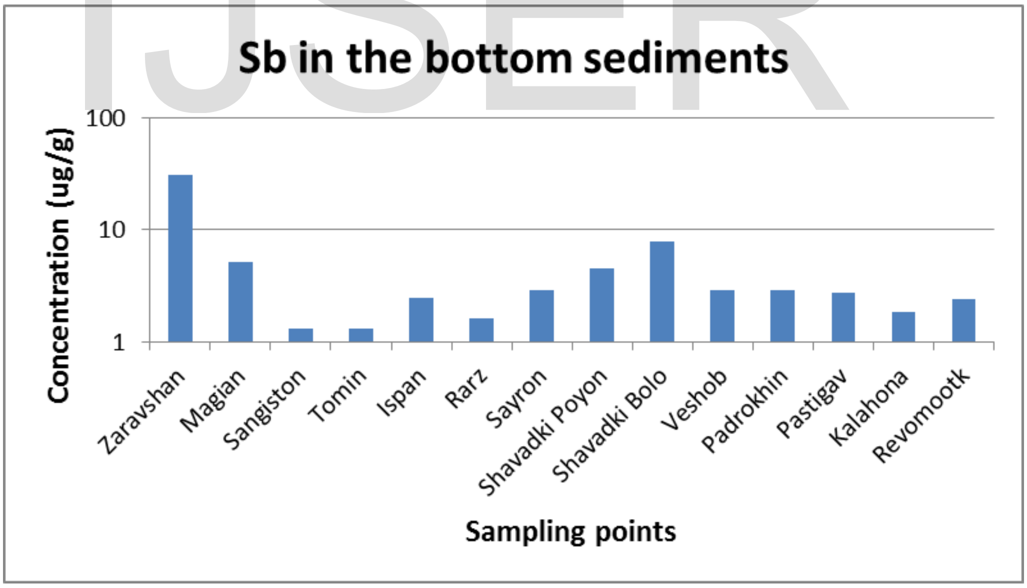

Fig. 4. Distribution of antimony in the bottom sediments of the tributaries of the Zeravshan river