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PRIMARY SALINIZATION OF MOUNTAIN RIVERS IN THE VAKHSH RIVER BASIN

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Annotation: *in the course of research, of the upper reaches of Vakhsh River an increased concentration of salts in the river waters was detected. Salinization of Mountain Rivers occurs due to erosion of deposits of rock salt of the Mesozoic period. Extra high salt concentration was detected in the stream Darei Namak. A method for reducing salinization of Mountain Rivers is proposed. The problem of the initial salinization of Mountain Rivers in Tajikistan is very relevant. Salinity of small mountain rivers can be significantly reduced by using water line (pipes or canals), in the highly mineralized zones. Such methods will be reducing the overall salinity of the Vakhsh River, and Amu Darya, respectively, and lie in the sphere of interest of many Central Asian countries.*

Key words: *Tajikistan, Vakhsh River, salinization, hydrochemistry.*

Introduction

The Vakhsh River is the right tributary and together with the Pyanj River forms the most powerful river of Central Asia, Amu Darya. The length of the Vakhsh River is 524 km; and the catchment area is 39,100 km². The river formed after the confluence of the Kyzylsu and Muksu rivers and under the name of Surkhob [1] flows down, and after confluence with the Obi Khinguou River, its name turned to Vakhsh [2].

The Kyzylsu River has a catchment area of 8380 km2 and a length of 254 km. Almost all flow of the Kyzylsu river is formed on the territory of Kyrgyzstan on the southern slopes of the Alai and northern slopes of the Zaalay Range. Feeding Kyzylsu is due to glacial (12%) and snow (13%) melting, most of the runoff is formed by groundwaters (75%), which are formed as a result of increased filtration of surface runoff in permeable rocks forming the river basin (limestones, shales, sands, conglomerates, pebbles, coarse-fragmented glacial deposits) [3].

The Muksu River is the second component of the Surkhob River. The length of the river is 88 km with a catchment area of 7070 km2. The basin of the river is located in the most elevated part of the Vakhsh basin, with an average height of the basin of 4540 m. Muksu is forms at the confluence of the Seldara and Suksaya rivers. The Seldara River originates from Fedchenko's largest glacier in Central Asia [4].

In the upper reaches Vakhsh flows in a narrow valley, sometimes in a deep gorge. About 170 km away from the mouth, the river reaches the wide Vakhsh valley. The river is fed mainly by glacial-snow melt, and in insignificant quantities by rainwater. Flood occurs in the period of intensive melting of glaciers: approximately from May to September, and low water is observed in November-April. The average flow of the river is 660 m^3/s, the highest flow (in July) is 3120 m^3/s, and the lowest consumption (in February) is 130 m^3/s. The waters of Vakhsh, like other of tributaries of Amu Darya, are characterized by a large turbidity (4.16 kg/m^3); however after the construction of the Nurek hydroelectric dam, the waters became transparent-blue. A cascade of Vakhsh hydroelectric power stations was built on Vakhsh. At the mouth, during formation of Amu Darya, the river has a width of 305 meters, and a depth of about 3.5 meters [5].

The Yavansu River is a comparatively small river, but it is subject of great anthropogenic impact. A tunnel from the Vakhsh River in the area of the Baipaza HPP reservoir was constructed in Yavan. The incoming water is mainly used for agriculture. Drainage water often comes back to the river. Several large enterprises operate in the river basin: Yavan electric heating plant; Salt enterprises; Chemical Combine; Cement plant, etc. In the region there is a large salt deposit, which is extracted on an industrial scale [6].

In July 2017, an expeditionary trip was carried out to the upper reaches of the Vakhsh River. The rivers Surkhob, Obi Khingou, Yarkhych, Yavansu, Vakhsh and their tributaries were explored. On these rivers, 28 water samples were taken. Selection points were chosen on the main rivers Surkhob, Obi Khingou, Vakhsh and their lateral tributaries. Some of inflows were difficult to access and we no conducted studies on them.

Methods and results

The sampling points are given in Figure 1.

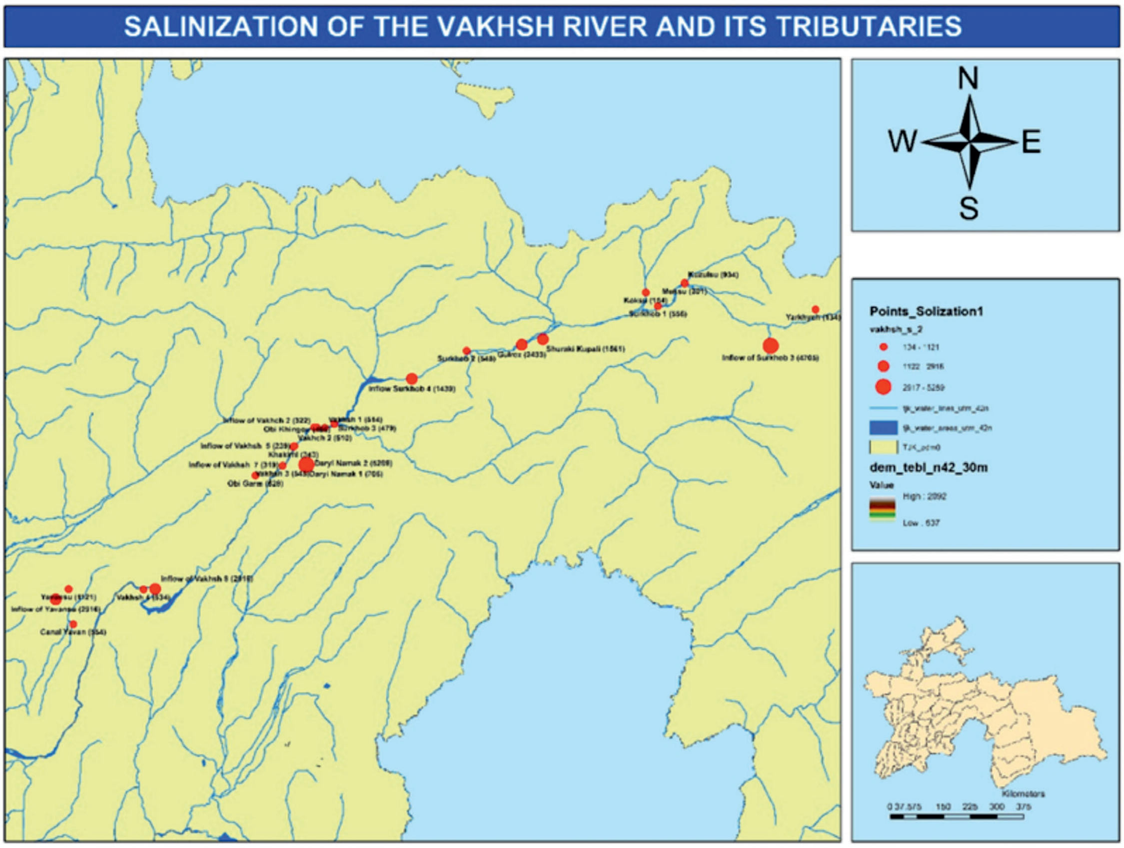

Figure1. Map of sampling points

The physical-chemical properties of water were studied directly on the sampling points with using standard, well now methods. To measure the physical-chemical characteristics of water, the equipment of the Wissenschaftlich-Technische Werkstatatten GmbH (Germany) firm was used. Cond 3110 with standard conductivity measuring cell: TetraCon 325; pH meter (pH 3110) with pH combination electrodes SenTix 21; Oxygenmeter Oxi 3205 with Dissolved Oxygen Sensor CellOx 325 was used.

The main measured parameters are given in Table 1.

Table 1

Main physical-chemical characteristic of river waters

Rivers	Redox potential (mV)	pH	Concen-tration of Oxygen (mg/L)	Saturation by Oxygen (%)	Condu-ctivity of waters (µS/cm)	Concen-tration of salt (mg/L)
Muksu	-58,7	7,8	4,97	78,1	572	301
Kuzulsu	-46,8	7,6	5,63	85,3	1711	934
Surkhob 1	-55,6	7,76	4,85	76,4	1031	556
Koksu	-67,2	7,95	5,09	78,8	307	154
Yarkhych	-52,2	7,69	6,39	98,6	272	134
Shuraki Kupali	-41,8	7,52	4,77	74,6	2840	1561
Gulrez	-49,3	7,64	4,52	69,8	4410	2433
Inflow of Surkhob 3	-41,8	7,52	5,59	87,2	8500	4705
Surkhob 2	-58,3	7,8	4,86	75,2	1016	548
Inflow Surkhob 4	-42,2	7,52	4,31	67,1	2620	1439
Surkhob 3	-56,6	7,75	4,82	75,1	892	479
Obi Khingou	-54,2	7,72	5,28	82,8	851	456
Vakhsh 1	-59,4	7,83	5,18	82,2	956	514
Inflow of Vakhch 1	-75,1	8,08	4,41	68,6	564	296
Inflow of Vakhch 2	-81,7	8,2	4,1	64,1	610	322
Vakhch 2	-57,7	7,79	4,76	74,1	948	510
Daryi Namak 1	-42,8	7,53	4,55	64,5	1299	705
Daryi Namak 2	-49,5	7,66	4,51	65,4	9550	5289
Inflow of Vakhsh 5	-70,2	8,01	4,83	74,8	461	239
Khakimi	-63,1	7,88	4,91	74,7	647	343
Vakhsh 3	-62,5	7,87	5,06	78,3	1011	545
Inflow of Vakhsh 7	-79,8	8,15	4,84	75,6	604	319
Obi Garm	-71,5	8,02	4,88	78,4	981	528
Inflow of Vakhsh 8	-52,3	7,63	4,24	65,2	3660	2016
Vakhsh 4	-67,6	7,96	5,21	77,2	993	534
Canal Yavan	-67,4	7,56	4,96	76,6	1029	554
Inflow of Yavansu	-66,5	7,91	5,25	81,8	5280	2916
Yavansu	-71,7	8,03	4,28	64,3	2050	1121

The water in all the measured points was slightly alkaline, with the highest index at the point "Inflow of Vakhsh 2" and with the smallest at the point "Shuraki Cupali", Figure 2.

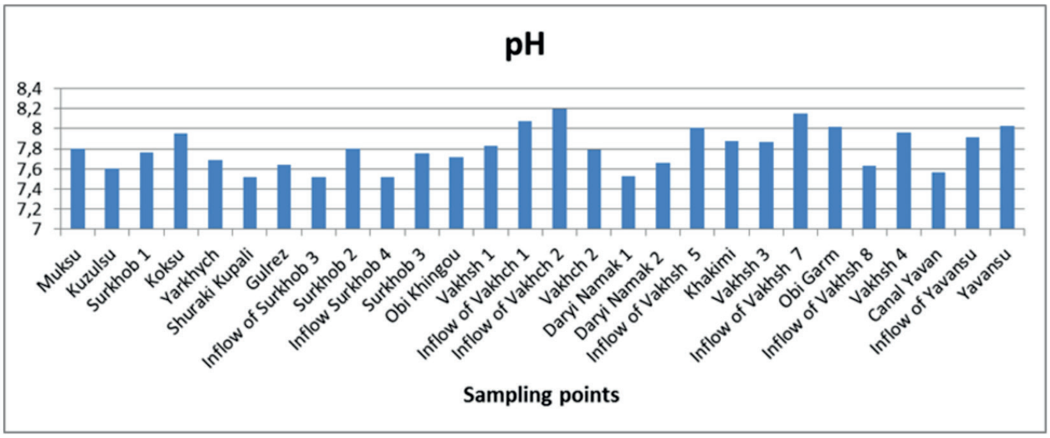

Figure 2. pH of water in rivers

The waters in all rivers are not sufficiently saturated with oxygen, except for the Yarchych River, Figure 3. The Yarkhich River (Khait) is probably the cleanest river in the region.

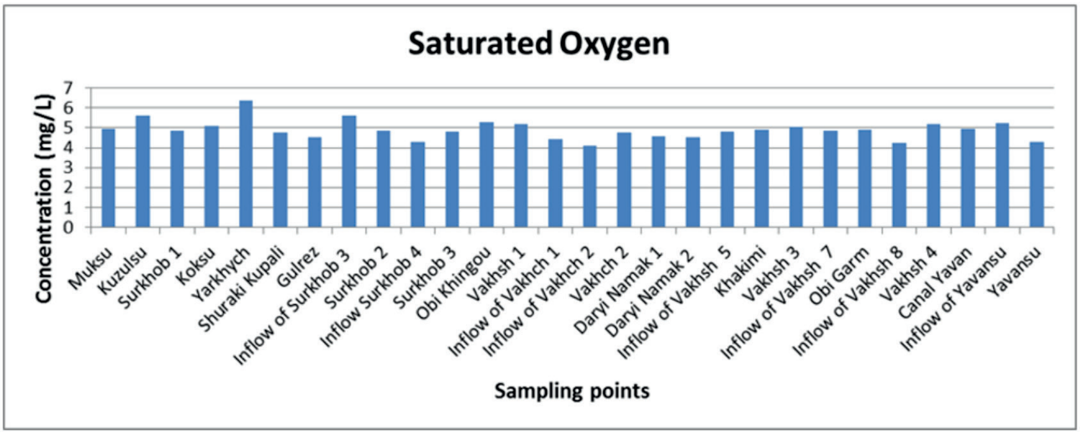

Figure 3. Concentration of saturated oxygen

The waters in all rivers are not sufficiently saturated with oxygen, except for the Yarchych River, Figure 3. The Yarkhich River (Khait) is probably the cleanest river in the region.

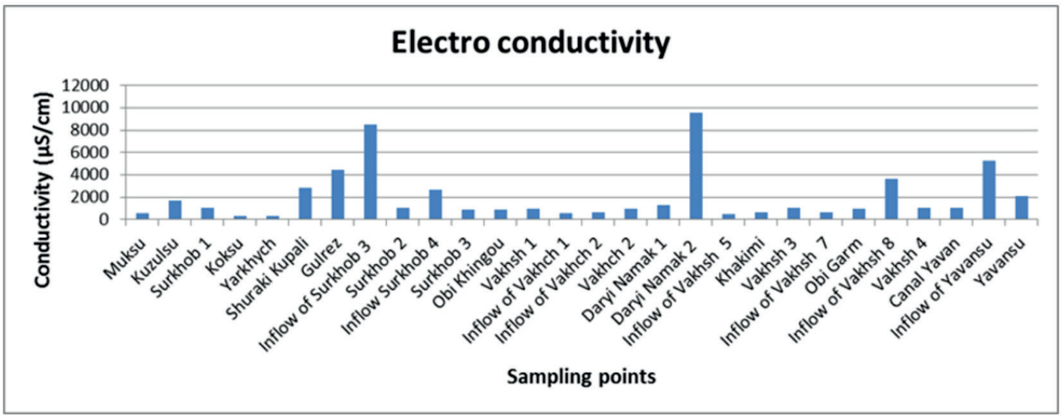

Figure 4. Electrical conductivity of water in measuring points

The concentration of salts in rivers is extremely unevenly distributed, Figure 5. According by common concept the upper limit of fresh water is the concentration of 1 g/L (1000 mg/L).

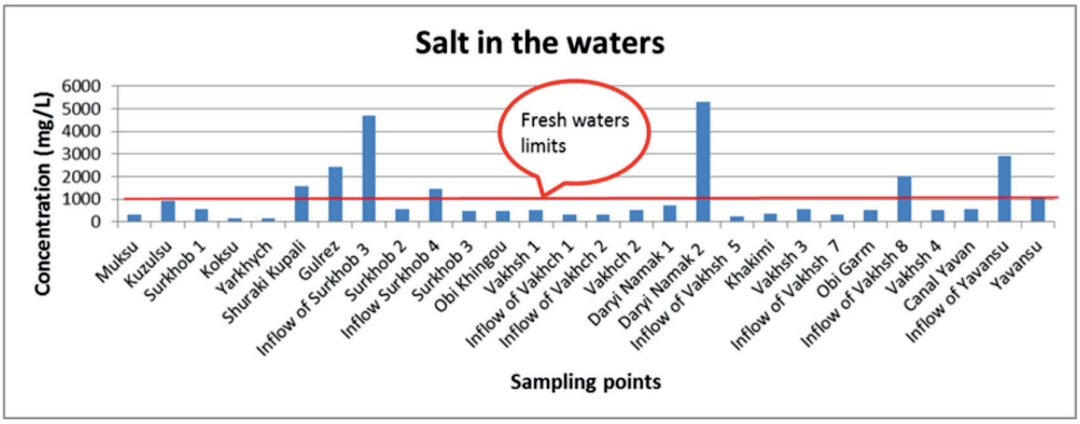

Figure 5. Distribution of salts in rivers

Discussion of the results

The hydrochemistry and geochemistry of the upper reaches of the Vakhsh River was studied by us earlier and published in articles [7, 8, 9, 10].

All streams on the left side of the Surkhob and Vakhsh rivers have increased turbidity, compared to streams flowing from the starboard side, which is obviously connected with different geological structures of the mountains.

Negative values of the Redox potential are inherent for thawed and underground waters. All waters can classify as "living water".

Water in all measured rivers is slightly alkaline. Low values are characterized for rivers with a high level of mineralization.

Usually the water after passing through the turbines of the HPP is saturated by oxygen, but this did not happen at the Vakhsh 4 (below the dam of the Nurek HPP). Unfortunately, the authors were not able to measure the parameters of the water in the reservoir itself, since access to the dam is limited. A similar phenomenon could be explained by the fact that the water in the reservoir accumulates for several years. During this time, due to bio and geochemical reactions, concentration of oxygen decreases. At the same time, when water passes through HPP turbines, the oxygen concentration increases again.

The water of the Kyzylsu River before the confluence with Muksu has an increased mineralization and is practically unsuitable for drinking water supply. The concentration of salts in it is practically equal to 1 g/L.

After the confluence with the Muksu River, the concentration of salts decreases almost twice (see point Surkhob 1).

Several streams with a high concentration of salts flow into the left side of the Surkhob and Vakhsh rivers were fund. These are the Daryei Namak, Dashti Namak, Shuraki Kupali, Gulrez, Yavansu and others rivers. We detected 8 tributaries with a salt concentration of more than 1 g/L. The maximum salt concentration was found in the left-bank inflow of Vakhsh: Daryei Namak 5.3 g/L. Some streams directly pass through deposits of Mesozoic salts [11]. As an example, Figures 6-7 show pictures of salt deposits located above the Daryei Namak (Roguni Bolo village).

Figure 6. Fragment of salt deposit above the village Roguni Bolo

Figure 7. Exit the streams of water from the salt depository (Roguni Bolo)

Such salinization of rivers is unique, since is it primary salinization of Mountain Rivers.

During the trip, about 10 hard-to-reach rivers were not explored. For their study, long walking routes needed. At the same time, the absence of settlements on some of this rivers pushes to the idea of unsuitability of water for use.

Recommendation and Conclusions

The physical and chemical properties of the waters of the Vakhsh River should be studied once more during the periods of low water level, in November. At low water period the share of underground feeding of rivers increases, accordingly it is inspected that mineralization of water in rivers must be increases too. It can be expected that the concentration of salts in rivers will increase significantly. The study of water properties in two seasons will give a more objective picture of the purity of water in rivers.

The problem of the initial salinization of Mountain Rivers in Tajikistan is very relevant. Salinity of small mountain rivers can be significantly reduced by using water line (pipes or canals), in the highly mineralized zones. Such methods will be reducing the overall salinity of the Vakhsh River, and Amu Darya, respectively, and lie in the sphere of interest of many Central Asian countries.

At present, all achievements are being taken to reduce the secondary salinization of the Central Asian Rivers. Drainage constructions and evaporative lakes are being built [12]. But for the problem of primary salinization of rivers is not paid any attention.

It is also important to study of the hydrochemistry of river waters for identification the presence of impurities of radioactive elements and heavy metals in the areas adjacent to Obi-Garm and the Khayit village (both areas are densely populated). In the upper reaches of the Yarkhych River industrial facility where coal-anthracite mines is operated. Usually coals also containing harmful impurities of heavy and radioactive elements. Also, the area of the Darai-Pioz Mineralogical Reserve with an increased radioactive background, mainly of thorium nature, needs revision, although further studies may reveal occurrences of uranium mineralization. The study of water geochemistry (hydrochemistry) can serve as the main search sign or refute the assumption – about geology of Darai Pioz. Especially since the slopes of the Darai Pioz valley are difficult to access, and ground geochemistry is difficult, as a result of which the area of the Reserve is generally poorly investigated.

We consider it necessary to obtain a grant for the comprehensive study of the rivers of Tajikistan, identify sources of river pollution and develop project proposals for reducing of overall salinity of the rivers in Central Asia.

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ШӮРШАВИИ ИБТИДОИИ ДАРЁҲОИ КӮҲӢ ДАР ҲАВЗАИ ДАРЁИ ВАХШ

Абдушукуров Ҷ.А.

Аннотатсия: *ҳангоми тадқиқи болооби дарёи Вахш консентратсияи зиёдшавии намакҳо дар оби дарёҳо ба қайд гирифта шуд. Шӯршавии дарёҳои кӯҳӣ асосан ба эрозияи (шӯсташавӣ) конҳои намаки давраи Мезозой вобаста мебошад. Консентратсияи зиёдтарини намак дар шохоби дарёи Намак ба қайд гирифта шудааст. Усулҳо оид ба кам кардани шӯршавии дарёҳои кӯҳӣ пешниҳод карда шуд.*

Калидвожаҳо: *Тоҷикистон, дарёи Вахш, шӯршавӣ, гидрохимия.*

ИЗНАЧАЛЬНОЕ ЗАСОЛЕНИЕ ГОРНЫХ РЕК В БАССЕЙНЕ РЕКИ ВАХШ

Абдушукуров Д.А.

Аннотация: *при исследовании верховий реки Вахш были обнаружены повышенные концентрации солей в речных водах. Засоление Горных рек в основном происходят из-за эрозии месторождений солей Мезозойского периода. Наибольшая концентрация солей была зарегистрирована в притоке Дарьеи Намак. Предложены методы по уменьшению засоленности горных рек. Проблема засоленности горных рек Таджикистана востребована и своевременна. Засоленность малых рек может быть сильно уменьшена путем строительства водоводов (труб и каналов) в сильно минерализованных зонах. Применение подобных методов позволит уменьшить общую засоленность рек Вахш и АмуДарья и лежат в сфере интересов ряда стран ЦентральнойАзии*

Ключевые слова: *Таджикистан, река Вахш, засоление, гидрохимия.*

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ELEMENTAL COMPOSITION OF THE RIVER BOTTOM SEDIMENTS IN THE TOP OF THE ZERAVSHAN RIVER BASIN

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Annotation: *the carried out of the work was devoted to the processing and interpretation of new data bases (2020 years) for the study of toxic metals in bottom sediments of the Zeravshan river basin. Particular attention was paid to the Fondarya River, the left tributary of the Zeravshan River. The Fondarya River is subject of a large anthropogenic impact. The most heavily polluted lower reaches of the Jijikrut, below the Anzob mining and processing plant (AGOK). In the 90s of the last century, due to an accident on the slurry pipeline, AGOC dumped flotation tailings directly into the Jijikrut River, which caused severe pollution of the bottom sediments of this river with metals such as Cr, Ni, Sb, Zn.*

Key words: *Zeravshan River, Fondarya River, toxic metals, pollution of river bed, arsenic, antimony, mercury.*

Zeravshan river has an annual average runoff of 5.3 km3, of which 97% (5.1 km3) are generated in Tajikistan. Currently Tajikistan is only using approximately 6% (0.3 km3) of the Zeravshan waters. The main proportion of the Zeravshan runoff is utilised for irrigation water, about 550,000 ha in Samarkand, Navoi, Jizzak and Kashkadarya Provinces of Uzbekistan. The annual water consumption for irrigation of this region is 6.6 km3 (12,000 m3/ha per year) and therefore 1.3 km3 above the available mean runoff. For balancing the higher irrigation demand drainage water is reused [1].