Modern Environmental Science and Engineering (ISSN 2333-2581)
November 2017, Volume 3, No. 11, pp. 796-804
Doi: 10.15341/mese(2333-2581)/11.03.2017/007
Academic Star Publishing Company, 2017
www.academicstar.us

Ecological Aspects of the Transboundary Rivers Water Resource Management of the Central Asia

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Abstract: In most cases the problem of water quality of the Zeravshan River consider in organic communication with activity of the Anzob Mountain-concentrating combine (AMCC). AMCC is the mining enterprise for extraction and enrichment of complex mercury-antimony ores of the Dzhizhikrut deposit. It is located in a right-bank part the rivers Dzhizhikrut which are the left inflow of the river Yagnob (the river Yagnob is the right inflow of the river Fondarya which in turn is the left inflow of the river Zeravshan). For definition influence of the AMCC on qualities of waters of the river Zeravshan were made sampling of water from the river in two points - on Fondarya and Pete Rivers is located accordingly before and after wastewater dams of AMCC. Comparison of results chemical analyses have shown about absence of the factor of pollution of the river Zeravshan by wastewaters of industrial complex. Detected change (heavier) isotopic composition (δ^2H, $\delta^{18}O$) of the Zeravshan River and its tributaries from upstream to the downstream of the river associated with the evaporation process. The exchanges of groundwater and surface waters in Muksu river basin was observed. The groundwater reservoirs of the Muksu River Basin (a tributary of the Vakhsh River) in dry periods nourishes the river Muksu.

Key words: transboundary, chemical analyses, isotope, Zeravshan, Vakhsh, Central Asia

1. Introduction

Water quality has become a global issue. Every day, millions of tons of inadequately treated sewage and industrial and agricultural wastes are poured into the world's waters. Every year, lakes, rivers, and deltas take in the equivalent of the weight of the entire human population — nearly 7 billion people — in the form of pollution. Every year, more people die from the consequences of unsafe water than from all forms of violence, including war — and the greatest impacts are on children under the age of five.

From the international level to watershed and community levels, laws on protecting and improving water quality should be adopted and adequately enforced, model pollution-prevention policies disseminated, and guidelines developed for ecosystem water quality. Standard methods to characterize in-stream water quality, international guidelines for ecosystem water quality, and priority areas for remediation need to be addressed globally [1].

Water relations between Central Asia republics during the Soviet Union time were regulated by "Complex Use and Protection of Water Resources Schemes" in Amudarya and Syrdarya basins.

The main purpose of working out basin "Schemes" was to define real volumes situated within the Amudarya and Syrdarya basins and available for using water resources. It was also providing their fair allocation among region republics, meeting all the water users' interests. It should be noticed, that the number of important aspects were not considered and included in "Schemes", for the situation has greatly changed after 1980 (years of the last "Schemes" specification and completion of hydraulic range

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composition). Mainly it concerns the ecologic acquirements and sanitarian clears thrown into rivers and channels. Overusing basin water in irrigational lands planned as maximum use by "Scheme" resulted in exhausting water resources and appearing new problems. They are:

- deterioration of ecological condition, sometimes leading to ecological disaster in river lowlands of Aral basin;
- great pollution of river water with pesticides, herbicides, other harmful elements and increasing of water mineralization.

The problem of the water quality change and development of mechanisms of its control is still actual and concerns not only the separately taken country of Central Asia (CA) but also all the states of the region. Nowadays one of the most polluted rivers of Central Asia is Zarafshan River. The capacity of this water is changed under the influence of collector drainage water of irrigating basin zone and wastewater of Samarqand, Kattakurgan, Navoi, and Bukhara cities. Mineralization of water exceeds from origin to estuary from 0.27-0.30g/l to 1.5-1.6g/l. The most exceed of MC among heavy metals is observed in Cr and Zn. Moreover in Zarafshan river high contain of antimony was found out and its phenol pollution composes 3-7.5 MC [2].

1.1 Anzob Mountain-Concentrating Combine (AMCC)

AMCC the mining enterprise for extraction and enrichment of complex mercury-antimony ores of the Dzhizhikrut deposit. It is located in area Ajni in 13 km of a highway of Dushanbe-Khujand in a right-bank part the rivers Dzhizhikrut which are the left inflow of the river Yagnob (the river Yagnob is the right inflow of the river Fondarya which in turn is the left inflow of the river Zeravshan). The Dzhizhikrut deposit has been opened in 1940 and industrial exploitation has begun from 1954. The Dzhizhikrut deposit is located in the ore field area with the same name that is a part of the Zeravshan-Gissar mercury-antimony belt. The main ore minerals are antimonite and cinnabar. For the period 1966-1970 reconstruction of industrial complex was spent and for the purpose of prevention of hit of sewage of industrial complex to the river Dzhizhikrut river in village of Ravot (8-10 km from industrial complex) on left to river bank Yagnob was are built waste water dams (WWD). The pipelines of sewage for the period 1974-1994 functioned normally. Because of heavy rains pipeline pieces has been destroyed. The industrial complex in 2009 has completely restored pipelines and now dams in the complete set and works in the established mode.

The first step is to clarify the importance of the problem the quality of the Transboundary Rivers and their tributaries. In the West in the 28-30 km below the city of Penjikent, Republic of Tajikistan the Zeravshan River crosses the border and flows through the territory of the Republic of Uzbekistan. Total length of the river Zeravshan 877 km out of which 303 km lies on the territory of the Republic of Tajikistan. The problem of water quality in Transboundary river basins, in particular in the Zeravshan river basin is compounded by the fact that up to now there is no network sharing of information regarding the quality of the waterways between the neighboring States of Central Asia. Herewith not developed a uniform standard for assessing of the degree of anthropogenic load on geoenvironmental systems (maximum permissible concentration). The problem of water quality of the Zeravshan River is mostly associated with the pollution of the river Zeravshan by wastewater of the Anzob mountain-concentrating combine — the mining enterprise for extraction and enrichment of mercury-antimony ores of the Dzidzikurut deposit. [3-11].

The Vakhsh River is the main river of the Republic of Tajikistan that merges with the Pyanj River forms the Amu Darya — the largest river in Central Asia. Potential energy resources of Vakhsh is 28.6 Million kWt·h (250 Million kWt·h/year of electricity). The development of the hydropower potential of the Vakhsh River is connected with the construction along with the now operating a number of large and medium Hydropower station (HPS) with reservoirs [12-17].

Now one of actual problems of the reservoirs of the HPS is the problem of sedimentation and the chemical composition of water caused by the problems of reducing the useful volume, corrosion of metal structures, as well as the degree of vital activity of living organisms in the reservoirs.

The aim of this work is to study the chemical and isotopic composition of the rivers Zeravshan and Vakhsh and its tributaries, the establishment of stationary sources of pollution in rivers basin.

2. Object and Methodology

The object of studies were the Transboundary Zeravshan and Vakhsh Rivers and its main tributaries and main glaciers of the Zeravshan River Basin. Sampling of water from the Zeravshan river and its tributaries were used by the scheme (Fig. 1) developed in [3]. The complex chemical analyses of waters carry out by methods described in [7].

Fig. 1 Scheme of sampling of water from the Zeravshan River and its tributaries: M1-M5 Meteorological data point; ∆D1-∆D11 Discharge data point; Water sampling point

Sampling of water for isotopic analysis was carried out according to the methodology developed at the University of Colorado at boulder (USA). Isotopic analysis of water were performed on Wavelength-Scanned Cavity Ringdown Spectroscopy (WS-CRDS). The individuality of each river from the point of view of chemical composition of water is compiled by sampling of the tributaries to the confluence with the main river and with other tributaries.

3. Results and Discussion

The results of chemical analyses of the Zeravshan river is present on the Fig. 5 that shows that the difference of the values of the chemical content of cations and anions of the water of the Zeravshan river up to and after of the Anzob mountain-concentrating combine (AMCC) wastewater dams insignificant and do not exceed their MPC. It is obvious that the Zeravshan River not polluted by wastewater of the AMCC.

The level of agriculture on upstream of the Zeravshan River determined by the orographic feature due to the limitation of irrigated land underdeveloped. Therefore, it can be expected that the flow of the runoff of collector-drainage water with high salinity to the river is negligible. An analysis of the histogram data (Fig. 2) the composition of the waters shows that the Zeravshan river and its tributaries in the upper reaches do not experience anthropogenic pressure, and their mineralization is mainly due to the flushing water coastal mineral deposits.

The main sources of formation of water flow of rivers and the climate forming factor glaciers as favorable natural media for accumulation of atmospheric aerosols, chemical compounds and metals are considered. A similar phenomenon observed at analyzing the content of heavy metals and distribution of heavy metals in the snow cover on the glaciers of the southern slope of Mount Elbrus due to their transport to long distances in the form of microparticles by an airflow [18].

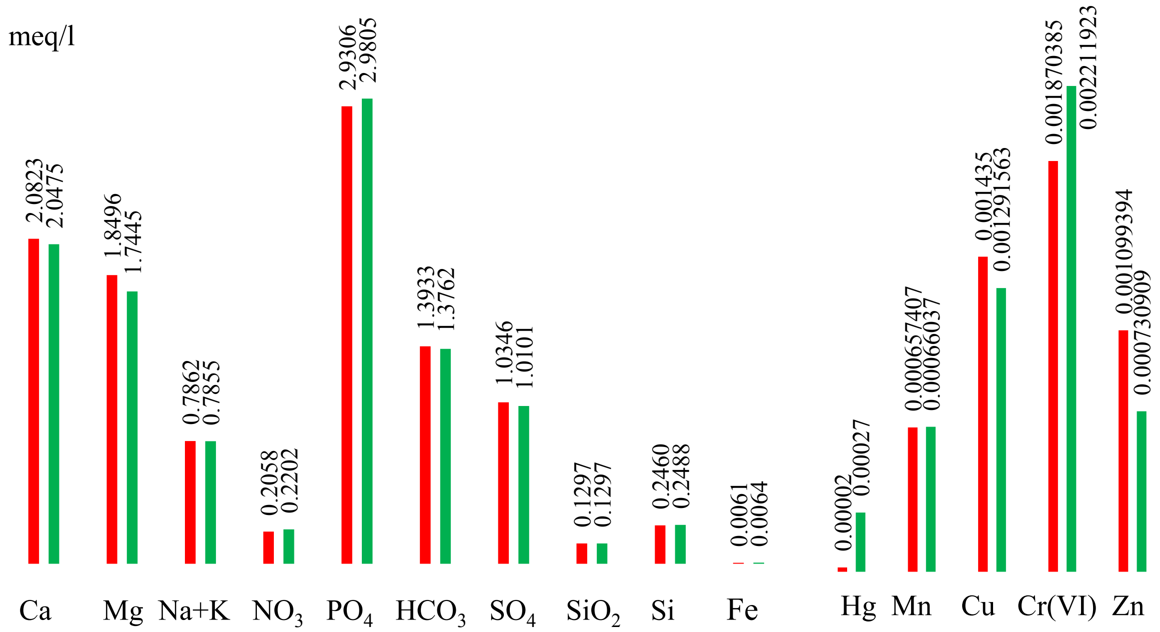

Fig. 2 Results of chemical analyses of the Zeravshan river waters up to (■) and after (■) wastewater dams of Anzob mining plant.

It is likely that accumulated in snow cover and glaciers contaminants in the process of melting of snow and glaciers to come to rivers and to distribute to long distances.

The choice of snow cover as a natural indicator to air pollution it is actual because the snow effectively absorbs impurities from the atmosphere and depositing dry dust emissions from anthropogenic sources [19].

The concentration of pollutants in the snow by 2-3 orders higher than in atmosphere. This allows measurement of the content of substances of quite simple methods with a high degree of reliability [20]. In order to have information about the chemical composition formed from glaciers water flow in the formation zone was conducted a complex of physical and chemical analyses of seasonal snow on the glaciers of the Zeravshan, Rossinj, and Tro of the Zeravshan river basin and tributaries of the Zeravshan River emerging from these glaciers. The river Zeravshan one of the major rivers of Central Asia originates at a height of 2775 m. The annual flow of the Zeravshan River is on average about 5.2 Bln. m^3.

According to the Fig. 3 in seasonal snow on the Zeravshan, Rossinj and Tro glaciers observed dominate of anions SO_4^{2-}, NO_3^-, Cl^- and cations of Ca^{2+} and Mg^{2+}.

The isotopic composition (δ^2H, $\delta^{18}O$) ad deuterium excess is an informative indicator for hydrological and glaciological researches.

The paper presents the results of isotopic analyses of samples of water from the tributaries of the Zeravshan River: Sabag, Yarm, Samjon, Tro, Dehavz, Dihadang, Gusn and Dashtioburdon. Sampling for isotopic analyses was carried out according to the methodology developed at the University of Colorado in Boulder. Analysis was performed on Wavelength-Scanned Cavity Ringdown Spectroscopy (WS-CRDS) and the isotopic composition of hydrogen and oxygen expressed in relative terms δ^2H and $\delta^{18}O$:

$$\delta = [(R_{sample}/R_{standard})-1]\cdot 1000‰$$

where R_{sample} and $R_{standard}$ relations $^2H/^1H$ and $^{18}O/^{16}O$ in the measured sample and the standard.

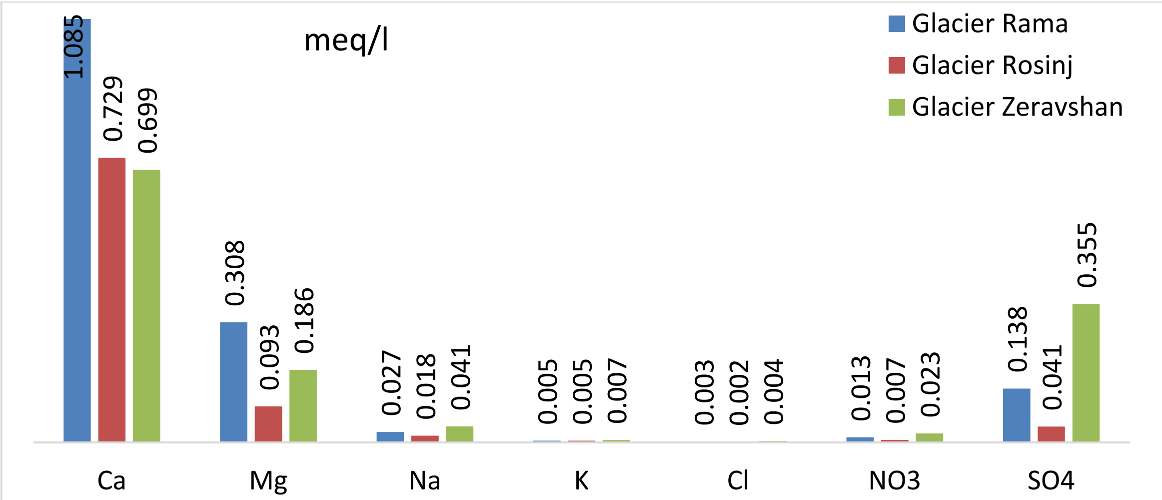

Fig. 3 Chemical composition of seasonal snow on glaciers of the Zeravshan river basin.

As the standard use ocean water (SMOW, Vienna, IAEA). Measurement precision was ±0.05‰. At the isotopic analyses it was found that the upstream tributaries of the Zeravshan river are characterized by light isotopic compositions of the oxygen and hydrogen isotopes: $\delta^{18}O$ (-13.23:-13.43)‰, $\delta^{2}H$ (-88.92: -88.32)‰ and deuterium excess 16.92-19.21. This suggests that the observed fractionation is a result of the freezing and the accumulation occurs in winter. In turn, the downstream tributaries of the Zeravshan river have the following isotopic composition: $\delta^{18}O$ (-11.98: -11.61)‰ and $\delta^{2}H$ (-78.45: -75.80)‰. The obtained results indicated about the existence of seasonal variations in the isotopic composition of precipitation and their influence on the isotopic composition of the river In other words, the change of the ratio of rainwater, meltwater from seasonal snow and underground waters.

The location of tributaries of the Zeravshan River shown on the Fig. 5. The comparison of the results of isotopic analyses (Fig. 4) with the scheme of location of the Zeravshan tributaries shows that as you move from the upstream to the downstream is the weighting of the isotopic composition of water of the relevant tributaries of the Zeravshan River. The main factor of this process is to increase the temperature and therefore the evaporation of water from the rivers.

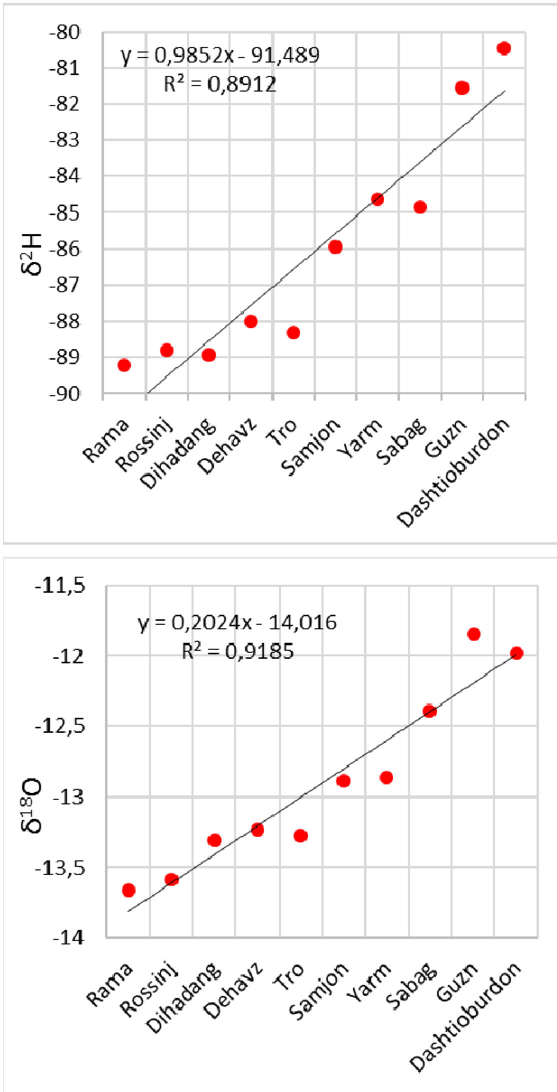

Fig. 4 Results of isotope analyses of the Zeravshan river tributaries.

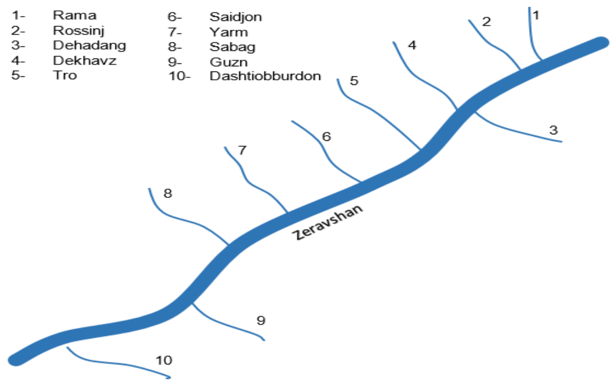

Fig. 5 Scheme of the Zeravshan river tributaries location.

4. Hydrochemistry of the Vakhsh River and Tributaries

Monitoring of water quality of Transboundary Rivers, identifying the sources of anthropogenic pressures and the adoption of adequate measures for their elimination through the development of modern techniques is a valid tool to regulate the relationship between the components of geoecosystem. To study the chemical composition of the waters of the Vakhsh River and its tributaries carry out by sampling of waters at the points shown on the scheme (Fig. 6).

The scheme of water sampling shows that respected the individuality of each tributary from the point of view of chemical composition by sampling of tributaries water up to the confluence with the main stream of the river and up to the junction with another tributary. We carried out chemical analysis of rivers water and groundwater of the rivers basin the results of which are present on the Fig. 7 respectively.

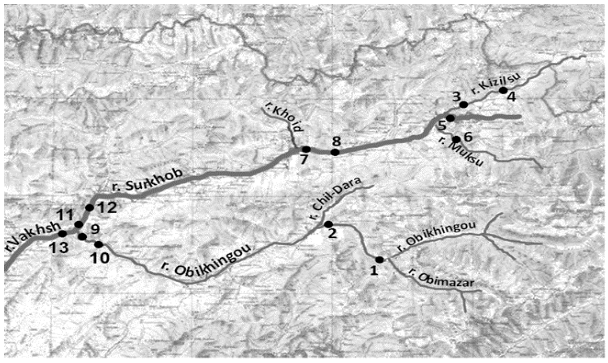

Fig. 6 Scheme of sampling of water from the Vakhsh River and its tributaries.

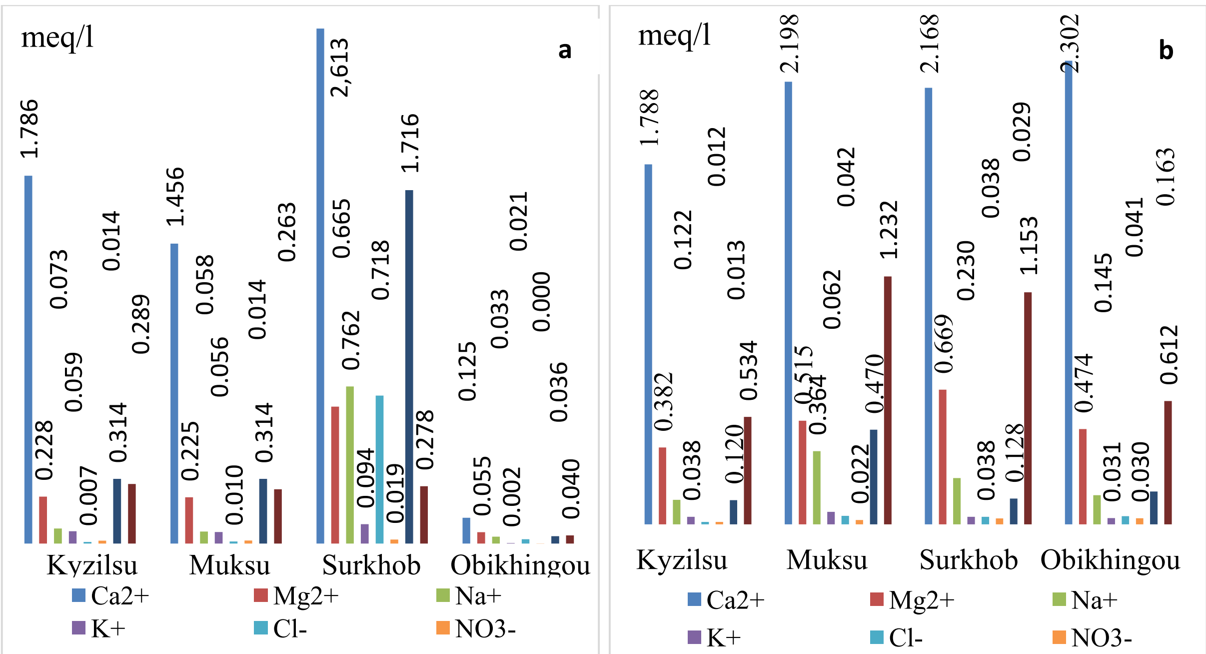

Fig. 7 (a) The results of chemical analysis of the waters of the tributaries of the Vakhsh river and (b) groundwater basins of these rivers.

The content of the chemical elements of the Vakhsh River shown on the Figs. 7 and 8 indicate that they do not exceed established for their maximum permissible concentration. This suggests that formation of chemical composition of the Vakhsh river waters is mainly due to leaching of mineral rocks.

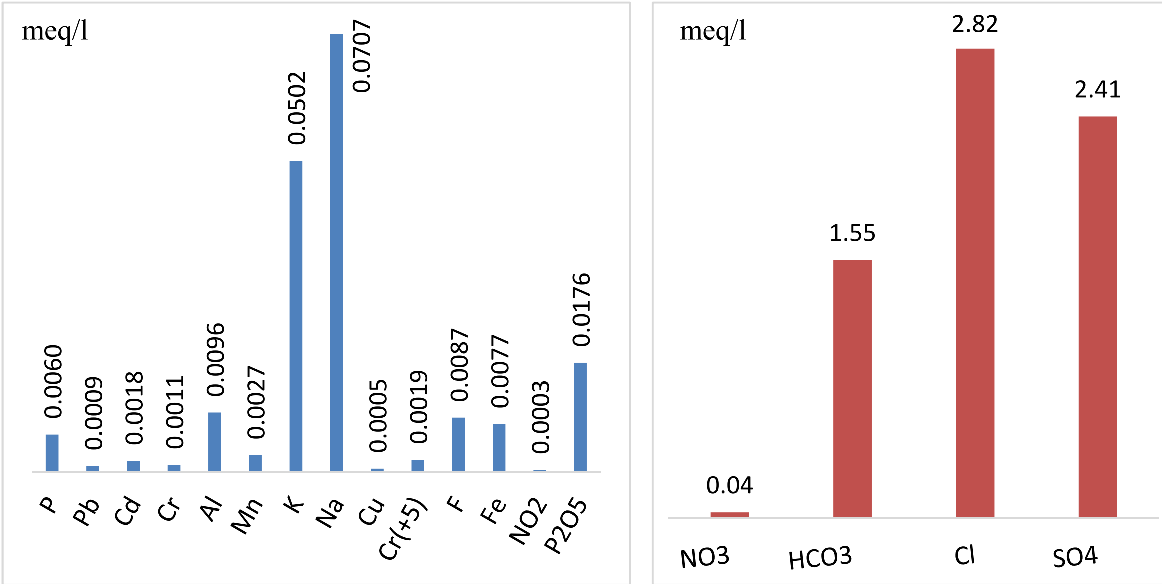

Fig. 8 The results of chemical analysis of the Vakhsh river waters.

The results of isotopic analysis of the Vakhsh River and their tributaries presents on the Fig. 9.

For interpreting the results of isotopic analysis of the Vakhsh River and its tributaries will analyze the state of glaciation in the river basins. In the Surkhob River basin, there are intensively melting small glaciers of the Northern slopes in the Western part of a ridge of Peter the Great. On the southern slopes of the Alay Ridge, glaciation decreases slower as there are larger glaciers. In the Obikhingou River basin, the largest glacier Garmo is intensively melting.

During the XX century, it became shorter by almost 7 km, having lost more than 6.0 km^2 in area. It is currently retreating at an average speed of 9 m/year, and the surface settles due to the melting of up to 4 m/year. Another glacier in the same basin, Skogach, retreats annually at 11 m.

In view of this it can be approve that the rivers and Surkhob Obikhingou are fed by glaciers and it can be assumed that precipitation mostly occur in winter and isotopic composition are significantly lighter.

The weather and climatic conditions of the Vakhsh valley are warmer than in the valleys of its tributaries Surkhob and Obikhingou and consequently due to evaporation process would have a heavy isotopic composition. However, the contribution of the water tributaries leads to the fact that the isotopic composition of water of the river Vakhsh become lighter.

The isotopic composition of the Kyzilsu river is characterized by values $\delta^{18}O$ = -13.36‰, $\delta^{2}H$ = -87.88‰ which is close to the values of the isotopic composition of the water areas with an average annual temperature above 0°C (Fig. 9). It was found that the isotopic composition of the Naryn river depending on the season is changes in the following range: spring ($\delta^{18}O$ = -13.4 ‰; $\delta^{2}H$ = -96 ‰) and autumn ($\delta^{18}O$ = -12.4 ‰; $\delta^{2}H$= -89 ‰) [21]. Consequently, it can conclude that to formation of water flow of the Kyzilsu River contribution of glacial runoff smaller and mainly occurs due to seasonal rains.

Previously [22] by analyses of the chemical composition of river water and groundwater in the river basins of Tajikistan was suggested about the processes of enrichment of underground water reservoirs by chemical elements of river water. Such a mechanism but in the opposite direction, i.e., the conversion of reservoirs of underground waters to the source of water for the river, for example, for the Muksu river basin was observed.

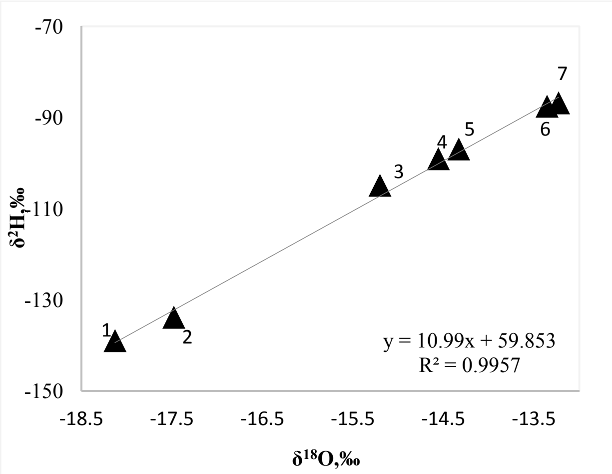

Fig. 9 The Isotopic composition of water in the Vakhsh River and tributaries: 1, 2- Garmo glacier; 3 - Surkhob river; 4 – Vakhsh river; 5 –Obikhingou river; 6 – Kyzilsu river; 7 – river Muksu.

The results of the isotope analyses of spring waters and groundwater basins of the rivers Muksu, Kizilsu, Surkhob, and Obikhingou shown on the Fig. 10. From the Fig. 10 can see that groundwater and spring water of the basin of the river Muksu by the values of the isotopic composition significantly lighter average composition of river water and close to the values of melted glacier water. During spring snowmelt by the processes of infiltration, underground reservoirs accumulated melt water and at dry periods turns to sources of runoff formation of river. Of course, it will affect to the isotopic composition of river water.

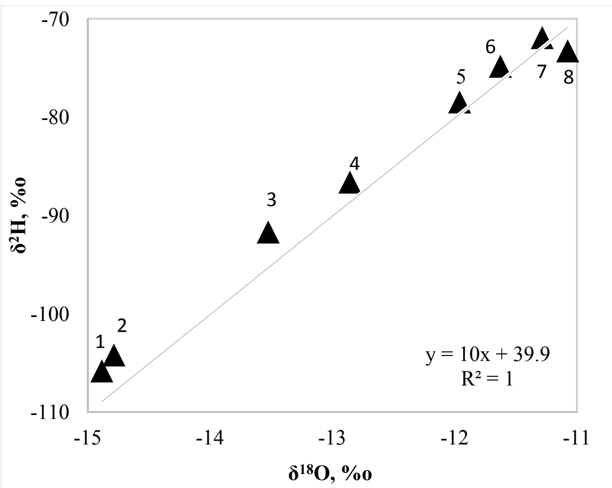

Fig. 10 Isotopic analysis of spring (1, 3, 4, 5) and underground waters (2, 6, 7, 8) the basin of the rivers Muksu, Kizilsu, Surkhob, Obikhingou, accordingly.

5. Conclusion

By chemical analyses demonstrated that the Zeravshan River and its tributaries in the upper reaches do not experience anthropogenic pressure and their mineralization is mainly due to the flushing water coastal mineral deposits.

Chemical analysis of water samples of the Zeravshan River before and after the AMCC is shown on the insignificant effect of wastewater factory on water quality. The content of heavy metals in the river do not exceed maximum permissible concentration. The existence of seasonal variations in the isotopic composition of precipitation and their influence on the isotopic composition of the Zeravshan River water is observed.

The comparison of the results of isotopic analyses with the scheme of location of the Zeravshan tributaries shows that at moving from the upstream to the downstream-stimulated weighting of the isotopic composition of water of the relevant tributaries of the Zeravshan River. The main factor of this process is to increase the temperature and therefore the evaporation of water from the rivers.

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Acknowledgments

The authors express their appreciation to the U.S. Agency for international development (USAID) & NSA supports this study through the CHARIS and PEER projects

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