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Satbayev University

ХАБАРЛАРЫ

ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
РЕСПУБЛИКИ КАЗАХСТАН
Satbayev University

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Қазақстан Республикасы Ұлттық ғылым академиясы «ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы» ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Webof Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

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SPECIFIC FEATURES OF FLOW FORMATION AND WATER USE IN THE CATCHMENT AREAS IN THE TOBOL RIVER BASIN

Abstract. On the basis of long-term information and analytical materials of the RSU Tobyl-Torgai Basin Inspectorate for Regulation of the Use and Protection of Water Resources of the Water Resources Committee of the Ministry of Agriculture of the Republic of Kazakhstan, characterizing the use of water resources in the economic sectors of administrative districts and cities of the Kostanay region, the conditions for the formation of surface flow and regional features of water use in the catchments of the Tobol river basin were determined.To assess the change in the average annual discharge in the catchments of the Tobol River basin under the influence of natural and anthropogenic activities, integral curves of average annual discharge were determined for the hydrological stations of Akkarga, Grishenka, Kostanay, and Milyutinka, which showed that in the period under consideration from 1996 to 2005, there was a slight increase in the average annual discharge for all hydrological stations under consideration, and from 2006 to 2017 - their constant decline, which is a signal to ensure the safety of economic activities in the region. To assess the peculiarities of water use in the catchments of the Tobol River basin, the volumes of water consumption by housing and public services, industry and agriculture were used, which gradually decrease over the period of 1996-2016, since the industry is mainly located in the cities of Lisakovsk, Kostanay and Rudny. and agriculture in Kamystinsky, Zhitikarinsky, Denisovsky, Taranovsky, Kostanaysky, Karabalyksky, Fedorovsky and Mendikarinsky districts is developing within the dryland cultivation, which determines the type of linear trend, which is characterized by a polynomial equation of third order.

Key words: river, basin, flow, expenditure, water, resources, water use, analysis, evaluation, method, trend.

Relevance. The catchments of the river basins of the steppe zone of Northern Kazakhstan, as a kind of component of geographic objects, perform to a certain extent environment-forming functions as a regulator of the water regime of landscapes, maintaining the ecological balance of natural systems. One of the main features of the river basins of the steppe zone, formed due to the melting of snow cover and atmospheric precipitation, determines their hydrological and hydrochemical specificity, that is, a close connection between the formation of flow and the landscape systems of the catchment area of river basins. At the same time, the main function of the catchment area of the river basins of the steppe zone, belonging to the system of small rivers, is the natural possibility of flow formation, providing the generation of ecological, economic and social environments, which seem to be the spatial bases of management of natural resources and environmental engineering. In this regard, the problem of water security has recently acquired special relevance to meet the needs for water resources of all categories of water users, including by increasing the rationality and ensuring the complexity of water use.

The goal of the researchis to analyze and assess the natural conditions for the formation of water resources in the catchment basins of the Tobol River and to identify the spatial features of the water use arrangement to optimize management decisions in the field of water use.

Target of study. The Tobyl River is one of the main waterways of Northern Kazakhstan, where the runoff formation zone is located on the eastern spurs of the Southern Urals, 10 km southwest of the Sarzhan village and flows into the Irtysh River from the left bank near the city of Tobylsk. The catchment basin of the Tobyl River is 395 thousand km^2, of which part 121 thousand km2 of its catchment area is located within the Kostanay region, and the total length of the river is 1591 km, of which 682 km is the upper river[2].

Research materials and methods. To achieve the objectives set there are used a basin approach, the method of an integrated study of geographical objects, mathematical statistics and hydrological calculations, based on linear trend using the Microsoft Excel.

On the basis of the obtained system of mathematical equations using the Microsoft Excel program, the

restoration of annual flows in the catchment area of the Tobol River basin at the hydrological stations of Akkarga, Grishenka, Kostanay and Milyutinka for the years 1996-2017 are shown in Figure 2.

As can be seen from Figure 2, the trend of the long-term course of hydrological flow in the catchments of the Tobol River basin at the hydrological stations of Akkarga, Grishenka, Kostanay and Milyutinka shows for the period under consideration that, on a spatial-temporal scale, there is a decrease in annual flow under the influence of natural and anthropogenic activities.

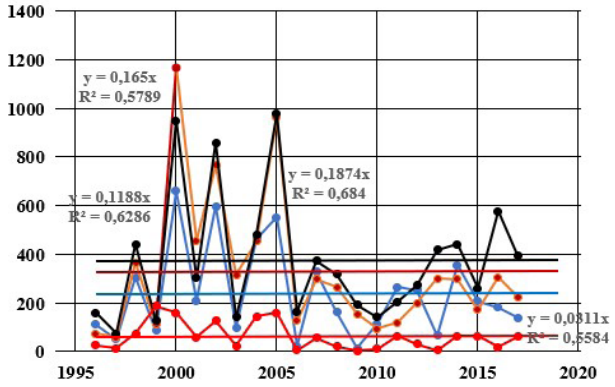

Figure 2 - The long-term progress of hydrological flow in catchments of the Tobol river basin (ordinate - annual flow volume (mln m^3); the abscissa - years; hydrological positions: 1- Akkarga 2- Grishenkov; 3- Kostanay; 4- Milyutinka)

To identify the peculiarities of water use in the catchment areas of the Tobol River basin, long-term information and analytical materials of the RSU Tobyl-Torgai Basin Inspectorate for the Regulation of the Water Resources Use and Protection of the Water Resources Committee of the Ministry of Agriculture of the Republic of Kazakhstan, characterizing the use of water resources in the sectors of the economy of administrative regions and cities of Kostanay region, located within the river basin proper, that is, for housing and public services, industry and agriculture (table 2).

Table 2 - Trend of water use by administrative districts in the catchment areas of the Tobol river basin, million m^3

Years	Trend of water use in the economy in the Tobol river basin, million m^3			
	Housing and public services	Industry	Agriculture	Total
1996	104.42	37.39	78.12	219.93
1997	90.77	37.05	48.71	176.53
1998	81.39	22.66	28.54	132.59
1999	70.86	21.41	16.42	108.79
2000	68.20	19.15	19.99	107.34
2001	58.29	15.40	19.50	93.19
2002	52.20	19.47	16.47	88.14
2003	54.14	19.31	17.21	90.66
2004	47.36	34.57	15.39	97.32
2005	42.22	22.74	13.87	80.20
2006	51.07	21.19	16.16	85.42
2007	42.35	28.69	12.96	87.03
2008	46.29	29.93	9.64	85.86
2009	43.11	30.18	10.09	84.61
2010	42.24	29.60	10.47	83.31
2011	41.98	27.48	9.60	79.06
2012	40.57	27.35	13.74	81.66
2013	42.23	34.21	12.12	88.78
2014	42.50	37.46	14.10	93.79
2015	38.77	32.35	15.14	86.26
2016	36.82	33.20	14.72	84.74

To determine the level of water situation, I.A. Shiklomanov proposed an indicator of specific available water supply (thousand m^3/year per person or km^3/year per million people), which determines not only the shortage of water resources, but also allows one to judge the overall state of water resources in the natural conditions of their formation and functioning [2].

In this case, the indicator of available water supply (PB) in the catchment areas of river basins is determined by the formula [2]:

$$PB=[1-(W_{бвв}/W_{ор})]$$

где $W_{ор}$ – real water resources of river basins, km^3/year; $W_{бвв}$ - irretrievable water consumption, km^3/year.

The water expenditure module of river basins was determined by the formula: $K_i=Q_i/Q_{cr}$ where Q_i– the average annual river water expenditure of year; Q_{cr}- the average long-term annual river discharge.

The estimated water flow in river basins is determined by the following equation: $p=[m/(n+1)]\cdot 100$, where m - ordinal number of order; n - quantity of order.

Research results. On the basis of long-term information and analytical materials of the RSU Tobyl-Torgai Basin Inspectorate for Regulation of Water Resources Use and Protection of the Water Resources Committee of the Ministry of Agriculture of the Republic of Kazakhstan, covering the years of 1996-2017 and the use of the method of hydrological calculations, the hydrological characteristics of the flow of the catchments of the Tobol river basin were determined for the hydrological stations of Akkarga, Grishenka, Kostanay and Milyutinka to reveal their

territorial differences in the space-time scale.

To evaluate the change in the average annual discharge in the catchments of the Tobol River basin under the influence of natural and anthropogenic activities, the integral curves of the average annual discharge were determined for the hydrological stations of Akkarga, Grishenka, Kostanay and Milyutinka (Figure 3).

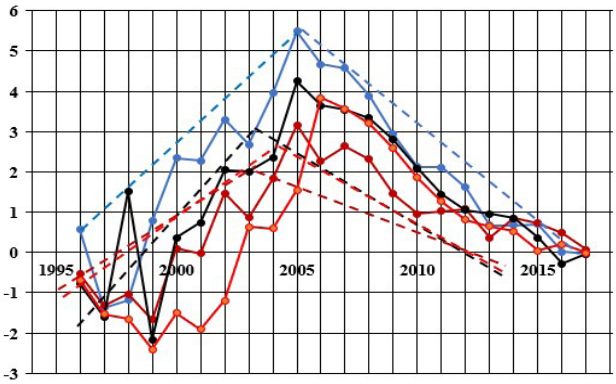

Figure 3- Integral difference curve of average annual flow in the catchments of the Tobol River basin (ordinate - integral difference curve; abscissa - years; hydrological stations: 1- Akkarga; 2- Grishenka; 3- Kostanay; 4- Milyutinka; trend in the area of maximum discharge by hydrological posts: 5- Akkarga; 6- Grishenka; 7- Kostanay; 8- Milutinka)

As can be seen from Figure 3, the shown differential integral curves of the average annual water flow of the Tobyl River, constructed from the hydrological stations of Akkarga, Grishenka, Kostanay and Milyutinka, describing the course of the accumulated difference $\sum_{i=1}^{n}(K_{cp}^{-1})$ in time show that the slope of the trend line atpositive value corresponds an increase in the average annual flow of the river in this period of time, and with a negative value corresponds to a decrease in the average annual flow.

The equation for the trend line for hydrological stations is as follows:

- at the Akkarga hydrological station: positive slope (Kp-1)=0,0009·t R^2=0,4525) and negative slope (Kp-1)=0,0014·t; (R^2=0,7564)
- at the Grishenka hydrological station: positive slope (Kp-1)=0,0001·t (R^2=0,0369) and negative slope (Kp-1)=0,0008·t (R^2=0,7721);
- at the Kostanay hydrological station: positive slope (Kp-1)=0,0004·t (R^2=0,7955) and negative slope (Kp-1)=0,0012·t (R^2=0,4525);
- at the Milyutinka hydrological station: positive slope (Kp-1)=0,0004·t (R^2=0,3005) and negative slope (Kp-1)=0,0011·t (R^2=0,7814);

Thus, until 2005 in the catchment basins of the Tobol River there has been a slight increase in the average annual water flow at all hydrological stations under consideration, and since 2006, their constant decrease, which is a signal to ensure the security of economic activities in the region.

The concept of "available water supply" mean not only ensuring the water consumption schedule of the population, but also providing the natural components of the landscape system and sectors of the region's economy with water resources. To evaluate the available water supply of the catchment area of the Tobol river basin, they are conditionally divided into two water-resources regions, that is, the upper reaches (from the flow formation zone to the Kostanay hydrological station) and the midstream (from the Kostanay hydrological station to Milyutinka) and within their determination of the level of water resources use in the economic sectors region (Figure 4).

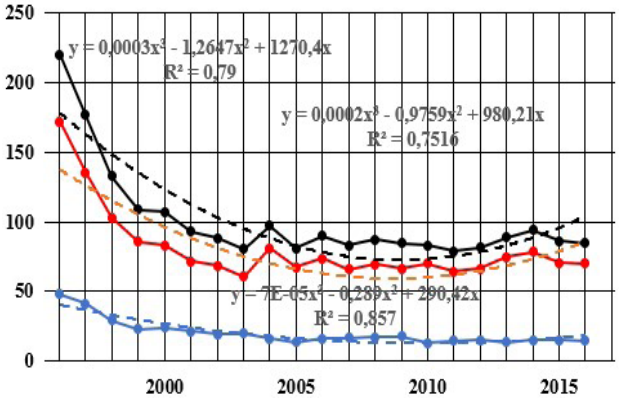

Figure 4 - Trend of water use by water-resources regions in the catchments of the Tobol river basin (mln.m^3) with linear trends (1-upstream water; 2- midstream; 3-catchment area of the river basin) (ordinate - volume of water consumption in economic sectors; abscissa - years)

The peculiarities of water use in the catchments of the Tobol River basin are determined by the volume of water consumption by housing and public services, industry and agriculture, which are gradually decreasing over the period 1996-2016, since industry is mainly located in the cities of Lisakovsk, Kostanay and Rudny, and agriculture in Kamystinsky, Zhitikarinsky, Denisovsky, Taranovsky, Kostanaysky, Karabalyksky, Fedorovsky and Mendikarinsky areas is developing within the dry farming, which determines the type of linear trend, which are described by a polynomial equation of third order, having the following shape:

- for the upper water of the river:

$$W_{бвв}=7E\text{-}0,5\cdot t^3\text{-}0,289\cdot t^2+290,42\cdot t;$$

- for middle reach:

$$W_{бвв}=0,0002\cdot t^3\text{-}0,9759\cdot t^2+980,21\cdot t;$$

- for the catchment of the river basin:

$$W^{бвв}=0,0003\cdot t^3\text{-}1,2647\cdot t^2+1270,4\cdot t.$$

Based on the information and analytical materials given in Tables 1 and 4, the predictive calculations

were made to determine the available water supply in the water-resources regions of the catchment areas of the Tobol River basin (Table 4).

Table 5 - Ecological indicators of specific available water supply in the catchment area of the Tobol river basin by water-resources regions

Years	Tobol water-resources regions		
	Upper reaches ofcatchment areas of the Tobol River		
	Actual water resources (W_{op}, mln. m^3)	Irretrievable water consumption ($W_{бвв}$, mln m^3)	Available water supply indicators (PB)
1996	111.00	48.31	0.565
1997	52.00	41.13	0.209
1998	306.0	29.54	0.903
1999	87.37	23.25	0.734
2000	659.19	24.22	0.963
2001	209.40	21.74	0.896
2002	596.00	19.58	0.967
2003	98.70	19.81	0.799
2004	463.6	16.06	0.965
2005	552.00	13.85	0.975
2006	23.97	16.52	0.311
2007	328.02	16.91	0.948
2008	162.75	17.35	0.893
2009	12.62	18.07	- 0.432
2010	114.17	13.33	0.883
2011	266.20	15.00	0.943
2012	252.95	15.07	0.940
2013	66.86	13.95	0.791
2014	356.40	15.52	0.956
2015	207.85	15.46	0.926
2016	181.00	14.93	0.918

Years	Tobol water-resources regions		
	Upper reaches ofcatchment areas of the Tobol River		
	Actual water resources (W_{op}, mln. m3)	Irretrievable water consumption ($W_{бвв}$, mln m3)	Available water supply indicators (PB)
1996	72.54	171.62	-1.366
1997	58.35	135.46	-1.321
1998	365.3	103.05	0.718
1999	111.02	85.54	0.230
2000	1171.20	83.12	0.929
2001	457.30	71.45	0.843
2002	766.40	68.56	0.910
2003	314.50	70.85	0.774
2004	454.20	81.26	0.821
2005	962.00	67.35	0.929
2006	127.00	73.53	0.421
2007	298.00	65.92	0.779
2008	264.00	69.68	0.736
2009	155.00	66.54	0.571
2010	95.00	69.98	0.263
2011	119.00	64.06	0.461
2012	200.00	66.59	0.667
2013	299.00	74.83	0.749
2014	297.00	78.27	0.736
2015	172.00	70.80	0.588
2016	305.00	69.81	0.771

As can be seen from Table 5 giving the available water supply in the catchments of the Tobol river basin by water-resources regions, show that in the upper reaches the available water supply indicator ranges from 0.209 to 0.967, which corresponds to values from low water supply to high water supply depending on the water content of the river, and in the middle reaches, their quantitative values range from -1.336 to 0.929, which shows a very high available water supply.

Discussion of results. The practical significance of evaluating the conditions for the formation of surface flow in the catchments of the Tobol River basin and the peculiarities of their use in the sectors of the regional economy resides in the fact that the research results focus on solving applied problems of increasing the efficiency and quality of management decisions in the water resources use and protection. The database obtained in the course of the study on the structure and trend of water use and available water supply indicators in the catchment areas of the Tobol River basin on a space-time scale may become a basic component for further research in the field of increasing and efficiency of water resources use, ensuring the standard quality of drinking water and wastewater treatment, protection of water bodies, as well as making timely management decisions towards achieving and maintaining a state of sustainable and environmentally safe water use.

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ТОБЫЛ ӨЗЕНІ БАССЕЙНІНІҢ СУ ЖИНАУ АЛАБЫНДА АҒЫНДЫ ҚАЛЫПТАСТЫРУ ЖӘНЕ СУДЫ ПАЙДАЛАНУ ЕРЕКШЕЛІКТЕРІ

Аннотация. Қостанай облысының әкімшілік аудандары мен қалаларының экономика салаларында су ресурстарын пайдалануды сипаттайтын Қазақстан Республикасы ауыл шаруашылығы Министрлігі су ресурстары комитетінің «су ресурстарын пайдалануды реттеу және қорғау жөніндегі Тобыл-Торғай бассейндік инспекциясы» РММ көпжылдық ақпараттық-сараптама материалдарының негізінде Тобыл өзені бассейнінің жер үсті ағынын қалыптастыру шарттары және суды пайдаланудың өңірлік ерекшеліктері айқындалған. Табиғи және антропогендік қызметтердің әсерінен Тобыл өзені бассейнінің су жинауларындағы орташа жылдық шығынының өзгеруін бағалау үшін Аққарға, Гришенка, Қостанай және Милютин гидрологиялық бекеттері бойынша орташа көп жылдық шығыстардың интегралдық қисықтары айқындалды, олар қаралып отырған кезеңде 1996 жылдан 2005 жылға дейін барлық қаралып отырған гидрологиялық бекеттер бойынша судың орташа жылдық шығынының біршама ұлғаюын, ал 2006 жылдан 2017 жылға дейін олардың тұрақты төмендеуі байқалғанын көрсетті, бұл өңірдің шаруашылық қызметінің қауіпсіздігін қамтамасыз ету сигналы болып табылады.

Тобыл өзені бассейнінің су жинауларында суды пайдалану ерекшеліктерін бағалау үшін тұрғын үй-коммуналдық шаруашылықтың (көрсетілетін қызметтің), өнеркәсіптің және ауыл шаруашылығының су тұтыну көлемі пайдаланылды, олар 1996-2016 жылдардардан бері біртіндеп азайып келеді, өйткені өнеркәсіп негізінен Лисаковск, Қостанай және Рудный қалаларында орналасқан, ал ауыл шаруашылығы Қамысты, Жітіқара, Денисов, Таран, Қостанай, Қарабалық, Федоров және Меңдіқара аудандарында богарлы жер өңдеу шеңберінде дамуда, бұл үшінші ретті полиноминалды теңдеумен сипатталатын желілік трендтің түрін айқындайды.

Түйін сөздер: өзен, бассейн, ағын, шығыс, су, ресурстар, суды қолдану, талдау, бағалау, әдіс, тренд.

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ОСОБЕННОСТИ ФОРМИРОВАНИЯ СТОКА И ВОДОПОЛЬЗОВАНИЯ НА ТЕРРИТОРИЯХ ВОДОСБОРОВ БАССЕЙНА РЕКИ ТОБОЛ

Аннотация. На основе многолетних информационно-аналитических материалов РГУ «Тобыл - Торгайская бассейновая инспекция по регулированию использования и охране водных ресурсов» Комитета по водным ресурсам Министерства сельского хозяйства Республики Казахстан, характеризующих использование водных ресурсов в отраслях экономики административных районов и городов Костанайской области определены условия формирования поверхностного стока и региональные особенности водопользования водосборах бассейна реки Тоблол. Для оценки изменения среднегодового расхода в водосборах бассейна реки Тобол под влиянием природных и антропогенных деятельностей определены интегральные кривые среднемноголетних расходов по гидрологическим постам Аккарга, Гришенка, Костанай и Милютинка, которые показали, что в рассматриваемый период с 1996 до 2005 года наблюдается некоторое увеличение среднегодовых расходов воды по всем рассматриваемым гидрологическим постам, а с 2006 года до 2017 года - постоянное их снижение, что является сигналом обеспечения безопасности хозяйственной деятельности региона.

Для оценки особенностей водопользования в водосборах бассейна реки Тобол использованы объемы водопотребления жилищно-коммунального хозяйства (услуги), промышленности и сельского хозяйства, которые за рассматриваемый период 1996-2016 годов постепенно уменьшаются, так как промышленность в основном расположена в городах Лисаковск, Костанай и Рудный, а сельское хозяйство в Камыстинском, Житикаринском, Денисовском, Тарановском, Костанайском, Карабалыкском, Федоровском и Мендикаринском районах развивается в рамках богарного земледелия, что определяет вид линейного тренда, который характеризуется полиноминалным уравнением третьего порядка.

Ключевые слова: река, бассейн, сток, расход, вода, ресурсы, водопользование, анализ, оценка, метод, тренд.

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