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Satbayev University

Х А Б А Р Л А Р Ы

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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ECOLOGICAL AND WATER ECONOMIC ASSESSMENT OF THE YESIL RIVER BASIN CATCHMENT AREA

Abstract. Based on the system analysis of the long-term information and analytical materials of the RSE «Kazhydromet» on water pollution in the Yesil river basin and the use of the Shannon index and the maximum pollution coefficient V.V. Shabanova made an assessment of water quality by hydrochemical indicators on a spatial and temporal scale in the conditions of anthropogenic activity to identify the causes and consequences of the formation of the hydrochemical regime of water bodies. On the basis of the conducted multivariate assessments and rationing of the water resources of the Yesil River, the directivity and intensity of changes in water quality, that is, their pollution with the main ions (*Cl*, *Na*, SO_4), biogenic elements (NH_4, NO_2, NO_3) and heavy metals (*Cu*, *Zn*) are shown on a spatial-temporal scale which are one of the main environment-forming systems for the life of the population of Central and Northern Kazakhstan. In this case, the maximum pollution coefficient ($K_{пз}$) in the catchment area of the Yesil River Basin on a time scale from the hydrological station - the village of Turgenevka to the village of Dolamatova are increasing and, by degree of pollution, mainly refers to the contaminated and trophic status of E.S. Shannon - eutrophic, which must be considered when developing environmental protection measures to restore and improve the eco-capacity of water bodies in Central and Northern Kazakhstan.

Key words: analysis, assessment, pollution, water, state, hydrochemistry, system, elements, ions.

Introduction. At the present time, in the catchment area of the Yesil river basin, there is a difficult water-ecological situation, which is explained, first of all, by its transboundary position, and also due to the upper and middle parts of the basin to the arid inland regions of Northern Kazakhstan, where the river almost does not accept tributaries. The situation is aggravated by the fact that it is in these areas within Kazakhstan and the Russian Federation that the Yesil River is the main waterway and the source of water supply for the population and various sectors of the economy. The main areas of population, as well as industrial and agricultural development, are gravitated to its valley. Irrational economic activity in the catchment area, including the use of water resources, also has a great influence on the ecological status of the catchment area of the Yesil river basin.

Thus, the catchment area of the Esil river basin is under a multifactorial anthropogenic impact that affects the biotic and abiotic characteristics of them, and in order to effectively manage their hydro-ecological state, it is necessary to have long-term information and analytical data, characterizing the state of the managed system, which are obtained during hydrological, hydrochemical and hydrobiological observations of water bodies, as well as data on all significant factors affecting this state using methods of comprehensive assessment of the state of natural systems, allowing to evaluate water quality.

The purpose of the research – on the basis of long-term information and analytical materials of RSE «Kazhydromet» on the pollution of the water resources of the Yesil River, to determine the features of the formation of their hydrochemical regime in the conditions of anthropogenic activity.

The object of research. The Yesil River originates in the low Niyaz mountain range of the Kazakh Hills and over 775 km flows from east to west, receiving a number of large tributaries flowing from the Kokshetau Upland from the spurs of the Ulytau Mountains. In the upper reaches flows mainly to the north-west and west, mainly in a narrow valley, in the rocky shores [1].

Below Astana, the valley widens, south-westward beyond Atbasar. At 1578 km near the town of Derzhavinsk (conditional boundary of the upstream Yesil), the riverbed drastically changes its direction to the meridian - from south to north. Below Sergeevka, the river enters the West Siberian Plain and flows along the flat Yesil plain in a wide flood plain with numerous waters, in the lower reaches it flows among the marshes and flows into the Irtysh near the village of Ust-Yesil [2,3].

The Yesil river catchment area is 177,000 sq.km, of which about 20% of the area falls on the territory of Russia, within which about 30% of the flow is formed.

The main tributaries (on the territory of Kazakhstan): the right - Kalkutan, Zhabay, Akkanburlyk, Imanburlyk, the left - Terisakkan. The main tributaries of the Yesil (in Russia): the right - Karasul (flows into the Yesil, near the village of Burovoye), Ik, the left - Badger.

The catchment area of the Kalkutan River is 17,400 sq.km, length - 233 km, the average height of the catchment area is 360 m, and the density of the river network is 0,10 km / sq.km. The catchment area of the Zhabay River is 8,800 sq.km, the length is 196 km, the average height of the catchment is 364 m, and the density of the river network is 0,11 km/sq.km. The catchment area of the Terisakkan River is 19,500 sq.km, the length of the river is 334 km, the average height of the catchment is 350 m, and the density of the river network is 0,15 km / sq.km. The Akkanburlyk River originates from the Zhaksy-Zhangiztau lake from the west bank, flows into the Yesil river to the right at 1,280 km from the mouth, 1,176 km long, the catchment area is 6,720 sq.km, including 731 sq.km of non-flowing river, the total fall of the river is 188 m, average slope is 1%.

The Yesil river nourishment predominantly snow. The river freezes in early November, opens in April - May. The average water discharge at the village of Vikulovo 100 km from the mouth is 56,3 m³/s, the largest 686 cub.m/s. The maximum water discharge of the Yesil River in the upper reaches near the Astana city is 1080-1100 cub.m/s, the annual flow volume is 1,299,967 thousand m³/year. Average annual water consumption 1,11cub.m/s.

The annual flow rate of the Yesil River, or the average long-term flow, is the main and stable characteristic that determines the total water content of the river and potential water resources[3].

The research of the regularity of the intra-annual distribution of the flow of the Yesil River is one of the most important issues, a solution that is necessary for the rational and integrated use of water resources for various purposes of the national economy. In general, the assessment of changes in the intra-annual distribution of runoff in a year depends not only on the methods of analyzing and comparing the monthly runoff and its distribution in a multiyear context with the dynamics of economic activity on the catchment area, but also to a certain extent on comparing the natural and disturbed flow distribution. In general, the relative stability of the intra-annual and seasonal distribution of the flow of the Yesil River in natural conditions is confirmed by data on the relative distribution of the flow over the seasons in the context of weak economic development of the region and after the construction of large reservoirs (figures 1, 2).

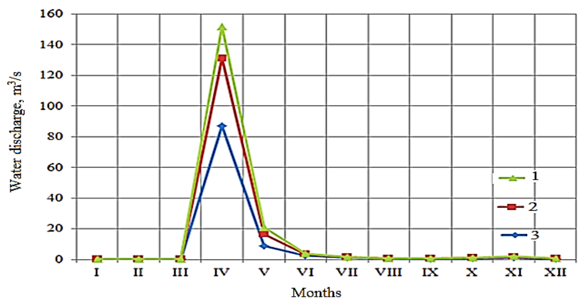

Figure 1 – Intra-annual distribution of the flow of the Yesil River (Astana gauging station) of different supply (1-25%; 2-50%; 3-75%)

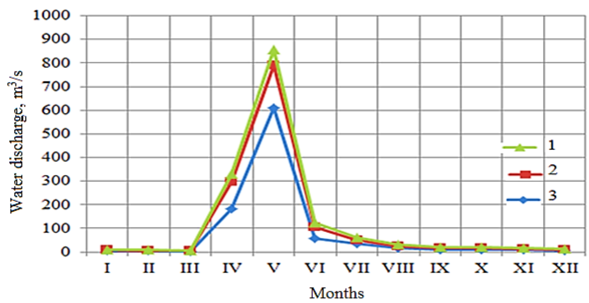

Figure 2 – Intra-annual distribution of the flow of the Yesil River (Peropavlovsk hydropost) of various types of supply (1-25%; 2-50%; 3-75%)

One of the factors affecting the formation of the socio-economic complex of the Yesil river basin catchment is the development of economic activity, that is, the main water consumers are agriculture (regular and estuarial irrigation, hayfield, agricultural water supply, watering of pastures), industry and the housing sector.

The volume of water consumption within the Republic of Kazakhstan is currently about 217,7 million cub.m and by 2020 the volume of water consumption will increase to 480,2 million cub.m.

Water consumption in the Russian part of the Yesil River Basin is an order of magnitude less than in the Republic of Kazakhstan, its volume currently stands at 16,0 million cub.m, an increase by 2020 is planned to 28 million cub.m [1].

Very high population density among the Akmola and North Kazakhstan regions, which constitute 12,46 people/sq.km, a high share of industrial production of 36,5 thousand dollars/sq.km, the maximum plowing of the territory (60%) and livestock loading in the range of 14,6 head/sq.km showed that within the Republic of Kazakhstan the catchment area of the Yesil River basin has an average degree of anthropogenic load. At the same time, the largest anthropogenic load falls on large industrial cities, the average is typical for agricultural areas, low prevails in areas with low population density [1].

The magnitude of the load on water resources is estimated by the coefficient of water use ($K_{ивр}$), equal to the ratio of total water consumption to available water resources, showed that the largest water load falls on large industrial cities and amounts to 40%, which corresponds to a high load, and in general the Esil river basin on average, water loads make up 14 -16%, which characterizes a moderate load on water resources.

Changes in the quality of water resources in the Yesil river basin occur under the influence of a number of reasons, the main of which was the development of economic sectors and, as a result, environmental pollution and water bodies. At the same time, the main sources of pollution of water resources in the watershed of the Yesil river basin, that is, from the sources of rivers to the Sergeyevsky reservoir, are industrial, household and mine sewage of enterprises of Karaganda-Temirtau industrial region [1].

In the Yesil river basin, the total volume of discharges is currently 94,28 million cub.m, including 26,34 million cub.m to natural surface water bodies. The main part of the discharge was wastewater – 86,62 million cub.m and mine- 6,40 million cub.m, collector-drainage water is formed in an insignificant amount – 1,26 million cub.m. In the future, a significant increase in total discharge is projected at 134,87 million cub.m, that is, up to 229,15 million cub.m, but the increase in natural surface water bodies is expected to be insignificant, only by 1,28 million cub.m. The main increase in discharges will occur due to wastewater, the volume of which will increase by 120,19 million cub.m [1].

Research materials. When solving the tasks set in the work, the long-term information and analytical materials «Annual data on the quality of surface waters» of the Republic of Kazakhstan of the RSE «Kazgidromet» and the Newsletter of the RSE «Kazgidromet» «On the state of the environment in the Republic of Kazakhstan» of MEWR RK in the period 1990-2012 were used years and studies of perennial stock and literature sources on hydrochemical indicators [4,5], including biochemical oxygen consumption(BOD_5), ammonia nitrogen (NH_4),nitrite nitrogen (NO_2), nitrate-nitrogen (NO_3), chlorides (*Cl*), sulfates (SO_4), copper *(Cu)*, zinc *(Zn)*, natrium *(Na)* and petroleum products. The research methods of RSE "Kazgidromet" of the Republic of Kazakhstan are based on systematization, system analysis and synthesis of monitoring results, which were carried out on the basis of the "Manual hydrometeorological stations and posts (part 3.1 - Hydrological observations at posts. Almaty, 2004)", according to which observations on transboundary sections are held at least 36 times a year [6].

At the same time, Horiba U-50 series (measuring the physicochemical parameters of water), the bottom grab gear and Peterson (for sampling macrozoobenthos) and the Jedi network (for sampling zooplanktons) were used to determine hydrobiological indicators and sampling.

Research methods. For evaluation and standardization of water quality in the river basins in the Americas and Europe uses water quality index CCME (CCQE WQI) - it is a tool to simplify the presentation of water quality data [7] as the only tool for managing water bodies. A significant contribution to the development of the theoretical base of the water quality index CCME (CCQE WQI) have been made by D. Couillard and Y. Lefebvre[8], D.G. Smith [9], M.A. House and J.B. Ellis [10], J. Saeger [11], P.A. Zandbergen and K.J. Hall [12], S. Hébert [13], R. Rocchini and L.G. Swain [14], S. Munger [15], W. Hart [16], B. Phippen [17], T. Husain [18], C.R. Wright, K.A. Saffran, A-M. Anderson, D. Neilson, N.MacAlpineandS. Cooke [19],H. Khan [20], as well as some work done by Canadian scientists W. Hart, Earle Baddaloo, Jackie Shaw, Kim Hallard, Murray Hilderman, Peter Rodgers, Karl Lauten, Ilze Reiss and Herb Vandermeulen, Scott Tessier and Margaret Gibbs in the implementation of the project «Canadian recommendations on water quality for the protection of aquatic life and fauna: water quality index CCME»[7].

For assessing the quality of water resources and the ecological state of aquatic ecosystems in the practice of water management in the Russian Federation and the Republic of Kazakhstan, methods based on the use of complex indicators, that is, the definition of limits of permissible changes (LPC) are widely used [21], critical threshold action (CTA) [22], maximum permissible concentration (MPC) [22], hydrochemical pollution index (HPI) [22],as well as methodological support of N.G. Bulgakov [23], V.P. Yemelyanova [24], T.N. Moiseenko [25], M.Zh. Burlibayev [26] and V.V. Shabanov [27].

In this case, to assess the water quality and ecological status of water bodies in the Yesil river basin, the method of V.Shabanov is used, by using the maximum pollution coefficient ($K_{пз}$) [27-29]:

$$K_{пз} = \frac{1}{N} \cdot \sum_{i=1}^{N} \frac{C_i}{ПДК_i} - 1 ,$$

where i – number of the water pollutant; N - quantity of substances taken into account; MPC_i - maximum permissible concentration of substances to be taken into account; C_i - actual concentration of substances taken into account; $K_{пз}$ - coefficient of pollution that characterize water quality, the state of the river water body and its water management value, which are estimated in accordance with the classification given in table 1.

Table 1 – Classification of water quality according to the coefficient of maximum pollution ($K_{пз}$)

Very clean	Clean	Moderately clean	Polluted	Unclean	Very clean
<-0.80	-0.80-0.0	0.0-1.0	1.0-3.0	3.0-5.0	>5.0

To assess the degree of water pollution in river basins used trophic status of E.S. Shannon (table 2) [30].

Table 2 – Classification of water quality index by Shannon (H) [30]

Trophic					
Oligotrophic	Mesotrophic	Meso Eutrophic	Eutrophic	Polyetrophic	Hyper eutrophic
3,06-1,89	1,89-1,69	1,69-1,52	1,52-1,35	1,35-1,25	1,25-1,11

Research results: Based on the methodological approach of V.V. Shabanov based on the coefficient of maximum pollution ($K_{пз}$) with the use of long-term information and analytical materials of RSE «Kazhydromet» on water pollution in the Yesil river basin and integral maximum allowable concentration criteria (MAC) for fishery water use [3; 4; 31] the water quality was assessed by hydrochemical parameters (figure 3 and 4).

Thus, the assessment of the quality of water in the catchment area of the Yesil river basin carried out on a spatial-temporal scale, starting with the flow formation zone (hydrological station Turgenevka) to the mouth of the river (hydrological station Dolamatova), made it possible to determine the directivity and intensity of their pollution with the main ions (Cl, Na, SO_4),biogenic elements (NH_4, NO_2, NO_3)and heavy metals (Cu, Zn). As can be seen from table 3, the waters in the catchment area of the Yesil river basin are mainly polluted with heavy metals (Cu, Zn), sulfates (SO_4)and petroleum products, which requires the need to take into account when developing environmental protection measures. It should be noted that the coefficient of maximum contamination ($K_{пз}$) in the watershed of the Yesil River Basin on a time scale from the hydrological station, the village of Turgenevka to the village of Dolamatovo increases and by degree of pollution, mainly refers to polluted (Figure 3), where the water pollution is represented by the trophic status of E.S. Shannon [30].

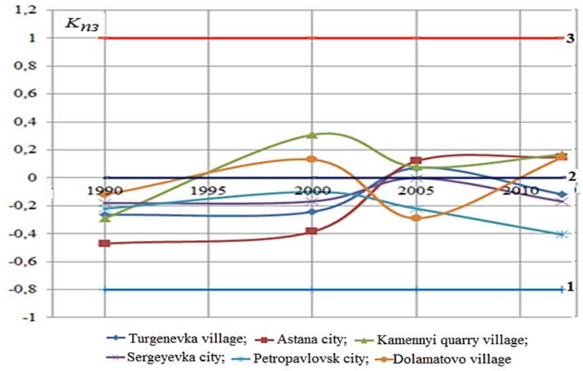

Figure 3 – Changes in water quality according to the limiting pollution factor in the Yesil river catchment area in the space-time scale: 1 - very clean (oligotrophic); 2- pure (mesotrophic); 3 - moderately polluted (meso-eutrophic)

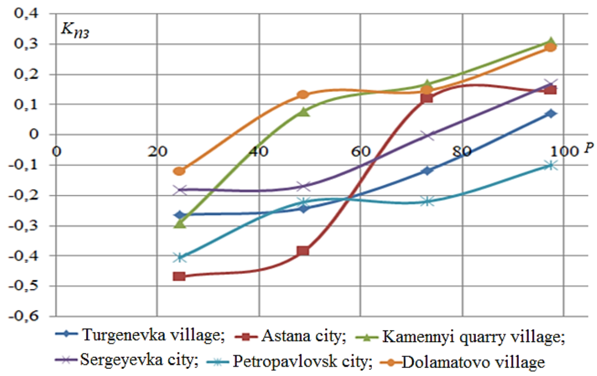

Figure 4 –
The probability curve of the coefficient of maximum pollution (K_{n3})

As can be seen from figure 3, water quality assessment by pollution factor was carried out in a multiyear section (1990-2012) and on a spatial scale, which allowed us to obtain water quality characteristics for years of varying degrees of supply and various hydrological posts located along the catchment area of the Yesil basin (figure 4).

To assess the ecological state of the aquatic ecosystem in the catchment area of the Yesil river basin the Shannon index (*H*) dependence is used and pollution limit coefficient of V.V. Shabanov (K_{n3}), which has the following form: $H = 3{,}06 \cdot exp[-0.23(K_{n3} + 2)]$.

Based on the coupling equation characterizing the dependence of the Shannon index and the pollution limit coefficient (K_{n3}) their quantitative values were determined by hydrological posts located in the catchment area of the Yesil river basin on a time scale (table 3).

Table 3 – Comparative assessment of the ecological state of the aquatic ecosystem in the catchment area of the Yesil river basin using the Shannon index (*H*) and coefficient of maximum pollution (K_{n3})

Hydrological posts	Years							
	1990		2000		2005		2012	
	K_{n3}	*H*	K_{n3}	*H*	K_{n3}	*H*	K_{n3}	*H*
Turgenevka village	-0,264	2,050	-0,243	2,041	0,072	1,900	-0,117	1,983
Astana city	-0,470	2,151	-0,385	2,111	0,120	1,876	0,146	1,867
Kamennyi quarry village	-0,291	2,066	0,309	1,799	0,078	1,897	0,168	1,860
Sergeyevka city	-0,181	2,013	0,168	1,860	-0,002	1,934	-0,169	2,007
Petropavlovsk city	-0,222	2,032	-0,100	1,977	0,220	1,836	-0,406	2,121
Dolamatovo village	-0,120	1,986	0,131	1,876	0,288	1,805	0,146	1,870

Thus, on the basis of systematization and system analysis, as well as predictive calculations to determine the pollution limit index and the Shannon index, it was possible to evaluate the water quality and ecological state of the aquatic ecosystem in the Yesil river basin in the space-time scale, that is, the water quality in all hydrological posts are estimated at the level of «moderately polluted (mesoeutrophic)» and «polluted (euthophic)».

Discussion. Currently, the hydrological regime of the Yesil river basin has changed under the influence of anthropogenic activities, that is, 80% of the river flow is completely regulated by the construction of large and small reservoirs to meet the water needs of growing and developing industrial facilities, cities and agriculture.

The volume of water consumption within the Republic of Kazakhstan is currently about 217.7 million cub.m and by 2020 the volume of water consumed will increase to 480.2 million cub.m.

Most of the wastewater from the Esil river basin is formed in the catchment areas of the Kazakhstan part, which in the future from 134.87 million cub.m to 229.15 million cub.m, are the main sources of chemical and biogenic pollution of surface runoff.

The magnitude of the load on water resources was estimated by using the coefficient of water resources use ($K_{ивр}$),equal to the ratio of total water consumption to available water resources showed that the largest water load falls on large industrial cities and makes up to 40%, which corresponds to a high load, and in general, the Yesil river basin has an average water load of 14 -16%, which characterizes moderate load on water resources.

The quality of water in the catchment area of the Yesil river basin carried out on a space-time scale, starting from the runoff formation zone (hydrological station Turgenevka) to the mouth of the river (hydrological station Dolamatovo), made it possible to determine the direction and intensity of their contamination with the main ions (Cl. Na, SO_4), biogenic elements (NH_4, NO_2, NO_3) and heavy metals (Cu, Zn). At the same time, it is mostly contaminated with heavy metals (Cu, Zn), sulfates (SO_4) and oil products, which requires the need to take into account when developing environmental protection measures. It should be noted that the coefficient of maximum pollution ($K_{пз}$) in the catchment area of the Yesil river basin on a time scale from the hydrological station of the Turgenevka village to the Dolamatovo village increases.

Assessing water quality and the ecological status of the aquatic ecosystem in the Yesil watershed by using the coefficient of maximum pollution ($K_{пз}$) and Shannon index (H) allowed to determine the degree, intensity, direction and nature of pollution of water bodies in the space-time scale and to obtain the dependence of the coefficient of maximum pollution ($K_{пз}$) and Shannon index (H) in the estimated provision (P), which showed that the quality of water for all the considered hydrological posts is estimated at the level of «moderately polluted (mesoeutrophic)» and «polluted (euthophic)».

At the same time, the obtained information on the current state of the aquatic ecosystem of the catchment area of the Yesil river basin within the Republic of Kazakhstan makes it possible to develop a system of measures for the rational use of natural resources and the prevention of possible emergency situations based on the quantitative characteristics of natural self-purification.

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ЕСІЛ ӨЗЕНІНІҢ СУ ЖИНАУ АЛАБЫН ЭКОЛОГИЯЛЫҚ-СУ ШАРУАШЫЛЫҚ ТҰРҒЫДА БАҒАЛАУ

Аннотация. Қазіргі уақытта Есіл өзенінің бассейнінде күрделі су-экологиялық жағдай орын алған, бұл, ең алдымен, шекараралық орналасуымен, сонымен қатар өзен бассейнінің жоғарғы және ортаңғы бөлігінің Солтүстік Қазақстанның құрғақ жерлерімен байланысты болуымен түсіндіріледі. Жағдайды одан әрі ушықтыратын мәселе Қазақстан мен Ресей Федерациясының шегінде Есіл өзені халықты және экономиканың әртүрлі салаларын, тұрғындардың негізгі аудандарын, сондай-ақ өнеркәсіптік және ауылшаруашылық дамуын магистральдық су жолы және сумен қамтамасыз ету көзі болып табылады. Су жинау алабындағы су ресурстарын тиімсіз пайдалануды ескеретін болсақ, Есіл өзені бассейнінің экологиялық жағдайына үлкен әсер етеді.

Есіл өзенінің бассейніндегі төгінді сулардың көп бөлігі Қазақстан бөлігінің су жинау учаскелерінде қалыптасады, олар болашақта 134,87 млн м^3-ден 229,15 млн м^3-ге дейін беткі ағынды ластаудың химиялық және биогендік негізгі көздері болып табылады..

Ақмола және Солтүстік Қазақстан облыстары арасында халықтың тығыздығы 12,46 адам/км^2, өнеркәсіп өндірісінің жоғары үлесі 36,5 мың доллар / км^2, аумақта жерді жыртудың жоғарғы көрсеткіші (60%) және 14,6 мал басы/км^2 жағдайдағы мал басының жүктемесі Қазақстан Республикасының аумағында Есіл өзені су жинау алабындаантропогендік жүктеменің едәуір жоғары екендігін көрсетті, бұл жер үсті су ресурстарының химиялық және биогенді ластануының қалыптасуына әсер етеді.

Осылайша, Есіл өзенінің су жинау алабы оның биотикалық және абиотикалық сипаттамаларына әсер ететін көп факторлы антропогендік әсерде болады, өзеннің гидроэкологиялық жағдайын тиімді басқару үшін

су нысандарына гидрологиялық, гидрохимиялық және гидробиологиялық зерттеулер жүргізу кезінде алынған бақыланатын жүйенің жағдайын сипаттайтын ұзақ мерзімді ақпараттық және аналитикалық мәліметтер болуы қажет, сонымен қатар оған әсер ететін барлық маңызды факторлар туралы мәліметтер бірге судың сапасын анықтауға мүмкіндік беретін табиғи жүйенің жағдайын жан-жақты бағалау әдісін пайдалану қажет.

Мақалада Есіл өзенінің бассейніндегі судың ластануы туралы «Қазгидромет» РМК ұзақ мерзімді ақпараттық-аналитикалық материалдарының жүйелік талдауы, Шеннон индексі мен В.В. Шабановтың максималды ластану коэффициенті негізінде су нысандарының кеңістік-уақыт масштабындағы гидрохимиялық көрсеткіштері бойынша судың сапасы бағаланып, антропогендік әсер кезінде гидрохимиялық режимінің пайда болу себептері мен салдарын анықталды. Есіл өзенінің су ресурстарын кеңістіктік-уақыттық масштабта бағалау үшін ж.ргізілген зерттеулер негізінде су ресурстарының жүктемесі су ресурстарын пайдалану коэффициентін *($К_{ивр}$)* қолдана отырып, су ресурстарының жалпы суды тұтынудың қол жетімді су ресурстарына қатынасы арқылы есептелген, ең үлкен су жүктемесі ірі өнеркәсіптік қалаларға 40% дейін жетті, бұл жоғары жүктемеге сәйкес келеді, ал жалпы Есіл өзенінің бассейнінде су жүктемесі орташа есеппен 14 -16% құрады, бұл су ресурстарына түсетін жүктеменің қалыпты жағдайын сипаттайды.

Есіл өзенінің су ресурстарына кеңістік-уақыт масштабында жүргізілген көп дәлелдемелі бағалаудың және мөлшерлеудің негізінде судың сапасының өзгеруінің бағыты және қарқыны көрсетілген, яғни Орталық және Солтүстік Қазақстанның тұрғындарының тіршілік қызметіннің орта жүйесін құрушы негізгі иондармен (Cl, Na, SO_4), биогендік элементермен (NH_4, NO_2, NO_3) және ауыр металдармен (Cu, Zn) ластану дәрежесі көрсетілген. Сонымен, Есіл өзенінің сужинау алабының уақыт мастштабындағы шектелген ластану көрсеткіші ($K_{пз}$) Тургеневка ауылының тұсындағы гидрологиялық бекеттен Доламатов ауылына дейін ластану дәрежесі өседі және ластану дәрежесі бойынша лас және Е.С. Шеннонның трофикалық мәртебесі бойынша эвтрофикалық топқа жатады, ал бұның өзін Орталық және Солтүстік Қазақстанның су нысандарының экологиялық сиымдылығын қалпына келтіру және жақсартуға арналған табиғаты қорғау шараларын құру кезінде ескеру керек.

Сонымен қатар, Қазақстан Республикасындағы Есіл өзені бассейнінің су айдынының су экожүйесінің қазіргі жағдайы туралы алынған ақпарат табиғи ресурстарды ұтымды пайдалану және мүмкін болатын төтенше жағдайлардың алдын алу бойынша шаралар жүйесін табиғи жүйелерді табиғи өзін-өзі тазарту процестерінің сандық сипаттамаларына сүйене отырып жасауға мүмкіндік береді.

Түйін сөздер: талдау, бағалау, ластану, су, жағдайы, гидрохимия, жүйе, элемент, иондар.

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ЭКОЛОГО-ВОДОХОЗЯЙСТВЕННАЯ ОЦЕНКА ВОДОСБОРА БАССЕЙНА РЕКИ ЕСИЛЬ

Аннотация. В настоящее время в водосборе бассейна реки Есиль сложилась сложная водно-экологическая обстановка, что объясняется, прежде всего, его трансграничным положением, а также приуроченностью к верхней и средней частей бассейна к засушливым внутриконтинентальным районам Северного Казахстана, где река почти не принимает притоков. Усугубляет ситуацию то, что именно на этих участках в пределах Казахстана и Российской Федерации река Есиль является основной водной артерией и источником водообеспечения населения и различных отраслей хозяйства, к его долине тяготеют основные ареалы заселённости, а также промышленной и сельскохозяйственной освоенности. Нерациональная хозяйственная деятельность на водосборе, включая использование водных ресурсов, также оказывает большое влияние на экологическое состояние водосбора бассейна реки Есиль.

Большая часть сточных вод бассейна реки Есиль формируется в водосборных территориях казахстанской части, которая в перспективе от 134,87 млн. $м^3$ до 229,15 млн. $м^3$, являются основными источниками химического и биогенного загрязнения поверхностного стока.

Очень высокая плотность населений среди Акмолинской и Северо-Казахстанской областей, которые составляют 12,46 чел/$км^2$, высокая доля промышленного производства 36,5 тыс. доллар/$км^2$, максимальная распаханность территории (60 %) и животноводческой нагрузки в пределах 14,6 усл. гол/$км^2$ показали, что в пределах Республики Казахстан водосборный бассейн реки Есиль имеет достаточно высокую антропогенную нагрузку, оказывающих влияние на формирования химических и биогенных загрязнений поверхностных водных ресурсов.

Таким образом, водосбор бассейна реки Есиль находится под многофакторным антропогенным воздействием, которое воздействует на биотические и абиотические их характеристики, что для эффективного управления их гидроэкологическим состоянием необходимо иметь многолетние информационно-анали-

тические данные, характеризующие о состоянии управляемой системы, которые получают при проведении гидрологических, гидрохимических и гидробиологических наблюдений за водными объектами, а также данные обо всех существенных факторах влияния на это состояние с использованием методов всесторонней оценки состояния природных систем, позволяющих оценить качество воды.

В статье на основе системного анализа многолетних информационно-аналитических материалов РГП «Казгидромет» по загрязнению воды в бассейне реки Есиль и использования индекса Шеннона и коэффициента предельной загрязненности В.В. Шабанова произведена оценка качества воды по гидрохимическим показателям в пространственно-временном масштабе в условиях антропогенной деятельности для выявления причин и следствия формирования гидрохимического режима водных объектов. На основе проведенных многофакторных оценок и нормирования водных ресурсов реки Есиль в пространственно-временном масштабе величина нагрузки на водные ресурсы оценивалась через коэффициент использования водных ресурсов ($K_{иср}$), равный отношению полного водопотребления к располагаемым водными ресурсам показал, что наибольшая водная нагрузка приходится на крупные промышленные города и составляют до 40%, что соответствует высокой нагрузке, а в целом бассейн реки Есиль в среднем водные нагрузки составляют 14 - 16%, что характеризует умеренную нагрузку на водные ресурсы.

Качество воды в водосборе бассейна реки Есиль проведенного в пространно-временном масштабе, начиная с зоны формирования стока (гидрологический пост село Тургеневка) до устья реки (гидрологический пост село Доламатово) позволило определить направленности и интенсивности их загрязнения главными ионами (Cl, Na, SO_4), биогенными элементами (NH_4, NO_2, NO_3) и тяжелыми металлами (Cu, Zn). При этом в основном загрязнена тяжелыми металлами (Cu, Zn), сульфатами (SO_4) и нефтепродуктами, что требует необходимости учитывать при разработке природоохранных мероприятий. При этом следует отметить, что коэффициент предельной загрязненности ($K_{пз}$) в водосборе бассейна реки Есиль во временном масштабе от гидрологического поста село Тургеневка до села Доламатово увеличивается.

Оценки качества воды и экологического состояния водной экосистемы в водосборе бассейна реки Есиль с использованием коэффициента предельной загрязненности ($K_{пз}$) и индекса Шеннона (H) позволили определить степень, интенсивность, направленность и характер загрязнения водных объектов в пространственно-временном масштабе и получить зависимость коэффициента предельной загрязненности ($K_{пз}$) и индекса Шеннона (H) в расчетной обеспеченности (P) , которая показала, что качество воды по всех рассматриваемых гидрологических постах оценивается на уровне «умеренно-загрязненная (мезоэвтрофные)» и «загрязненная (эвтофные)».

При этом полученная информация по современному состоянию водной экосистемы водосборной территории бассейна реки Есиль в пределах Республики Казахстан дает возможность разработать систему мероприятий по рациональному природопользованию и предотвращению возможных чрезвычайных ситуаций на основе количественной характеристики процессов естественного самоочищения природных систем.

Ключевые слова: анализ, оценка, загрязнение, вода, состояние, гидрохимия, система, элементы, ионы.

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