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GEOMORPHOLOGICAL ANALYSIS OF THE ILI RIVER BASIN CATCHMENT AREA FOR INTEGRATED DEVELOPMENT

Abstract. Based on long-term informational and analytical materials of the World Meteorological Organization (WMO), the Weather and Climate reference portal and stationary meteorological stations of the RSE Kazhydromet located in the catchments of the Ili River basin, which cover the Almaty region (Narynkol, Tekes, Sumbe, Dobyn, Aydarly, Kapshagay, Usharal, Bakanas, Kokzhide, Kuigan) of the Republic of Kazakhstan, Xinjiang Uygur Autonomous Region (Tekes, Xinyuan, Tokkuztara, Yamata, Kuldzh) of the People's Republic of China and using the law of geographic vertical zoning, the energy resources of river basins and groundwater, the climatic potential of natural systems that characterize the heat and moisture supply of natural landscapes and ecological and hydrogeochemical indicators showing the direction and intensity of the hydrogeochemical process on a spatial scale, which allowed for geomorphological zoning, are determined catchments of the Ili river basin, characterizing the natural functions of the river basin, to have runoff and environment formation, which are the basis for environmental management and environmental engineering.

Key words: climate, nature, resources, river, pool, environment, landscape, catchment, system, heat, moisture, security, potential, process, nature management, environmental management, function.

Relevance. The general current situation of the catchment of the basin of the transboundary Ili River, located on the territory of the People's Republic of China and the Republic of Kazakhstan, is characterized by a rather intense geoecological state. This situation is caused by the progressive involvement and development of the natural resource potential of vast territories (in our case, watersheds), the increase in technogenic impact on them and the disruption of the relationship between natural components in geosystems and in the human-nature system.

Therefore, to solve the geoecological problems of the watersheds of the transboundary river basin, it is necessary to consider and study them in the form of geosystems of a certain rank, including an interdependent set of components and developing as a whole on the basis of geomorphological schematization, describing the main processes of the functioning of watersheds with a possibly large set of parameters that take into account changes in the components of geosystems catchment areas.

The main natural function of the river basin is, firstly, drainage, secondly, peculiar combined geosystems (the principle of unification here is the unity of hydrogeochemical flows having one object for their discharge) and, thirdly, this is a spatial basis for nature management (allocation of land for various purposes) and environmental management, that is, objects of a comprehensive arrangement of their watersheds.

With a comprehensive arrangement of the catchments of the river basin, the catenary approach is the basis of the geomorphological schematization of the catena, which consists of four facies with different altitudinal positions. The eluvial facies represents a hill near the dividing line, the transeluvial facies represent the slope to the inflection point, the transaccumulative facies represent the slope after the inflection point, and the supersquale is the lowland of the floodplain terraces. The floodplains of the rivers, despite their significance, were not considered in the work. The transeluvial and transaccumulative facies form the transit facies of the slope, and the supequal facies adjoins the watercourse.

Purpose of the study – based on geomorphological schematization of catchments of river basins using the catenary approach, zoning of the landscape system of catchments of the Ili River basin to identify regional differences and the need to accurately determine their economic and economic capabilities.

Object of study - The Ili River, which originates in the Central Tien Shan on the territory of the People's Republic of China (PRC) after the confluence of three tributaries - the rivers Kash, Kunes and Tekes, with the latter having a large tributary - the Koksu River and its flow formation zone (Halyktau and Narat) is characterized by the largest layer of precipitation - more than 1300 mm / year. The sources of the Tekes river are located on the territory of Kazakhstan on the Muzart glaciers and their length is 438 km, the catchment area is 28100 km^2 (within the Republic of Kazakhstan, respectively, 218 km and 4250 km^2). The river, high in the upper reaches, at the intersection of the Tekes Depression loses a significant part of its flow for water consumption in the branches of the economy, but after the confluence of the tributaries Kokpak, Bayankol, Narynkol, which feed on meltwater from the Khan-Tengri glaciers, the water content of the river increases significantly. Then it flows through the territory of the People's Republic of China (East Turkestan), where it merges with the Kunes and Kash rivers, and at the 250-th km from their confluence enters the territory of Kazakhstan with the Ili river with many waters. After exiting the Kapshagai Gorge, the Ili River flows through the deserted Balkash plain to Lake Balkhash. Downstream the riverbed is unstable, replete with elders and islets. When it flows into the lake, the river forms a delta with an area of about 9000 km^2, which is divided into three systems of branches - Topar, Ili and Zhideli [1].

Research Methods and Materials. The work used information and analytical materials of the World Meteorological Organization (WMO), the reference and information portal «Weather and Climate» and stationary meteorological stations of the RSE «Kazhydromet» located in the catchments of the Ili River basin, which cover the Almaty region (Narynkol, Tekes, Sumbe, Dobyn, Aydarly, Kapshagay, Usharal, Bakanas, Kokzhide, Kuigan) of the Republic of Kazakhstan, Xinjiang Uygur Autonomous Region (Tekes, Xinyuan, Tokkuztara, Yamata, Kulja) of the People's Republic of China [2]

By the methodology of the comprehensive arrangement of the catchments of river basins, given the multidimensional nature of the problem, the whole set of methodological approaches that exist in environmental management, that is, the geosystem and catenary approaches, has been adopted.

The catenary approach is the basis of the geomorphological schematization of catenas when substantiating the need for a comprehensive arrangement of catchments of river basins [3,4,5].

In the geomorphological schematization of landscape catenas of catchment areas, in order to justify the need to equip river basins, each catchment within the same physical and geographical area is represented by a catena consisting of four facies with different altitude positions, determined by the depth of the relief: eluvial, transit, superaqual and subaquatic. If the watersheds have extended slopes, the transit facies is divided into the transeluvial and transaccumulative facies [5].

Thus, the basis of geomorphological schematization of watershed landscapes based on the geosystem approach, based on the excess of the earth's surface over the watercourse, makes it possible to more objectively differentiate the zones of facies locations.

However, in the quantitative description of the hydrogeochemical processes of catchments of river basins, the main integral factor is the energy of the groundwater flow, that is, the speed of their movement, the mass of water, depending on the thickness of the aquifer, filtration energy, and evaporation energy, which are not taken into account when using the excess of the earth's surface over the watercourse as a criterion for geomorphological schematization of river basins, i.e Δ_i and ΔH characterize the excess of the earth's surface over the watercourse, then you can imagine the energy or work performed by the flow of groundwater in the following form [4]: $\Delta E = A_i = m_i \cdot g \cdot \Delta H = m_i \cdot g \cdot \Delta_i$, where ΔE – change in energy at the site *dx*, kJ; A_i – work performed in an elementary volume by the flow of groundwater in the area *dx*, kJ; m_i – groundwater mass; Δ_i и ΔH – height exceeding the Earth's surface above the bank of the watercourse, m.

Construct geomorphological circuit landscape catenas possible using hydrogeochemical potential groundwater flow river basin ($\bar{M}$), characterizing work ($\bar{A}_n$),committed by a liquid in the process of precipitation to the ratio of the concentration of soil solution ($\bar{C}_n$),that is, they can be considered as the ability of the soil cover to be released from readily soluble salts from the upper to the lower reaches of the river basins: $\bar{M} = \bar{A}_n / \bar{C}_n$, where: $\bar{M}$ – hydrogeochemical potential of river basins; $\bar{A}_n$ – work performed in an elementary volume by the flow of infiltration water in the soil layer of river basins; $\bar{C}^*$ – average salt concentration in groundwater flow [4]: *г*

$$\bar{A}_n = O_c / \left[\frac{R}{L} - (1-t)\frac{R}{L}(1-\bar{\Delta})\right], \; \bar{C}^* = \left[C_o + (1-t)\frac{R}{L}(1-\bar{\Delta}) \cdot C_{\Gamma}/O_c\right] / C_{\partial on},$$

where: R – radiation balance; O_c – precipitation; L – latent heat of vaporization; C_o – initial concentration of soil solution in the soil layer; - permissible concentration of salts in the soil solution, which corresponds to the parameter of non-saline soils; C_{Γ} – salt concentration in groundwater; $(1 - t)$ – infiltration action time ($t = T/365$), T – duration of the biological active period; $\bar{\Delta} = \Delta/\Delta_{kp}$, Δ – groundwater depth: Δ_{kp} – critical groundwater depth.

Research results. For the geomorphological zoning of the watershed territories of the Ili River basin, a catenary approach was used, which involves a geomorphological schematization of landscape catenas of the watersheds of river basins characterizing landscapes in the mountain class (eluvial facies), piedmont landscape subclass (transelyuvial facies), foothill plain landscape subclass (transaccus) flat class of landscapes (super-aquatic and sub-aquatic facies).

Based on the above methodological approach, the energies and work performed by the groundwater flow in the catchments of the Ili River basin are determined (table 1).

Table 1 – Energy resources of the catchments of the Ili River basin

Natural and climatic zones		Weather stations	The absolute height of the earth's surface, m	ΔH, m	Groundwater flow energy, kJ	
landscape class	facies				A_i	$\sum A_i$
Mount	Eluvial	Basuarkor	4059,0	–	–	–
		Narynkol	1806,0	1797,0	17628,6	31961,3
		Tekes	1766,0	40,0	392,4	14333,3
Piedmont	Trans-eluvial	Sumbe	1232,0	534,0	5238,5	13940,3
		Tekes (China)	1203,0	29,0	284,5	8701,8
		Xinyuan (China)	947,0	256,0	2511,4	8417,3
		Tokkuztara (China)	773,0	174,0	1707,0	5905,9
Piedmont lowland	Trans accumulative	Yamato (China)	723,0	50,0	490,5	4198,9
		Gulja (China)	663,0	60,0	588,6	3708,4
		Kokdala (China)	627,0	36,0	353,2	3119,8
		Dubyn	596,0	31,0	304,1	2766,6
		Aydarly	576,0	20,0	196,2	2462,5
		Kapshagay	540,0	36,0	353,2	2266,3
Plain	Super aqual	Ili	490,0	50,0	490,5	1913,1
		Bakbakty	459,0	31,0	304,1	1422,6
		Usharal	397,0	62,0	608,2	1118,5
		Bakanas	396,0	1,0	9,8	510,3
		Akdala	390,0	6,0	58,9	500,5
		Akkol	384,0	6,0	58,9	441,6
	Subaquatic	Araltobe	357,0	27,0	264,9	382,7
		Kokzhide	350,0	7,0	68,7	117,8
		Kuigan	345,0	5,0	49,1	49,1

As can be seen from table 2, in the catchment areas of the Ili River basin in the territory of the Raiymbek district of Almaty region, that is, the zone of runoff formation, where the mountain class of landscapes with eluvial facies is located, has rather high energy resources of river basins and groundwater, which are 23259.5 kJ. At the same time, in the watershed territories of the Ili River basin, which pass through the borders of the Xinjiang Uygur Autonomous Region of the People's Republic of China, are located in the piedmont class of landscapes with transeluvial facies, the energy resources of river basins and groundwater are reduced to 8034.4 kJ. The energy resources of river basins and groundwater in the foothill lowland class of landscapes with a transaccumulative facies of catchments of the Ili River basin, which cover part of the territory of the Xinjiang Uygur Autonomous Region of the People's Republic of China and the Uyghur District of the Almaty Region of the Republic of Kazakhstan, amount to 2285.8 kJ. At the same time, in the territories of the catchment part of the Republic of Kazakhstan, covering from the Dobyn hydrological post to the city of Kapshagai, it amounts to 500.3 kJ, that is, the energy resources of the river basin and groundwater are sharply reduced. In the territories of the flat class of landscapes with superaqual facies, covering the Ili and Balkhash districts of the Almaty region, the energy resources of the river basin and groundwater are reduced to 1530.3.1 kJ, and in the zone of the subaquatic facies it decreases sharply to 333.6 kJ.

Thus, in accordance with the principle of geographical zonality existing in energy and groundwaters, from 31,961.3 to 49.1 thousand catchment areas of the Ili River basin (table 2).

Table 2 – Geomorphological schematization of landscape catenas in the catchment areas of the Ili River basin according to the energy resources of the river basin and groundwater

Natural and climatic zones		Geomorphological indicator	
Landscape class	Facies	The absolute height of the earth's surface, m	Groundwater flow energy, kJ
Mount	Eluvial	<1800	<175000
Piedmont	Trans-eluvial	800-1800	8000-17500
Piedmont lowland	Trans accumulative	540-800	5500-8000
Plain	Super aqual	350-540	3500-5500
	Subaquatic	>350	>3500

The natural heat and moisture supply of the active surface is the most important constituent element of the complex of natural productive forces, that is, natural landscapes that are actively involved in the biological process in general and in the formation of natural-technogenic complexes, especially the catchments of river basins [6,7,8].

Based on the long-term information and analytical materials of the located meteorological stations in the catchments of the Ili River basin, their average long-term energy resources and natural and climatic potentials are determined, that is (table 2): the sum of the air temperature for the biologically active period of the year ($\sum t,°C$), amount of precipitation (O_c, mm), evaporation level (E_o, mm), and photosynthetically active radiation (R, kJ/cm^2) (table 3).

As can be seen from table 3, the energy resources of the watersheds of the Ili River basin from the mountainous class of landscapes (eluvial facies) to the plain class of landscapes (subaquatic) increase, the sum of the biological active air temperature from 2338.0 to 3800.0 ° C, volatility from 844, 0 to 1472.0 mm and the radiation balance from 134.0 to 182.0 kJ / cm^2, and precipitation decreases from 433.0 to 144.0 mm. Under these conditions, landscape-geochemical catenes are formed in the catchment areas of the river basin, that is, the simplest cascade landscape-geochemical system, characterized by the intensity of hydrogeochemical flows, which largely depend on their energy resources.

Table 3 – Natural and energy resources of the catchments of the Ili River basin

Natural and climatic zones (landscape class, facies)	Weather stations	Absolute height (H), m	Natural and climatic indicators			
			O_c, mm	$\sum t$, °C	E_o, mm	R, kJ/cm^2
Mountain class of landscapes (eluvial facies)	Narynkol	1806,0	433,0	2805,0	1001,0	149,0
	Tekes	1766,0	421,0	2338,0	844,0	134,0
Piedmont subclass of landscapes (transeluvial facies)	Sumbe	1232,0	377,0	3074,0	1122,0	158,0
	Tekes (China)	1203,0	259,0	3100,0	954,0	159,0
	Tokkuztara (China)	773,0	248,0	3579,0	894,0	175,0
Piedmont lowland subclass of landscapes (trans accumulative facies)	Yamato (China)	723,0	252,0	3130,0	1269,0	162,0
	Gulja (China)	663,0	248,0	3800,0	1284,0	182,0
	Zharkent	641,0	213,0	3950,0	1661,0	187,0
	Dobyn	596,0	226,0	4100,0	1748,0	192,0
	Aydarly	576,0	364,0	4305,0	1247,0	199,0
	Kapshagay	540,0	370,0	3750,0	1528,0	180,0
Plain class of landscapes (superaqual facies)	Usharal	397,0	354,0	3622,0	1168,0	176,0
	Bakanas	396,0	273,0	3700,0	1527,0	179,0
Plain class of landscapes (subaquatic)	Kokzhide	350,0	224,0	3700,0	1474,0	179,0
	Kuigan	345,0	144,0	3800,0	1472,0	182,0

At the same time, the energy resources of river basins and groundwaters of the natural system are additionally characterized by hydrogeochemical processes of groundwater, which are characterized by ecological and hydrogeochemical parameters of landscape of river basins, which are extremely important in the ecological and hydrogeochemical zoning of landscape and geographical zones and water management assessment of catchments of the Ili River basin (table 4).

Table 4 – Environmental-hydrogeochemical indicator
of the landscape system of the catchment area of the Ili River basin

Natural and climatic zones (landscape class, facies)	Weather stations	H, m	Indicators					
			C_o, g/l	C_z, g/l	Δ, m	$\bar{A}_n$	$\bar{C}^*$	$\bar{M}$
Mountain class of landscapes (eluvial facies)	Basuarkor	4059,0	0.30	1.00	10.0	0,73	0,60	1,21
	Narynkol	1806,0	0,30	1,00	10,0	0,79	0,60	1,32
	Tekes	1766,0	0,30	1,00	10,0	0,60	0,60	1,00
Piedmont subclass of landscapes (transeluvial facies)	Sumbe	1232,0	0.40	1.20	10.0	0.60	0,80	0,75
	Tekes (China)	1203,0	0.40	1.30	10.0	0.41	0,80	0,51
	Tokkuztara (China)	773,0	0,40	1,30	10,0	0,35	0,80	0,44
Piedmont lowland subclass of landscapes (trans accumulative facies)	Yamato (China)	723,0	0.50	1.50	6.0	0.39	1,00	0.39
	Gulja (China)	663,0	0.50	1.50	6.0	0.29	1,00	0.29
	Zharkent	641,0	0,50	1,50	6,0	0,34	1,00	0,34
	Dobyn	596,0	0,50	1,50	6,0	0,29	1,00	0,29
	Aydarly	576,0	0,50	1,50	6,0	0,46	1,00	0,46
	Kapshagay	540,0	0,50	1,50	6,0	0,51	1,00	0,51
Plain class of landscapes (superaqual facies)	Usharal	397,0	0,90	3,50	3,0	0,50	1,50	0,33
	Bakanas	396,0	0,90	3,50	3,0	0,38	2,50	0,25
Plain class of landscapes (subaquatic)	Kokzhide	350,0	1,50	6,00	3,0	0,31	1,80	0,17
	Kuigan	345,0	1,50	6,00	3,0	0,20	1,80	0,13

In this case, the work, as can be seen from table 4, performed in an elementary volume by a flow of infiltration water in the soil layer ($\bar{A}_n$) from the mountain side (eluvial facies) to the lowland (subaquatic) zones gradually decreases from 0.73 to 0.20, and the average salt concentration in surface water - soil – "groundwater" system ($\bar{C}^*$), on the contrary, increases from 0.60 to 1.20. Consequently, the ecological-hydrogeochemical potential or soil-reclamation indicator of the landscape ($\bar{M}$), obeying the law of vertical zonality, decreases from 1.21 to 0.13, which characterizes a saline collection basin in the area of hydrogeochemical flow stacking. This regularity shows the available possibilities for the formation of hydrogeochemical processes in the catchment areas of the Ili River basin, which are damaged by the spread in the flat class of landscape with superaqual and suaqual facies, where salinization of soils with low ecological productivity are widespread [57], which are estimated using integrated criteria for environmental and climatic productivity natural landscapes (table 5):

- humidification coefficient ($K_y = O_c$ / E_o), where O_c – precipitation, mm; E_o – volatility over the biological active period of the year, mm: $E_o = 0.0018 \cdot (25 + t)^2(100 - a)$, where t – is the average monthly temperature °C; a – monthly average relative humidity, % [9];

- dryness index ($\bar{R} = R/LO_c$, where L – specific heat of vaporization, assumed constant and equal to 2,5 kJ/cm^2); R – photosynthetically active radiation, kJ/cm^2[10]: $R = 13.39 + 0.0079 \cdot \sum t > 10°C$, here $\sum t$, °C – the sum of the air temperature for the biological active period of the year [11].

At the same time, under natural conditions, the formation of landscape hydrogeochemical facies largely depends on the heat and moisture supply of the catchment areas of the Ili River basin, since the natural humidity coefficient decreases from 0.50 from the mountain class of landscapes (eluvial facies) to the Plain class of landscapes (subaquatic) to 0.10, and the "dryness index", which characterizes the degree of balance of moisture and heat, rises from 1,273 to 5,056, which show the presence of sufficiently high energy resources.

Table 5 – Geomorphological schematization of landscape catenas of catchments of the Ili River basin

Humidity zones	Indicators of heat and moisture			The absolute height of the earth's surface, m	Administrative districts
	Weather stations	K_y	$\bar{R}$		
Mountain class of landscapes (eluvial facies)					
Wet mountain	Narynkol	0,43	1,370	1806,0	Raiymbek
	Tekes	0,50	1,273	1766,0	
Piedmont subclass of landscapes (transeluvial facies)					
Arid mountain	Sumbe	0,34	1,676	1232,0	Raiymbek
	Tekes (China)	0,27	2,456	1203,0	Ili Kazakh Autonomous Prefecture
	Tokkuztara (China)	0,29	2,822	773,0	
Piedmont lowland subclass of landscapes (trans accumulative facies)					
Arid piedmont	Yamato (China)	0,20	2,571	723,0	Ili Kazakh Autonomous Prefecture
	Gulja (China)	0,19	2,935	663,0	
	Zharkent	0,13	3,510	641,0	Panfilov
	Dobyn	0,13	3,398	596,0	Uigur
	Aydarly	0,29	2,187	576,0	Kerbulak
	Kapshagay	0,24	1,946	540,0	Kapshagay city
Plain class of landscapes (superaqual facies)					
Arid plain	Usharal	0,30	1,988	397,0	Ili
	Bakanas	0,18	2,622	396,0	Balkhash
Plain class of landscapes (subaquatic)					
Very arid desert	Kokzhide	0,15	3,200	350,0	Balkhash
	Kuigan	0,10	5,056	345,0	

Thus, using the laws of geographic vertical zonality, the energy resources of river basins and groundwater, the climatic potential of natural systems characterizing the heat and moisture supply of natural landscapes, and ecological and hydrogeochemical indicators showing the direction and intensity of the hydrogeochemical process on a spatial scale, which allowed geomorphological zoning of catchments of the Ili River basin, characterizing the nature valued functions of the river basin, ie runoff and environment formation and is a basis for environmental management and environmental engineering (table 5).

Thus, based on the geomorphological schematization of the catchments of the transboundary Ili river, based on the drainage of river basins as a thermodynamic system, the boundary of which coincides with the altitudinal zonality, it is possible to assess changes in the hydrological, ecological, soil, and ecological-hydrogeochemical regime of landscape systems taking into account natural and territorial differences as performing important environment formation or environmental functions.

Conclusions. Based on long-term informational and analytical materials of the World Meteorological Organization (WMO), the Weather and Climate reference portal and stationary meteorological stations of the RSE Kazhydromet, located in the catchments of the Ili River basin, which cover the Almaty region (Narynkol, Tekes, Sumbe, Dobyn, Aydarly, Kapshagay, Usharal, Bakanas, Kokzhide, Kuigan) of the Republic of Kazakhstan, Xinjiang Uygur Autonomous Region (Tekes, Xinyuan, Tokkuztara, Yamata, Kuldzh) of the People's Republic of China and using the law of geographic vertical zoning, the energy resources of river basins and groundwater, the climatic potential of natural systems that characterize the heat and moisture supply of natural landscapes and ecological and hydrogeochemical indicators showing the direction and intensity of the hydrogeochemical process on a spatial scale, which allowed for geomorphological zoning, are determined catchments of the Ili river basin, characterizing the natural functions of the river basin, to have runoff and environment formation, which are the basis for environmental management and environmental engineering.

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КЕШЕНДІ ҮЙЛЕСТІРУ ҮШІН ІЛЕ ӨЗЕНІНІҢ СУ ЖИНАУ АЛАБЫН ГЕОМОРФОЛОГИЯЛЫҚ ТАЛДАУ

Аннотация. Қазақстан Республикасы Алматы облысының (Нарынқол, Текес, Сүмбе, Добын, Айдарлы, Қапшағай, Үшарал, Бақанас, Кокжиде, Құйған) және Қытай Халық Республикасының Синьцзян-Ұйғыр автономиялық ауданының аймағын қамтитын Іле өзенінің су жинау алабына орналасқан «Қазгидромет» РМӨ-нің тұрақты метеорологиялық бекеттерінің және Әлемдік метеорологиялық ұжымның (ӘМҰ) «Ауа-райы және климат» анықтамалық-ақпараттық жүйесінің көпжылдық мәліметі негізінде және географиялық тік белдеу заңын пайдалана отырып, өзен алабының және жерасты суы ағынынын энергетикалық ресурстары, табиғи жүйенің табиғи-климаттық потенциалын сипаттайтын табиғи ландшафттардың ылғалмен қамтамасыз етілу көрсеткіштері, гидрогеохимиялық үдерістер бағытын және қарқынын бейнелейтін уақыт-кеңістік масштабындағы экологиялық-гидрогеохимиялық көрсеткіштері анықталды, ал ол оның нәтижесі өзен алабының табиғи қызметін сипатайтын Іле өзенінің су жинау алабында геоморфологиялық ауданды жүргізуге мүмкіндік берді, яғни оның су ағынын және ортаны құрушы қасиеті, табиғатты пайдалану және табиғаты үйлестірудің негізі болып саналады.

Іле өзенінің су жинау алабы аймағының табиғи энергетикалық ресурстары ландшафтардың таулы топтарынан (элювиалдық фациядан) ландшафттардың жазықтық тобына (субаквальдық фацияға) қарай өседі, яғни биологиялық белсенді ауа температурасының жиынтығы 2338,0 °С-тан 3800,0 °С-қа, буланудың шамасы 844,0 мм-ден 1472,0 мм-ге және радиациялық теңгерме 134,0 кДж/см^2-тан 182,0 кДж/см^2-қа дейін, ал атмосфералық жауын-шашын шамасы 433,0 мм-ден 144,0 мм-ге дейін төмендейді және осы жағдайға тән ландшафттық-геохимиялық катен, яғни геохимиялық ағын қарқыны арқылы ерекшеленетін, географиялық аймақтық (белдеулік) заңдылығына байланысты сатыланған ландшафттық-геохимиялық жүйе пайда болады және көптеген жағдайда жерасты суы ағынының энергетикалық қуаты соған байланысты болғандықтан, оның сандық шамасы элювиалдық фациядан субаквальдық фацияға қарай 31961,3 кДж-дан 49,1 кДж-ға дейін біртіндеп төмендейді, ал ол өзен аймағын геоморфологиялық желілеуге мүмкіндік береді.

Сонымен, табиғи ортаның нақтыланған көлемдегі топырақ қабатындағы сүзілген су ағынының атқаратын жұмысын ($\bar{A}_n$) таулы (элювиалдық фациядан) жазықтық (субаквалдық фацияға) аймаққа қарай 0,73-тен 0,20 -ға дейін төмендесе, «жер беті суы-топырақ-жерасты суы» жүйесіндегі су ағынының орташа тұздылығы 0,60-тан 1,80-ге дейін өседі. Сондықтан, географиялық аймақтық (белдеулік) заңдылығына байланысты экологиялық-гидрогеохимиялық немесе топырақ-мелиоративтік көрсеткіш ($\bar{M}$) 1,21-ден 0,11-ге дейін төмендейді, ал ол гидрогеохимиялық ағынның қорлану аймағында тұз жиналатын алаптың қалыптасатынын сипаттайды, яғни бұл заңдылық Іле өзеннің су жинау алабының аймағындағы гидрогеохимиялық үдерістердің қалыптасу мүмкіншілігіне байланысты, оның жазықтық аймағында супераквалдық және суаквалдық фациялардың таралуына дәлел бола алады.

Сонымен қатар, табиғи жағдайдағы ландшафттық-гидрогеохимиялық фацияларының қалыптасуына Іле өзенінің су жинау алабының жылу және ылғалмен қамтамасыз ету дәрежесіне тікелей байланысты, себебі ландшафттардын таулы топтарынан (элювиалдық фациядан) ландшафттардын жазық топтарына (субаквалдық фацияға) қарай табиғи ылғалдану көрсеткіші 0,50-ден 0,10-ға дейін төмендей бастайды, ал жылу және ылғалдың теңгермелік дәрежесін сипатайтын «құрғақшылық белгісі» 1,273- тен 5,056-ға дейін жоғарылайды, ал бұдай жағдай аймақтың энергетикалық ресурстарының өте жоғары екендігін көрсетеді.

Сонымен, өте маңызды ортаны құрушы және экологиялық қызмет атқаратын өзеннің су жинау алабы су ағынының қалыптасу жағдайын термодинамикалық жүйе ретінде қарастыра отырып, шекаралық Іле өзенінің су жинау алабын геоморфологиялық желілеу негізінде және аймақ шекарасының биік белдеулікке сай келуі, оның ландшафт жүйесінің гидрологиялық, экологиялық-топырақ және экологиялық-гидрогеохимиялық тәртібінің өзгеруін, табиғи-аймақ өзгешілігін ескере отырып бағалауға мүмкіндік береді.

Түйін сөздер: климат, табиғат, қор, өзен, алап, орта, ландшафт, су жинау, жүйе, жылу, ылғал, қамтамасыз ету, потенциал, үдеріс, табиғатты пайдалану, табиғат үйлестіру, қызмет.

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ГЕОМОРФОЛОГИЧЕСКИЙ АНАЛИЗ ВОДОСБОРА БАССЕЙНА РЕКИ ИЛИ ДЛЯ КОМПЛЕКСНОГО ОБУСТРОЙСТВА

Аннотация. На основе многолетних информационно-аналитических материалов Всемирной метеорологической организации (ВМО), справочно-информационного портала «Погода и климат» и стационарных метеорологических станций РГП «Казгидромет», расположенных в водосборах бассейна реки Или, которые охватывают Алматинскую область (Нарынкол, Текес, Сумбе, Добын, Айдарлы, Капшагай, Ушарал, Баканас, Кокжиде, Куйган) Республики Казахстан, Синьцзян-Уйгурский автономный район (Текес, Синьюань, Токкузтара, Ямату, Кульджа) Китайской Народной Республики и с использованием закона географической вертикальной зональности, определены энергетические ресурсы речных бассейнов и подземных вод, природно-климатического потенциала природных систем, характеризующих тепло- и влагообеспеченности естественных ландшафтов и эколого-гидрогеохимических показателей, показывающих направленность и интенсивность гидрогеохимического процесса в пространственном масштабе, которые позволили провести геоморфологическое районирование водосборов бассейна реки Или, характеризующих природные функции речного бассейна, то есть стокообразование и средообразование, являющихся базисом для природопользования и природообустройства.

Природные энергетические ресурсы территории водосборов бассейна реки Или от горного класса ландшафтов (элювиальная фация) в сторону равнинного класса ландшафтов (субаквальная) повышается, то есть сумма биологической активной температуры воздуха от 2338,0 до 3800,0 °С, испаряемость от 844,0 до 1472,0 мм и радиационный баланс от 134,0 до 182,0 кДж/см^2, а атмосферные осадки уменьшаются от 433,0 до 144,0 мм и в этих условиях в водосборных территориях речного бассейна формируется ландшафтно-геохимические катены, простейшая каскадная ландшафтно-геохимическая система, отличающаяся интенсивностью гидрогеохимических потоков, которые во многом зависят от их энергетических ресурсов подземных вод, подчиняющихся от закона географической зональности, от элювиальной до субаквальной фации постепенно уменьшается от 31961,3 кДж до 49,1 кДж, что дает возможность на их основании производить геоморфологическую схематизацию ландшафтных катенов водосборной территории бассейна реки Или.

При этом работа, совершаемая в элементарном объеме потоком инфильтрационных вод в почвенном слое ($\bar{A}_n$) от стороны горных (элювиальная фация) к равнинным (субаквальная) зонам, постепенно уменьшается от 0,73 до 0,20, а средняя концентрация солей в системе «поверхностная вода - почва - грунтовая вода» ($\bar{C}^*$), наоборот, увеличивается от 0,60 до 1,80. Следовательно, эколого-гидрогеохимический потенциал

или почвенно-мелиоративный показатель ландшафта ($\bar{M}$), подчиняясь закону вертикальной зональности, уменьшается от 1,21 до 0,11, что характеризует в области магазинирования гидрогеохимического потока формируется солесборный бассейн, то есть эта закономерность показывает имеющиеся возможности формирования гидрогеохимических процессов в территориях водосбора бассейна реки Или, что повреждаются распространением в равнинном классе ландшафта с супераквальной и суаквальной фациями.

При этом в естественных условиях формирования ландшафтно-гидрогеохимических фаций во многом зависят от тепло- и влагообеспеченности территорий водосборов бассейна реки Или, так как от горного класса ландшафтов (элювиальная фация) до равнинного класса ландшафтов (субаквальная) коэффициент естественного увлажнения уменьшается от 0,50 до 0,10, а «индекс сухости», характеризующий степень сбалансированности влаги и тепла, повышается от 1,273 до 5,056, которые показывают наличие достаточно высоких энергетических ресурсов.

Таким образом, на основе геоморфологической схематизации водосборов трансграничной реки Или, базирующейся на положениях стокообразования речных бассейнов как термодинамической системы, граница которых совпадает с высотной поясностью, позволяют оценить изменения гидрологического, эколого-почвенного и эколого-гидрогеохимического режима ландшафтных систем с учетом природно-территориальных различий как выполняющие важные средообразующие или экологические функции.

Ключевые слова: климат, природа, ресурсы, река, бассейн, среда, ландшафт, водосбор, система, тепло, влага, обеспеченность, потенциал, процесс, природопользование, природообустройство, функция.

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