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RANKING OF RIVER SYSTEMS OF THE NORTHEASTERN SLOPE OF THE GREATER CAUCASUS ACCORDING TO THEIR SELF PURIFYING ABILITY DEPENDING ON ABIOGENIC FACTORS

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РАНЖИРОВАНИЕ РЕЧНЫХ СИСТЕМ СЕВЕРО-ВОСТОЧНОГО СКЛОНА БОЛЬШОГО КАВКАЗА ПО ИХ САМООЧИЩАЮЩЕЙ СПОСОБНОСТИ В ЗАВИСИМОСТИ ОТ АБИОГЕННЫХ ФАКТОРОВ

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Abstract. The ability of aquatic ecosystems to self-purify is closely dependent on many natural factors. The purpose of the study is to assess the self-purifying ability of surface waters for pollutants along the coastal zone of the Caspian Sea (in the territory of Azerbaijan) under the influence of abiogenic factors - climatic, hydrodynamic, hydro chemical, etc. The system analysis revealed a general pattern : in general, the self-purifying ability of river systems along the Caspian coastal zone increases in the direction from south to north. In order to preserve water quality in river systems, it is important to develop a set of measures to protect biodiversity in these coastal terrestrial ecosystems and water catchments (watersheds) on the northeastern slope of the Greater Caucasus.

Аннотация. Способность водных экосистем к самоочищению находится в тесной зависимости от многих природных факторов. Цель исследования — оценить способность поверхностных вод к самоочищению от загрязняющих веществ вдоль прибрежной зоны Каспийского моря, на территории Азербайджана. Самоочищающаяся способность речных систем вдоль прибрежной зоны Каспия возрастает в направлении с юга на север. Для сохранения качества воды в речных системах важна разработка комплекса мер по охране биоразнообразия в этих прибрежных наземных экосистемах и водосборах (водоразделах) северо-восточного склона Большого Кавказа.

Key words: Azerbaijan, Caspian Sea, coastal zone, river systems, pollution, abiogenic factors.

Ключевые слова: Азербайджан, Каспийское море, прибрежная зона, речные системы, загрязнение, абиогенные факторы.

The anthropogenic impact on surface water systems in the coastal zone of the Caspian Sea is high. The coastal zone of the Caspian Sea varies in the density of the river net. Thus, the Absheron-Gobustan region is characterized by a minimal density of the river net — less than 0.05 km/km^2 (Sumgayitchay, etc.), only in the Khachmaz region the density of river systems increases to 0.3-0.4 km/km^2. These rivers originate from lower catchments and therefore deliver significantly less water. When moving north along the coastal zone, the density of the river net increases to 0.6-0.7 km/km^2. These rivers are fed by glaciers and snow, and when they enter the foothill and flat parts of the territory, they provide ground flow. At the same time, at the southeastern tip of the Greater

Caucasus, river systems are poorly developed and have low water levels. The largest river systems in the area are Sumgaitchay with a length of 198 km and Pirsaatchay with a length of 202 km. These rivers are fed mainly by rain and groundwater [9].

Rivers are directly affected by natural factors and anthropogenic impacts and are also subject to technogenic impacts. The degree of technogenic impact on the natural landscapes, including the river systems of the Caspian coastal zone, is constantly increasing. Conducted studies [1] show that the river basins of the coastal zone of the Caspian Sea on the territory of Azerbaijan are under conditions of low — 2%, moderate — 25% and high — 73% of anthropogenic load,which include water intake from rivers and groundwater, the entry of industrial, agricultural and municipal wastewater into water bodies, as well as plowing of land, technical impact on natural landscapes during urban planning, the formation of modern social infrastructure, etc. [2].

Of the river systems of the northeastern slope of the Greater Caucasus, the Kudialchay River [1] is the most anthropogenically affected. The enterprises of the city of Cuba annually discharge over 1.4 million m^3 of wastewater into this river, and the enterprises of the city of Khachmaz discharge about 100 thousand m^3 of untreated domestic wastewater, as a result of which the physio-chemical and sanitary-hygienic properties of the river sharply deteriorate. The Gudialchay Rive (0.5 km downstream of Khachmaz) was noted to be polluted with petroleum products, phenols, surfactants, nitrates, ammonium, phosphates, heavy metals (Cu, Al, Mn), as well as the Atalchay and Karachay deposits: compounds of copper, phosphates, surfactants, exceeded the MPC by 3 times, phenols by 2 times [8].

Water pollution is a contributing factor to environmental degradation and an even greater pressure on already overburdened ecosystems. During river floods, pesticides and herbicides are washed off agricultural lands, and flooding of contaminated industrial areas along banks can result in a mixture of pollutants ending up in rivers. Polluted rivers, for example, the Khachmaz rivers [8], pose an environmental threat to the soil ecosystems of the coastal zone of the sea — when these waters are used in irrigation systems, a wide range of organic and inorganic pollutants contained in them enter the soil and accumulate in them.

The ability to self-purify is one of the most valuable properties of natural waters. It occurs in the waters of rivers, lakes and other water bodies. It consists in the restoration of their natural properties, which occurs as a result of natural processes — physical-chemical, biochemical, etc., while biotic factors are at the center of the entire system of self-purification of water [10, 13, 14].

The ability of aquatic ecosystems to self-purify is determined by many natural factors — physical and geographical conditions, solar radiation, hydrometeorological regime, etc. [4, 14].

Dilution, physical dispersion and removal of pollutants from the river basin are among the main physical factors contributing to the self-purification of river systems. Average annual water flows provide a basis for preliminary prediction of the intensity of pollution dispersion.

The assessment of cascade landscape-geochemical systems (CLGS) is of no small importance for predicting the self-purification of rivers [5-7].

Physical (the sum of annual air temperatures with a stable temperature above 10°C), annual runoff, characterizing the possibility of dispersion of pollution, sedimentation (deposition) of suspended substances, the nature of solid runoff, wind mixing, currents), chemical (degree of mineralization, voidability of surface waters), and biotic refer to the main processes that ensure the self-purification of aquatic ecosystems.

Biological self-purification of water is carried out as a result of the vital activity of phytocenosis, animals, macro- and microbiota, it is closely related to physicochemical processes [10, 14].

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Biotic processes leading to water purification include water filtration by hydrations and oxidative decomposition of organic substances [10, 11], as well as the activity of microbiota [13].

Organic matter is oxidized by many hydrations, but microorganisms play a special role. All groups of organisms — microbiota, phytoplankton, higher plants, animals, fish — take a direct active part in the self-purification of aquatic ecosystems, and each of them participates in more than one or two processes. The habitat for aquatic microbiota is the water column and silt sediments, stratified by physicochemical properties. These microlayers contain unequal amounts of nutrient substrates and therefore represent a complex dynamic system that provides conditions for the development of diverse types of microbiotas. Protists, aquatic fungi and related organisms (the so-called “biofilters”), as well as aquatic flora, are of great importance in the processes of destruction of organic substances. The ability to use organic substances as sources of nitrogen, phosphorus, etc., makes aquatic vegetation active participants in the process of self-purification of natural waters.

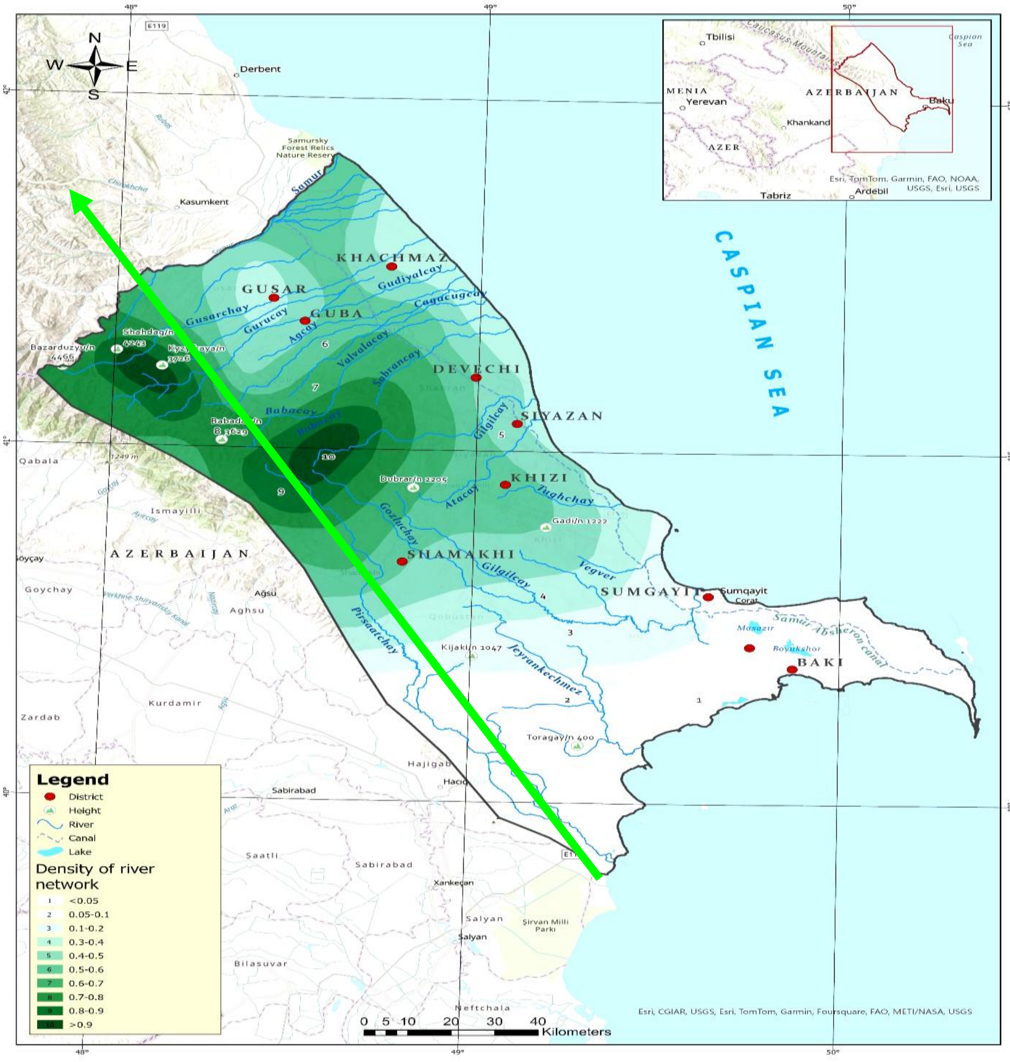

Figure. Growing trends in self-purification of river systems along the coastal zone of the Caspian Sea (→ Increase in self-purifying abilit)

Despite the availability of information in assessing water quality within the coastal zone of the Caspian Sea on the northeastern slope of the Greater Caucasus [1, 8, 9, 15], their ability to self-purify is not fully reflected.

Purpose and objectives of research. As a first approximation, evaluate the self-purifying ability of the waters of river systems of the northeastern slope of the Greater Caucasus (in the territory of Azerbaijan) in relation to pollutants under the influence of abiogenic factors - climatic, hydrodynamic, hydro chemical, etc., one of the leading factors in the self-purification of waters of river ecosystems.

Research methods

The research was carried out based on a systemic analysis of data from abiogenic factors that determine the self-purification of river systems in the coastal zone of the Caspian Sea based on existing scientific information [11, 14].

The physicochemical features of the waters of the studied river systems are reflected in a few works [3, 9].

Climatic potential as an abiogenic factor of self-purification of the territory is used by us as climatic coefficient when assessing the self- purification ability of river waters

Results and its discussion

Just as for soil cover, one of the main abiogenic factors that determine the intensity of the self-purification processes of water systems when they are polluted with organic substances is the temperature factor — the sum of annual temperatures of air and water with a stable temperature above 100C: the decomposition of organic substances increases with temperature. Temperature conditions positively influence the development, growth and functional activity of aquatic microbiota, as well as the growth and development of aquatic phytocenosis. In this regard, the potential for self-purification of river systems in the coastal zone of the Caspian Sea on a comparative basis, as a first approximation, can be assessed depending on the temperature in the landscapes covering these river systems, as well as their physical and chemical indicators.

In this regard, the first approximation of the self-purification of flowing water will depend on the temperature, flow rate and degree of mineralization of the water and can be determined by the following formula [12]:

$$Кс = \frac{\sum T > 10^0 C * W}{К_{мин}}$$

where Кс — coefficient of self-purification of flowing water; $\sum T > 10^0$ — is the average annual sum of active temperatures above 10^0C; W — flow rate; $К_{min}$ — water mineralization coefficient.

When assessing the significance of temperature as an abiogenic factor in the self-purification of river systems, it can be noted that the relative average annual fluctuations in air temperature in the regions of the Greater Caucasus are within the range of 0.4-0.6^0 C [3].

Fluctuations in average annual temperatures, as a rule, can negatively affect the stability of biological processes of self-purification of river systems. In this regard, average annual air isotherms are of great importance for assessing the self-purification potential of river systems of the Greater Caucasus. The number of days with an average daily air temperature above 15^0C consistently decreases from the southeastern slope to the northeastern slope of the Greater Caucasus (Table).

This means that, due to the temperature factor, the least favorable conditions for self-purification of river systems exist on the northeastern slope of the Greater Caucasus. This pattern of landscape temperatures for regions, depending on the altitude of the area, is also true for other seasons of the year, except for the winter months. For example, unlike other regions, the northeastern slope of the Greater Caucasus is open to cold northern and northeastern winds and is characterized by cold winters, which could potentially reduce the self-purifying ability of river systems in the winter.

Table

AIR TEMPERATURE GRADIENTS

Mountain areas	*>0⁰C*	*> 5⁰C*	*> 10⁰C*	*> 15⁰C*
Greater Caucasus:				
Southern slope	170	165	175	205
Northeastern slope	129	155	130	100

Hydrodynamic factors, such as flow intensity indicators, are important in the processes of mechanical dispersion of pollution and make it possible to predict, to a first approximation, the intensity of pollution dispersion. In accordance with general patterns, the decomposition of organic substances increases with temperature, the acceleration of catabolite outflow and the influx of anabolites. As a result, in flowing river systems with intense turbulent mixing of water, self-purification occurs faster than in stagnant reservoirs. The degree of self-purification of water in rivers, depending on the flow speed, is a hyperbolic function, the sharp increase of which begins from 0.7 m^3/s. (http://geopriroda.ru/water).

The processes of self-purification of water from pollution are also largely determined by the volume of pollution, which optimally should not be more than 1/35-45 of the volume of the reservoir [12]. As the volume of pollution increases, natural self-purification processes will gradually be suppressed.

The conditions for the dilution of pollutants in river systems are determined by the average annual water flow, in this regard, the indicators of the average annual flow also make it possible to preliminarily predict the intensity of the dispersion of pollutant in them. Thus, the river systems of the northeastern slope of the Greater Caucasus, which in general, compared to other river systems, have a relatively low self-purification potential, differ from each other in average annual water flow. For example, the average annual water flow of the Vesharud and Kusarchay rivers significantly exceeds the average annual flow of the Jeyrankechmyaz and Beyuktepe rivers — 4.54-6.83 and 0.19-1.44 m^3/sec, respectively. Naturally, all other conditions being equal, the waters of the Visharud and Kusarchay rivers, compared to the waters of the Jeyrankechmyaz and Boyuktepe rivers, are characterized by a higher potential for dilution of pollutants.

Mountain rivers are characterized by high water flow rates, which helps improve aeration processes and, accordingly, reduce the content of organic substances in self-purification processes. In the foothills, depending on zonal features and exposure of microscopes, the flow intensity may decrease, which will undoubtedly reduce the intensity of mechanical dispersion of pollution. In the lower reaches, the hydro morphological characteristics of river systems change, the banks become flatter, the flow velocity decreases, which slows down the process of natural aeration and leads to an increase in BOD5 concentrations. The results of the system analysis show that when moving from north to south along the coastal zone of the sea, the potential ability of river system waters to mechanically disperse pollution decreases. One of the main factors ensuring the process of self-purification of water in river systems is their saturation with oxygen, mainly in the process of its invasion from the atmosphere, as well as its separation by photosynthetic organisms. The oxygen content in water is also determined by the degree of wind waves and currents. With increasing temperature, the adsorption coefficient decreases and the O2 content in water decreases. In this regard, river waters in their upper reaches are more saturated with oxygen than in their lower reaches.In the upper reaches of mountain rivers in the study area, more favorable conditions for oxygen self-purification are created, as we move into the accumulation zone — the coastal zone of the Caspian Sea — oxygen saturation will decrease, which may affect the intensity of self-purification.

The degree of mineralization of the water can also influence the processes of self-purification-with an increase in total mineralization, the intensity of self-purification decreases [4]. The mineralization of river waters in the study area depends on climatic conditions (aridization and humidification). During the dry periods, evaporation processes lead to salt concentrations. During the rainy season, dilution occurs due to precipitation. On the northeastern slope of the Greater Caucasus, the degree of water mineralization increases as you move from north to south (within 300-1000 mg/l), and on the southeastern slope — from west to east — within 150-500 mg/l. During the summer low-water period in these river systems, the mineralization of water sharply increases, in this regard, the rivers become collectors.The mineralization and total hardness of water in the Absheron-Gobustan rivers is more than 2 times higher compared to other rivers, which can negatively affect the self-purification of water in them when a significant volume of untreated wastewater enters.

After the subsidence of the flood at the end of June-July, the rivers begin summer-autumn low water, which sometimes, in the absence of autumn floods, turns into winter low water. During this period, the share of highly mineralized groundwater in the region in the supply of river systems may increase (up to 40-45%). In this regard, during this period the degree of mineralization (1.5-2 times) and the content of ions (35-65%) in the waters of the region increases. In this regard, in mountain rivers during this low-water period, an increase in the degree of mineralization can reduce the intensity of self-purification of flowing waters. This is especially typical for the rivers of Gobustan — Sumgaitchay, Pirsaat, Jeyrankechmyaz, etc. During low-water periods, minimal water flow is observed on the rivers of the Gobustan region, formed mainly due to highly mineralized groundwater.During long dry periods in the region, rivers dry up mainly in the middle and lower reaches, and the degree of mineralization increases (800-2000 mg/l).

Taking into account the average annual temperature — the most important abiogenic factor ensuring the most efficient self-purification processes, as well as hydrodynamic and hydrochemical indicators, river systems in the study area can, to a first approximation, be arranged in the following sequence (Table).

Greater Caucasus (southeast slope) > Greater Caucasus (northeast slope). A systemic analysis of abiogenic factors reveals a general pattern: in general, the self-purifying capacity of river systems along the Caspian coastal zone increases in the direction from south to north (Figure).

The results of the system analysis create a scientific basis for managing the self-purifying ability of river systems in the study area as components of natural landscapes, improving their quality in order to prevent the discharge of technogenic pollutants into the coastal waters of the Caspian Sea, and developing quantitative pollution standards. Purification of aquatic ecosystems in this region, being a priority environmental problem, will help maintain the stability of aquatic habitats and an important parameter determining the stability of its ecosystems.

Species of terrestrial ecosystems and habitats bordering these river basins actively participate in the processes of self-purification of the waters of river systems along the coast of the Caspian Sea. In this regard, in order to preserve water quality in river systems, it is important to develop a set of measures to protect biodiversity in these coastal terrestrial ecosystems, forest areas of catchment (watersheds) on the northeastern slope of the Greater Caucasus in order to increase the assimilation potential of water systems and their self-purification potential and prevent the entry of technogenic pollutants into the coastal waters of the sea, which is ultimately extremely important for restoring the quality of coastal waters and its bioproductivity.

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