ISSN 2518-170X (Online)
ISSN 2224-5278 (Print)

«ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫ» РҚБ
«ХАЛЫҚ» ЖҚ

Х А Б А Р Л А Р Ы

ИЗВЕСТИЯ

РОО «НАЦИОНАЛЬНОЙ
АКАДЕМИИ НАУК РЕСПУБЛИКИ
КАЗАХСТАН»
ЧФ «Халық»

N E W S

OF THE ACADEMY OF SCIENCES
OF THE REPUBLIC OF
KAZAKHSTAN
«Halyk» Private Foundation

SERIES

OF GEOLOGY AND TECHNICAL SCIENCES

4 (460)

JULY – AUGUST 2023

THE JOURNAL WAS FOUNDED IN 1940

PUBLISHED 6 TIMES A YEAR

ALMATY, NAS RK

В 2016 году для развития и улучшения качества жизни казахстанцев был создан частный Благотворительный фонд «Халык». За годы своей деятельности на реализацию благотворительных проектов в областях образования и науки, социальной защиты, культуры, здравоохранения и спорта, Фонд выделил более 45 миллиардов тенге.

Особое внимание Благотворительный фонд «Халык» уделяет образовательным программам, считая это направление одним из ключевых в своей деятельности. Оказывая поддержку отечественному образованию, Фонд вносит свой посильный вклад в развитие качественного образования в Казахстане. Тем самым способствуя росту числа людей, способных менять жизнь в стране к лучшему – профессионалов в различных сферах, потенциальных лидеров и «великих умов». Одной из значимых инициатив фонда «Халык» в образовательной сфере стал проект Ozgeris powered by Halyk Fund – первый в стране бизнес-инкубатор для учащихся 9-11 классов, который помогает развивать необходимые в современном мире предпринимательские навыки. Так, на содействие малому бизнесу школьников было выделено более 200 грантов. Для поддержки талантливых и мотивированных детей Фонд неоднократно выделял гранты на обучение в Международной школе «Мирас» и в Astana IT University, а также помог казахстанским школьникам принять участие в престижном конкурсе «USTEM Robotics» в США. Авторские работы в рамках проекта «Тәлімгер», которому Фонд оказал поддержку, легли в основу учебной программы, учебников и учебно-методических книг по предмету «Основы предпринимательства и бизнеса», преподаваемого в 10-11 классах казахстанских школ и колледжей.

Помимо помощи школьникам, учащимся колледжей и студентам Фонд считает важным внести свой вклад в повышение квалификации педагогов, совершенствование их знаний и навыков, поскольку именно они являются проводниками знаний будущих поколений казахстанцев. При поддержке Фонда «Халык» в южной столице был организован ежегодный городской конкурс педагогов «Almaty Digital Ustaz.

Важной инициативой стал реализуемый проект по обучению основам финансовой грамотности преподавателей из восьми областей Казахстана, что должно оказать существенное влияние на воспитание финансовой грамотности и предпринимательского мышления у нового поколения граждан страны.

Необходимую помощь Фонд «Халык» оказывает и тем, кто особенно остро в ней нуждается. В рамках социальной защиты населения активно проводится работа по поддержке детей, оставшихся без родителей, детей и взрослых из социально уязвимых слоев населения, людей с ограниченными возможностями, а также обеспечению нуждающихся социальным жильем, строительству социально важных объектов, таких как детские сады, детские площадки и физкультурно-оздоровительные комплексы.

В копилку добрых дел Фонда «Халык» можно добавить оказание помощи детскому спорту, куда относится поддержка в развитии детского футбола и карате в нашей стране. Жизненно важную помощь Благотворительный фонд «Халык» оказал нашим соотечественникам во время недавней пандемии COVID-19. Тогда, в разгар тяжелой борьбы с коронавирусной инфекцией Фонд выделил свыше 11 миллиардов тенге на приобретение необходимого медицинского оборудования и дорогостоящих медицинских препаратов, автомобилей скорой медицинской помощи и средств защиты, адресную материальную помощь социально уязвимым слоям населения и денежные выплаты медицинским работникам.

В 2023 году наряду с другими проектами, нацеленными на повышение благосостояния казахстанских граждан Фонд решил уделить особое внимание науке, поскольку она является частью общественной культуры, а уровень ее развития определяет уровень развития государства.

Поддержка Фондом выпуска журналов Национальной Академии наук Республики Казахстан, которые входят в международные фонды Scopus и Wos и в которых публикуются статьи отечественных ученых, докторантов и магистрантов, а также научных сотрудников высших учебных заведений и научно-исследовательских институтов нашей страны является не менее значимым вкладом Фонда в развитие казахстанского общества.

С уважением, Благотворительный Фонд «Халык»!

NAS RK is pleased to announce that News of NAS RK. Series of geology and technical sciences scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of geology and technical sciences in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of geology and engineering sciences to our community.

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.

«ҚР ҰҒА» РҚБ Хабарлары. Геология және техникалық ғылымдар сериясы».
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Меншіктеуші: «Қазақстан Республикасының Ұлттық ғылым академиясы» РҚБ (Алматы қ.).

Қазақстан Республикасының Ақпарат және қоғамдық даму министрлігінің Ақпарат комитетінде 29.07.2020 ж. берілген **№ KZ39VPY00025420** мерзімдік басылым тіркеуіне қойылу туралы куәлік.

Тақырыптық бағыты: *геология, мұнай және газды өңдеудің химиялық технологиялары, мұнай химиясы, металдарды алу және олардың қосындыларының технологиясы.*

Мерзімділігі: жылына 6 рет.

Тиражы: 300 дана.

Редакцияның мекен-жайы: 050010, Алматы қ., Шевченко көш., 28, 219 бөл., тел.: 272-13-19

http://www.geolog-technical.kz/index.php/en/

«Известия РОО «НАН РК». Серия геологии и технических наук».
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Собственник: Республиканское общественное объединение «Национальная академия наук Республики Казахстан» (г. Алматы).

Свидетельство о постановке на учет периодического печатного издания в Комитете информации Министерства информации и общественного развития Республики Казахстан **№ KZ39VPY00025420,** выданное 29.07.2020 г.

Тематическая направленность: *геология, химические технологии переработки нефти и газа, нефтехимия, технологии извлечения металлов и их соеденений.*

Периодичность: 6 раз в год.

Тираж: 300 экземпляров.

Адрес редакции: 050010, г. Алматы, ул. Шевченко, 28, оф. 219, тел.: 272-13-19

http://www.geolog-technical.kz/index.php/en/

News of the National Academy of Sciences of the Republic of Kazakhstan. Series of geology and technology sciences.
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)
Owner: RPA «National Academy of Sciences of the Republic of Kazakhstan» (Almaty).
The certificate of registration of a periodical printed publication in the Committee of information of the Ministry of Information and Social Development of the Republic of Kazakhstan **No. KZ39VPY00025420,** issued 29.07.2020.
Thematic scope: *geology, chemical technologies for oil and gas processing, petrochemistry, technologies for extracting metals and their connections.*
Periodicity: 6 times a year.
Circulation: 300 copies.
Editorial address: 28, Shevchenko str., of. 219, Almaty, 050010, tel. 272-13-19
http://www.geolog-technical.kz/index.php/en/

NEWS of the National Academy of Sciences of the Republic of Kazakhstan
SERIES OF GEOLOGY AND TECHNICAL SCIENCES
ISSN 2224–5278
Volume 4. Number 460 (2023), 157–175
https://doi.org/10.32014/2023.2518-170X.306

IRSTI: 37.01.94

© Zh.S. Mustafayev[1*], B.T. Kenzhaliyeva[2], G.T. Daldabayeva[2], E.N. Alimbayev[2], 2023
[1]Institute of Geography and Water Security JSC, Almaty, Kazakhstan;
[2]Kyzylorda University named after Korkyt-Ata, Kyzylorda, Kazakhstan.
E-mail: z-mustafa@rambler.ru

HYDROCHEMICAL EXPLORATION AND ECOLOGICAL STATE OF THE TERRITORY IN THE LOWER DOWN OF THE SYRDARYA RIVER

Mustafayev Zh.S. — Doctor of Technical Sciences, Professor, Leading Researcher, Laboratory of Landscape Science and Environmental Problems, JSC «Institute of Geography and water security», Almaty, Kazakhstan
E-mail: z-mustafa@rambler.ru, https://orcid.org/0000-0003-2425-8148;
Kenzhalieva B.T. **—** candidate of Agricultural Sciences, Associate Professor, Kyzylorda University named after Korkyt-Ata, Kyzylorda, Kazakhstan
E-mail: sagaev_51@mail.ru, https://orcid.org/ 0000-0002-1815-9461;
Daldabaeva G.T. — Candidate of Technical Sciences, Associate Professor, Kyzylorda University named after Korkyt-Ata, Kyzylorda, Kazakhstan
E-mail: gulnur-d@mail.ru, https://orcid.org/ 0000-0002-9586-798X;
Alimbaev E.N. — master, senior lecturer, Kyzylorda University named after Korkyt-Ata, Kyzylorda, Kazakhstan
E-mail: hagrid25@mail.ru, https://orcid.org/ 0000-0002-5596-7791.

Abstract. To conduct a qualitative and quantitative assessment of surface waters in the catchment areas of the lower reaches of the Syrdarya River, research bases have been created for the hydrological posts of Shardara, Kyzylorda and Kazaly based on the annual report «Aral-Syrdarya Basin Inspectorate for the Rational Use and Protection of Water Resources» of the Water Resources Committee Ministry of Geology, Ecology and natural resources of the Republic of Kazakhstan in the period 1996–2020 and used integral hydrochemical indicators of the water pollution index, the coefficient of maximum water pollution, the coefficient of maximum permissible water pollution and the Shannon trophic index , taking into account the regulatory criteria for maximum permissible concentrations for fisheries water use. The obtained results show that in modern conditions of the catchment areas of the lower reaches of the Syrdarya River, despite the quantitative indicators of water quality for all indicators, it has a negative trend, does not meet regulatory requirements, since pollution varies from the level from «polluted» to «moderately polluted», in general, not suitable for drinking water supply, and the ecological situation changes from «eutrophic» to «mesotrophic», indicating, as a rule, the degree of influence of anthropogenic activity is within the limits of uncontrolled and unaccounted for consequences (deterioration in the quality of water and land resources, as well as agricultural products)., which has become the reason for the impossibility of fulfilling the environment-forming and ecological functions of the surface waters of river basins.

Keywords: surface water, pollutant, river basin, water quality, hydrochemical indicators, assessment, ecological state

© Ж.С. Мұстафаев[1*], Б.Т. Кенжалиева[2], Г.Т. Далдабаева[2], Е.Н. Алимбаев[2], 2023

[1]«География және су қауіпсіздігі институты» АҚ, Алматы, Қазақстан;
[2]Қорқыт-Ата атындағы Қызылорда университеті, Қызылорда, Қазақстан.
E-mail: z-mustafa@rambler.ru

СЫРДАРЬИЯ ӨЗЕНІНІҢ ТӨМЕНГІ САЛАСЫНЫҢ АЙМАҒЫНЫҢ ГИДРОХИМИЯЛЫҚ ЗЕРТТЕЛУІ ЖӘНЕ ЭКОЛОГИЯЛЫҚ ЖАҒДАЙЫ

Мұстафаев Ж.С. — техника ғылымдарының докторы, профессор, «Ландшафттану және табиғаты пайдалану мәселесі» зеретханасының жетекші ғылыми қызмеикері, «География және су қауіпсіздігі институты» АҚ, Алматы, Қазақстан
E-mail: z-mustsfs@rambler.ru, https://orcid.org/0000-0003-2425-8148;
Кенжалиева Б.Т. — ауылшаруашылық ғылымдарының канжидаты, қауымдастырылған профессор, Қорқыт-Ата атындағы Қызылорда университеті, Қызылорда, Қазақстан
E-mail: sagaev_51@mail.ru, https://orcid.org/ 0000-0002-1815-9461;
Далдабаева Г.Т. — техника ғылымдарының канжидаты, қауымдастырылған профессор, Қорқыт-Ата атындағы Қызылорда университеті, Қызылорда, Қазақстан
E-mail: gulnur-d@mail.ru, https://orcid.org/ 0000-0002-9586-798X;
Алимбаев Е.Н. — магистр, аға оқытушы, Қорқыт-Ата атындағы Қызылорда университеті, Қызылорда, Қазақстан
E-mail: hagrid25@mail.ru, https://orcid.org/ 0000-0002-5596-7791.

Аннотация. Сырдария өзенінің төменгі ағысындағы су жинау алабының жер үсті суларына сапалық және сандық бағалау жүргізу үшін Қазақстан Республикасының геология, экология және табиғи ресурстар министрлігінің Су ресурстары комитетінің «Арал-Сырдария алабының су ресурстарын тиімді пайдалану және қорғау инспекциясының» 1996–2020 жылдар аралығындағы жылдық есебі бойынша Шардара, Қызылорда және Қазалы гидрологиялық бекетеріні бойынша зерттеу қоры құрылған және судың ластану белгісінің интегралдық гидрохимиялық көрстекіштері, судыі ластануының шектелген көрсеткіші, судың ластануыны шектелген-мүмкіншілік көрсеткіші және Шенноның трофикалық белгісінің негізінде, балық шаруашылығына суды пайдалану үшінрұқсат етілген шектелген қойрытпақтардың мөлшерлік сынықтарының ескре отырып жүргізілген. Алынған нәтижелер Сырдария өзенінің төменгі ағысының су жинау алқаптарының қазіргі

жағдайында барлық көрсеткіштер бойынша су сапасының сандық көрсеткіштері бойынша өзгеру бағытының теріс екендігін қарамастан, мөлшерленген талаптарға сай келмейтінін көрсетеді, өйткені ластану деңгейі «ластанған» мен «орташа ластанған» аралығында болғандықтан ауыз сумен қамтамасыз ету үшін жарамсыз болып табылады, ал экологиялық жағдайы – «эвотрофтылықтан» «мезотрофты» дейін өзгеретіндіктен, бұл, әдетте, антропогендік әрекеттің әсер ету дәрежесі бақыланбайтын және ескреілмейтін шектерде екенін (су және жер ресурстарының, сондай-ақ ауыл шаруашылығы өнімдерінің сапасының нашарлауы) көрсетеді, ал бұл өзендер алабының жер үсті суларының қоршаған ортаны құраушы және экологиялық қызметерін орындау мүмкіншілігінен айырылуының негізгі салдары болып табылады.

Түйін сөздер: жер беті суы, ластаушы заттар, өзен алабы, судың сапасы, гидрохимиялық көрсеткіштер, бағалау, экологиялық жағдайы

© Ж.С. Мустафаев[1*], Б.Т. Кенжалиева[2], G.T. Daldabayeva[2], Е.Н. Алимбаев[2], 2023

[1]АО «Институт географии и водной безопасности», Алматы, Казахстан;
[2]Кызылординский университет имени Коркыт-Ата, Кызылорда, Казахстан.
E-mail: z-mustafa@rambler.ru

ГИДРОХИМИЧЕСКАЯ ИЗУЧЕННОСТЬ И ЭКОЛОГИЧЕСКАЯ СОСТОЯНИЯ ТЕРРИТОРИИ В НИЗОВЬЯХ РЕКИ СЫРДАРЬИ

Мустафаев Ж.С. — доктор технических наук, профессор, ведущий научный сотрудник лабoротории ландшафтоведения и проблем природопользования, АО «Институт географии и водной безопасности», Алматы, Казахстан
E-mail: z-mustsfs@rambler.ru, https://orcid.org/0000-0003-2425-8148;
Кенжалиева Б.Т. — кандидат сельскохозяйственных наук, ассоцированный профессор, Кызылординский университет имени Коркыт-Ата, г. Кызылорда, Казахстан
E-mail: sagaev_51@mail.ru, https://orcid.org/ 0000-0002-1815-9461;
Далдабаева Г.Т. **—** кандидат технических наук, ассоцированный профессор, Кызылординский университет имени Коркыт-Ата, г. Кызылорда, Казахстан
E-mail: gulnur-d@mail.ru, https://orcid.org/ 0000-0002-9586-798X;
Алимбаев Е.Н. — магистр, старший преподователь, Кызылординский университет имени Коркыт-Ата, г. Кызылорда, Казахстан
E-mail: hagrid25@mail.ru, https://orcid.org/ 0000-0002-5596-7791.

Аннотация. Для проведения качественной и количественной оценки поверхностных вод в водосборных территориях низовьях реки Сырдарьи созданы базы исследования по гидрологическими постами Шардара, Кызылорда и Казалы на основе ежегодного отчета «Арало-Сырдарьинская бассейновая инспекция по рациональному использованию и охране водных ресурсов» Комитета водных ресурсов Министерство геология, экология и природных ресурсов Республики Казахстан в период 1996–2020 годов и использованы интегральные гидрохимические показатели индекса загрязнения воды, коэффициента предельной загрязненности воды, коэффициента предельно-допустимой загрязненности воды и индекса трофность Шеннона, с учетом нормативных критериев предельно допустимых концентрации для рыбохозяйственного водопользования. Полученные результаты показывают, что в современных условиях водосборных территориях низовьях реки Сырдарьи, не смотря количественные показатели качества воды по всем индикатором имеет отрицательный тренд, не отвечает нормативных требования, так как загрязненность изменяется от уровня от «загрязненная» до «умеренно-загрязненная», что не пригодны для питьевого водоснабжения, а экологическая состояния — от «эвотрофная» до «мезотрофная», свидетельстующего, как правило, степни влияния антропогенной деятельности находиться в пределах неконтролируемых и неучитвываемых последствий (ухудшение качества воды и земельных ресурсов, а также сельскохозяйственных продукции), которые стало причиной невозможности выполнения средообразующих и экологических функции поверхностных вод речных бассейнов.

Ключевые слова: поверхностная вода, загрязняющая вещества, бассейн реки, качества воды, гидрохимические показатели, оценка, экологическая состояния

Introduction

To ensure the safe water management activities of the catchment areas of the basin of any river and the management of their water resources, it is necessary to systematize objective information about the hydrological and geochemical regime, which allows predicting changes in water quality on a spatio-temporal scale, since the main natural function of river basins is runoff formation, that is, it is a spatial the basis of population and nature management, where the solution of geoecological problems is carried out in the aspect of the triad of ecology (ensuring the quality of the human environment), economy (increasing the purchasing power of society) and society (improving the welfare of the population).

The solution to this problem, especially in the lower reaches of river basins, which are zones of hydrochemical runoff storage, formed as a result of natural and «hard» economic activities in the upper reaches and middle reaches of any rivers, requires a monitoring system, the data of which serves as spatio-temporal forecasting of water quality for making management decisions in water management activities, allowing the development of programs for the development of the catchment area and the assessment of the ecological state of river basins.

The purpose of the study is to study the formation of the hydrochemical regime of the catchment areas in the lower reaches of the Syrdarya River in order to assess the quality of water and the ecological state in order to identify their cause-and-effect relationships within the framework of modern «hard» anthropogenic activities of nature management.

The object of the study is the catchment areas of the lower reaches of the Syrdarya River, which perform important environmental and environmental functions, within which it is possible to comprehensively assess the quality of water formed in the conditions of «hard» economic activity in the upper reaches and middle reaches of the river basins and used to organize the territorial development of the Turkestan and Kyzylorda regions of the Republic Kazakhstan (Mustafayev, 2012).

The Syrdarya River is formed at the confluence of the Naryn and Karadarya rivers, the sources of which lie in the Central Tien Shan and on the southwestern slope of the Ferghana Range.

The Naryn River is formed from the confluence of rivers of glacier-snow nutrition, by chemical composition they belong to the hydrocarbonate class of the calcium group, with a total mineralization of 141,0–428,0 mg/l.

The Karadarya River is formed from the confluence of small rivers and all its tributaries of glacier-snow nutrition, in terms of chemical composition they belong to the hydrocarbonate class of the calcium group, with a total mineralization of 172,0–574,0 mg/l.

The Syrdarya rivers, formed at the confluence of the Naryn and Karadarya rivers, the emerging mountain systems of Central Asia with tributaries of the Akbura, Aravansay, Isfairamsay, Shakhimardin, Akhangaran, Chirchik, Keles and Arys, for thousands of years provided high-quality drinking water to the population of the Naryn, Jalal-Abad and Osh regions of the Kyrgyz Republic, Sughd region of the Republic of Tajikistan, Andijan, Namangan, Fergana, Tashkent, Dzhezak and Syrdarya regions of the Republic of Uzbekistan and Turkestan and Kyzylorda regions of the Republic of Kazakhstan. At present, as a result of «hard» anthropogenic activities related to the regulation of flow, the use of water resources and uncontrolled collection of wastewater from industrial facilities, domestic water supply and agriculture, the catchment area of the Syrdarya River basin, as a water body, has lost its ecological properties for drinking water supply, which requires a careful study of the process of formation of their hydrochemical regime on spatio-temporal scales in order to determine and assess the development of the potential risk of pollution of surface waters under different types of nature management.

Materials and research methods

To create a research base for potential sources of technogenic pollution, the multi-year annual report «Aral-Syrdarya Basin Inspectorate for the Rational Use and Protection of Water Resources» of the Committee for Water Resources of the Ministry of Geology, Ecology and Natural Resources of the Republic of Kazakhstan, covering the period 1996–2020.

The concentrations of the studied ingredients in the composition of the river waters of the main tributaries of the Syrdarya River forming the upper reaches and the middle course, that is, the runoff formation zones (FFS) are presented in Table 1, which show that in the Naryn, Karadarya, Akhangaran, Chirchik and Keles rivers, the quantitative values of ammonium nitrogen (NH_4), nitrite nitrogen (NO_2), nitrate nitrogen (NO_3), total iron (Fe), copper (Cu), zinc (Zn), mercury (Hg), lead (Pb), fluorine (F), aluminum (Al), manganese (Mn), COD is lower and BOD_5 above the maximum permissible concentration (MPC_i), which confirms the quality of water corresponds to the classification of «clean water».

Table 1 - Indicators of the hydrochemical composition of river waters of the tributaries of the Syrdarya River (average for 2000-2020)

Ingredients, mg/l	MPC	Rivers in the catchment area of the Syrdarya river basin				
		Naryn	Karadarya	Akhangaran	Chirchik	Keles
Mineralization, mg/l	1000,0	135–360	180–400	130–520	110–240	360
BOD_5	3,00	4,5–6,0	3,7–6,7	4,0–7,0	2,7–9,5	6,8–7,8
COD	15,0	0,5–1,6	0,3–2,3	1,4–2,6	0,5–2,2	1,0–1,8
Ammonium nitrogen (NH_4)	0,39	0,06	0,08	0,03	0,02	0,03
Az o t nitrite (NO_2)	0,02	0,006	0,015	0,021	0,100	0,080
Nitrate nitrogen (NO_3)	9,00	1,31	1,06	0,88	1,19	0,90
Iron total (Fe)	0,30	0,025	0,030	0,030	0,110	0,030
Oil products	0,05	0,02	0,02	0,05	0,06	0,04
Copper (Cu)	1,00	5,05	2,80	1,95	3,15	3,95
Zinc (Zn)	10,0	13,4	4,8	9,50	8,20	6,05
Mercury (Hg)	0,01	-	-	0,13	0,08	-
Lead (Pb)	10,0	1,51	0,38	2,84	6,30	0,06
Fluorine (F)	0,75	-	-	0,45	0,08	0,36
Aluminum (Al)	-	-	-	0,40	3,50	3,45
Manganese (Mn)	10,0	5,25	3,35	6,05	3,30	0,55

At the same time, the indicators of the hydrochemical composition of surface waters in the lower reaches of the Syrdarya River presented in Table 2, according to long-term data from the hydrological posts of Shardara, Kyzylorda and Kazaly, show that the quantitative values of the ingredients under consideration are several times higher than the maximum allowable concentration (MPC_i), which are due to discharges highly mineralized return waters of industrial facilities, domestic water supply and collector-drainage waters of irrigated lands in the zone of intensive runoff consumption (IPWS) into the riverbed (Figure 1).

Table 2 - Indicators of the hydrochemical composition of the surface waters of the Syrdarya River

Years	Ingredients, mg/l									
	pH	C_0	$БПК_5$	NO_2	NO_3	NH_4	Ca	Mg	SO_4	Cl
1	2	3	4	5	6	7	8	9	10	11
Hydrological post Shardara										
1996	7,5 0	1400	1,68	0,09	12,0	0,12	142,0	87,0	650,0	152,0
1997	7,4 0	1508	2,00	0,08	16,0	0,10	145,0	70,0	700,0	141,0
1998	7,5 0	1484	3,00	0,04	18,5	0,25	140,0	63,0	680,0	126,9
1999	7,3 0	1243	3,10	0,09	11,4	0,22	120,0	65,0	685,0	165,2
2000	7,4 0	1303	3,25	0,11	17,0	0,14	93,0	64,5	690,0	117,0
2001	7,2 0	1350	3,44	0,12	15,0	0,15	97,0	65,0	500,0	135,0
2002	7,5 0	1300	2,80	0,10	14,0	0,30	102,0	66,0	570,0	125,0
2003 _	8,5 0	909	2,80	0,19	5,0	2,01	105,2	66,9	472,0	85,1
2004	7,6 0	988	0,92	0,041	1,06	0,03	120,0	70,5	519,0	88,6
2005	7,7 0	952	2,40	0,013	1,02	0,06	114,0	73,9	527,0	109,5
2006	7,2 0	1080	1,40	0,040	23,2	0,04	200,0	45,7	296,0	124,0

2007	7,2 0	1086	1,42	0,033	7,6 0	0,70	200,0	45,8	297,0	121,0
2008	7,2 0	1091	1,40	0,025	7,5 0	0,60	200,1	45,7	296,0	122,0
2009	7,2 0	1086	1,42	0,032	7,5 0	0,70	126,0	45,7	296,0	121,0
2010	8,09	1020	1,82	0,037	1,7 0	0,05	134,0	55,6	457,0	86,5
2011	8,02	1052	1,68	0,032	1,8 0	0,06	129,0	57,3	428,0	100,1
2012	8,20	1070	1,61	0,030	2,1 0	0,23	132,0	60,2	329,0	131,5
2013	8,19	1042	1,70	0,028	1,59	0,56	132,0	65,9	458,0	82,4
2014	8,00	918	3,00	0,020	1,60	0,56	116,0	63,1	188,0	121,0
2015	8,03	744	2,14	0,030	3,50	0,57	92,5	61,0	344,0	161,0
2016	8,05	1111	2,28	0,032	22,3	0,02	131,0	59,9	461,0	197,4
2017	7,80	940	1,10	0,004	7,9 0	0,40	130,0	85,3	511,4	88,7

Continuation of table 2

1	2	3	4	5	6	7	8	9	10	11
2018	8,04	960	1,97	0,098	3,4 0	0,30	128,0	60,5	479,5	90,0
2019	7,60	913	1,80	0,090	7,8 0	0,14	110,0	63,6	497,0	98,3
2020	7,80	938	1,60	0,100	6,40	0,30	122,7	69,8	496,0	92,3
Hydrological post of Kyzylorda										
1996	7,30	1373	2,50	0,110	5,34	0,58	56,5	98,3	596,0	195,0
1997	7,00	1346	2,20	0,100	4,45	0,31	106,2	93,3	572,8	119,3
1998	7,30	1337	2,60	0,018	5,50	0,36	109,0	73,9	540,2	127,4
1999	7,20	1331	2,50	0,020	5,10	0,32	75,5	97,0	583,3	113,4
2000	7,30	1394	2,20	0,040	8,00	0,38	95,3	63,3	444,6	133,8
2001	7,10	1595	2,96	0,040	6,60	0,50	133,2	80,5	573,0	176,2
2002	7,20	1289	2,66	0,083	7,18	0,43	91,1	85,3	466,8	123,2
2003	7,33	1275	2,35	0,034	8,17	0,33	82,2	62,9	426,3	126,8
2004 _	7,20	1512	2,66	0,115	7,69	0,40	99,7	68,3	496,0	97,8
2005	7,02	1319	3,14	0,021	4,64	0,35	89,6	82,4	585,4	144,1
2006	7,20	1208	1,97	0,020	3,15	0,25	105,6	62,6	503,4	125,2
2007	7,18	1028	2,15	0,036	6,24	0,24	90,4	51,4	408,4	146,7
2008	7,25	1136	2,12	0,087	2,94	0,29	87,1	47,7	436,2	118,8
2009	7,20	1361	1,88	0,019	3,25	0,37	99,4	50,9	452,4	181,9
2010	7,15	987	2,16	0,020	5,00	0,19	89,8	39,1	380,2	183,7
2011	7,25	1194	2,00	0,020	2,85	0,28	91,1	80,2	411,5	156,0
2012	7,20	1287	2,00	0,020	3,78	0,23	85,0	66,9	472,5	64,1
2013	7,17	1061	2,00	0,073	5,19	0,20	98,5	60,9	590,5	166,5
2014	7,20	1235	1,17	0,046	3,55	0,30	108,2	55,8	448,5	129,4
2015	7,20	1120	2,40	0,055	4,45	0,32	99,5	44,5	325,5	145,5
2016	7,20	1200	1,10	0,046	4,40	0,30	105,0	43,4	535,4	110,0
2017	7,20	1490	1,10	0,018	5,70	0,40	124,0	38,0	354,0	158,0
2018	7,80	1133	1,14	0,048	7,94	0,01	95,3	43,2	395,8	120,2
2019	7,20	1340	1,08	0,008	0,12	0,02	40,1	42,2	382,4	124,0
2020	7,4 0	1321	1,1 0	0,0 25	4,6 0	0,1 0	86,5	41,1	377,4	134,1
Hydrological post Kazaly										
1996	7,20	1497	2,16	0,15	2,15	0,60	64,0	97,2	400,2	106,4
1997	7,43	1489	2,99	0,12	8,80	0,60	135,8	87,7	663,0	215,3
1998	7,32	1594	3,09	0,10	5,74	0,42	119,6	90,4	606,5	145,0
1999	7,70	1568	3,10	0,05	9,90	0,64	101,4	74,9	575,0	170,7

2000	7,54	1550	3,10	0,07	10,5	0,50	122,9	66,3	574,6	157,5
2001	7,58	1816	3,18	0,06	11,4	0,48	138,4	99,3	633,8	184,4
2002	7,54	1547	3,19	0,055	12,1	0,45	104,6	81,2	616,4	117,1
2003	7,55	1545	3,16	0,077	14,3	0,46	102,3	74,9	624,0	120,8
2004	7,70	1568	3,00	0,064	15,6	0,49	104,4	69,8	621,6	114,6
2005	6,95	1640	3,53	0,023	6,01	0,38	110,0	114,1	614,3	143,0
2006	7,20	1426	2,24	0,022	3,94	0,23	132,0	88,7	412,8	203,5
2007	7,19	1461	2,52	0,038	10,0	0,29	107,3	80,3	513,3	159,1
2008	7,20	1376	2,26	0,033	4,98	0,29	125,0	49,4	508,8	126,5
2009	7,21	1467	1,98	0,021	4,69	0,38	103,5	47,4	460,3	138,9
2010	7,20	1220	2,16	0,037	5,03	0,38	30,0	44,9	406,6	113,4
2011	7,20	1459	1,92	0,010	3,30	0,39	116,0	94,3	424,7	152,4
2012	7,20	1459	1,92	0,010	3,30	0,39	116,0	94,3	424,7	152,4
2013	7,25	1460	1,92	0,000	0,03	0,39	116,0	94,7	424,7	152,4
2014	7,15	1400	1,02	0,044	1,00	0,33	145,5	60,0	485,0	180,0
2015	7,15	1310	1,00	0,060	2,10	0,40	133,0	53,0	354,3	164,0
2016	7,20	1320	1,00	0,044	2,20	0,39	133,0	42,1	520,2	175,0
2017	7,22	1355	1,00	0,055	3,40	0,25	133,0	45,0	155,0	133,0
2018	7,50	1420	1,02	0,080	2,20	0,01	89,5	35,5	345,0	120,5
2019	7,50	1420	1,20	0,008	0,21	0,02	48,3	33,5	322,8	122,2
2020	7,40	1398	1,10	0,048	1,90	0,10	90,3	38,0	274,3	125,2

As a result of the intensive development of irrigated agriculture, irrational use of water, as well as the regulation of flow in all states located in the catchment areas of the river basin, until 1985 there has been a positive trend and a trend towards an increase in the volume of return water, and since 1995, despite the ongoing decline in agricultural and industrial production , contributing to the reduction of discharges, the chemical composition and salinity, especially in the lower reaches of the Syrdarya River, practically remains several times higher than the maximum permissible concentration for fishery and domestic water use (Figure 2).

As can be seen from Table 1 and Figures 1–2. The chemical composition and mineralization of the Syrdarya river basin in spatio-temporal scales, until 1960, was largely formed under the influence of natural factors, and since 1961, directly under the influence of anthropogenic factors and until 1985, it has a positive trend, and since 1986, despite the negative trend, a tense trend has been maintained. the situation in terms of safe supply of drinking water to the population.

The main pollutants enter the lower reaches of the Syrdarya River with wastewater from enterprises of the chemical, oil refining, machine-building industries, non-ferrous metallurgy and domestic water supply, where ammonium nitrogen (NH_4), nitrite nitrogen (NO_2), nitrate nitrogen (NO_3), copper (Cu), zinc (Zn), mercury (Hg), lead (Pb), fluorine (F), aluminum (Al), manganese (Mn) and petroleum products (Table 1).

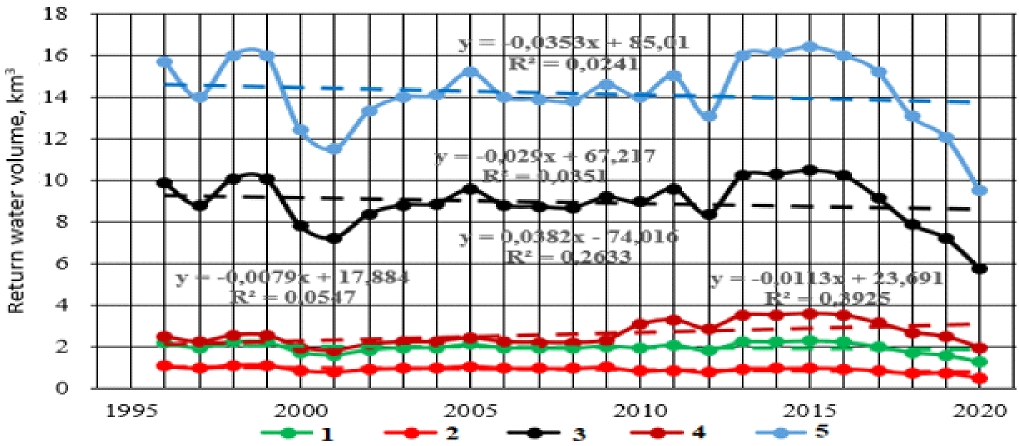

Fig. 1 - Disposable volume of return waters of the Syrdarya river basin in the context of Central Asian countries and Kazakhstan in the period (1 - Kyrgyzstan; 2 - Tajikistan; 3 - Uzbekistan; 4 - Kazakhstan; 5 - Syrdarya river basin)

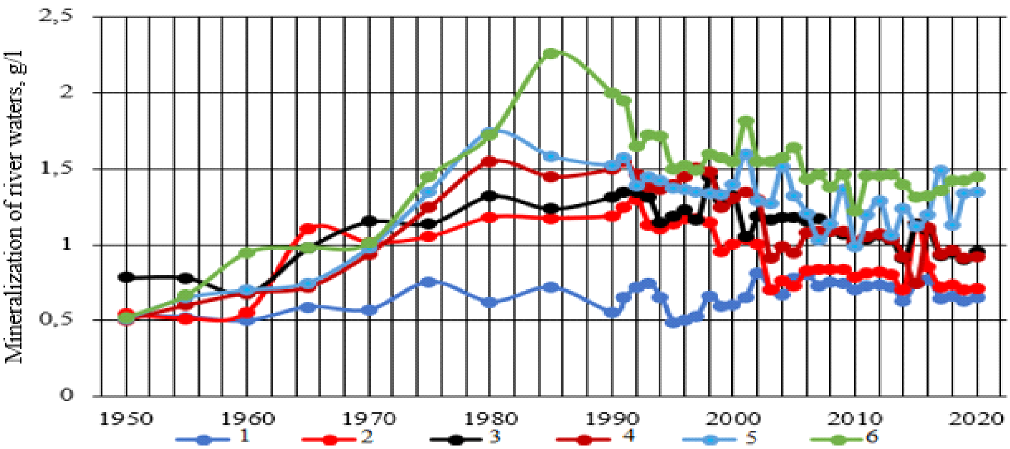

Fig. 2 - Dynamics of mineralization of surface waters in the Syrdarya river basin (hydrological post: 1 - Kal; 2 - Bekabad; 3 - Nadezhdinsk; 4 - Shardara; 5 - Kyzylorda; 6 - Kazaly)

At the same time, it should be noted that the process of formation of ionic runoff, as a product of mineralization and surface runoff in the catchment areas of the Syrdarya river basin, obeys the law of vertical zoning, that is, their quantitative value increases from the runoff formation zone (mountainous) to runoff magnification (desert), which requires the need for their regulation to ensure water security of the population.

The spatio -temporal positive trend of mineralization and all chemical pollutants of surface waters of the Syrdarya river basin downstream is due to the large-scale development of industry and agriculture in the zone of intensive runoff consumption (ZIRC) and remains largely unsatisfactory up to the delta and the confluence with the northern Aral Sea (Figure 2).

The research methodology consisted in selecting the main components of the chemical composition in the waters in the riverbeds and assessing their quality, taking into account the normative indicators of maximum permissible concentrations (MPC_i), of pollutants for a reservoir of fishery water use and potential sources of pollution.

To assess the water quality of surface waters of river basins, there are a large number of integral indicators, among which the proposed integral indicators by V.P. Emelyanova, G.N. Danilova, I.D. Rodziller (1980), A.F. Alimova (1990), N.G. Bulgakov, V.G. Dubinina, A.P. Levich, A.T. Terekhina (1995), T.I. Moiseenko (1995), A.D. Kalikhman, A.D. Pedersen, T.P. Savenkova, A.Ya. Sukneva (1999), M.Zh. Burlibaeva (2012), H. Gharibi, A.H. Mahvi, R. Nabizadeh, Arabalibeik H., Yunesian M., & M.H. Sowlat, (2012), W. Ocampo — Duque, C. Osorio, C. Piamba, M. Schuhmacher & J.L. Domingo (2013), which is one of the modifications of the water pollution index ( ), representing the average multiplicity of pollutant concentration () above the maximum allowable concentration () of the established value for the corresponding type of water body:

$$WPI_i = \sum_i^N [(C_i/MPC_i)/N], \tag{1}$$

where N is the number of indicators used to calculate the index.

To assess the quality of water resources and the ecological state of aquatic ecosystems in the practice of water management in the Russian Federation, methods based on the use of complex indicators by V.V. Shabanova (2009), based on the water pollution index (WPI_i):

$$LPF_i = (1/N)\sum_i^N (C_i/MPC_i) - 1 = WPI_i - 1. \tag{2}$$

On the basis of the development of natural-scientific representations and deepening of the concept of aquatic ecosystems known in geoecology, based on natural laws «Everything is connected with everything» and «Physical-chemical unity», as well as the properties of «Nonlinearity of natural processes», (Mustafaev, 2022) formed new directions in assessing the quality of surface waters in river basins by constructing a logistic regression model:

$$MPPC_i = WCR_{rbi} \cdot LPF_i = (W_{cp}/W_i) \cdot (1/N) \cdot \sum_{i=1}^N [1 - exp(-WPI_i)], \tag{3}$$

where $MPPC_i$ — is the coefficient of the maximum permissible pollution of surface waters of river basins; WCR_{rbi} - coefficient of water content of river basins; LPF_i - coefficient of water pollution in river basins; W_{cp} - average long-term flow volume, km^3; W_i - the actual volume of runoff, km^3.

At the same time, it should be noted that the coefficient of water content (WCR_{rbi}) and the coefficient of limiting pollution (LPF_i) are a parameter (coefficient) of quantity and quality, characterizing the action of the activity of water consumption and the transformation and metabolism of river basins, and their combination, namely the coefficient of maximum permissible concentration ($MPPC_i$) allows you to determine the simultaneous action of the activity of two natural processes with high accuracy and reliability, which meets the requirements for the method for determining the quality of river surface water pools.

Assessment of the ecological state of the catchment area of the Syrdarya river basins was carried out using the Shannon trophic index (Shannon, Warren Weaver, 1949):

$$H_i = -\sum(n_i/N) \cdot ln(n_i/N). \quad (4)$$

where H - is the species diversity; n_i - number of individuals of each species in all samples; N- the total number of individuals of all species in all samples), which are determined on the basis of its relationship with the index om water pollution (WPI_i), coefficient of limiting water pollution (LPF_i) And a classification was developed according to the coefficient of maximum permissible water pollution ($MPPC_i$) according to the classification tables of water quality (Table 3).

Based on the construction of graphs of the relationship between the relative values of the Shannon trophic index, taking into account the probabilistic distribution of the runoff volume and the modular coefficient (Table 3), using the Microsoft Excel program, systems of logarithmic and exponential equations were obtained:

- dependence of the Shannon trophicity index (H_i) on the water pollution index (WPI_i): $H_i = 1.8467 \cdot WPI_i^{0,244}$, correlation coefficient R_i=0.9904;

- dependencies of the Shannon trophicity index (H_i) on the limiting pollution coefficient (LPF_i): $H_i = 3,06 \cdot exp[-0.23\,(LPF_i + 2)]$, correlation coefficient R_i= 0.8500;

- dependence of the Shannon trophicity index (H_i) on the coefficient of maximum permissible pollution ($MPPC_i$): $H_i = 2.9709 \cdot exp(-1.039 \cdot MPPC_i)$, correlation coefficient R_i= 0.9768.

Table 3 - Classification of water quality and the state of water resources according to hydrochemical and hydrobiological indicators

Index	Water quality class					
	I	II	III	IV	V	VI
WPI_i	<0 , 2	0 , 20-1 , 0	1,00-2,00	2,00-4,00	4,00-6,00	>6,00
LPF_i	≤-0,80	-0,8-0,0	0,0-1,0	1,0-3,0	3,0-5,0	>6,0
$MPPC_i$	<0,16	0,16-0,32	0,32-0,48	0,48-0,64	0,64-0,80	>0,80
H	3 , 06-2 , 30	2 , 30 -1,89	1,89-1,52	1,52-1,25		1,25-1,11
water quality	very clean	clean	moderate polluted	polluted	dirty	very dirty
trophy	oligotrophic	mesotrophic		eutrophic		Hypertrophic

Thus, the study of the hydrochemical regime and the ecological state of the catchment area in the lower reaches of the Syrdarya river basin, which are under «hard» technogenic loads, using statistical relationships between hydrological and hydrochemical indicators, allows us to get a general idea of the processes of water quality formation in the region and has the most important scientific and practical importance in the development of environmental protection measures.

Research results

Hydrochemical assessments of the quality of surface waters and the ecological state in the lower reaches of the catchment area of the Syrdarya river basin were carried out on the basis of the use of the water pollution index (WPI_i), the coefficient of maximum water pollution (LPF_i), the coefficient of maximum permissible water pollution ($MPPC_i$) and the Shannon trophicity index (H_i) and the normative criteria for maximum permissible concentrations (MPC_i) of pollutants for fishery water use (Table 4).

Table 4 - Relative values of the concentration of chemicals in surface waters (C_i) to their maximum allowable concentration (MPC_i) for fishery water use

years	Relative values of the concentration of chemicals in surface waters (C_i) to their maximum allowable concentration (MPC_i) for fishery water use								Water quality indicators		
	C_o	NO_2	NO_3	NH_4	Ca	Mg	SO_4	Cl	WPI_i	LPF_i	$MPPC_i$
1	2	3	4	5	6	7	8	9	10	11	12
Hydrological post Shardara											
1996	1.400	4.500	1.333	0.308	0.789	2.175	6,500	0.507	2.189	1.189	0.696
1997	1.508	4.000	1.778	0.256	0.806	1,750	7,000	0.470	2.196	1.196	0.696
1998	1.484	2.000	2.056	0.641	0.778	1.575	6,800	0.423	1,970	0.970	0.708
1999	1.243	4.500	1.267	0.564	0.667	1.625	6,850	0.551	2.158	1.158	0.695
2000	1.303	5.500	1.889	0.359	0.517	1.613	6,900	0.390	2.309	1.309	0.675
2001	1.350	6.000	1.667	0.385	0.539	1.625	5,000	0.450	2.127	1.127	0.681
2002	1,300	5.000	1.556	0.769	0.567	1,650	5,700	0.417	2.120	1.120	0.703
2003 _	0.909	9.500	0.556	5.154	0.584	1.673	4,720	0.284	2.923	1.923	0.689
2004 _	0.988	2.050	0.118	0.077	0.667	1.763	5.190	0.295	1.394	0.394	0.531
2005	0.952	0.650	0.113	0.154	0.633	1.848	5.270	0.365	1.248	0.248	0.494
2006	1.080	2.000	2.578	0.103	1.111	1.143	2,960	0.413	1.424	0.424	0.648
2007	1.086	1.650	0.844	1.795	1.111	1.145	2,970	0.403	1.376	0.376	0.688
2008	1.091	1.250	0.833	1.538	1.112	1.143	2,960	0.407	1.292	0.292	0.670
2009	1.086	1.600	0.833	1.795	0.700	1.143	2,960	0.403	1.315	0.315	0.666
2010	1.020	1.850	0.189	0.128	0.744	1,390	4,570	0.288	1.272	0.272	0.536
2011	1.052	1.600	0.200	0.154	0.717	1.433	4.280	0.334	1.221	0.221	0.540
2012	1.070	1.500	0.233	0.590	0.733	1.505	3.290	0.438	1.170	0.170	0.588
2013	1.042	1.400	0.177	1.436	0.733	1.648	4,580	0.275	1.411	0.411	0.610
2014	0.918	1.000	0.178	1.436	0.644	1.578	1,880	0.403	1.005	0.005	0.576
2015	0.744	1.500	0.389	1.462	0.514	1.525	3.440	0.537	1.264	0.264	0.620
2016	1.111	1.600	2.478	0.051	0.728	1.498	4.610	0.658	1.592	0.592	0.650
2017	0.940	0.200	0.878	1.026	0.722	2.133	5.114	0.296	1.414	0.414	0.583
2018	0.960	4.900	0.378	0.769	0.711	1.513	4.795	0.300	1.791	0.791	0.625
2019	0.913	4.500	0.867	0.359	0.611	1,590	4,970	0.328	1.767	0.767	0.624
2020	0.938	5.000	0.711	0.769	0.682	1.745	4,960	0.308	1.889	0.889	0.653

Continuation of table 4

1	2	3	4	5	6	7	8	9	10	11	12

Hydrological post of Kyzylorda											
1996	1.373	0.314	2.458	5,960	0.650	5,500	0.593	1.487	2.292	1.292	0.703
1997	1.346	0.590	2.333	5.728	0.398	5,000	0.494	0.795	2.086	1.086	0.668
1998	1.337	0.606	1.848	5.402	0.425	0.900	0.611	0.923	1.507	0.507	0.629
1999	1.331	0.419	2.425	5,833	0.378	1,000	0.567	0.821	1.597	0.597	0.616
2000	1.394	0.529	1.583	4,446	0.446	2,000	0.889	0.974	1.533	0.533	0.673
2001	1.595	0.740	2.013	5,730	0.587	2,000	0.733	1.282	1.835	0.835	0.717
2002	1.289	0.506	2.133	4.668	0.411	4.150	0.798	1.103	1.882	0.882	0.692
2003	1.275	0.457	1.573	4.263	0.423	1.700	0.908	0.846	1.431	0.431	0.649
2004	1.512	0.554	1.708	4,960	0.326	5.750	0.854	1.026	2.086	1.086	0.688
2005	1.319	0.498	2.060	5,854	0.480	1.050	0.516	0.897	1.584	0.584	0.628
2006	1.208	0.587	1.565	5.034	0.417	1.000	0.350	0.641	1,350	0.350	0.584
2007	1.028	0.502	1.285	4.084	0.489	1.800	0.693	0.615	1.312	0.312	0.616
2008	1.136	0.484	1.193	4.362	0.396	4.350	0.327	0.744	1.624	0.624	0.608
2009	1.361	0.552	1.273	4.524	0.606	0.950	0.361	0.949	1.322	0.322	0.608
2010	0.987	0.499	0.978	3.802	0.612	1,000	0.556	0.487	1.115	0.115	0.565
2011	1.194	0.506	2.005	4.115	0.520	1,000	0.317	0.718	1.297	0.297	0.596
2012	1.287	0.472	1.673	4.725	0.214	1,000	0.420	0.590	1.298	0.298	0.565
2013	1.061	0.547	1.523	5.905	0.555	3,650	0.577	0.513	1.791	0.791	0.637
2014	1.235	0.601	1.395	4.485	0.431	2,300	0.394	0.769	1.451	0.451	0.627
2015	1.120	0.553	1.113	3.255	0.485	2,750	0.494	0.821	1.324	0.324	0.625
2016	1,200	0.583	1.085	5.354	0.367	2,300	0.489	0.769	1.518	0.518	0.616
2017	1,490	0.689	0.950	3,540	0.527	0.900	0.633	1.026	1.219	0.219	0.621
2018	1.133	0.529	1.080	3.958	0.401	2,400	0.882	0.026	1.301	0.301	0.573
2019	1.340	0.223	1.055	3.824	0.413	0.400	0.013	0.051	0.915	-0.085	0.412
2020	1.321	1.250	0.511	0.256	0.480	1.028	3.774	0.447	1.133	0.133	0.554
Hydrological post Kazaly											
1996	1.497	7.500	0.239	1.538	0.356	2,430	4.002	0.355	2.240	1.240	0.658
1997	1.489	6.000	0.978	1.538	0.754	2.193	6.630	0.718	2.538	1.538	0.764
1998	1.594	5.000	0.638	1.077	0.664	2.260	6.065	0.483	2.223	1.223	0.710
1999	1.568	2.500	1.100	1.641	0.563	1.873	5,750	0.569	1.946	0.946	0.736
2000	1.550	3.500	1.167	1.282	0.683	1.658	5.746	0.525	2.014	1.014	0.735
2001	1.816	3.000	1.267	1.231	0.769	2.483	6.338	0.615	2.190	1.190	0.766
2002	1.547	2.750	1.344	1.154	0.581	2.030	6.164	0.390	1.995	0.995	0.722
2003	1.545	3.850	1.589	1.179	0.568	1.873	6.240	0.403	2.156	1.156	0.733
2004	1.568	3.200	1.733	1.256	0.580	1.745	6.216	0.382	2.085	1.085	0.734
2005	1.640	1.150	0.668	0.974	0.611	2.853	6.143	0.477	1.815	0.815	0.672
2006	1.426	1.100	0.438	0.590	0.733	2.218	4.128	0.678	1.414	0.414	0.639
2007	1.461	1.900	1.111	0.744	0.596	2.008	5.133	0.530	1.685	0.685	0.692
2008	1.376	1.650	0.553	0.744	0.694	1.235	5.088	0.422	1,470	0.470	0.632
2009	1.467	1.050	0.521	0.974	0.575	1.185	4.603	0.463	1.355	0.355	0.618
2010	1.220	1.850	0.559	0.974	0.167	1.123	4.066	0.378	1.292	0.292	0.591
2011	1.459	0.500	0.367	1,000	0.644	2.358	4.247	0.508	1.385	0.385	0.608
2012	1.459	0.500	0.367	1,000	0.644	2.358	4.247	0.508	1.385	0.385	0.608
2013	1,460	0.200	0.003	1,000	0.644	2.368	4.247	0.508	1.304	0.304	0.544
2014	1,400	2.200	0.111	0.846	0.808	1,500	4,850	0.600	1.539	0.539	0.637
2015	1.310	3.000	0.233	1.026	0.739	1.325	3.543	0.547	1.465	0.465	0.647

2016	1.320	2.200	0.244	1,000	0.739	1.053	5.202	0.583	1.543	0.543	0.635
2017	1.355	2.750	0.378	0.641	0.739	1.125	1,550	0.443	1.123	0.123	0.601
2018	1.420	4.000	0.244	0.026	0.497	0.888	3,450	0.402	1.366	0.366	0.533
2019	1.420	0.400	0.023	0.051	0.268	0.838	3.228	0.407	0.829	-0.171	0.407
2020	1.398	2.400	0.211	0.256	0.502	0.950	2.743	0.417	1.110	0.110	0.545

Preliminary estimates of the water pollution index (WPI_i), characterizing the multiplicity of exceeding the normative excess of the concentration of the studied ingredients in the sections of the hydrological station located downstream of the Shardara reservoir in the zones of the border of the Republic of Uzbekistan and the Republic of Kazakhstan, showed that over the period 1996-2020, the mineralization of surface waters changes (C_o) – 0,744-1,400, nitrite nitrogen (NO_2) – 0,200-9,500, nitrate nitrogen (NO_3) – 0,113-2,518, ammonium nitrogen (NH_4) – 0,077-1,795, calcium (Ca) – 0,517-1,112, magnesium (Mg) – 1,143-2,175, sulf ata (SO_4) -1,880-7,000, chlorine (Cl) – 0,284-0,507.

In the section of the Kyzylorda hydrological station, located in the middle between the Shardara reservoir and the Small Aral, for the period 1996-2020, the mineralization of surface waters changes (C_o) – 0,987-1,512, nitrite nitrogen (NO_2) – 0,200-7,500, nitrate nitrogen (NO_3) – 0,511-2,458, ammonium nitrogen (NH_4) – 0,256-5,960, calcium (Ca) – 0,214-0,650, magnesium (Mg) – 0,400-5,500, sulfates (SO_4) – 0,013-0,908, chlorine (Cl) – 0,051-1,487.

In the alignment of the Kazaly hydrological station located in the Malago Aral zone, the lower reaches of the Syrdarya River, for the period 1996-2020, the mineralization of surface waters changes (C_o) – 1,220-1,816, nitrite nitrogen (NO_2) – 0,200-7,500, nitrate nitrogen (NO_3) – 0,003-1,733, nitrogen ammonium (NH_4) – 0,051-1,538, calcium (Ca) – 0,167-0,808, magnesium (Mg) – 0,838-2,853, sulfates (SO_4) -1,550-6,630, chlorine (Cl) - 0.335-0.718.

To identify the trend in water quality indicators, that is, the water pollution index (WPI_i), coefficient of maximum water pollution (LPF_i), coefficient of maximum permissible water pollution ($MPPC_i$) and Shannon's trophic index, all calculations and plotting using a linear trend in were made in the Microsoft Excel program (Figures 3-6) show that for the considered 1996-2020 there is a negative trend in general characterizing the improvement of water quality in the lower reaches of the Syrdarya River.

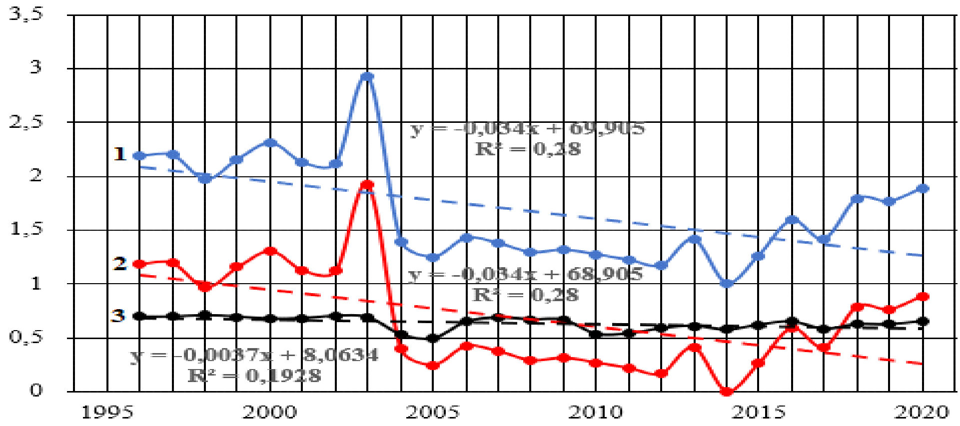

Figure 3 - Graph of changes in water quality indicators in the Shardara hydrological stations in the lower reaches of the Syrdarya River (ordinate - water quality indicators; abscissa - years; 1 - water pollution index (WPI_i); 2 - coefficient of maximum water pollution (LPF_i); 3 - coefficient of maximum permissible water pollution ($MPPC_i$) for 1996-2020 and their linear trend

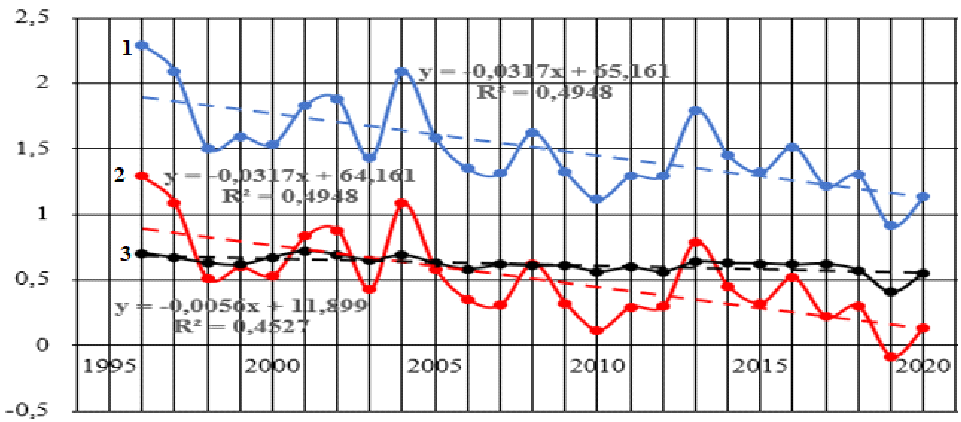

Figure 4 - Graph of changes in water quality indicators in the hydrological stations of Kyzylorda in the lower reaches of the Syrdarya River (ordinate - water quality indicators; abscissa - years; 1 - water pollution index (WPI_i); 2 - coefficient of maximum water pollution (LPF_i); 3 - coefficient of maximum permissible water pollution ($MPPC_i$) for 1996-2020 and their linear trend

Water quality assessments carried out using integral hydrochemical indicators of the hydrological stations of Shardara located below the Shardara reservoir show (Table 4 and Figure 3) that over the period under review 1196-2020, the water pollution index changes WPI_i) – 0,913-2,189 (from clean to contaminated), coefficient of maximum water pollution (LPF_i) – 0,414 -1,196 (from moderately polluted to polluted) and coefficient of maximum permissible water pollution ($MPPC_i$) -0,531-0,708 (from polluted to dirty).

In the section of the Kyzylorda hydrological station located in the middle of the Shardara reservoir and the Small Aral in the lower reaches of the Syrdarya river basin for the period under review 1996-2020, the water pollution index (WPI_i) – 0,915-2,292 (moderately polluted to polluted), coefficient of maximum water pollution (LPF_i) - 0,219-1,292 (from moderately polluted to polluted) and coefficient of maximum permissible water pollution (($MPPC_i$) – 0,412-0,717 (from moderately polluted to dirty) (Table 4 and Figure 4).

In the closing hydrological posts of Kazaly located in the zone of the Small Aral in the lower reaches of the Syrdarya River for the period under review 1196-2020, the water pollution index changes ($ИЗВ_i$) – 0,826-2,538 (from clean to contaminated), coefficient of maximum water pollution (LPF_i) – 0,123 -1,538 (from moderately polluted to polluted) and coefficient of maximum permissible water pollution ($MPPC_i$) – 0,407-0,766 (from polluted to dirty) (table 4 and figure 5).

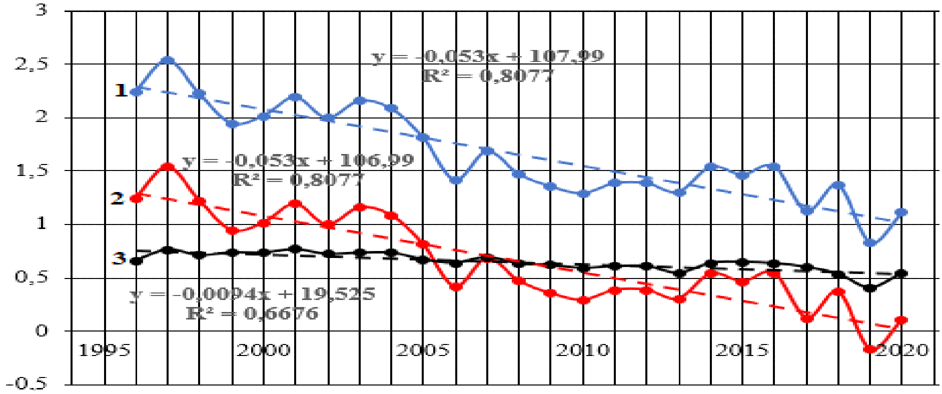

Figure 5 - Graph of changes in water quality indicators in the Kazaly hydrological stations in the lower reaches of the Syrdarya River (ordinate - water quality indicators; abscissa - years; 1 - water pollution index (WPI_i); 2 - coefficient of maximum water pollution (LPF_i); 3 - coefficient of maximum permissible water pollution ($MPPC_i$) for 1996-2020 and their linear trend

The studies carried out to assess the quality of water using integral hydrochemical indicators in the catchment areas of the lower reaches of the Syrdarya River made it possible to draw the following main conclusions about the quality of surface waters, in general, according to the standards for the maximum permissible concentration of harmful substances of fishery water use, they are not suitable for drinking water supply to the population and for irrigation agricultural crops that ensure the food security of the region.

An assessment of the ecological state of the catchment areas in the lower reaches of the Syrdarya River using the Shannon trophic index in the context of hydrological stations under conditions of «hard» anthropogenic activity showed that in the Shardara section their quantitative values vary from 1.430 to 1.858, in Kyzylorda - from 1.4355 to 1.837 and Kazaly - from 1.356 to 2.009. Consequently, the ecological state of the lower reaches of the Syrdarya River for the period under review 1996–2020 changes from mesotrophic to evotrophic stages, where the degree of influence of anthropogenic activity is within the limits of uncontrolled and unaccounted for consequences (deterioration of the quality of water and land resources, as well as agricultural products (Figure 6).

Structural and system analysis of the formation of the hydrochemical regime of the watershed in the lower reaches of the Syrdarya River showed (Tables 1–4 and Figures 1–6) that the main sources of water pollution are highly mineralized return waters coming upstream of the Shardara reservoir from the territories of neighboring states of the Kyrgyz Republic, the Republic of Tajikistan and the Republic of Uzbekistan, which make up about 50 % of the available water resources of the Turkestan and Kyzylorda regions of the Republic of Kazakhstan.

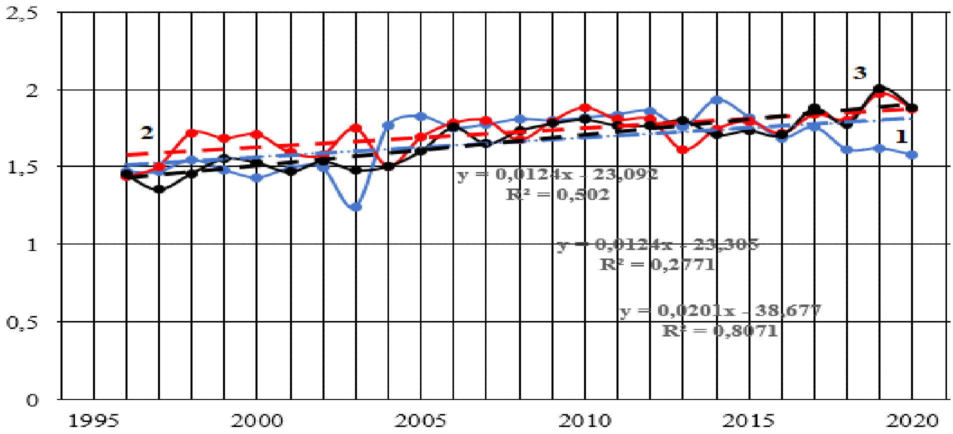

Fig. 6 - Graph of the change in the Shannon trophic index in the lower reaches of the Syrdarya River (ordinate - Shannon trophic index; abscissa - years; hydrological station: 1 - Shardara; 2 - Kyzylorda; 3 - Kazaly) for 1996–2020 and their linear trend

To identify the cause-and-effect relationships of the formation of the hydrochemical regime in the catchment areas of the lower reaches of the Syrdarya River, we write the expression for the hydrochemical balance below the Shardara reservoir:

$$W_{lwi} \cdot C_{lwi} \cdot k_i = W_{swi} \cdot C_{swi} + W_{rwi} \cdot C_{rwi}, \quad (5)$$

where W_{lwi} - the available volume of water resources of the Syrdarya River below the Shardara reservoir, km3 ; C_{lwi}- salinity of surface waters of the Syrdarya river below the Shardara reservoir, g/l; W_{swi}- the volume of water of the incoming surface waters of the Syrdarya River above the Shardara reservoir, km3 ; C_{swi}– salinity of surface waters of the Syrdarya river above the Shardara reservoir, g/l; W_{rwi}- the volume of incoming return waters the channel of the Syrdarya river above the Shardara reservoir, km3 ; C_{rwi} - salinity of return waters of the Syrdarya river bed upstream of the Shardara reservoir, g/l; k_i- coefficient of water self-purification of the Shardara reservoir.

If the hydrochemical balance equation is solved with respect to the salinity of the surface waters of the Syrdarya River below the Shardara reservoir, then we obtain the following expression:

$$C_{lwi} = [W_{swi} \cdot C_{swi} + W_{rwi} \cdot C_{rwi}]/W_{lwi} \cdot k_i. \quad (6)$$

As can be seen from equations (5), the salinity of the surface waters of the Syrdarya River below the Shardara reservoir (C_{lwi}) ensuring the safety of the life of the population of the Turkestan and Kyzylorda regions of the Republic of Kazakhstan directly depends mainly on the volume of incoming return waters, the bed of the Syrdarya River above the Shardara reservoir (W_{rwi}) and their salinity (C_{rwi}), what should be taken into account in the regulation and management of water resources in the catchment area of the Syrdarya river basin at the interstate level.

Conclusions

The results of hydrochemical analysis and study of the ecological state of the catchment area in the lower reaches of the Syrdarya River in accordance with the maximum permissible concentrations of pollutants at the hydrological posts of Shardara, Kyzylorda and Kazaly using long-term annual reports of the «Aral-Syrdarya Basin Inspectorate for the Rational Use and Protection of Water Resources» of the Committee Water Resources Ministry of Geology, Ecology and Natural Resources of the Republic of Kazakhstan, based on the water pollution index, the maximum pollution coefficient, the maximum permissible pollution coefficient and the Shannon trophic index showed that for the period under review 1996–2020, all estimated indicators have a negative trend, where the quality waters change from «polluted» to «moderately polluted», in general, not suitable for drinking water supply, and the ecological situation changes from «eutrophic» to «mesotrophic», indicating, as a rule, the degree of influence of anthropogenic activity is within the limits of uncontrolled and unaccounted for consequences (deterioration in the quality of water and land resources, as well as agricultural products).

In general, potential pollutants of surface waters in the lower reaches of the Syrdarya River are the incoming highly mineralized return waters of industrial facilities, domestic water supply and collector-drainage waters of irrigated lands from the territory of the Kyrgyz Republic, the Republic of Tajikistan and Uzbekistan, which make up about 50 % of the available water resources downstream of the Shardara reservoirs, which became the reason for the impossibility of fulfilling the environmental and ecological functions of the surface waters of the river basins, which ensure the water and food security of the population of the Turkestan and Kyzylorda regions of the Republic of Kazakhstan, where a triple natural and technogenic impact occurs, that is, «moderate pollution» of surface water, «the rise of highly mineralized groundwater» and «air pollution by fine salt dust on the dry bottom of the Aral Sea».

REFERENCES

Alimov A.F. (1990). The main provisions of the theory of the functioning of aquatic ecosystems // Hydrobiological journal, 1990. -T. 26. -№ 6.- Pp. 3–12.

Burlibaev M.Zh., Amirgaliev N.A., Shenberger I.V., Sokolsky V.A., Burlibaeva D.M., Uvarov D.V., Simernova D.A., Efimenko A.V., Milyukov D.Yu. (2014). Problems of pollution of the main transboundary rivers of Kazakhstan. -Almaty: "Kanagat", 2014.- volume 1.- 744 p.

Bulgakov N.G., Dubinina V.G., Levich A.P., Terekhin A.T. (1995). A method for searching for conjugations between hydrobiological indicators and abiotic environmental factors. Izvestiya Rossiiskoi Akademii Nauk. Biological series. - 1995. - № 2. - Pp. 218–225.

Burlibaev M.Zh., Amirgaliev N.A., Shenberger I.V., Sokalsky V.A., Burlibaeva D.M., Uvarov D.V., Simernova D.A., Efimonko A.V., Milyukov D.Yu. (2014). Problems of pollution of the main transboundary rivers of Kazakhstan. - Almaty: Kanagat, 2014. - T. 1. - 742 p.

Bulgakov N.G. (2004). Ecologically acceptable levels of abiotic factors in the water bodies of Russia and neighboring countries. Dependence on geographical and climatic features // Water resources, 2004.- № 2. – Volume 31.- Pp. 193–198.

Emelyanova V.P., Danilova G.N., Rodziller I.D. (1980). A method of generalizing indicators for assessing the quality of surface water // Hydrochemical materials, 1980. - V. 77.- Pp. 88–96.

Gharibi H., Mahvi A.H., Nabizadeh R., Arabalibeik H., Yunesian M. & Sowlat M.H. (2012). A novel approach in water quality assessment based on fuzzy logic // Journal of Environmental Management, 112. Pp. 87–95.

Guidelines for the organization and functioning of the subsystem for monitoring the state of transboundary surface waters of Kazakhstan. - Almaty, 2012.- 140 p.

Kalikhman A.D., Pedersen A.D., Savenkova T.P., Suknev A.Ya. (1999). Methodology of «limits of acceptable changes» in Lake Baikal - a UNESCO World Heritage site. Irkutsk: Print, 1999.- 100 p.

Mustafayev Zh.S., Kozykeyeva A.T. (2012). The Aral Sea basin: past, present and future. - Taraz: BIG NEO SERVICE LLP , 2012. - 318 p.

Mustafayev Zh.S. (2022). Forecast of surface water quality in river basins using physical and chemical indicators of natural systems // Reports of the national academy of sciences of the republic of Kazakhstan, 2022.- volume 3, number 343 (2022). Pp. 132–144

Moiseenko T.I. (1995). Methodical approaches to the regulation of anthropogenic loads on water bodies of the Subarctic (on the example of the Kola North) // Problems of chemical and biological monitoring of the ecological state of water bodies of the Kola North. - Appatity: Kola Scientific Center, 1995.- Pp. 7–23.

Mahapatra S.S., Nanda S.K., Panigrahy B. (2011). KA Cascaded Fuzzy Inference System for Indian river water quality prediction // Advances in Engineering Software. 2011, № 42(10). - Pp. 787–796.

Ocampo-Duque W., Osorio C., Piamba C., Schuhmacher M. & Domingo J.L. (2013). Water quality analysis in rivers with non-parametric probability distributions and fuzzy inference systems: application to the Cauca River // Colombia. Environment International. - 2013.- 52. Pp.17–28.

Shabanov V.V., Markin V.N. Method for assessing water quality and the state of aquatic ecosystems - M: MGUP, 2009.- 154 p.

Shabanov V.V., Markin V.N. (2008). Assessment of water quality and the ecological state of water bodies // Water treatment, Water treatment, Water supply, 2008. - № 8. - Pp. 28–37.

Shannon C.E., Warren Weaver 1949). The mathematical theory of communication. Urbana: the University of Illinois Press. 1949.-117 p.

Vershinskaya M.E., Shabanov V.V., Markin V.N. (2008). Ecological and water management assessment of the catchment area and water bodies in the Irtysh basin // Environment Engineering, 2008.- № 2.- Pp. 50–56.

CONTENT

Publication Ethics and Publication Malpractice in the journals of the National Academy of Sciences of the Republic of Kazakhstan

For information on Ethics in publishing and Ethical guidelines for journal publication see http://www.elsevier.com/publishingethics and http://www.elsevier.com/journal-authors/ethics.

Submission of an article to the National Academy of Sciences of the Republic of Kazakhstan implies that the described work has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis or as an electronic preprint, see http://www.elsevier.com/postingpolicy), that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder. In particular, translations into English of papers already published in another language are not accepted.

No other forms of scientific misconduct are allowed, such as plagiarism, falsification, fraudulent data, incorrect interpretation of other works, incorrect citations, etc. The National Academy of Sciences of the Republic of Kazakhstan follows the Code of Conduct of the Committee on Publication Ethics (COPE), and follows the COPE Flowcharts for Resolving Cases of Suspected Misconduct (http://publicationethics.org/files/u2/New_Code.pdf). To verify originality, your article may be checked by the Cross Check originality detection service http://www.elsevier.com/editors/plagdetect.

The authors are obliged to participate in peer review process and be ready to provide corrections, clarifications, retractions and apologies when needed. All authors of a paper should have significantly contributed to the research.

The reviewers should provide objective judgments and should point out relevant published works which are not yet cited. Reviewed articles should be treated confidentially. The reviewers will be chosen in such a way that there is no conflict of interests with respect to the research, the authors and/or the research funders.

The editors have complete responsibility and authority to reject or accept a paper, and they will only accept a paper when reasonably certain. They will preserve anonymity of reviewers and promote publication of corrections, clarifications, retractions and apologies when needed. The acceptance of a paper automatically implies the copyright transfer to the National Academy of Sciences of the Republic of Kazakhstan.

The Editorial Board of the National Academy of Sciences of the Republic of Kazakhstan will monitor and safeguard publishing ethics.

Правила оформления статьи для публикации в журнале смотреть на сайтах:
www:nauka-nanrk.kz
http://www.geolog-technical.kz/index.php/en/
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Подписано в печать 14.06.2023.
Формат 70x90 $^{1}/_{16}$. Бумага офсетная. Печать – ризограф.
20,0 п.л. Тираж 300. Заказ 3.

РОО «Национальная академия наук РК»
050010, Алматы, ул. Шевченко, 28, т. 272-13-19