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

«ҚАЗАҚСТАН РЕСПУБЛИКАСЫ ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫ» РҚБ

ҚАЙЫРЫМДЫЛЫҚ ҚОРЫ HALYK CHARITY FOUNDATION

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

ХАБАРЛАРЫ

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

3 (465)

MAY – JUNE 2024

THE JOURNAL WAS FOUNDED IN 1940

PUBLISHED 6 TIMES A YEAR

ALMATY, NAS RK

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.

ЧФ «ХАЛЫҚ»

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»!

«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 3. Number 465 (2024), 119–132
https://doi.org/10.32014/2024.2518-170X.414
IRSTI: 70.27.17

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INTEGRAL ASSESSMENT OF THE WATER QUALITY OF THE MARKAKOL LAKE IN KAZAKHSTAN PART OF WESTERN ALTAI

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Abstract. This article presents the results of an integrated water quality assessment of Markakol lake. The adopted integrated water quality index is a mathematical tool used to transform the complex influence of large multi-parameter water quality indicators into unambiguous indices, to facilitate informing the public and legislative decision makers, to establish a common reference system of the water body. Integral assessment of water quality of Lake Markakol was carried out according to physico-chemical and toxicological parameters, which is based on already existing developments, but due to a number of objective reasons it is extremely simplified, contains limited data, was made using values of pH of water, total mineralization, total water hardness and the complex index of water pollution ($CIWP_{hc}$) taking into account the hazard class, based on groups of toxic ingredients on the signs of the hazard class. The optimal parameters selected for the integral assessment, although limited, the resulting assessment for each parameter is representative. Conducted integral assessment of water quality of Markakol lake by hydrochemical and toxicological indicators shows that the water generally meets regulatory requirements and refers to class 1 (conditionally clean).

Keywords integral coefficient, water quality, number of ions, mineralization, alkalinity, hardness

Funding: *This research was funded by the grant of the Ministry of Science and Higher Education of the Republic of Kazakhstan individual registration number AP14870595 "Monitoring and evaluation of micro- and macroplastics in the aquatic environment of Markakol lake".*

Conflicts of Interest: The authors declare no conflict of interest.

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БАТЫС АЛТАЙДЫҢ ҚАЗАҚСТАНДЫҚ БӨЛІГІНДЕГІ МАРҚАКӨЛ КӨЛІНІҢ СУ САПАСЫН ИНТЕГРАЛДЫ БАҒАЛАУ

Мұсақұлқызы А. — т.ғ.к., Гидрохимия және экологиялық токсикология зертханасының аға ғылыми қызметкері, «География және су қауіпсіздігі институты» АҚ, Алматы, Қазақстан
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Аннотация. Мақалада Марқакөл көлінің су сапасын интегралды бағалау нәтижелері келтірілген. Су сапасының қабылданған интегралдық көрсеткіші су сапасының үлкен көп параметрлік көрсеткіштерінің күрделі әсерін бір мәнді индекстерге түрлендіру, халықты және заңнамалық шешімдер қабылдаушыларды хабардар етуді жеңілдету, су объектісінің жай-күйін есептеудің бірыңғай жүйесін құру үшін пайдаланылатын математикалық құрал болып табылады. Марқакөл көлінің су сапасын интегралды бағалау физика-химиялық және токсикологиялық көрсеткіштер бойынша жүргізілді, ол бұрыннан бар әзірлемелерге негізделген, бірақ бірқатар объективті себептерге байланысты өте жеңілдетілген, шектеулі деректер көлемін қамтиды, судың pH мәндерін, жалпы минералдануын, судың жалпы қаттылығын және судың ластануының кешенді индексін (КИЗВ) пайдалана отырып орындалды. қауіптілік класының белгілері бойынша улы ингредиенттер топтарына негізделген қауіптілік класы. Интегралды бағалау үшін таңдалған оңтайлы параметрлер шектеулі болғанымен, әр параметр бойынша алынған баға өкілді болып табылады. Гидрохимиялық және токсикологиялық көрсеткіштер бойынша Марқакөл көлінің су сапасына жүргізілген интегралдық бағалау судың жалпы нормативтік талаптарға сәйкес келетіндігін және 1-сыныпқа жататындығын көрсетеді (шартты түрде таза).

Түйін сөздер: интегралдық коэффициент, су сапасы, иондар саны, минералдану, сілтілік, қаттылық

Қаржыландыру: *Жұмыс ҚР БҒМ Ғылым комитетінің қаржылық қолдауымен орындалды (№АП14870595 гранты «Марқакөл көлінің су ортасының микро - және*

макропластикамен ластану деңгейін бағалау және жай-күйінің мониторингі»).

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ИНТЕГРАЛЬНАЯ ОЦЕНКА КАЧЕСТВА ВОДЫ ОЗЕРА МАРКАКОЛЬ В КАЗАХСТАНСКОЙ ЧАСТИ ЗАПАДНОГО АЛТАЯ

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Аннотация. В статье представлены результаты интегральной оценки качества воды озера Маркаколь. Принятый интегральный показатель качества воды представляет собой математический инструмент, используемый для преобразования сложного влияния больших многопараметрических показателей качества воды в однозначные индексы, облегчения информирования населения и лиц, принимающих законодательные решения, создания единой системы отсчета состояния водного объекта. Интегральная оценка качества воды озера Маркаколь проводилась по физико-химическим и токсикологическим показателям, которая базируется на уже существующих разработках, но в силу ряда объективных причин является крайне упрощенной, содержит ограниченный объем данных, выполнена с использованием значений pH воды, общей минерализации, общей жесткости воды и комплексного индекса загрязненности воды (КИЗВ) с учетом класса опасности, основанного на группах токсичных ингредиентов по признакам класса опасности. Оптимальные параметры, выбранные для интегральной оценки, хотя и ограничены, но полученная оценка по каждому параметру является представительной. Проведенная интегральная оценка качества воды озера Маркаколь по гидрохимическим и токсикологическим показателям показала, что вода в целом соответствует нормативным требованиям и относится к 1 классу (условно чистая).

Ключевые слова: интегральный коэффициент, качество воды, количество ионов, минерализация, щелочность, жесткость

Финансирование: *Работа выполнена при финансовой поддержке Комитета науки МОН РК (грант № AP14870595 «Мониторинг состояния и оценка уровня загрязнения микро- и макропластиком водной среды озера Маркаколь»).*

Introduction

Markakol lake is of significant importance as a natural resource, ecosystem and object of scientific research. Its conservation and sustainable use play an important role in maintaining the biodiversity, ecological balance and economic development of the region. It is surrounded by dense forests, since the lake is located in a mountainous area, the lake shores are partially cut by steep slopes, and in some places are covered with meadows. The lake is rather deep, in some places it reaches 25 meters and is considered one of the largest lakes of Altai, it is located relatively high, almost 1.5 km above the sea level, so scientists refer it to the lake of Alpine type. Markakol resembles the great Baikal in its natural and climatic characteristics, it has the same fresh and very clean water, so it is sometimes called the younger brother of the legendary lake (Markakol – mesto sily, 22.07.2019).

The lake and its adjacent territories are part of the Altai-Sayan ecological region. According to the Decree № 365 of the Council of Ministers of the Kazakh SSR dated August 4, 1976 to preserve and study natural complexes of the southern part of the Altai Mountains, to develop methods of restoration of black taiga biocenoses, to study ecology and dynamics of the number of fish in Markakol lake. Due to its unique landscape and biodiversity, the territory of Markakol reserve is protected as a key area of the International program of Global Environment Facility (GEF), United Nations Development Programme (UNDP), World Wildlife Fund (WWF), Nature And Biodiversity Conservation Union (NABU) and German agency for technical cooperation (GTZ) for conservation of the Altai-Sayan biologically diverse ecological region and is included into 200 priority global ecological regions determined by the International organization “WWF Living Planet” (Official website of RSE “Markakol State Nature Reserve”). Kazakhstan, as a party of the Convention on Conservation of Biological Diversity (Rio de Janeiro, June 5, 1992), approved by the Republic of Kazakhstan on August 19, 1994, № 918, has its own commitments to the conservation of biological diversity (On the approval by the Republic of Kazakhstan of the Convention on Biological Diversity, 19.08.1994). At the 34th session of the International Coordinating Council of the Man and Biosphere Program the Markakol reserve was accepted into the World Network of Biosphere Reserves of UNESCO. All of the above mentioned demonstrates the attention of the world community to the issues of preserving the biological diversity of Kazakhstan as a whole and Markakol lake in particular.

However, different countries, in their own way, need tools for assessing water quality. The work (Tampo et. al., 2023) discusses the categories of water quality indicators their use and scope in West African countries. But do not have biotic and physico-chemical water quality indices specific to the areas of West Africa.

The study (Labib et. al., 2023) aims to evaluate water quality monitoring data. Among the 13 indices used in this study to determine water quality in East Harbor, 6 are dependent on physical and chemical variables and the remaining 6 are biological.

Physical qualities, sanitary and bacterial indicators, as well as the chemical composition of water are considered the main criteria for the suitability of water used (Kumar et. al., 2023). Physical properties include temperature, odor, taste, color, and turbidity. Chemical composition tells the content of chemical elements in the form of impurities: the number of ions, mineralization, alkalinity, hardness, pH level. In a sanitary-bacteriological study, attention is paid to the number of bacteria, Escherichia coli, toxicity and radioactivity.

The water in the lake is clear and clean (Markakol – mesto sily, 22.07.2019). The purity of water in the lake is due to the fact that Markakol is a flowing body of water, and in its

southern parts, the bottom can be seen up to 7 meters deep. The large flow of tourists in recent decades and the rich aquatic world of the lake has always attracted attention. Subsequently found in freshwater ecosystems heavy metals and organic matter, can contaminate aquatic biota, cause physical damage and enter the food chain. Currently, there is very limited data on pollution in a remote lake, with state monitoring sampling done only once a year. Even remote from civilization, the clear lake has been severely affected by human encroachment and toxic substances can enter with atmospheric precipitation even in remote protected areas. The work shows that many European mountain lakes remote from industrial centers (in Scotland, Southern Norway, and the Alps, Pyrenees and Tatras) are acidified, polluted with heavy metals (HM), pesticides and other substances due to transboundary transport of polluted air masses from industrialized centers. Formation of water quality of such lakes occurs mainly due to atmospheric precipitation, with which pollutants arrive. Also, low water temperatures and their ultraprecious nature cause weak self-purification ability of water bodies. On this basis, lake water quality assessment becomes relevant and necessary for early detection of aquatic habitat degradation and general disturbances in the aquatic ecosystem (Madibekov et. al., 2018).

Materials and research methods

Man uses water in many spheres of his life. Water sources are evaluated according to various hygienic characteristics, the most important among which are the following: water quality, its exposure to anthropogenic (social) and natural factors, as well as the sanitary reliability of the source, that is, its resistance to anthropogenic and natural factors. Water source is characterized by properties of water and its composition. Data on the composition and requirements of water consumers form the basic requirements for water quality. Each object has certain quality values, and the type of use - quality standards. The quality control of used water is understood as its compliance with the main characteristics of the water source to the existing standards.

The great diversity of the composition of natural waters does not allow applying generally accepted norms in a number of places. As a consequence, sometimes local norms corresponding to the average composition of waters widespread in the area are used. There are relatively many such norms of local importance. Proposed at different times by a number of organizations and individual specialists, they are based mainly on observations of the quality of waters used in a particular locality.

Water quality standardization is to establish a set of allowable values of indicators of composition and properties within which public health, favorable conditions of water use and environmental wellbeing of water body are reliably ensured. Water quality class — water quality level established in the range of numerical values of properties and composition characterizing its suitability for specific type of water use.

Each of the water quality indicators in isolation cannot serve as a measure of water quality because it does not allow to judge the values of other indicators, although sometimes indirectly related to some of them. The result of water quality assessment should be some integral indicators that encompass the main indicators of water quality for use, and simplified tools for water quality assessment are needed for the safe management of water resources.

An integrated water quality indicator should be a mathematical tool used to convert the complex influence of large multi-parameter water quality indicators into unambiguous indices that simplify the expression of water quality status (Agbasi and Egbueri, 2022). It is useful to facilitate informing the public and legislative decision makers to establish a

common reference frame for different water bodies (Xu et. al., 2014). Despite the efforts and ongoing discussions of indices around the world, it is extremely difficult to develop a universally acceptable general water quality index (Bordalo et. al., 2014). On this basis, in the development of criteria for assessing the water quality of Markakol lake, the task is to determine the criteria to assess the quality of lake water in relation to the territory, the resource of which is determined (Ismailova, 2015). Thus, the integral assessment of water quality of Markakol lake was carried out according to physico-chemical and toxicological parameters. Such assessment is based on the existing developments, but due to a number of objective reasons it is extremely simplified, contains limited data, which in turn is representative for each indicator. Integral assessment of water quality of Markakol lake was made with the use of values of pH of water, total mineralization, total hardness of water and the complex index of water pollution ($CIWP_{hc}$), taking into account the hazard class, based on the group of toxic ingredients on the signs of the hazard class.

Thus, an integral assessment of hydrochemical parameters, taking into account the importance of each indicator, where the application of the integral assessment of water quality of water bodies is based on the use of private assessments of individual indicators of water composition and properties to obtain a comprehensive assessment of water quality as a single number and transition to a dimensionless indicator (Romashova, 2013).

A separate block is the assessment of the quality of water bodies according to toxicological indicators, since toxic pollution is one of the most dangerous manifestations of anthropogenic impact on aquatic ecosystems, leading to the poisoning of the aquatic environment and its inhabitants (Ismukhanova et. al., 2022). Toxicants usually enter water bodies with wastewater and atmospheric precipitation. When toxic pollution is detected, assessment of water quality is carried out on the basis of data on changes in individual parameters and the frequency of their excess in relation to the established standards - Maximum Allowable Concentration (MAC). In our work, assessments of water quality were made according to the class of danger, according to the methodological recommendations given in (Burlibayev, 2012).

Each element was evaluated by water use norms and an integral coefficient (δ) and degree of importance was assigned to them. According to the degree of importance for water use, total salinity was evaluated as follows - 5, total hardness - 4, $CIWP_{hc}$ - 3, pH - 2.

In view of the fact that the classification characteristics of mineralization are of great variety (ST RK GOST R 51232–2003, 2008; Cherkinsky, 1965; Nikanorov and Yemel'yanova, 2001; Burlibayev, 2012; Sanitarnye pravila, 2015; Alekin, 1970), in accordance with the requirements of different types of water use for evaluation, the classification was adopted by the approved order of the Chairman of the Committee on Water Resources of the Minister of Agriculture of the Republic of Kazakhstan dated November 9, 2016 № 151 (On approval of the unified system of water quality classification in water bodies, 2016), the adopted integral coefficients for total water salinity are given in Table 1.

Table 1 - Water quality class by salinity and integral coefficient

Water quality classes	Mineralization		Integral coefficient δ1
	mg/l	classification	
Conditionally clean	≤1000	fresh	5

Good quality	1000	mildly salty	4
Satisfactory	1300	brackish	3
Not satisfactory	≥2000		2

Along with the total mineralization the hardness of water is of great importance, determined mainly by the content of bicarbonates, sulfates and chlorides of calcium and magnesium. Water with a total hardness of more than 7 mg-eq/l has unfavorable hygienic properties. Soap foam does not form well, and in connection with this water is unsuitable for washing and washing. Meat, vegetables and pulses are worse boiled in hard water. Large economic losses are associated with the use in industry and thermal power industry water with high removable hardness, as in boilers and pipes during boiling scale is formed as a result of the transition of bicarbonates into insoluble carbonates (Cherkinsky, 1965). Depending on the hardness value, the following gradations of natural waters can be distinguished, which are shown in Table 2.

Table 2 - Water quality class by hardness and integral coefficient

Water quality classes	Hardness		Integral coefficient δ2
	mg-eq/l	classification	
Conditionally clean	<1,5; 1,5-3,0	very soft	5
Good quality	3,0-6,0	medium-hard	4
Satisfactory	6,0-9,0	hard	3
Not satisfactory	>9,0	very hard	2

According to the requirements for the quality of drinking water, the presence of harmful impurities in excess of their natural content is unacceptable (Alekin, 1970). Therefore, the calculation of a complex index of water pollution ($CIWP_{hc}$), taking into account the class of danger are based on indicators characterizing different degrees of danger of chemical compounds for humans, depending on the toxicity, cumulative, ability to cause long-term side effects in relation to the limiting indicators of harmfulness. According to the methodology (Burlibayev, 2012), heavy metals and nutrients exceeding the norm were taken into account when calculating the $CIWP_{hc}$ (Table 3).

Table 3 - Water quality class by $CIWP_{hc}$ and integral coefficient

Water quality classes	$CIW_{Ph}C$		Integral coefficient δ_3
	value	classification	
Conditionally clean	≤2,0	regulatory-clean	5
Good quality	2,1-6,0	moderate	4
Satisfactory	6,1-10,0	high profile	3

Not satisfactory	≥10,1	extremely high levels of contaminated	2

The chemical composition of natural waters is a complex set of mineral and organic substances in different forms of ionic-molecular and colloidal states. Hydrogen ions (pH), being in natural waters in very small amounts, but playing a very important role in chemical and biological processes occurring in natural waters, occupy a special position. The classification according to pH value according to (Tshai et.al., 2001) is given in Table 4.

Table 4 - Water quality class by pH value and integral coefficient

Water quality classes	pH		Integral coefficient δ_4
	value	classification	
Conditionally clean	7,5-8,5	weakly alkaline	5
Good quality	6,5-7,5; 8,5-	neutral, alkaline	4
Satisfactory	5,0-6,5; 9,5	slightly acidic, strongly alkaline	3
Not satisfactory	<3; 3,0-5,0	strongly acidic, sour	2

In accordance with the accepted integral coefficients and assigned degrees of importance, the integral characteristic (S) for the lake is calculated according to the following formula:

$$S = 5\delta_1 + 4\delta_2 + 3\delta_3 + 2\delta_4 \quad (1)$$

δ_1 - integral coefficient of total mineralization;
δ_2 - integral coefficient of total hardness;
δ_3 - integral coefficient of $CIWP_{hc}$;
δ_4 - integral coefficient of pH.

According to the results of calculations, we determine the quality class of water in the lake, which is an integral characteristic of water for use (Table 5).

Table 5 - Water quality class by integral characteristic

Water quality classes	Mineralization	Hardness	$CIWP_{hc}$	pH	Integral coefficient S	Estimates of the integral coefficient
Conditionally clean	25	20	15	10	70	57-70
Good quality	20	16	12	8	56	43-56
Satisfactory	15	12	9	6	42	29-42
Not satisfactory	10	8	6	4	28	<28

The resulting integral characteristic of water makes it possible to assess the pollution and quality of surface waters, condensing the original information on a wide range of the most informative hydrochemical parameters, including heterogeneous in their properties, in order to obtain a single-valued assessment.

Results

According to the results of analysis of available monitoring data (2000–2020) of the State observation network "Kazhydromet" water of Markakol lake is ultra-pretty, general mineralization varies from 38.7 (2010) to 116 mg/l (2002), general hardness 0.44-1.17 mg-eq/l, very soft. Changes in total salinity and water hardness for the period 2000–2020 is shown in Fig. 1.

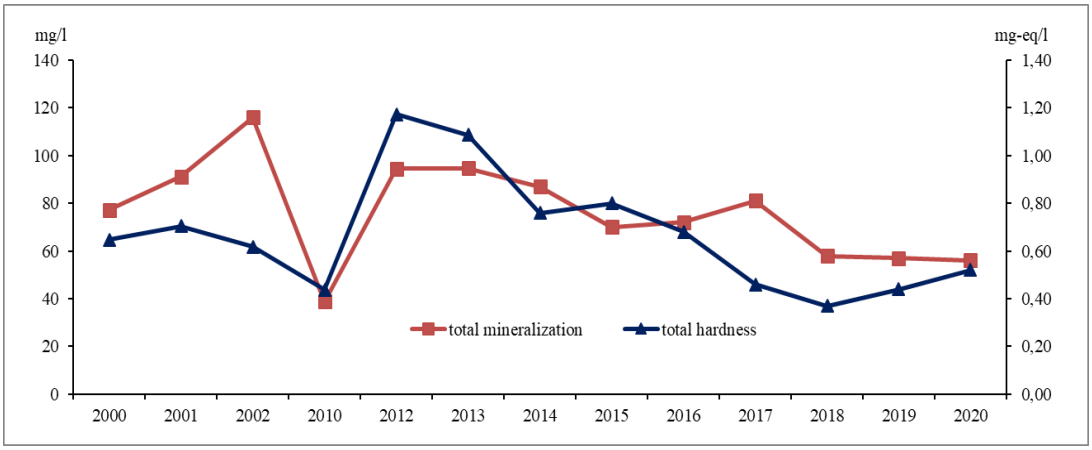

Figure 1 - Dynamics of total mineralization and hardness of Markakol lake water

According to the ionic composition, the water of Markakol lake belongs to the hydrocarbonate class of the calcium group (Fig. 2). Relatively high values of lake water salinity - 111 and 119 mg/l were in 2002 and 2008 respectively. The water salinity for the lake as a whole ranged from 38.0 to 93.0 mg/l.

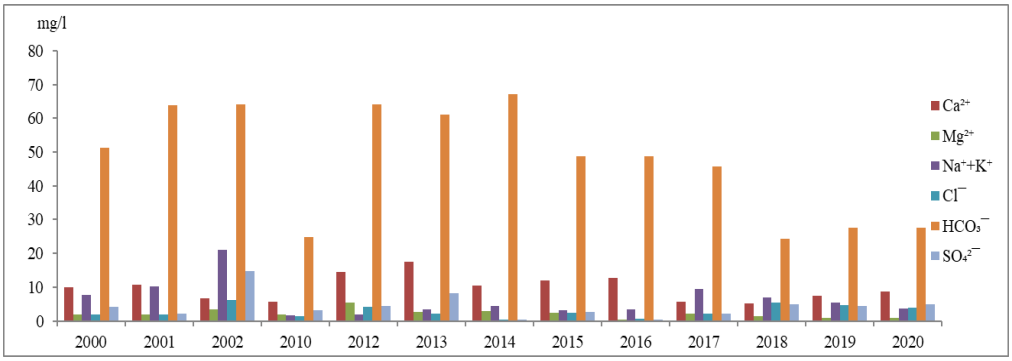

Figure 2 - Dynamics of the ion-salt composition of Markakol lake water

According to the approved unified system of water quality classification in water bodies of the Republic of Kazakhstan (On approval of the unified system of water quality classification in water bodies, 2016), the water of Markakol lake belongs to the “very good” class and is considered suitable for all types of water use. However, the use of excessively demineralized (soft), and especially distilled water is also unfavorable for the body. Such water has reduced taste properties. Its prolonged use for drinking disturbs regulation of water-electrolyte balance, causes increase of electrolytes content in blood serum and urine with their accelerated excretion from the body, decrease of osmotic resistance of erythrocytes, changes in cardiovascular system. According to scientists, water with a total mineralization of less than 100 mg/l is not recommended for drinking purposes (Alekin, 1970). On this basis, according to the developed integral assessment lake water is estimated conditionally pure, and are assigned integral coefficients to the total mineralization and water hardness - 5, degree of importance 5 and 4, respectively.

The general and basic requirement imposed on drinking water is the unconditional absence in it of chemical compounds harmful to the human organism (Alekin, 1970). Taking into account the maximum compliance with the requirements of various water consumers (water users), groups of pollutants (heavy metals and nutrients) were involved in the calculation process to calculate the CIWP. To strengthen the role of pollutants in determining their level of impact on water potential, the calculation of the water pollution index ($CIWP_{hc}$) was based on a list of polluting ingredients according to their hazard class. It should be emphasized that the complex index of water pollution is determined only with the ingredients that exceed their own MAC. For the period from 2000 to 2020, exceedances of standards were recorded for copper from 1 to 7 MAC (2002), ammonium nitrogen from 2010 to 2013 from 1.7–7.5 MAC. The dynamics of concentrations of nutrients and heavy metals in water from 2000 to 2020 are shown in Fig. 3, 4.

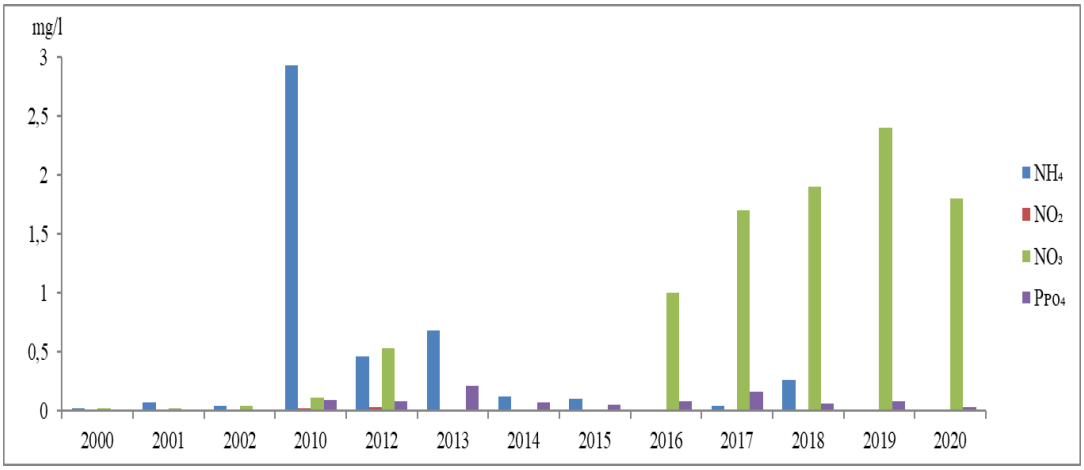

Figure 3 - Dynamics of the concentration of nutrients in the water of Markakol lake

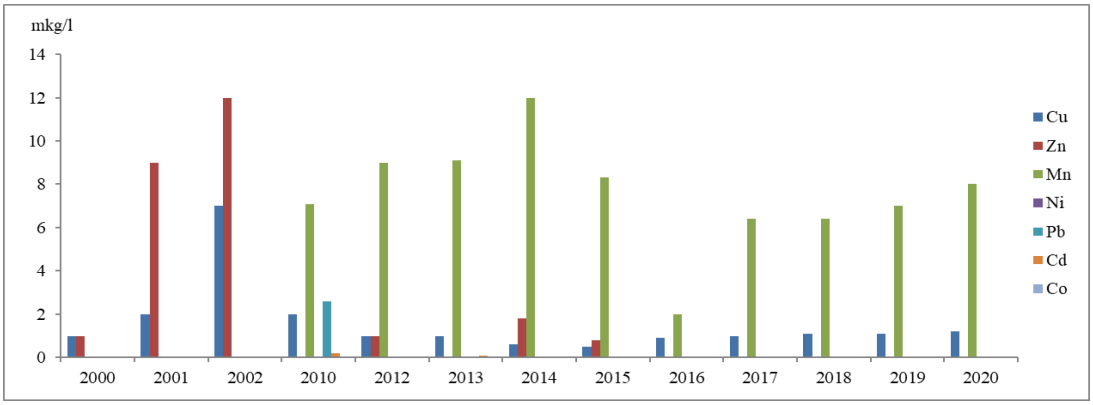

Figure 4 - Dynamics of concentration of heavy metals in the water of Markakol lake

Established by numerous medical-biological and sanitary-epidemiological studies of the predominant health effects of the polluting ingredients of the first and second classes of danger in the water of Markakol lake within normal limits. $CIWP_{hc}$ of Markakol lake refers to the normative clean class, and is based on the fact that the level of pollution on average meets the criterion of ≤1 (Fig. 5). According to calculations, in many cases of CIWP determination, concentrations of many pollutants in the lake water are equal to their MAC criteria or the absence of multiplicity of exceeding of MAC is fixed. Integral coefficient by $CIWP_{hc}$ of Markakol lake is equal to 5, the hazard degree to 3.

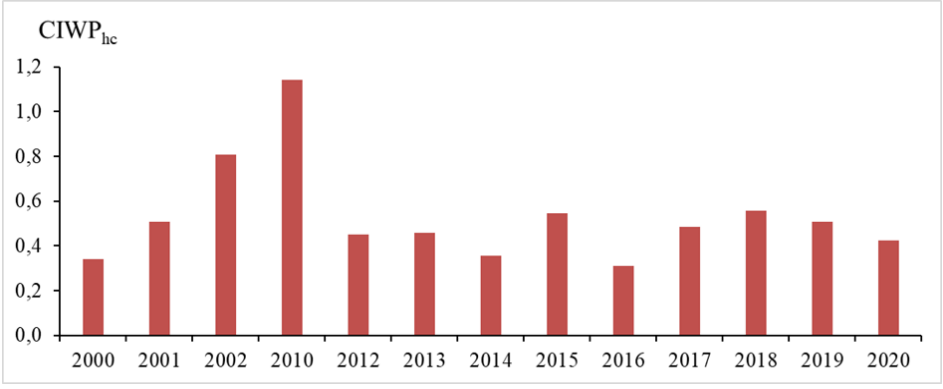

Figure 5 - The dynamics of the complex index of water pollution by hazard class of Markakol lake

Hydrogen index of lake water varies from neutral - 7.2 (2010) to slightly alkaline - 8.0 (2013), according to the average long-term pH value of Lake Markakol water (Fig. 6) is characterized as slightly alkaline, and is assigned an integral factor - 5, degree of importance - 2.

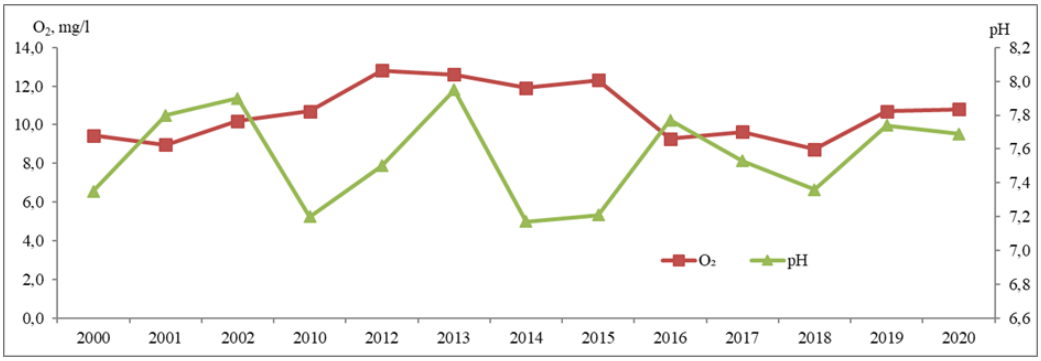

Figure 6 - Dissolved oxygen content and pH of Lake Markakol

According to the considered data of ecological monitoring of RSE "Kazhydromet", the concentration of dissolved oxygen in water varied within insignificant limits from 8.73 to 12.8 mg/l, water saturation with oxygen averages 89 %, which favorably affects the vital activity of aquatic organisms. The results of the developed integral assessment of water quality of Markakol lake by physicochemical and toxicological parameters are given in Table 6.

Table 6 - Water quality class by integral characteristic

Parameters	Value	Integral coefficient	Level of importance	Integral characteristic	Water quality class
Mineralization	76.4	5	5	70	1 (conditionally clean)
Total hardness	0.67	5	4		
CIWP with the hazard class	0.53	5	3		
pH	7.5	5	2		

Conclusion

The pH value in the water of Markakol lake during the studied periods varies from neutral to slightly alkaline reaction. The oxygen regime of the lake is favorable for the life activity of flora and fauna.

Biogenic compounds in the lake water with insignificant excesses were present in the studied years. According to the presence, quantity and ratio of nitrogen compounds in the water it is possible to judge about the degree and duration of water pollution by products of organic origin. According to the ionic composition, the water of Markakol lake belongs to the hydrocarbonate class of the calcium group. In general, the lake water is fresh, with minor fluctuations, the exception is 2010, when the mineralization of water was low - 38.0 mg/l, this is probably due to the abundance of precipitation in the area, which led to an increase in the volume of water in the lake.

The results of the analysis of the literature, scientific and project data allows to conclude that in recent decades the lake ecosystem has been experiencing a number of adverse factors, which include pollution by animal wastes, chemical and toxicological pollution of water and soil, overfishing, poaching of salmonid fish inhabiting it, invasion of alien species (Proceedings of the Institute of Hydrobiology and Ecology, 2017; Biological rationale for the program, 2021).

Based on the conducted integral assessment, we can conclude that the hydrochemical and toxicological regimes of Markakol lake generally meet the regulatory requirements and belong to class 1 (conditionally clean).

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www:nauka-nanrk.kz
ISSN 2518-1483 (Online), ISSN 2224-5227 (Print)
http://geolog-technical.kz/en/archive/

Подписано в печать 15.06.2024.
Формат 60x88 1/8. Бумага офсетная. Печать - ризограф.
15,0 п.л. Тираж 300. Заказ 3.

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