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**G. M. SHYKHALEYEVA**<sup>1</sup>, PhD (Chemistry),

Leang Researcher of the Environmental Monitoring Department

e-mail: [i.l.monitoring@ukr.net](mailto:i.l.monitoring@ukr.net) ORCID ID: <http://orcid.org/0000-0002-1475-4415>

**Yu. Yu. YURCHENKO**<sup>1</sup>, PhD (Biology),

Senior Researcher of the Environmental Monitoring Department

e-mail: [sscu@ukr.net](mailto:sscu@ukr.net), [i.l.monitoring@ukr.net](mailto:i.l.monitoring@ukr.net) ORCID ID: <https://orcid.org/0009-0006-1132-052X>

**G. M. KIRYUSHKINA**<sup>1</sup>,

Senior Researcher of the Environmental Monitoring Department

e-mail: [i.l.monitoring@ukr.net](mailto:i.l.monitoring@ukr.net) ORCID ID: <http://orcid.org/0000-0003-4445-9879>

<sup>1</sup>*Physical-Chemical Institute of the Environment and Human Protection of the Ministry of Education and Science of Ukraine and the National Academy of Sciences of Ukraine,  
3, Preobrazhenska Str., Odesa, 65082, Ukraine*

## **THE HISTORY OF RESEARCH AND STATUS OF STUDY OF HYPERHALINE KUYALNYK ESTUARY GEOECOSYSTEM (UKRAINE, NORTH-WESTERN BLACK SEA)**

The work is devoted to the comprehensive analysis of studies of one of the oldest estuaries of North-West Black Sea — the hyperhaline Kuyalnyk Estuary (an analogue of the Dead Sea in Ukraine). The interest for its study is determined by the richness of its mineral and balneological resources. The special attention attracts the valuable sulphide muds, which value, according to preliminary estimates, is about 7 billion dollars. Currently estuary is suffering from an ecological disaster: it is drying up, its morphometric characteristics are changing catastrophically (the water area surface and the depth are decreasing), the brine mineralization reaches 300 ‰ or more, and the salt from the exposed bottom of the estuary is transported to considerable distances, which threatens the salinization of agricultural lands and homesteads of coastal settlements. In such conditions the estuary loses the ability to restore its invaluable natural resources. Comprehensive information on the assessment of Kuyalnyk Estuary state and the state of its resources is extremely important for the development of measures for protection, restoration and preservation of this unique treasury of natural resources and the implementation of strategy for their rational use.

For the first time, we carried out a critical analysis and generalization of Kuyalnyk Estuary geoecosystem research results for the over a nearly 200-year period (1829-2020). Here are highlighted the main stages and reflected directions of research, presented their chronology. The research and publishing activities are also highlighted. The role and the work of societies members which were created at the Imperial Novorossiysk University (now the Odesa National University named after I.I. Mechnikov) in direction of research into the nature of Odesa estuaries, and in particular Kuyalnyk Estuary, its mineral and balneological resources, are discussed. The contribution of scientific organizations and scientists to development of research on the current stage were also analyzed. The main attention is paid to the fundamental complex research of the geo-ecosystem of Kuyalnyk Estuary. It was shown that the modern period is characterized by quite powerful system of data collection and intensive accumulation of knowledge about this unique reservoir. This made possible to generalize the material accumulated over these two centuries, which was reflected in the work started in 2018. "Encyclopedia of Kuyalnik estuary" (in 8 volumes) was published by the Physical-Chemical Institute of Environmental Protection of the Ministry of Education and Science of Ukraine and the National Academy of Sciences of Ukraine.

**KEY WORDS:** *geoecosystem of Kuyalnyk Estuary, history of research, state of research*

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## Introduction

The Kuyalnyk Estuary (KE) is a valuable natural object of national and international importance [1–6]. It is characterized by significant recreational and touristic, balneological (sulfide mud, the value of which is about 7.5 billion USD, healing brine, table mineral water) resources. KE is included in the list of the 14 most valuable estuarine complexes of the Black Sea region of Ukraine. The recreational capacity of KE and the balneological value of "Kuyalnyk" resort located in its southern end are increased by the close location of the Black Sea (about 2 km), a favorable microclimate, which is characterized by a combination of the influence of the sea and the estuary valley wide steppe territories. As a result air is saturated with sea salts and phytoncides of seaweed and vascular plants of the estuary valley, among which about 60% of the species have medicinal properties. In addition the recreational attraction increased by diversity of the landscapes, wonderful views, sandy beaches and the proximity of the world-wide known cultural center – the city of Odesa [3–6].

Its slopes of varying steepness are represented by relatively well-saved untransformed areas covered by fescue-feather grass steppe communities; and flat areas are covered by saline-meadow and salt-marsh vegetation [5, 7]. The decision to create the Kuyalnyk National Nature Park on its territory within the Emerald Network of Europe (Decree of the President of Ukraine No. 3/2022) is another recognition by the State of the uniqueness of this nature creation and the value of its natural resource potential.

Unfortunately, over the past two decades, the ecological condition of KE has deteriorated catastrophically: heavy metals are

present in all natural components of the geocosystem, the morphometric characteristics have changed (the length has shortened, the water level has decreased, the water area surface and the volume of water also have decreased). The brine mineralization in most cases exceeds 300 or more ‰ – is exists a real threat of irreversible loss of balneological resources and the resort "Kuyalnyk" itself, occurs salinization of agricultural lands and homesteads of coastal settlements, as well as desertification of ~ 30 km<sup>2</sup> of the Berezivskiy and Odesa districts territory of Odesa region due to climate change and excessive anthropogenic pressure on the water area and the catchment area of the estuary [8–18].

The replacement of natural communities species by synanthropic species resistant to anthropogenic influence is observed [3, 5, 19–21]. These processes are intensified by aridization of the climate, which leads to the threat of steppe coenoses destruction. Preservation, multiplication and rational use of the natural resources of this unique reservoir is an important task of the socio-economic development of Ukraine. The elaboration of a strategy for the rational use of its unique natural potential is impossible without detailed information about the natural components of the estuary geo-ecosystem.

This work is devoted to the generalization, systematization and analysis of publications concerned to comprehensive research of the KE geocosystem for almost two hundred years (1829-2022). Also, it is evaluated the publications dynamics and the development of priority research fields.

## Materials and methods

The informational basis of this article were archival, reference and original materials and literary sources devoted to the study of the KE and natural complexes of the surrounding

territories for the period 1829-2022. In total, more than 650 literary sources were analyzed (theses of reports on various levels conferences, symposia and congresses, the articles in

scientific journals and newspapers, books, reference publications). The funds of the Odesa National Scientific Library, the scientific library of Odesa National University named after I.I. Mechnikov, the libraries of Odesa State Ecological University, the Institute of Marine Biology of the National Academy of Sciences of Ukraine, Physical-

Chemical Institute of Environmental and Human Protection of the Ministry of Education and Science of Ukraine and the National Academy of Sciences of Ukraine, the databases of the National Library of Ukraine named after V.I. Vernadsky, as well as publications on the Internet were used in the preparation of this article.

## Results

The Kuyalnyk Estuary, as one of the most old ones on the Northwest Black Sea has attracted attention from the ancient times. The first documented memories of KE can be found in Polish chronicles of the 16th century and Lithuanian chronicles, in particular in the documents of King Sigismund and Crimean Khan Sagyb-Girey [22]. Later references to the location of Odesa estuaries can be found in the works of the famous cartographer Joseph Billings entitled "Description of the Black Sea Coasts stretching from Akhtiar to Kuban' and from Akhtiar to Ovidiopolis" (1797). These data were used in the compilation of Budishchev's maps (1812).

The estuary is often mentioned in the works of Hepites (1839) and Boplan (1650) [23], but they are interesting mostly from a historical point of view. From the end of the 18th century. Khadzhibey and Kuyalnyk Estuaries attracted interest as useful harbors for sea vessels [22]. In 1817 the duty-free import and export of goods (porto-franco) was introduced in Odesa and implemented in 1819, and Odesa became the center of Black Sea trade, contributing to the settling and development of the lands of southern Ukraine. The finding in 1910 of an iron four-legged "Genoese" anchor of the 12th century in Kuyalnyk Estuary testified the parking of medieval sea vessels in the estuaries. In 1915 another iron anchor dating back to the 13th century was found 4 miles from the coast [24].

In fact, the first studies of the Odesa estuaries, mainly geographical investigations, date back to the first half of the 19th century [22]. Single hydrochemical observations of brine in KE were carried out in the twenties of the 19th century by Prof. I. Vitzman [25], and the estuary mules – in the middle century of century by prof. Chr. Gassagen [26].

The earliest mentions of the vegetation cover of the Northern Black Sea region are mainly in the works of travelers and ancient Greek scientists (end of the XVII century) reflected. The Black Sea steppes are generally in Boplan's work "Description of Ukraine" (1650) described [23].

A more detailed description of the flora of southern Ukraine and the Black Sea region is given in the works of P. Pallas (1771-1776) [98-99]. However, the greatest contribution to the study of the flora of the Black Sea region was made by L.S. Shesterikov, E.E. Lindeman, M.K. Sredinsky, V.I. Lipsky [5, 23].

From the second half of the XIX century by branch of the Novorossiia Society of Naturalists began detailed local studies of Odesa estuaries, that were concerning mainly the Kuyalnyk and Khadzhibey estuaries, which were located in their southern parts within the boundaries of Odesa city administration. The commission of the Novorossiia Society of Naturalists for the study of the Odesa estuaries included, in particular: O. A. Verigo, I. F. Sintsov, F. M. Kamenskiy, P. M. Buchynskiy, M. P. Rudskiy, E. M. Brusilovskiy. The publications of this period are covered in the reference edition [23]. The most valuable work on KE study in geodetic field was the work of A.S. Vasiliev [27], in which the author examined the bottom sediments by laying out a number of profiles, dividing them into separate varieties. According to the results of research of A.S. Vasiliev were compiled the topographic maps of KE, which formed the basis of all subsequent geographical studies of the estuary [28-29].

Physical-chemical and analytical studies of brine and sediment samples selected by profiles were carried out under the supervision of O.O. Lebedintsev and O.A. Verigo respectively [23, 30-31].

The geological and hydrogeological aspects of the study of the Odesa estuaries for that period were reflected in the works of M.P. Rudskoy (1895), I.F. Sintsov (1795, 1894), M.A. Sokolov, [1895–1896 [3, 5, 23], biological aspects – in the works of G.N. Buchinskiy (1885, 1895, 1897) and I.G. Shmakov (1867) [3–5, 23]. The results of petrographic studies of the silt of KE were highlighted by M.D. Sydorenko (1897) [23].

It should be noted that in that period the main interest was the issue of the maximum use of KE as a resource for salt extraction. The information on the salt industry is given in the works of A.O. Skalkovsky. (1849, 1850, 1853), I.O. Komarov (1858), P.O. Shostak (1865), V. Rozhkov (1859), L. Pershke (1880, 1882) [3, 23]. But already then there was a conscious interest in estuary as a balneological resource. This was reflected in the works of doctors and prominent scientists of the second half of the 19th century: B.Ya. Abrahamson (1850), O.O. Mochutkovsky (1883), F.I. Yahimovich (1889), E.S. Andreevsky (1892), O.A. Verigo (1880, 1887, 1896), D.K. Zabolotny (1892), E.M. Brusilovskiy (1894), A.A. Lebedintsev (1896) [3, 5, 23, 30]. It should be noted that all balneological researches were conducted strictly under the control of Odesa Balneological Society, the initiator of its foundation (1876) was bacteriologist Y.Y. Mochutkovskiy. He headed the society in the period 1877-1893 and played a significant role in studying the healing properties of Odesa estuaries and developing the scientific basis of “estuarine treatment” [23]. An active associate of Y.Y. Mochutkovsky and the most active member of the Odesa Balneological Society since its foundation was the outstanding chemist O.A. Verigo, who in 1877 began researching of brine and mud of Odesa estuaries, in particular the KE [23, 31]. Analyzing the composition of organic acids in mud, he came to the conclusion that it is the microorganisms exactly take an active part in the processes of mud formation. In further research he concluded that the mud formation process cannot occur without microorganisms. In fact, prof. O.A. Verigo was the first to develop a scientific technology for restoring of estuarine mud from its dry substrate with the help of microorgan-

isms and proved the biochemical nature of mud formation processes [31].

In general, during that period, the Odesa branch of the All-Russian Technical society (1866), whose members included industrialists, entrepreneurs, architects, artists, doctors, and scientists, played a huge role in the preparation of the fundamental base for research work on radiology, spa medicine, and balneology. At the meetings of the Technical society, together with the members of the Odesa Balneological society, the issues related to the expansion and reconstruction of Odesa resorts were discussed. Among them was the decision to build a mud hospital on KE.

The beginning of the XX century was marked by a number of major works on the geology and hydrogeology of Odesa estuaries [33–34]. From a practical point of view, the works on the study of groundwater in this area were interesting [35].

In 1901 M.D. Sydorenko conducted a petrographic study and lithological description of the surface sediments of the Kuyalnyk-Khadzhibey sand bar, and in 1925 G.I. Potapenko published a note on the lithological study of the Kuyalnyk sand bar [5, 23].

The vegetation of the region at the beginning of the 20th century studied I.K. Pachoskiy, G.I. Potapenko, G.I. Bilyk et al. [3, 5, 36].

Information on the study of herpetofauna in the vicinity of Odesa (including the Odesa estuaries) at the beginning of the XX century was most fully reflected in the works of O.O. Browner, B.E. (1906), Volyanskiy (1928) [23].

This period is also characterized by increased interest in the healing factors of the Odesa estuaries. In 1927, the Academy of Sciences of the Ukrainian SSR created the “Lake Commission” for a comprehensive study of the Odesa estuaries and their treatment facilities.

In 1910, by the initiative of the outstanding geochemist and radiologist E.S. Burkser, the first radiological laboratory in Russia was created in Odesa. The work started in 1911. In laboratory were conducting investigations of radioactivity of water, silt, rocks and natural objects of Odesa estuaries, well waters and water from the Odesa aqueduct [3, 23].

In 1931, the Ukrainian Geological Exploration Trust organized a comprehensive research of KE estuary with the aim of studying the bottom sediments and counting the reserves of therapeutic mud for the expansion of the mud base of the Kuyalnyk resort. During the expedition, 1,036 boreholes with a depth of 2.5-25 m were laid at the bottom of KE. Employees of the Ukrainian Scientific Research Institute of Resort Therapy (today Ukrainian Research Institute of Medical Rehabilitation and Resort Therapy of the Ministry of Health of Ukraine) – E.S. Burkser, L.O. Rubenchyk, D.G. Goykherman, M.A. Zahorovskiy, V.V. Stepanov, M.V. Komar, P.I. Goncharov, D.I. Sklyaruk – took an active part in this work [3–4, 23].

It should be noted that the great merit in the comprehensive study of the Odesa estuaries of that period belongs to M.A. Zagorovskiy, who carried out an extremely large volume of research on physical geography, geology, hydrobiology, the history of the study of Kuyalnik and Khadzhibey estuaries, the rational use of their medicinal natural resources [23].

An important factor in the development of climate research was the creation of the hydrometeorological service in Ukraine (1921). From the 1930, hydrometeorological data began to be published in «Hydrological Annuals». The data on microclimatic characteristics of Odesa resorts for that period were reflected in the works of G.I. Tanfilyev, V.O. Pal'chinskiy, I.Ya. Tochidlovskiy, etc. [23].

Most of the publications of the first half of the XX century aimed at solving the practical problems regarding the rational use of balneological resources of the estuary, the impact of changes in its hydrological and hydrochemical regime on biocenoses and their productivity.

Because of the Second World War all researches during the war years were pause a little, but the post-war period (the second half of the XX century) was characterized by the intensification of research of the Odesa estuaries balneological resources, in particular Kuyalnyk Estuary [23].

The foundation of systematic studies of algae, as an important producer of the organic mass of estuary peloids was laid by I.I.

Pogrebnyak. By results of long-term research he (1931-1962) evaluated the dynamics of the structural organization of algae communities under conditions of different salinity of water in estuary [4]. Algological studies (1983-1989), namely the diatom algae, continued by students of I.I. Pogrebnyak: M.O. Guslyakov and V.P. Gerasimyuk [4, 37].

In connection with the latest anthropic transformations, the design of water management complexes, and the development of nature protection research, research on the vegetation cover of the Kuyalnyk Estuary valley was being intensified. The fundamental works of L.V. Klimentov, E.M. Lavrenko, articles of L.A. Shaposhnikova, V.S. Tkachenko, O.V. Kostilyov and others appeared in 1960-1980 [3, 5, 36].

The study of resource potential of invertebrates was started by Yu.M. Makarov, which was reflected in his joint work with V.I. Lisovskaya publication «Artemia of Kuyalnik estuary as a fodder object for the development of maritime industry in the northwestern part of the Black Sea» [38]. That was the first work in which this very important and valuable biological resource began to be considered as an independent object of study and the most important biological resource of KE.

The hidrography and topography researches after works of A.S. Vasil'ev (1898) were continued by Black Sea Geological Survey Station (1961-1963), and the last survey was carried out in 1973-1975 by the Ukrainian Scientific and Research Institute of Resort Therapy. At that time the experts of the Odesa Hydrogeological Regime and Operation Station and scientists of the Odesa Hydrometeorological Institute, Odesa (today Odesa State Environmental University), State University named after I.I. Mechnikov and the Institute of Hydrobiology National Academy of Sciences of Ukraine were actively engaged in issues of the water regime. The results of these works are presented in the works of: E.D. Hopchenko et al. (1966), M. Sh. Rosengurt (1965), M. Sh. Rosengurt et al. (1967), G.I. Shwebs et al. (1996), I.F. Burlai, M.A. Panchenko (1965) and others [23].

As for hydrochemical research, it should be noted that regular monitoring of changes in the main salt composition of brine in KE was

started by the hydrogeological operational station in 1953 and concerned only the southern part of the estuary, mainly the area where the Kuyalnyk resort and the Korsuntsy salt mines were located. Since 1965 was added the polygon in the northern part of the estuary near village Kovalivka. In the period of 1973-1974 the mineralization of the estuary brine was studied during a detailed exploration and calculation of the silt stock carried out by the Ukrainian Scientific and Research Institute of Resort Therapy.

In that period, the generalization of long-term results already began, which was reflected in numerous monographs [39–44].

The first two decades of the XXI century. are characterized by the conduct of systematic complex synchronous interdisciplinary researches initiated by the Physical-Chemical Institute of the Environment and Human Protection of MES of Ukraine and NAS of Ukraine in connection with the catastrophic ecological state of KE geoecosystem, the need to implement measures aimed at restoring its water-salt regime, reproducing the biodiversity of the estuary valley, as well as developing a strategy for rational use mineral, balneological and biological resources in the interests of the socio-economic development of the city of Odesa and the Odesa region.

In order to assess the dynamics of long-term changes in the morphometric characteristics of KE, in 2003-2005, the specialists of the Institute measured the depths of the estuary along axial and 13 transverse profiles, the position of which was close as possible to the profiles made by A.S. Vasilyev in 1895-1899. The survey of the water cut was made every 20-100 m, depending on the tortuousness of the coastline. Clarification of the dynamics of changes in the coastline of the estuary was carried out in 2009-2010 [13].

Summarization of data on the dynamics of changes in morphometric characteristics of the estuary synchronously performed hydrochemical studies of the the estuary brine and its main watercourses, geochemical and biochemical studies of bottom sediments of the estuary and its watercourses, hydrobiological studies of the estuary, its watercourses and different types of water bodies of the

catchment basin, and geobotanical studies of the coast and coastal-slope areas reflected in a number of joint fundamental works of employees of the Physical-Chemical Institute of the Environmental and Human Protection of MES of Ukraine and NAS of Ukraine, M.G. Kholodny Institute of Botany of the NAS of Ukraine, Odesa I.I. Mechnikov National University [7–21, 36–37, 45–51].

The logical conclusion of the generalization and analysis of multi-year (2000-2018) systemic synchronous original studies of the natural components of KE geoecosystem and the literary data for the entire almost 200-year period was the publication of the Encyclopedia of Kuyalnik estuary (in 8 volumes), initiated by the Physical-Chemical Institute of the Environmental and Human Protection of MES of Ukraine and NAS of Ukraine which for the first time systematized the results of complex multi-year monitoring of natural components in the basin of KE. Volume 1 "Vascular plants of the coast" was published in 2018, in 2020 published volume 2 "Algae", in 2021 – the volumes 3 "Vegetation" and 4 "Medicinal plants" [3–6].

The first volume of the Encyclopedia contains a synopsis that includes information about the area, features of flowering and fruiting, morphological features and possibilities of economic use, the results of a comprehensive floristic analysis of 474 species of vascular plants that grow on the coast of KE, together with 26 species included in the protection lists of different levels and catalogs of international conventions; their geographical and ecological-phytocenotic analysis and recommendations for protection, reproduction and restoration. The second volume illustrates the results of systematic multi-year (2001-2018) studies of the diversity of algae in estuary basin, water area and coast, the dynamics of changes in the species composition, taxonomic structure, the dependence of species tolerance limits on modern abiotic factors against the background of periodic salinization of the reservoir over the 150-year study period. The results of the analysis of the algae distribution features in the estuary basin are presented. Also there were reflected the specifics of the species composition of these organisms, the characteristic coenotic and typological complexes

were illustrated, the long-term and seasonal successions of their species diversity, the adaptation possibilities of individual species and leading algal groups under the conditions of dynamic changes in the hydrological and hydrochemical regime of the estuary were evaluated. A consolidated list of algae of KE basin and the list of new and regionally rare taxa of its basin were created. 153 species were illustrated with 515 color and black-and-white photographs. The third volume of the Encyclopedia contains the general information about the vegetation of the valley of KE and the surrounding areas. For the first time, using modern information technologies, a holistic view of the vegetation cover of the mega-geosystem of KE was presented, a vegetation classification scheme based on ecological and floristic criteria was also presented, the results of a structural and comparative analysis of the coenoflora of higher classification units were presented too, ecological and coenotic profiles of the valley and geobotanical maps of its key territories were given. Considered issues of vegetation dynamics — its seasonal, fluctuating and multi-year changes and the forecast of probable changes that will occur under the influence of natural and recent anthropogenic factors. Zoological classification of vegetation was proposed and issues of its protection and ways of practical implementation were discussed. The fourth volume is devoted to medicinal wild plants, distributed in the valley of Kuyalnik estuary. A description of 328 species of medicinal plants found in the water area of the hyperhaline KE and its adjacent territories was given, their taxonomic affiliation, scientific and popular names were indicated, and the botanical characteristics were described. Special attention focused on the chemical composition,

pharmacological properties and medical use of these plants, species that have poisonous properties and require dosed use were noted. A separate section is dedicated to algae as a special group of medicinal plants that is actively being introduced into modern medical practice. Spatial distribution of common, highly poisonous and rare species of medicinal plants is presented on the maps.

The above-mentioned volumes of the Encyclopedia are illustrated with color photographs, mostly original.

During this period, geological and hydrological studies of KE were intensified by scientists of the Odesa National University named after I.I. Mechnikov, which was reflected in the articles of E.A. Cherkez, A.V. Medinets, S.V. Svetlychniy et al. [52–54]; hydrological and hydrometeorological studies in the basin of KE provided by Odesa State Environmental University scientists, which are reflected in collective monographs: in 2016, the collective monograph «Water regime and hydroecological characteristics of the Kuyalnitskyi Liman» was published [55], in 2021 – «Variability of the hydrological characteristics of the lagoons of North-Western Black Sea region under conditions of regulated water exchange with the sea (as applied to the Tylihulskyi Lyman and the Kuyalnitskyi Lyman lagoons)» [56]. Scientists of the Institute of Market Problems and Economic-Ecological Researches of the NAS of Ukraine and Ukrainian Research Institute of Medical Rehabilitation and Resort Therapy of the Ministry of Health of Ukraine in 2019 published a collective monograph «Kuyalnik estuary: realities and prospects of recreational use» [57].

## Conclusions

Summarizing the available materials, it should be noted that references to KE appear as early as the XVII-XVIII centuries and mainly reflect its location, have navigational and historical interest.

In the first half of the XIX century, KE was considered to a greater extent as an object of supplying salt to Europe, the publications of this period are a few.

In the second half of the XIX century the accumulation of information, mainly of botanical (floristic) orientation and balneological significance, publications devoted to the hydrology and hydrochemistry of the estuary, the chemical properties of brine and sulphide muds, are being discussed, and the issues of the salt industry are being discussed. The publications of this period are

more numerous (there are about 60 literary sources).

Most of the publications of the first half of the XX century aimed at solving practical problems regarding the rational use of natural resources of the estuary, the impact of changes in its hydrological and hydrochemical regime on biocenoses and their productivity. The consequences of the involvement of scientists from almost all areas of Earth and life sciences in the study of hyperhaline reservoirs are reflected in ~ 100 publications. Reference materials are periodically printed as separate brochures.

In the post-war years (the second half of the XX century), studies of the KE were gradually resumed, in particular, studies of its hydrochemistry, physico-chemical and microbiological properties of peloids continued, and the generalization of the results of studies of Odesa estuaries began. That was reflected in numerous monographs devoted to the study of Odesa estuaries [39–44].

The first two decades of the XXI century are characterized by large-scale complex synchronous studies of the aquatic and terrestrial ecosystem of the Kuyalnyk Estuary, which were initiated by the Physico-Chemical Institute of Environmental and Human Protection of MES of Ukraine and NAS of Ukraine because of the catastrophic ecological state of the estuary geo-ecosystem, the need to implement measures aimed at restoring its water-salt regime, reproducing the biodiversity of the estuary valley, as well as developing a strategy of rational use of mineral, balneological and biological resources in the interests of the socio-economic development of the city of Odesa and the Odesa region.

Scientists of the Odesa National University named after I.I. Mechnikov and Odesa State Ecological University during this period

paid serious attention to the issue of restoring the water regime of KE.

As a result, in two decades of the XXI century about 400 works were published, including monographs entirely devoted to KE [52–57].

Based on the results of summarizing the original comprehensive research for 2000–2018 and literary data for the almost 200-year period of research of Kuyalnyk Estuary the Physico-Chemical Institute of Environmental and Human Protection of MES of Ukraine and NAS of Ukraine launched the publication of the “Encyclopedia of Kuyalnyk Estuary” (in 8 volumes): in 2018, volume 1 “Vascular plants of the coast” was published, in 2020 – volume 2 “Algae”, in 2021 volume 3 “Vegetation” and volume 4 “Medicinal plants” also issued [3–6].

The main goal of this publication is the purposeful processing of comprehensive information that will contribute to the solution of many resource-economic, economic and environmental problems for the harmonious development and improvement of the investment attractiveness of Odesa region. The information presented in the Encyclopedia represents the scientific foundation of the strategy for the preservation, restoration and rational use of the natural resources of KE and the territory and its coasts (~70 km<sup>2</sup>), surrounding the area between estuaries (~165 km<sup>2</sup>) and the Khadzhibey-Kuyalnyk barrier beach (~28 km<sup>2</sup>), the prospects for their large-scale involvement in economic circulation in the interests of social and economic development of Odesa town and Odesa region. In addition, this publication is led to preserve the scientific knowledge gained over the centuries for future research and activities, due to the global nature of ecosystems functioning in problem regions, to which the Black Sea region belongs.

### **Conflict of interest**

The authors declare that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.



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Г. М. ШИХАЛЄЄВА<sup>1</sup>, канд. хім. наук,  
провідний науковий співробітник відділу моніторингу навколишнього середовища  
e-mail: [i.l.monitoring@ukr.net](mailto:i.l.monitoring@ukr.net) ORCID ID: <http://orcid.org/0000-0002-1475-4415>

Ю. Ю. ЮРЧЕНКО<sup>1</sup>, канд. біол. наук,  
старший науковий співробітник відділу моніторингу навколишнього середовища  
e-mail: [sscu@ukr.net](mailto:sscu@ukr.net) ORCID ID: <https://orcid.org/0009-0006-1132-052X>

Г.М. КІРЮШКІНА<sup>1</sup>,  
старший науковий співробітник відділу моніторингу навколишнього середовища  
e-mail: [i.l.monitoring@ukr.net](mailto:i.l.monitoring@ukr.net) ORCID ID: <http://orcid.org/0000-0003-4445-9879>

<sup>1</sup>Фізико-хімічний інститут захисту навколишнього середовища і людини  
МОН України та НАН України,  
вул. Преображенська, 3, м. Одеса 65082, Україна

## ІСТОРІЯ ДОСЛІДЖЕНЬ ТА СТАН ВИВЧЕННЯ ГЕОЕКОСИСТЕМИ ГІПЕРГАЛІННОГО КУЯЛЬНИЦЬКОГО ЛИМАНУ (УКРАЇНА, ПІВНІЧНО-ЗАХІДНЕ ПРИЧОРНОМОР'Я)

Надано всебічний аналіз досліджень одного з найстаріших лиманів Північно-Західного Причорномор'я – гіпергалінного Куяльницького лиману. Інтерес до його вивчення визначається багатством його мінеральних і бальнеологічних ресурсів, серед яких особливе місце посідають цінні сульфідні мули, вартість яких складає близько 7 млрд. дол. США. В даний час лиман висихає, катастрофічно зменшуються його морфометричні характеристики, мінералізація ропи сягає відмітки 300 проміле і більше, а сіль з оголеного дна лиману розноситься на великі відстані, що загрожує засоленням сільгоспугідь та присадибних ділянок прибережних населених пунктів. В таких умовах лиман втрачає здатність до відновлення своїх безцінних природних ресурсів. Всебічна інформація щодо оцінки стану Куяльницького лиману та його ресурсів вкрай важлива для розробки заходів щодо охорони, відновлення і збереження цієї унікальної скарбниці природних ресурсів і стратегії їх раціонального використання.

Вперше проведено критичний аналіз та узагальнення результатів досліджень геоєкосистеми Куяльницького лиману за майже 200-літній період (1829-2020 рр.), виділені основні етапи та відображені напрямки досліджень, представлена їх хронологія. Висвітлено дослідницьку, видавничу діяльність та розглянуто роль і роботу членів товариств, які були створені при Імператорському Новоросійському університеті (нині Одеський національний університет імені І.І. Мечникова), у напрямку досліджень природи одеських лиманів і зокрема Куяльницького лиману, його мінеральних і бальнеологічних ресурсів. Проаналізовано внесок наукових організацій та вчених у розвиток досліджень сучасного стану лиману. Головна увага приділена фундаментальним комплексним дослідженням геоєкосистеми Куяльницького лиману. Показано, що сучасний період характеризується доволі потужною системою збору та накопиченням знань про цю унікальну водойму. Це дало можливість провести узагальнення накопиченого за ці два століття матеріалу, що знайшло відображення в зачаткованому в 2018р. Фізико-хімічним інститутом захисту навколишнього середовища і людини МОН України та НАН України виданні «Енциклопедія Куяльницького лиману» (у 8 томах).

**КЛЮЧОВІ СЛОВА:** геоєкосистема Куяльницького лиману, історія досліджень, стан вивченості

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