

Estuaries as a component of the Black Sea monitoring system

V.O. Iemelianov (*Center for Problems of Marine Geology, Geoecology and Sedimentary Ore Formation of NAS of Ukraine*), **O.M. Ivanik** (*Taras Shevchenko National University of Kyiv*), **T.B. Kulaha** (*Center for Problems of Marine Geology, Geoecology and Sedimentary Ore Formation of NAS of Ukraine*)

SUMMARY

The Black Sea estuaries are unique natural formations that are important objects for the inhabitants of the region. They have a significant impact on their life, health and well-being. However, today the ecological conditions of these estuaries are critical, which requires systematic monitoring studies based on geocosystem methodology. The presented research identify some features of the state of geological and ecological subsystems of estuaries geocological systems and their surrounding, outline the main factors of violation of the state of the elements of estuarine geocosystems. In order to preserve the natural value of the estuaries, the main principles and approaches to comprehensive geo-ecosystem studies of these natural objects have been proposed. The application of the proposed approaches assumes that the geocosystem of estuaries is multistable; it features the dynamic transition zone between the sea and the continent (geocoton) and requires specialized methods to analyze its past and present state and predict the future changes. The structure of this system is space-time related. The spatial aspect reflects the order of elements in the system, time aspect corresponds to the changing in the system during the period of time and its dynamic. The ecosystem of estuaries is affected by significant natural and anthropogenic stresses and characterized by the pollutions of heavy metals.



Introduction

The estuaries of the Black Sea coast (Fig. 1) are unique geoecosystems that are important for the inhabitants of coastal areas. They have a significant impact on their livelihoods, well-being and health. They serve as a source of water for various needs, they are important objects for fishing, fish farming and navigation, balneological treatment, tourism and extraction of different types of minerals. The Black Sea estuaries are associated with the location of major seaports (Belgorod-Dniester sea trade port in the Dniester estuary, port "Southern" - in the Small Adzhalytsky (Grigoriv) estuary, port "Black Sea" (until 2016 - Illichivsk) commercial port - in the Suhly Estuary, the Dnieper-Bug Sea Commercial Port and the Port of Olbia - in the Dnieper-Bug Estuary). Today, the ecological state of all Black Sea estuaries is critical, which requires comprehensive monitoring studies based on a geoecosystem approach (Emelyanov et al., 2004). As a result of the conducted researches the ecological condition of geological-ecological subsystems of the specified estuaries is defined and the main factors of disturbance of an equilibrium condition of some elements of their geological environment are outlined. In order to preserve the value of their geoecosystems, the main principles and approaches to their comprehensive research are proposed, taking into account all components, their properties and peculiarities of interaction.

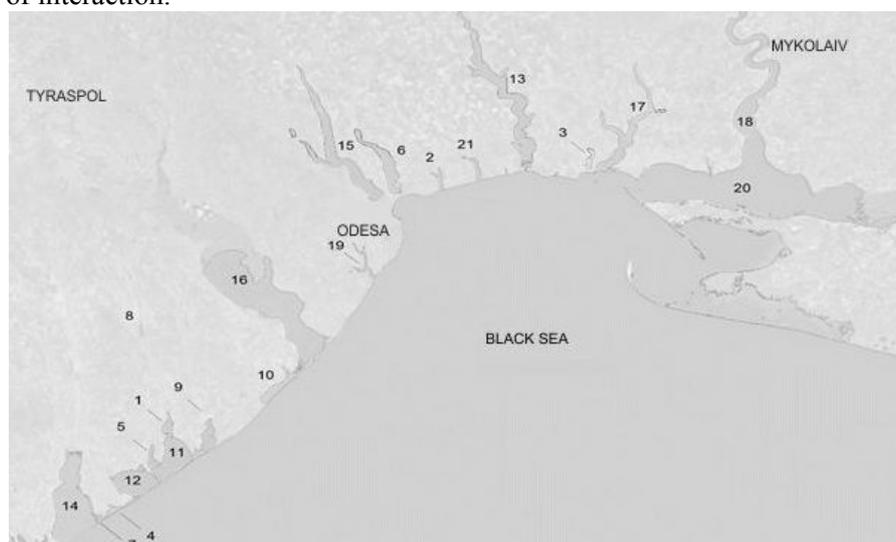


Figure 1 Estuaries of the northwestern coast of the Black Sea. Placement scheme (Minicheva and Sokolov, 2014; SASGIS): 1 - Hadzhider, 2 - Dafinivsky, 3 - Solonets Tuzla, 4 - Maly Sasyk, 5 - Karachaus, 6 - Kuyalnytsky, 7 - Dzhantsheysky, 8 - Kuchurgansky, 9 - Burnas, 10 - Budatsky, 11 - Alibey, 12 - Shagany, 13 - Tiligulsky, 14 - Sasyk, 15 - Hadzhibeysky, 16 - Dniester, 17 - Berezansky, 18 - Buzky, 19 - Suhly, 20 - Dnieper, 21 - Grigorievsky

Research and monitoring of estuaries as complex geoeological systems

The geoecosystem of estuaries is multistable, it features the dynamic transition zone between the sea and the continent (geocoton) and requires specialized methods of analysis of its current state and forecasting the changes in the future. The structure of this system is space-time related. The spatial aspect reflects the order of elements in the system, time aspect reflects changing in the system during the period of time and as a consequence - the movement of the system. Multistable systems consist of ultrastable systems, which provides stability due to the stability of each ultrastable subsystem.

World experience in the study of water systems confirms the effectiveness of modern integrated approaches to the analysis of different water objects. These principles are used to assess the water basins of the United States, Brazil, India and other countries. Thus, a group of scientists from Montana State University (USA), in order to study possible ways to preserve archaeological finds and remains of late Holocene vertebrates, have used this approach to assess the geoecosystem of the Marias River (left tributary of the Missouri River). In (Schmitt et al., 2017), the authors implemented this approach by studying the relationship between the mechanism of sediment transport (with



subsequent deposition), the state of the living component of the geocosystem of the reservoir and human activities. The geocological approach was used to analyze the Ganganeru River Basin (Balram et. al, 2013). Based on a consistent detailed study of all components of the geocosystem of the river, the authors assessed possible ways to optimize the use of natural resources of the reservoir. The paper (Silva et al., 2011) presents the results of geocological assessment and zoning of the estuaries of the northern coast of Brazil.

Dnieper-Bug estuary. The Dnieper-Bug estuary is an open estuary, which is the largest among the estuaries of the Black Sea coast. The aquatic subsystem of the geocosystem of the Dnieper-Bug estuary is characterized by free water exchange with the sea and a significant impact of annual runoff on the features of its aquatic environment. This factor is defined by researchers as the main one, which also affects the formation of the geological and ecological system of bottom sediments as a subsystem of the geocosystem of the estuary. In particular, the results of the study of the influence of annual runoff on the formation of modern bottom sediments are shown in several publications, where it is established that the factor of annual runoff reduction increases the salinity of the aquatic environment of the estuary and reduces its bioproductivity. Scientists from Odessa university studied the species composition of microalgae of the estuary, and also found that it is characterized by the largest species diversity (according to the latest data of 296 species) among the Black Sea estuaries (Gerasimyuk, 2018). According to O.A. Andreeva, the ecological condition of the aquaecological subsystem of the Dnieper-Bug estuary is characterized by constant excess of pollution standarts, and its aquatic environment does not meet the requirements of the State Sanitary Rules (Andreeva, 2011). The geocosystem of the Dnieper-Bug estuary is a natural absorber of carbon dioxide from the atmosphere. These findings are quite important, because the carbon dioxide formed as a result of oxidation of organic matter accumulates in the aqua-ecological subsystem on its border with the geological-ecological subsystem of the estuary. This process leads to the leaching of carbonate components of the geological and ecological subsystem of bottom sediments and to an increase in the share of fine component. And this in turn provokes a decrease in the ability of rocks - geological and ecological subsystem of bottom sediments to cementation, makes them more unstable, thereby complicating the processes of sorption and sedimentation. Eventually, this leads to the intensification of the processes of secondary pollution of the estuary (Moiseenko, Orekhova, 2014).

The Dniester estuary is also an open estuary. Today, this estuary is the most fully explored, but it is also one of the most hazardous areas of the southwestern coast of the Black Sea due to the formation of landslides on its coast (Fig. 2) (Ivanik, 2015; Ivanik et al., 2019).



Figure 2 Landslides on the coast of the Dniester estuary, Roksolana village, 2020

The generalization of the obtained data allowed to identify four separate hydrological regions within the water area of the Dniester estuary, which differ, in particular, in the values of turbidity (Shuisky, Berezhnytska, 2008). The aquatic environment of the aqua subsystem of the estuary geocosystem, as well as the geological environment of the geological-ecological subsystem of bottom sediments is characterized by exceeding the pollution standards.



Kuyalnyk and Khadzhibey estuaries. The Kuyalnyk estuary, which still attracts the attention of researchers, mainly due to the existing environmental problems, has been an important object for balneological treatment for many years. This is confirmed by the fact that in accordance with the resolution of the Cabinet of Ministers of Ukraine of December 5, 2018, the territory of the estuary was declared as a resort of the national importance. Mud and brine of the Khadzhibey estuary are also of significant value for balneological treatment. In recent decades, the ecosystem of the Kuyalnyk estuary is affected by significant natural and, even greater, anthropogenic stress (Fig. 3). According to G.N. Shikhaleeva et al. (2012) the heavy metals (V, Zn, Pb, Cd, Mn, Cu) are observed in all samples of bottom sediments of the Kuyalnytsya estuary, the highest level of pollution was found among the elements of the first hazard class (Pb, Zn, Cd). In addition, researchers of the Physico-Chemical Institute of Environmental and Human Protection of the Ministry of Education and Science of Ukraine and the National Academy of Sciences of Ukraine have found that both estuary and bottom sediments are characterized by exceeding the maximum allowable concentrations of phenols and petroleum products.

Kuyalnyk estuary is currently quite unstable, it is characterized by constant fluctuations in the water level, the estuary is shallow (Fig. 3). Thus, recent research on this object is aimed at finding possible ways to improve the situation.



Figure 3 Current state of the southern part of the Kuyalnyk estuary, 2020

Tiligul estuary. The estuary is separated from the Black Sea by an artificial shallow channel. It is included in the international list of reservoirs of the Ramsar Convention on the Protection of Wetlands. This estuary is a unique natural formation that has significant recreational resources. It is an interesting object in terms of tourism, mud treatment, as well as fishing.

Data on the ecological condition of the Tiligul estuary are published in the paper (Bayraktar, Polukarova, 2017). As a result of 5 years of observations, the authors have found that the estuary is shallow, and the salinity of the estuary has almost doubled. Undoubtedly, this has a detrimental effect on biodiversity.

Suhiy estuary. The bottom sediments of the estuary are mainly polluted with oil products, phenols and organochlorine pesticides, and its poor ecological condition is largely due to the difficult water exchange of the estuary with the sea.

Tuzla group of estuaries and Budatsky estuary. The estuaries of Shagan, Alibey, Burnas, Hadjider, Karachaus, Sasyk, Maly Sasyk, Dzhantshey are part of the estuaries of the Tuzla group and belong to the estuaries of mainly closed-filtration type.

Their water exchange with the sea is difficult, which leads to their classification in water basins with minimal natural stability. It is known that this parameter is determined by the ability of estuaries to resist anthropogenic impact. Therefore, it is not surprising that in the practical absence of water exchange with the sea and increasing anthropogenic load, the ecological condition of estuaries of this group is deteriorating.

Muds of this group of estuaries have high characteristics for balneological treatment.



The coast in the estuary zone has a subsidence at a rate of 1-2 mm / year. The fact of the landslides formation on the coast of these estuaries is confirmed by recent observations.

Conclusions

Based on the analysis of the state of geoecosystems of the Black Sea estuaries, it is confirmed that these unique natural objects need constant monitoring and forecasting of dynamic changes. In order to preserve the natural value of the estuaries, the main principles and approaches to comprehensive geoecosystem studies of these natural objects have been proposed. The application of the proposed approaches assumes that the geoecosystem of estuaries is multistable; it features the dynamic transition zone between the sea and the continent (geocoton) and requires specialized methods to analyze its past and present state and predict the future changes. The structure of this system is space-time related. The spatial aspect reflects the order of elements in the system, time aspect corresponds to the changing in the system during the period of time and its dynamic. The ecosystem of estuaries is affected by significant natural and anthropogenic stresses. The heavy metals (V, Zn, Pb, Cd, Mn, Cu) are observed in the bottom sediments of some estuaries, the highest level of pollution was found among the elements of the first hazard class.

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