

Assessment of the Environmental State of North-Western Black Sea Coast Territories, Ukraine using Indicators of Sustainable Development

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Abstract. The concept of "sustainable development" is interpreted as a process of development of countries and regions based on coordination and harmonization of social, economic, and environmental components in order to meet the needs of present and future generations. The concept of sustainable development aims at the socially desirable, economically viable and environmentally safe development of society. To assess the ecological state of the environment from the standpoint of sustainable development, certain indicators and parameters have been developed. The paper evaluates the state of the environment of the North-Western Black Sea region according to the indicators of sustainable development as factors in assessing the technogenic load. It is discovered that in the category «Ecological systems» of ecological policy the best conditions of sustainable development are noted in the Mykolayiv area, the least good - in the Odessa region. In the category "Environmental load" the best conditions are noted for the Kherson region, the worst – also for the Odessa region. In general, the most unfavorable environmental situation from the standpoint of sustainable development among the territories of the North-Western Black Sea Coast is observed in the Odessa region. Kherson region is characterized by the best conditions. Among all the analyzed indicators, the category of policy "Environmental load" plays a predominant role.

Key words: sustainable development, environmental assessment index, indicator.

Introduction

The inconsistency of economic development and environmental safety requirements, the dominance of industries with a high share of resource- and energy-intensive obsolete technologies, lack of rational consumption of natural resources all have led to the formation of technogenic economic development and environmental degradation (Wan et al., 2020).

Human awareness of the real danger of environmental catastrophe initiated the development of the concept of sustainable development, which should be understood not only in the context of changing human-nature relations to expand economic growth but also as a coordinated global survival strategy aimed at preserving and restoring the environment.

It should be noted that the sustainable development of any country is a controversial issue. Such development can be said only when economic growth, material production and consumption, and other social activities occur within the limits determined by the ability of ecological systems to recover (Geets, 2000).

Today there are many interpretations, and a single point of view on the essence of the concept of "sustainable development" has not been developed. Summarizing the achievements of scientists (United Nations, 2015; Dorogunsov & Ralchuk, 2001; Rudenko, 2001; Pidlisnyuk, 2001) it can be noted that the interpretation of the concept of "sustainable development" extends to the process of change in society, in which the exploitation of resources, scientific and technical development and institutional change are coherent and do not diminish the ability of future generations to meet human needs and aspirations.

The Decree of the President of Ukraine "On the Sustainable Development Goals of Ukraine until 2030" defines certain goals of sustainable development, a third of which relate to environmental security and preservation of a quality environment for future generations (President of Ukraine, 2019). In general, the peculiarities of the strategy of sustainable development in Ukraine in recent years have been considered by many researchers, in particular (Molokanova, 2018; Smirnova & Mykhailyuta, 2018; Haustova & Omarov, 2018). Particularly, the need to develop appropriate measures to consider the issue of further practical implementation, combining all levels of the socio-economic system with mandatory consideration of the environmental component is being given particular attention.

According to the research of leading scientists (Danilov-Danilyan & Losev, 2000; NAS of Ukraine, 2007; Zgurovsky, 2009; Prischepa & Klimenko, 2009; Shapar, 2009; Alexandrov et al., 2010; Klimenko & Klimenko, 2010; Kutsenko et al., 2013; Necos

& Soloshych, 2014; Emas, 2015; Mensah, 2019; Powe, 2020), such an assessment should be made based on analysis of the dynamics of changes in certain indices and indicators that most broadly characterize all components of the ecological state of regions. According to the metrics for measuring the processes of sustainable development (MMSD) (Zgurovsky, 2009), sustainable development is assessed from the standpoint of economic, environmental and socio-institutional nature. According to the data (NISS, 2012), the UN Commission on Sustainable Development determines the level of development of countries by 96 indicators, 19 of which characterize the state of the environment. Experts from Yale University (USA) have proposed to determine the Environmental Performance Index, which characterizes the effectiveness of public policy in the field of environmental protection and ecosystem conservation. This index is calculated using 22 indicators, divided into 10 categories that characterize the quality of the environment and the viability of ecosystems. According to the value of this indicator in 2012, Ukraine ranked 102nd among 132 countries (NISS, 2012). This list of indicators largely repeats the parameters of the indicators of the environmental evaluation of sustainable development and from some points of view reflects the technogenic impact on certain components of the environment more objectively.

Materials and Methods

According to the metrics for measuring sustainable development processes proposed in the paper (Zgurovsky, 2009), the environmental evaluation index (I_e) can be determined taking into account three categories of environmental policy: 1) ecological systems (I_{SYS}); 2) environmental load (I_{STR}); 3) regional environmental management (I_{REG}). These categories contain 13 parameters and 44 indicators.

An indicator of sustainable development is an indicator that reflects economic, social,

and/or environmental development in a particular region, and has such properties as ease of interpretation, wide range, sensitivity to change, quantification and allows to make forecasts and identify trends in time (Zgurovsky, 2009).

The category "Ecological systems" includes 6 indicators (air I_{AIR} , biodiversity I_{VIO} , land I_{LAN} , water quality I_{WQL} , water quantity I_{WQN} , radiation, and environmental hazard I_{RAD}), as well as 20 parameters in its composition. The category "Environmental load" contains 4 indicators (air emissions I_{EMS} , load on ecosystems I_{ECO} , generation and use of waste I_{WST} , water load I_{WAT}) and 19 parameters. The category "Regional environmental management" contains 3 indicators (participation in I_{COL} environmental projects, greenhouse gas emissions I_{GHG} , transboundary environmental pressure I_{GPC}) and 5 parameters (Zgurovsky, 2009).

It should be noted that these indicators and parameters are in fact indicators of technogenic load on individual components of the environment and the state of ecosystems in general. This applies, first of all, to indicators of emissions and discharges of pollutants, waste generation and accumulation, water consumption, and drainage, land use indicators, etc. Therefore, the assessment of the ecological condition of any territory with the use of the index of ecological measurement according to the MMSD can also be considered a result of the assessment of technogenic load.

The paper (Matviychuk & Sidoruk, 2018) proposes a model of a comprehensive system of environmental safety indicators in Ukraine. It should be noted that the environmental parameters included indicators of natural and technogenic hazards. Besides, the proposed model also includes economic and social indicators, i.e. the authors also consider the environmental safety of the state from the standpoint of sustainable development.

The analysis of literature sources (Zgurovsky, 2009; Prischepa & Klimenko, 2009; Harris, 2000; NISS, 2012) showed that

there is no single methodological approach to assessing the ecological status of regions in terms of sustainable development. Thus, from the standpoint of assessing the technogenic load on the environment, the most optimal is the method proposed in the paper (Zgurovsky, 2009). Based on the above, the work aims to assess the state of the environment of the regions of the North-Western Black Sea Coast (NWBC) on the indicators of sustainable development as factors in assessing the technogenic load.

Results and Discussion

The recommendations for calculating the environmental evaluation index (I_e) state that the parameters and indicators of the environmental evaluation are balanced averages (Zgurovsky, 2009). In this case, none of the parameters is assigned a weighting factor. Also, it is noted that assigning certain weights to environmental parameters is a difficult task. Statistical methods have shown almost equivalent weights of individual parameters within the indicators to which they are included.

Analysis of the initial information on the values of individual parameters of the environmental evaluation showed that the above statement (Zgurovsky, 2009) is somewhat erroneous. Thus, in some cases, the parameters have equivalent weights, such as air indicator (I_{AIR}), which is defined as the weighted average of the concentrations of nitrogen dioxide, sulfur dioxide and dust (in units of maximum permissible concentrations). But if the concentrations of pollutants are greater than the maximum allowable concentrations, then when calculating the I_{AIR} in the summation (according to the method of Zgurovsky, 2009) the result may exceed 1. In this case, it is not a confirmation of the best indicators of sustainable development. Similar conclusions can be made for other indicators, which sum up the values with quite different units of measurement. Such illustrative examples are indicators of land (I_{LAN}), load on ecosystems (I_{ECO}), where individual

parameters are measured in points, square kilometers, percentages, hectares per capita, cubic meters per capita, etc.

For the analysis of 44 proposed parameters of the environmental evaluation, we used 27 to assess the sustainable development of the regions of the NWBSC. Note that the assessment was conducted based on analysis of individual parameters and in some cases without calculation of environmental measurement indicators. For analysis, the original data were normalized so that all parameters took values from 0 to 1 using the principle of linear normalization:

$$\tilde{x}_i = \frac{x_i - x_{min}}{x_{max} - x_{min}}. \quad (1)$$

The analysis of the obtained normalized values showed that the minimum indicators in the vast majority characterize the best conditions, and the maximum - the worst. That is, the best conditions for sustainable development indicators, in this case, are characterized by indicators close to 0. Only for some parameters that we took into account (I_{PZF} , I_{EF1} , I_{EF2} , I_{EF3} , and I_{ORG}), it is fair to say that close to 1 values characterize the best conditions of sustainable development (Zgurovsky, 2009). Therefore, to unify the calculations, all parameters were reduced to such a form that their best values are close to 0.

The results of the ranking of the areas of NWBSC by individual indicators of the environmental evaluation of sustainable development are shown in Table 1.

As can be seen from Table 1, most often according to the list of the above parameters, the Odessa region is in the red zone (the one with the worst indicators of the ecological component of sustainable development), Kherson region, however, is in the green zone (the one with the best indicators). Although within certain categories of environmental policy on the worst indicators, such distribution differs.

Considering the principle of calculating environmental indicators and categories of

environmental policy (Zgurovsky, 2009), we calculated indices for two categories of policy - environmental systems and environmental load. The spatial representation of these policy categories is shown in Fig. 1, 2.

The analysis of the presented figures shows that in the category of ecological policy "Ecological systems" (see Fig. 1) the best conditions of sustainable development are noted in the Mykolayiv region, the least good - in Odessa. Such an unfavorable situation in the Odessa region is due to such indicators as the content of sulfur dioxide and dust in the air, the spread of exogenous geological processes, high rates of disturbed and exhausted lands, nitrate content in the aquatic environment, the presence of a significant number of environmentally hazardous enterprises.

In the category "Environmental load" (see Fig. 2) the best conditions were observed for the Kherson region, the least good - also for Odessa. In this case, this situation is formed due to higher indicators of polluting emissions into the atmosphere, lower rates of arable land and forests, significant volumes of return water discharges. It was interesting to compare the results of the assessment of the categories of environmental policy for (Zgurovsky, 2009) for the territories of Ukraine, including the regions of the NWBSC with our results (Table 2).

The table shows that without taking into account the obtained numerical values, the general situation has not changed significantly. The most unfavorable situation from the standpoint of sustainable development in both categories of policy among the territories of the NWBSC is observed for the Odessa region. In the category of policy "Ecological systems" indicators for the Kherson area worsened and for the Mykolayiv area improved. In the category of policy "Environmental burden," the distribution of indicators has not changed.

The results of the general assessment of the index of ecological evaluation of sustainable development, considering all the indicators taken into account during the analysis are shown in Fig. 3. The analysis of the presented figure shows that the most unfavorable environ-

Table 1. Ranking of the territories of the North-Western Black Sea Coast according to the indicators of the ecological evaluation of sustainable development (2014 – 2018).

Index	Odessa region	Mykolayiv region	Kherson region
<i>"Ecological systems" I_{SYS} policy category</i>			
<i>I_{NO2}</i> (<i>NO₂</i> concentration)	0.23	0	1
<i>I_{SO2}</i> (<i>SO₂</i> concentration)	1	0.14	0
<i>I_{TCP}</i> (dust concentration)	1	0.33	0
<i>I_{PZF}</i> (NRF objects)	0.77	1	0
<i>I_{EGP}</i> (spread of exogenous geological processes)	1	0.79	0
<i>I_{EXH}</i> (worked and re-cultivated lands)	1	0.67	0
<i>I_{NIT}</i> (nitrate concentration)	1	0	0.23
<i>I_{MIN}</i> (mineralization)	0	1	0.45
<i>I_{WAV}</i> (water abstraction from natural sources per 1 person)	0.22	0	1
<i>I_{GAV}</i> (water intake from underground sources per 1 person)	0.16	0	1
<i>I_{RHZ}</i> (potential radiation hazard)	0	1	0
<i>I_{IHZ}</i> (environmentally hazardous enterprises)	1	0	1
<i>"Environmental load" I_{STR} policy category</i>			
<i>I_{NOX}</i> (<i>NO_X</i> emissions)	0.67	1	0
<i>I_{SOT}</i> (<i>SO₂</i> emissions)	1	0.26	0
<i>I_{CAR}</i> (emissions from motor vehicles)	1	0	0.02
<i>I_{EKM}</i> (emissions per 1 km ²)	1	0.09	0
<i>I_{EPC}</i> (emissions per 1 person)	0.81	1	0
<i>I_{EF1}</i> (arable land)	1	0.29	0
<i>I_{EF2}</i> (hayfields and pastures)	0.775	0	1
<i>I_{EF3}</i> (forests and wooded areas)	1	0.64	0
<i>I_{EF4}</i> (built-up land)	0	1	0.23
<i>I_{EF5}</i> (use of freshwater per 1 person)	0	0.09	1
<i>I_{ACC}</i> (waste accumulation)	0.18	1	0
<i>I_{WKM}</i> (generation of wastes of I - III classes of danger on 1 km ²)	0	1	0.63
<i>I_{WPC}</i> (generation of wastes of I - III hazard classes per 1 person)	0	1	0.82
<i>I_{REW}</i> (discharge of return water into surface water entities)	1	0.11	0
<i>"Regional Environmental Management" I_{REG} policy category</i>			
<i>I_{ORG}</i> (public environmental organizations)	0	1	0.18

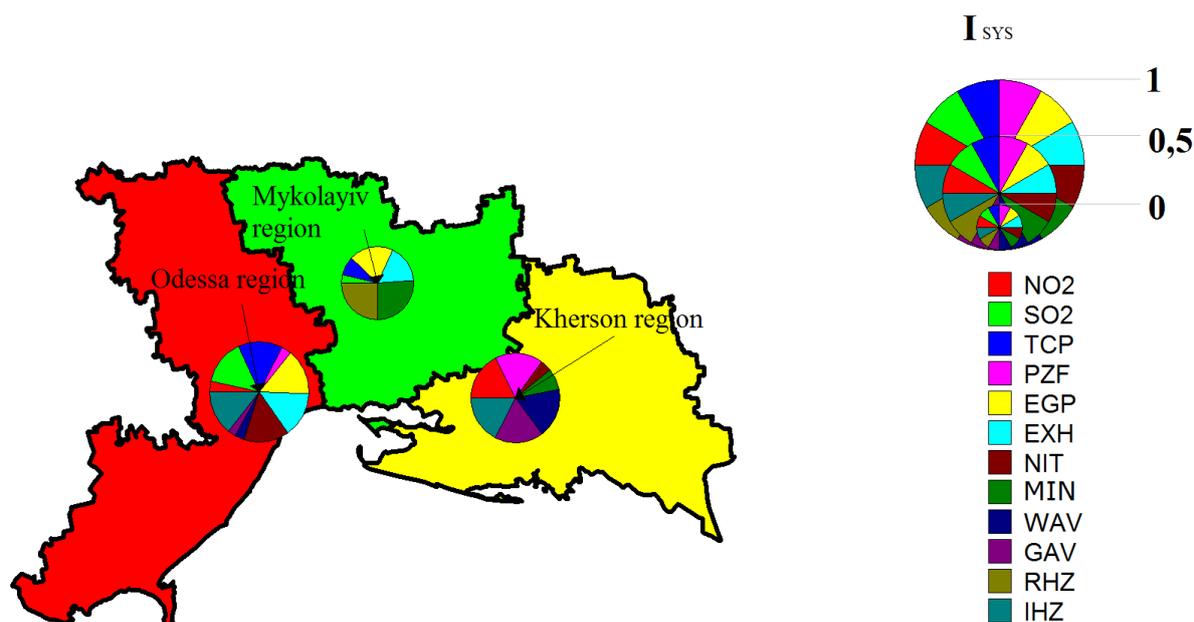


Fig. 1. Spatial distribution of the I_{SYS} index of the category "Ecological systems" for the territories of the North-Western Black Sea Coast (2014 - 2018).

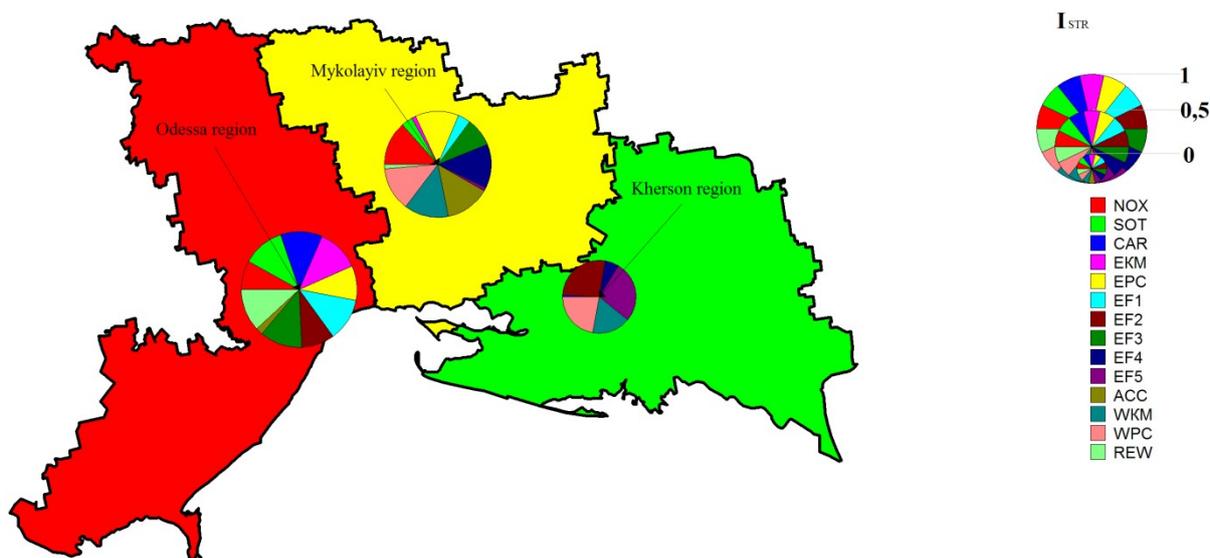


Fig. 2. Spatial distribution of the I_{STR} index of the category "Ecological load" for the territories of the North-Western Black Sea Coast (2014 - 2018).

mental situation from the standpoint of sustainable development is observed in the Odessa region. Kherson region is characterized by the best conditions for sustainable

development of the region. It should be noted that among all the analyzed indicators, the category of policy "Environmental load" plays a predominant role.

One of the prerequisites for sustainable development is the minimization of technogenic load on certain components of the environment, the main directions of which can be considered the following measures:

Table 2. Comparative analysis of the assessment of environmental policy categories of the North-Western Black Sea coast.

Region	Category "Ecological systems"		Category "Ecological load"	
	2006 (20 indicators, Zgurovsky, 2009)	2014 - 2018 (12 indicators, from authors)	2006 (19 indicators, Zgurovsky, 2009)	2014 - 2018 (14 indicators, from authors)
Odessa region	0.418	0.699	0.753	0.603
Mykolayiv region	0.588	0.327	0.828	0.533
Kherson region	0.602	0.473	0.915	0.265

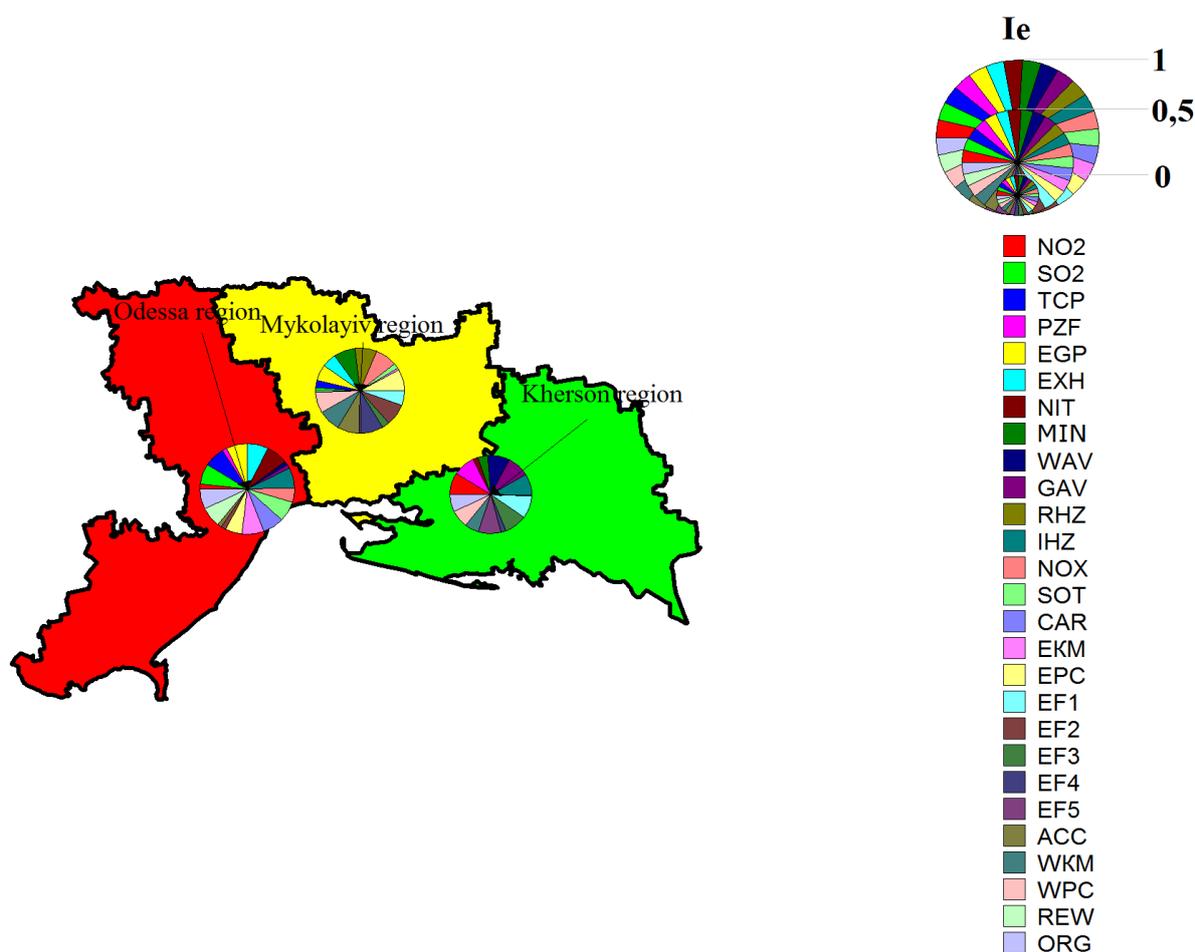


Fig. 3. Spatial distribution of the index of ecological evaluation of sustainable development *Ie* for the territories of the North-Western Black Sea Coast (2014 - 2018).

1) optimization of the monitoring network of the air basin, water entities, soil cover, and geological environment following modern EU requirements, organization of systematic observations of physical pollution under the influence of technogenic objects;

2) increasing the level of environmental safety of stationary sources of air pollution by improving technological processes, air protection measures, streamlining the configuration of sanitary protection zones, creating "green belts" around industrial and urban agglomerations, etc.;

3) given the dominance of mobile sources, the redistribution of traffic flows requires justification from the standpoint of logistics, the creation of a system of high-speed public transport, green boulevards with low traffic;

4) improving the efficiency of wastewater and other return water treatment, creating a system for drainage and treatment of stormwater, which is a powerful source of pollution of the coastal zone of the North-Western Black Sea, improving the technical condition of worn-out main and distribution networks that provoke high levels of secondary drinking water pollution;

5) limitation of the negative impact on the pollution of the soil cover and other natural environments of the accumulators of industrial toxic waste and numerous landfills of solid household waste;

6) creation of necessary capacities for processing, treatment of neutralization, and utilization of hazardous waste;

7) improvement of the system of management and treatment of solid household waste, which accounts for more than 90 % of the sum of all waste in the study area;

8) restriction of forms of economic activity that provoke the development of dangerous exogenous geological processes.

Conclusions

The conducted researches allow us to draw the following conclusions:

1) The analysis of indicators of the index of ecological measurement showed that most of them are used including for an assessment of a condition and technogenic loading on components of the environment;

2) Along with the indicators of the MMSD, the level of sustainable development of countries can be determined by UN recommendations, scientific developments of domestic and foreign scientists;

3) The analysis of the MMSD revealed that the authors' statement about the balance of parameters and indicators of the environmental measurement index is erroneous (analysis of the obtained normalized values showed that the minimum indicators characterize the best conditions and the maximum - the worst, in contrast to these conditions in the MMSD);

4) According to the results of ranking the territories of the North-Western Black Sea coast by individual indicators of ecological evaluation of sustainable development, it was found that most often the zones with the worst indicators of the ecological component of sustainable development included the Odessa region and the zones with the best indicators - Kherson region;

5) In the category of ecological policy "Ecological systems" the best conditions of sustainable development are noted in the Mykolayiv area, the least good - in Odessa region. In the category "Environmental load", respectively, the best conditions were noted for the Kherson region, the least - also for Odessa region;

6) In general, the most unfavorable environmental situation from the standpoint of sustainable development among the territories of the North-Western Black Sea Coast is observed in the Odessa region. Kherson region is characterized by the best conditions for sustainable development of the region, and among all the analyzed indicators, the category of policy "Environmental load" plays a predominant role.

7) In order to ensure the sustainable development of the study areas it is

necessary to implement a set of technical and technological solutions that will minimize the technogenic load on individual components of the environment.

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