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ALGAL INDICATION RESEARCH IN UKRAINE

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The development and establishing of the algal indicator focus of investigations in Ukraine are analyzed. The main achievements and results of work by algologists, hydrobiologists and ecologists in terms of the use of algal indicators for the ecological state of water bodies and streams, as well as ecological and biological indices of species composition, characterizing and determining the type of watercourse studies are characterized. The possibility of attracting these data to the general ecological characteristics of the state of the water body is presented. Multifaceted use and exponent of freshwater and marine groups of micro- and macroalgae, their taxonomic structure and individual indicator species in studying the specific features of water bodies and determining their state or characteristics of individual sections of the watercourse are shown. The complementarity and conformity of algal indicators in the assessment of water quality in accordance with the methods and standards of the "Water Framework Directive 2000/60/EC" is noted. The methodologically determining role of diagnostic algal species in the formation of names of algocoenosis, their bio- and ecotopic confinement, the indicator of anthropogenic load, the level of saprobity and trophicity of water bodies, as well as the importance of attracting individual ecological and physiological indices of these species during algal indication of polluted water bodies is discussed. The relevance of algal indicator studies as a modern method for assessing not only the aquatic ecosystem as a whole, but also the quality of water, is demonstrated.

Key words: algal indicators, Ukraine, waterbodies, ecological indicators, micro-, macroalgae, water quality

The algoecological research was formed within the algofloristic studies in the territory of Ukraine. However, the primary data in parallel with the initial floristical studies had a different direction and ecotope as well as typology of water nature. First of all, in the early algofloristic works, the alien species composition was markedly related to the type of water body, and eventually – to its specific ecotops and the formation of water-typological groups of these organisms. Such an algorithmic characteristic is inherent in most floristic and hydrobiological studies of different study periods on algal flora in the Ukrainian territory up to now.

The ecosystem approach, which covers a rather sincere complex presentation of both abiotic and biotic components (Zhukinsky et al., 1976; Oksijuk, Davydov, 2006, 2011; Davydov, 2009; Didukh, 2012) is the basic principle of assessing the ecological status of water bodies under current conditions. This methodology is called "ecological indication" (Yakushin et al., 2006), sometimes it is opposed to bioindication – the usage of indicator organisms, indicative in the aspect of the action of any factor (saprobity, halobity, acidity, etc.). To the contrary, such approach in assessing anthropogenic impact, is often revealed as not enough informative (Semenchenko, 2004; Oksijuk, Davydov, 2006). Presently, in the methodology of bioindication, a response of groups of hydrobionts and algal groups is being found, in particular, on the influence of interconnected environmental factors. The specificity of the modern approach in assessing the ecological status of water bodies is in the priority value of the biota and its level of change, reproduced in the Water Framework Directive 2000/60/EC (Directive …, 2000) and noted in "Metodyka …" (Romanenko et al., 1998; Grytsenko et al., 2012) nationally. It is the response of biotic components (groups, individual groups or species of hydrobionts as well as algae) that reflects the comprehensive effect of natural and anthropogenic factors on these objects, and is considered to be the most representative of this type of investigation.

The assessment of the ecological status of water bodies and their changes under the influence of anthropogenic factors are based on a comparative analysis of the composition, structure and wealth of the groups (as well as their species composition, abundance and biomass) such as phytoplankton, microphytobenthos and microperiphyton as important components of aquatic ecosystems (Oksijuk et al., 1993, 1994 a, b, 2008; Didukh, 2012; Barinova et al., 2015). The changes in the composition and richness of hydrobionts (algo complexes) on these biotopes at the abiotic indices consolidation is the basis of such bioindicative assessment. Microalgae are rapidly responding to changes in the ecological state of the environment, and therefore they are quite convenient objects for bioindicative research.

The first detailed water-typological works on the formation of the taxonomic composition of algae and their characteristic groups, as well as specific species complexes of ponds of different origin and type of water supply were conducted by D.O. Svirenko (1922 a, b, c). At the same time, bioindicative works on the determination of the sanitary and displaying the value of individual species or taxonomic groups of algae were carried out by L.A. Shkorbatov (1926 a, b, 1928, 1936) at the study of the sanitary-and-hydrobiological state of the Siversky Donets river and its basin (for example, the rivers of the city of Kharkiv and the projected water supply), and later – the Donbas reservoirs. These works were directed at the formation of a regional scale of saprophy, or a critical optimization of the scale of R. Kolkwitz and M. Marsson (Kolkwitz, Marsson, 1909) in the conditions of the East European Plain and Ukraine, in particular. To this period, the work of D.O. Svirenko (1926) and A.I. Proschkina-Larvenko (1932) are pertain, in which generalized materials on typological nature of waterbodies, in particular, established a special type of "steppe salted rivers" with a peculiar composition of algae and the presence of diatom indicator species. Sanitary and indicative studies were carried out as additional studies on the hydrobiological state of reservoirs and waterbodies over Ukraine. They were carried out during the period of formation of the reservoirs system on the Dnipro river, as well as transformation and modification of small river ecosystems and a development of a comprehensive fishery and also the determination of the algal role in the typology of reservoirs with standing waters on a par with biological processes of water purification.

The ecologically indicative, floristic and typological focus of works and the formation of ideas on the algal species composition specifics of certain types of waterbodies, as well as the analysis of the data, encourage recognizing the leading role of these organisms in the diagnostics of reservoirs and watercourses, their ecological status, specifics and characteristics.

G.M. Palamar (1953) revealed the originality of the taxonomic composition of algae on different types of marshes, depending on the degree of their trophy, also N.P. Masyuk (1958, 1959 a, b) and D.O. Radzymovsky (1961) – lake and pond algae complex depending on biotic and abiotic factors in the northern regions of the country. Along with this the diagnostic role of algae in environmental parameters reconstruction in previous geological epochs (Holocene) and the nature of the existing reservoirs of that time was noted (Oksijuk, 1957). To establish the ecotope specificity of the taxonomic composition of algae to the plant substrate was attempted by N.O. Moshkova (1953). Subsequently, the specificity of the distribution of macrophyte algae and their resource significations in the sublittoral zone of the north-western part of the Black Sea from the gradient of salinity was made by T.I. Yeremenko (1968). A phytosaprobe composition of mactophyte algae of the same sea and indicative species for their concrete floristic and eutrophic areas were proposed (Kalugina-Gutnik, 1975). Therewith indicators are determined among diatom algae for heavily polluted marine subterritories of the Odesa region of the Black Sea (Guslyakov, 1978)

In the late 70's – early 80's of the twentieth century, investigations were focused on the indicative role of soil algae as indicators of environmental pollution in the industrial zones of the enterprises of the chemical industry of the Donbas region (Eastern Ukraine). The degree of development of algal flora in soil disturbed by technogenesis and a certain species composition of algae were revealed indicative characterizing separate zones of contamination (Lypnitskaya, 1974; Khyzhnyak, Datsun, 1982; Maltseva, 2009; Maltseva, Baranova, 2014; Shekhovtseva, 2016 and others). In addition, the zonal specificity of the systematic structure and species composition of the groundwater algae of the natural along with climatic zones of Ukraine, as well as certain types of phytocoenoses and its originality in the conditions of the metropolis were highlighted (Kostikov, 1991 a, b; Demchenko et al., 1993; Romanenko et al., 1993; Molozhanova et al., 1995; Solonenko, Kostikov, 1995; Levanets, 1998; Kostikov et al., 2001; Maltseva, 2009; Scherbina, 2012).

Significant indicators of algae are actively used in regional and typological studies from the beginning of 90th years of XX century. The data on the water quality in the Pripyat region of the Ukrainian Polissya, as well as the species composition of algae along with the development of the degree of saprobity quantitative species-indicators in the conditions of large-scale land reclamation of the region were led by A.F. Krakhmalny (1990). The diagnostic significance of the algal communities (directly, algo-unions) and indicator syntaxa with the specification of certain types of diatoms in the characteristics of the ecological conditions of some rivers in Mountain Crimea and Tisa river basin in Ukrainian Carpathians indicated by L.M. Bukhtiyarova (1999; Bukhtiyarova et al., 1996).

Floristic and ecotopic investigations on algae of waterbodies in Dniprovsko-Orilsky nature reservoir conducted by O.V. Gerasimova (2006), as a result of which the presence of 426 species (445 infr.) of saprobity indicators (63.6% of the general species composition) was established. Indicator species are distributed between 5 main and 10 transitional zones of saprobity (there are no beta-polysaprobes only). The main number of indicators refers to the range of oligo- and alpha-mesosaprobic zones (418 species with infr. taxa – 93.9% representative forms), the dominating group among them is formed by beta-mesosaprobes (215 – 48.3%, respectively).

In addition, to the group of indicators oligo-alpha and xenosaprobic zone belongs 19 taxa, and to the polysaprobic zone – 8. The indicators of saprobity index were within the limits of 1.61 – 2.35, located within the beta-mesosaprobic zone and depended on the type of water body, it flow and season of the year. The average value of the saprobity index was 1.89, which corresponds to the oligo- alfa-mesosaprobic zone, the third class of water quality is "satisfactorily" clean, the quality grade is "fairly clean" (Gerasimova, 2006). Along with this, 286 species (308 infr. taxa – 42.7% of the total species composition of the algae on the reserve) were identified among water salinity indicators, of which the most indifferent group compose 71.3%, and less diverse – halophiles (6.8%) and halophobes (0.8%). Also 159 species (178 vs.-23.9%) of indicators were found with respect to the pH of the environment, 9.5% of which belonged to indifferent, 2.8% to alkalibionts, and 1.7% – acidophiles. According to the results of the conducted studies, it is established that the species composition of the algae of the reserve characterizes it as freshwater, with a neutral and slightly alkaline waters and satisfactory water quality.

High level of dependence between the morphofunctional organization of algal macrophytes in the Black Sea basin and the level of their production process, as well as the availability of empirical data characterizing the structure of benthic vegetation in the entire spectrum of the autotrophic process from the oligotrophic conditions of the Antarctic coast to the hypertrophic level of the smooth ecosystems of the Danube outfall (Ukraine) was demonstrated (Minicheva, 1998). These investigations made it possible to propose tropho-saprobiont classification of the aquatic environment on the basis of surface parameters of benthic algae. At the same time, the degree and nature of the variability of the taxonomic groups of the algal macrophytes of the Black Sea in the regional representation of saprobity indicator species and their percentage in geographic terms was indicated by I.I. Maslov (2004). Similar studies for the near Crimea and Odessa coast algofloric regions, as well as the determination of the nature of the anthropogenic transformation of their macrophytobenthos, were carried out by F.P. Tkachenko (2007). The author established that oligosaprobic species (52.7%) were the prevailing group of macrophyte algal macrophytes in the Ukrainian Black Sea with respect to saprobity, while the role of mesosaprobic and polysaprobic is less pronounced (29.2% and 18.1%, respectively). However, regional algospecificity has also been noted – oligosaprobic species dominate in the more clean floristic regions near Crimea coast (Karkinitskaya, Yagorlytsko-Tendrovsko-Dzharylgachsko-Perekopsky) and Zernov's phyllophora field, and mesosaprobic – Odessa coast and the estuary water areas.

Such representation and ratio of saprobic groups of algae-macrophytes indicate a rather significant eutrophication of the waters on the northwestern part of the Black Sea. At the same time, it is observed the anthropogenic transformation of microphytobenthos is accompanied by a reduction in species diversity and the replacement of oligo- and mesosaprobes with polysaprobic species. The correlation and representation of halobic forms of algae in the studied regions indicates the features of the formation of this algal flora, as well as the existing ecological conditions of the aquatic habitat and the degree of desalination / salinity, i.e. the impact of freshwater runoff. For the studied region, these indicators corresponded to such data; marine forms (~ 50%), brackish-water (~ 22%), brackish-water (> 18%) and freshwater (> 11%). Along with this, a comparative analysis of the salinity complex factor of the three largest estuaries in the south of Ukraine (Tiligulsky, Kuyalnytsky and Hadzhibey) showed that the dynamics of changes in the number of indicator groups among diatoms depends to a large extent on changes in salinity and the rapid factor, especially in closed and semi-enclosed estuaries (Kovtun, 2012). The author noted a significant predominance of marine polyhalobous algae in the Black Sea, in contrast to the compared estuaries with unstable salinity, where the dominant complex consists of mesohalobous and oligohaline halophiles. In addition, it was found that the group of beta mesosaprobes is the most numerous in the investigated estuaries, and the quantity of indicator species has undergone significant fluctuations. Over the past 30 years in the Kuyalnik estuary, with an increase in the salinity level, an increase on beta mesosaprobic has been registered from 23.3% to 35.3% (and a decrease in alpha mesosaprobic from 72.1% to 55.9%). At the same time, under insignificant conditions, a slight increase in the number of beta mesosaprobes (28.0% to 29.8%) and a one-percent decrease in alpha mesosaprobes, as well as the presence of a large group (43.7%) of species intraspecific taxa with an indeterminate type saprobity were distinguished (Kovtun, 2012).

In the early 2000s, diatom algae were studied in the lakes of the Shatsk National Park (Volyn Region, Shatsky Algofloristic District) and the assessment of their water quality according to the procedures defined by the EU Requirements and Standards according to the "Water Framework Directive 2000/60/EC" (Directive …, 2000). In the samples of the periphyton of the investigated lakes, 207 indicator species were detected (Kryvenda, 2008), which were used to assess water quality according to the diatom index methodology (Prygiel et al., 1999). As a result of the work, a complex of saprobity indicator species was identified according to the Sladeček index, which numbered 133 taxa (64% of the total number of species) with different sensitivity to organic contamination. In addition, 130 taxa-indicators (63%) of the trophic status (oligotrophic hypertrophies), 123 species-indicators of the total water quality according to the biological diatom index and 189 species-indicators of the level of organic contamination and eutrophication (Kryvenda, 2008). It is shown that the spectrum of indicator species of specific pollution is the richest in comparison with the spectra of indicator taxa for the calculation of other indices and it is considered to be the most accurate one in the conditions of the investigated region.

It has been established that the level of organic pollution and eutrophication of the Shatsky national nature park is “insignificant” or “medium”, with predominance of the waters of the alpha-oligo-beta-mesosaprobic zone, and most water bodies belong to the mesotrophic type and II class (“good” quality) of the total water quality (ibid). The conducted researches made it possible to attribute Lakes Ozertse and Male Chorne as reference ones, according to the requirements of the Water Framework Directive. At the same time, in the study of the algal flora of the water bodies of the natural reserve “Medobory”, 143 species-indicators (149 infr. species) saprobity were identified, representing 75.7% of the total species diversity of the reserve (Gerasimova et al., 2009). Indicator species refer to 4 main and 10 transition zones of the saprobity. Among them beta-mesosaprobic forms is prevailed – 46 taxa, or 30.9% of all indicator forms. Most indicator species gravitate to oligosaprobic zones (xeno-oligo-alpha). In this range, 53.02% of the indicators are concentrated, while the beta alpha and alpha range corresponds to only 16.11%. This indicates a sufficiently good sanitary and biological state of water in the water of the reserve. Saprobity indicator species include 75.7% of species, among which a beta mesosaprobic forms predominate, with a common bias toward the oligosaprobic zone. The obtained data testify to the algo-floristic representativeness of the reserve as a guard area, the demonstrability in preserving the species composition of algae in Ukraine and the relatively good state of water bodies in the preserve territory of the “Medobory” reserve (Gerasimova et al., 2009).

When assessing the current state of the ecosystem in the Kyiv section of the Kanevsky reservoir and establishing priority natural and anthropogenic factors that determine it based on an analysis of the species, taxonomic, information and quantitative diversity of phytoplankton, the intensity of production and destruction processes and their correlation, the formation of self-cleaning potential and water quality.

It was revealed that the lowest water quality in the upper part of the reservoir in the “Desna-estuary-reservoir” system: the component of the xeno- and oligo-saprobity indicator types that develop in pure Desna river water was 36%, in the reservoir 11%, and the alpha-mesosaprobic zone indicators are 14% and 33%, respectively (Scherback, Maystrova, 2001). It is noted that the saprobiological situation of the river over the last 60 years has undergone significant changes in the direction of increasing the level of saprobity – an increase in the number of indicator species of the alpha-mesosaprobic zone in the 90’s of the XX century, as a result of the progressive anthropogenic impact on the river ecosystem and, first of all, the increased organic pollution. At the same time, up to 40% of the indicator species belonged to the alpha-mesosaprobic zone in the reservoir of the system "Lybid river-estuary-reservoir", while at the mouth of the river their constituent did not exceed 25%, and the amount of xeno-, oligo-saprobionts was 50% and 40% in the river and reservoir, respectively (Scherback, Maystrova, 2001). Along with this, studying the phytoplankton of the river Desna as an indicator of the state of the river ecosystem found that the crisis phenomena that are localized within the city of Chernigiv and associated with excessive contamination of the Desna channel and its tributary Stryzhen and Bilous were accompanied by massive development of algae indicators of organic pollution and simplification of the structure of communities (Sereda, 2008). In addition, assessing the water quality and establishing the trophic status of the Desna river, it were used the informativeness of phytoplankton indicators in the spatio-temporal aspect and the river ecosystem condition were assessed as "satisfactory" and the river is ranked as eutrophic waterbody.

Also the assessment of the ecological status of water bodies (on the example of Kaniv reservoir) has been carried out regarding the communities of microphytobenthos, which aims to establish the nature and extent of the impact of anthropogenic factors leading to deterioration in the state of aquatic ecosystems, the quality of the surrounding natural environment, water and biological resources for economic use.

In accordance with the strategy of the Water Framework Directive EC (Directive …, 2000) the main role in the assessment of the ecological status of water bodies is given to bioindications according to the degree of deviation of the composition and abundance of communities from the original reference in undisturbed or very slightly changed conditions (Oksijuk, Davydov, 2006). Studying the microphytobenthos, the basic ecological and morphological groups of algae of this ecotope and the ecological characteristics of the species included in their composition were established (Oksijuk et al., 2008). Diagnostic species were considered as determining when forming the names of algocenoses of microphytobenthos, biotopic confinement, and some of them for indicating anthropogenic pollution, the level of saprobity and trophic state of water bodies.

Along with this, a study was made of the urbanized floodplain water bodies ecological state and it were assessed the quality of the subordinate network of the river section of the Kanevsky reservoir in the vicinity of Kyiv (Timchenko, Dubnyak, 2009; Timchenko, 2011). According to the results of the phytoplankton and phytobenthos analysis, it has been established that in the studied water bodies there are from 50 to 64 species of indicators (specific water bodies differ in their number) and characterize the pollution of the water from the category "very clean to pure water" by the presence of xeno-oligo-saprobes up to "dirty – very dirty" for alpha-poly-saprobes. It is shown that the indicator species in the phytoplankton of Berkovschyna Bay make up 62% of the total amount and beta mesosaprobic species predominate throughout the water area and the water quality corresponds to the category "moderately polluted" – "dirty" with indications of the saprobity index for the population of 2.01–2.54, and for biomass – 2.05–2.58. In addition, it has been established that the littoral of the bay is characterized by the worst quality of water (Timchenko, Dubnyak, 2009). However, the water mass of the investigated reservoirs of the Osokorky Bay in winter corresponds to the category "satisfactorily clean" – "moderately polluted" with a tendency to deteriorate in the most remote area from the reservoir and an increase in the saprobity index from 1.83 to 2.01 (Timchenko, 2011). The lotic and lentic conditions of the upper part of the Kaniv reservoir are also characterized by ecological characteristics of algae: habitat, rheophility, temperature regime, pH and salinity (Zadorozhna, 2016).

The issue of ecotopic confinement during the periphyton of the Dnipro reservoirs algal studies, was also assigned an important role. It has been established that the type of substrate greatly influences the distribution of periphyton algae. On a substrate of various types (solid artificial inorganic substrate, higher aquatic plants and green filamentous algae), it is formed different algal communities that has special species composition and richness, the floristic-taxonomic spectra of the leading families and genera, the composition of the dominant species as well as the intensity of development. Special attention should be paid to the substrate confinement of certain taxonomic groups of algae. Thus, it was demonstrated that the phytoepiphyton of green filamentous algae differed most strongly from fouling of other types of substrate. A somewhat greater similarity is established between the species composition of algae fouling of a solid artificial inorganic substrate and higher aquatic plants. At the same time, the species composition of *Bacillariophyta* and a very similar – *Chlorophyta*. The species composition of *Cyanophyta*, *Euglenophyta* and *Charophyta*, living on the investigated types of substrate, was significantly different. The obtained data indicate that a lesser selective to the substrate are *Bacillariophyta* and, *Chlorophyta*. At the same time, there were clearly expressed association of *Charophyta* and *Euglenophyta* to the tangles of higher aquatic plants, and *Cyanophyta* ("class *Hormogoniophyceae*") – to the hard artificial inorganic substrate (Shevchenko, 2011).

The ecological state of the Kyiv reservoir, which was subject to intensive pollution as a result of the Chernobyl nuclear power plant accident in 1986, was assessed using the species characteristics of epiphytic algae that were found on higher aquatic plants (Shevchenko, 2006; Klochenko et al., 2014). In the phytoepiphton of the Kyiv reservoir, the inhabitants of slowly flowing and moderately warm waters, alkaliphiles, indifferent organisms with respect to salinity of water, nitrogen-autotrophic taxa, carrying increased concentrations of organically bound nitrogen, beta mesosaprobes and eurisaprobes (relative to organic contamination) predominance, and also eutrophic organisms (indicators of the trophic state) were revealed. As a result of comparison of the initial results with the literature data obtained before the accident, it was established that for a period of about 30 years (from the 1970s to the 1980s and through 2010–2013), the taxonomic structure of the phytoepiphyton remained almost unchanged. At the same time, the intensity of the processes of eutrophication, alkalization, and temperature regime increased.

A study of the ecosystems of Kyiv reservoirs under the influence of urbanization factors was carried out for quite a long time by researchers of the Institute of hydrobiology (Romanenko et al., 2015). With the help of indicator parameters of phytoplankton, the ecological status of Babye lake was evaluated, saprobity index equalled 1.85, the amount of xeno-, oligo-saprobes - 29%, as well as alpha-, polysaprobes was 11%. Using also other indices of phytoplankton development, the ecological state characteristic of the lake corresponded "good" level (Scherback et al., 2009). Also, by the use of the indicator parameters of phytoplankton development, the degree saprobity Kyrilovske lake was evaluated. According the saprobity index – 1,97 the state of the reservoir was characterized as "satisfactory", while the proportion of alpha, polysaprobes – 15% indicated a "bad" state of the lake. The generalized characteristic, as well as a number of other parameters, showed that the ecological state of the reservoir corresponded to the "bad" level. In addition, investigating the phytoplankton of the lakes Verbne and Syne, it is established that water according to the saprobiological characteristic belonged to the mesosaprobic level (Scherback, 2005).

Peculiarities of ecological condition of ponds “Golosievo” NNR (Orechovatski, Kytaivski, Dydorivski ponds), located within the Kyiv city, were conducted using the indicator characteristics of algae (Klochenko et al., 2006; Klochenko, Tsarenko, 2007; Klochenko, Shevchenko, 2017). The results of the conducted studies showed that the distribution of salinity indicators in three pond systems was similar. Regarding the indicators of the temperature regime, the greatest contribution of the inhabitants of moderately warm waters is noted for Kytaivski ponds with the maximum water temperature. The distribution of pH indicators of the aquatic environment was also uneven. Thus, the proportion of alkaliphiles in the Kitaivski ponds system, at higher average values of water pH in the summer, was higher, and the proportion of indifferent substances is lower than in other pond systems. It is also important to note that, a part of eutrophic organisms, as well as autotrophs that develop at elevated concentrations of nitrogen-containing organic compounds, and eurysaprobes (inhabitants of moderately polluted waters) were higher in the Orekhovatski ponds system than in other ponds. The carried out investigations testified more intensive pollution of these reservoirs by nutrients and organic substances. It was also confirmed by the data of direct hydrochemical measurements (Klochenko, Shevchenko, 2017).

Taking into account the peculiarities of the phytoepiphyton development of diverse Kyiv city water bodies, bioindicative analysis to display the degree of pollution and degradation of urban areas was carried out. The role of epiphytic algae as reliable natural bioindicators is shown, in connection with their attached mode of existence and the ability to accumulate a variety of pollutants (Kharchenko et al., 2008). The analysis of the distribution of indicator forms of algae showed that freshwater algae prevail in the water bodies of Kyiv, alkaliphiles and neutrophiles dominate the active reaction of the aquatic environment. The indifferent species are the most abundant species among the indicators of temperature conditions. Regarding water masses dynamics in the studied epiphyton composition, species that are able to develop both in standing water bodies and in watercourses prevailed. In the studied reservoirs, beta-mesosaprobionts were the most abundant, indicating a moderate contamination of these reservoirs by non-toxic organic substances.

Scientists also analyzed the species composition of algae found in different biotopes in the lakes of Kyiv (Klochenko et al., 2013). The authors emphasize the role of a high degree of algal adaptation to environmental conditions in certain biotopes, which should be taken into account when assessing the ecological state of water bodies. Thus, it is shown that algae from other biotopes (about 40% of the total number of species in a certain ecological group) are constantly found in the water column, as well as in the fouling of higher aquatic plants. Among the 113 species (116 infr. taxa) of algae, found in the plankton, and also in the epiphyton, 53 species are confined to the water column, 30 species to fouling of higher aquatic plants, 25 species (28 infr. taxa) are rarely and in large numbers occurred in both biotopes, and only five species of algae with the same frequency and abundance are noted in the plankton and in the epiphyton (Klochenko et al., 2013).

The indicative role of phytoplankton and species specific diatoms and cyanoprokaryotes is shown by the determination of the concentration of water pollutants contained in emissions of industrial enterprises along with domestic wastewaters of water bodies of urban ecosystems on the Lugansk city example (Komisova et al., 2012). Meanwhile, in the methodical aspect, it has been shown that the determination of delayed fluorescence of algal chlorophyll during the algal indication of polluted water bodies of Donbas is recommended for express analysis as the most effective method that has proved itself in the world practice (Lyaljuk, 2012).

Recently, an attempt to determine the ecological and biological characteristics of the species composition of indicators of taxonomic groups such as *Cyanophyta*, *Euglenophyta*, *Cryptophyta*, *Chrysophyta* and *Desmidiales* (*Charophyta*) of the continental water bodies on Ukraine has been made (Gorbulin, 2011, 2013, 2014 a, b; 2015). As a result of the generalization of the literature and original data, ecological groups were identified with respect to temperature, halobity, pH, reservoir typology, saprobity and geographical criteria, and also some species individual indicator characteristics were supplemented. Along with this, according to the results of complex studies of phytoplankton in the hatchery ponds and the assessment of the water quality in them when fertilizers were introduced, it was found that most of the indicator types of the dominant algocomplex belong to the group of beta mesosaprobes (up to 77.1%) (Grytsnyak et al., 2014). The valuation of the saprobity indices in the experimental and control ponds did not go beyond the β'-β"mesosaprobic zone, and the mean values of the saprobity indices were within 1.97-2.01. According to the composition of dominant species in phytoplankton and saprobity indicator species, the fishpond ponds studied are classified as "moderately polluted" in the III class of water quality, and their ecological state is characterized as "relatively satisfactory" (Grytsnyak et al., 2014).

At the same time, using the bioindication method for estimating the state of the river it being established the Southern Bug has planktonic and plankto-benthic algal species prevail in the water column of the upper and middle part of the river, as well as indicators of average water flow, moderate temperature regime, slightly alkaline indicators and indifferent species with respect to pH and salinity level (Bilous, 2014). The river water of the investigated sections of the river according to the level of organic pollution of the Pantle-Buck (in the modification of Sladeček) was classified to the III class of water quality, and according to the Watanabe system it was characterized by a moderate content of organic compounds. In the water column of the upper and middle sections of this river, indicators of eutrophic waters and autotrophic organisms prevailed, which withstand higher concentrations of nitrogen-containing organic compounds. According to integral criteria for assessing the ecological state of the river were used the RPI (River Pollution Index) indices and WESI (Water Ecosystem Status Index) for the Southern Bug River. It is noted the high self-cleaning ability of the river ecosystem and the water belonging to the sites studied, in most cases, to the class of "water of satisfactory quality" (Bilous, 2014). In addition, assessing the ecological state of the lower part of the river, based on the composition and abundance of plankton algae, in conjunction with the abiotic components of the aquatic environment and the values of this WESI index, it is established that the functioning of phytoplankton provides a sufficient level of self-purification of water in the investigated site (Belous et al., 2016).

Along with this, an analysis of the bioindication features of phytoplankton to characterize the areas of the environment with the same conditions that were formed under the influence of specific intraspecific processes in the Sasyk reservoir was carried out (Bilous et al., 2016). As a result of these studies it is possible to characterize the Sasyk reservoir as having a moderate temperature regime, the water content of the salts is close to fresh, low acidity and low alkalinity, standing or slightly mobile water masses, medium enriched with oxygen, moderately polluted, III class, eutrophic, mainly with a moderate concentration of nitrogen. The presence of indicator species on certain groups throughout the water area of the reservoir was noted. Regarding its distribution noted it was uneven, which characterized the heterogeneity of some abiotic conditions in the reservoir. In addition, studies have shown the measurement data of some indicators (temperature, oxygen, salinity) at stations do not always coincide with the data of bioindication. To obtain a complete and detailed ecological situation on the water body, it is necessary to combine different research methods - the bioindication method and standard hydrological and hydrochemical methods of field studies. Therefore, in the future, it is advisable to assess the ecological state of a given reservoir not by individual stations, but by regions.

With the help of the bioindication method, the characteristics of the ecological state of Slavyansky salty lakes were given and directions of its modulations are established, information on the bioindication capabilities of some species of algae is supplemented, in particular, by indicator responses to quantitative indicators to individual chemical elements (Klimjuk, 2015). Along with this, prevalence of benthic and plankton-benthic species of algae was established in the water column of saline lakes of the RLP "Slavyansky resort". The prevalence of the corresponding groups of indicators indicates a moderate temperature regime, sufficient oxygen saturation of water, a significant chloride content, a slightly alkaline pH, and an insignificant level of organic contamination. The waters of the lakes were of II-III class of water quality. Analysis of the type of algae nutrition and their relationship to the amount of nitrogen-containing organic compounds, as well as the trophic state of lakes, testifies to the non-toxicity of the anthropogenic load on the investigated lakes at present.

Studying the diversity of algae in the reservoirs of the Desniansky algofloristic district, the groups of indifference varieties and the pH of the environment (50.3% and 47.7%, respectively) were noted, which makes it possible to characterize the composition of algae as confined to freshwater reservoirs with a neutral reaction of the medium (Zhezhera, 2015). Saprobity indicators of water were 59.6% of the total species composition, among which oligo- and beta-mesosaprobic forms predominated, and the mean value of the saprobity index of the studied reservoirs corresponded to the beta mesosaprobic zone, the II class of water purity related to "satisfactorily clean".

Algal indication research in Ukraine remains a topical modern method of assessing not only water quality, but also the state of the aquatic ecosystem as a whole, since they cover a wide range of indicators and are based on the ecological preferences of species. In conclusion, it should be noted that most algologists use obtained algal lists to characterize the ecological state of the water bodies they investigate. However, the publication of all these researchers can not be listed here, and the authors did not set themselves such a task. The value of this work compose indicating the scale of the indicator characteristics of algae usage in the comprehensive study of different water bodies in Ukraine. The authors apologize to those scientists whose works are not mentioned in this analytical generalization, but we confirm their contribution as an extremely important for understanding the regularities, as well as explanations for the changes that occur in water bodies.

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АЛЬГОІНДИКАЦІЙНІ ДОСЛІДЖЕННЯ В УКРАЇНІ

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Проаналізовано розвиток та становлення альгоіндикаційного напряму досліджень в Україні з часу його започаткування. Охарактеризовано основні здобутки та результати робіт альгологів, гідробіологів та екологів щодо використання водоростей-індикаторів екологічного стану водойм та водотоків, а також еколого-біологічних показників видового складу при характеристиці та визначенні типу дослідженого водотоку Представлено можливості залучення зазначених відомостей до загальноекологічної характеристики стану водного об'єкту. Показана багатогранність використання та показовість прісноводних і морських альгоугруповань мікро- та макроводоростей, їх таксономічної структури та окремих видів-індикаторів при дослідженні специфіки водойм і встановленні їхнього стану чи характеристики окремих ділянок водотоку. Відзначена комплементарність та відповідність водоростей-індикаторів в оцінці якості вод за методиками та стандартами «Водної рамкової директиви 2000/60/ЄС». Встановлена методично визначальна роль діагностичних видів водоростей при встановленні назв альгоценозів, їх біо- та екотопічної приуроченості, індикаторності антропогенного навантаження, рівня сапробності та трофності водних об'єктів, а також важливість залучення окремих еколого-фізіологічних показників цих видів при альгоіндикації забруднених водойм. Продемонстрована актуальність альгоіндикаційних досліджень як сучасного методу оцінки не лише якості води, але і стану водної екосистеми загалом.

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