UDC 574.21:58.087:581.5:582.001.4:574.23:57.012.22+23:911.2:581.4:57.018.634.725:581.15 (477.60)

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NEW DIAGNOSTIC CRITERIA OF COMPLEX PHYTOINDICATION FOR APPROBATION IN DONBASS

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Safonov A. I. **New diagnostic criteria of complex phytoindication for approbation in Donbass. –** Practical means of principally important blocks of integration of industrial indicational botany trends have been grounded. Indices of structural transformation of plants, their fluctuation asymmetry in technogenic and natural ecotopes have been potentialized. Strategies of plants' survival under unfavorable conditions of growth have been taken into consideration.

Key words: phytoindication, diagnostics of the environment state, Donbass.

In the conditions of contemporary technogenesis and urbanization it's important to apply universal, accessible and fast-acting informative methods of evaluation of the state and safety of the environment. To ascertain various characteristics of the environment methods of bioindication are widely used. In spite of all this, ways and means of complex evaluation of anthropogenically transformed biogeocenosis (BGC) are still not systematized [6, 10]. That's why they are always non-comparable and are not even likened. This necessitates approbation of integral approach to evaluation of territories [12]. The sense of such a process consists in different components being used as criteria of indication, and diagnostic evaluation must be complex – according to their physical, chemical and biological parameters. The use of biological indices are strategically more advisable [11, 17]. Such an approach is topical and gives opportunities to assess peculiarities of the environment on the basis of qualitative and quantitative characteristics of topic and biotic components of BGC, technogenic and urban ecological factors [10, 20, 22].

The aim of this work is to define long-term prospects and to present the initial data on the expediency of their application on the territory of the Donetsk region on the basis of modern global trends of development of phytoindicational direction in industrially developed regions.

The material is structurally presented by the following scheme:

- peculiarities of the environment state in industrial regions (edaphotopes and superficial pollution of biogeocenosis);
- ways of determining of plants' reaction to the action of factors of technogenic stress;
- indication trends: asymmetry of plants texture, structural transformations, abnormalities, functional criteria;
- strategies of species' survival under conditions of industrial pollution, ways of realization of vital positions of species of plants and signs of functional adaptation in the anthropogenically transformed environment.

In the previous publication [16] we have conducted an ecological analysis of the territory of an industrial town on the example of the Donetsk city with the use of bioindicational indices. The basic strategies of city development have been taken into account. A working scheme of bioindicational estimation of urban environment has been suggested. We suggested the following phyto-indices which range as follows for Donetsk according to a preliminary estimation: correlation of violents, patients and explerents, reproductive capacity of explerents, reproductive capacity of patients, reproductive effort of indicator plants, reproductive success of indicator plants among patients, demographic full value of patients, structural plasticity of species of plants on the level of organ morphology, structural plasticity of species of plants according to histological distinctions (tissue deformations, mostly conformational functionally active tissues), percentage of species with wide ecological amplitude, percentage of species having formed strategies of adaptation to air pollution, percentage of species having formed adaptation to soil and water and soil solution pollution.

Peculiarities of the environment state in industrial regions. Not every strong polluter is surrounded by industrial barrens. Their development seems only possible under specific combination of landscape characteristics, human activities, and co-occurring stressors; however, to our knowledge, no attempt was made to explore this problem by means of comparative analysis. It is only rarely appreciated that severely contaminated sites and other postindustrial landscapes may support regionally rare and endangered species [10, 12, 17, 21].

Industrial barrens are usually surrounded by strongly modified ecosystems that have a potential to turn into industrial barrens under some circumstances. Due to these positive feedbacks, industrial barrens may be to a certain extent resilient to external impacts, including both emission decline and restoration efforts. Soils of industrial barrens contain huge amounts of toxic pollutants deposited from aerial emissions. Since majority of heavy metals accumulated in soils are in non-soluble forms, their complete leaching from upper soil horizons will take centuries, e.g. 160-270 years for nickel and 100-200 years for copper accumulated in industrial barrens [14, 15, 17].

Disappearance of vegetation, especially of trees, strongly modifies the climate of industrial barrens. Although this problem is investigated insufficiently, it seems that the most important changes are imposed by altered temperature and wind regime. Even at early stages of pollution-induced forest deterioration air and soil temperatures during the growth season may substantially increase, leading to an increased water loss from upper soil layers. Aerial emissions of the smelter consist of dozens of substances, many of which may cause toxic effects. However, concentrations of principal metal pollutants, nickel and copper, are reported most frequently [5, 17]. Concentrations of other pollutants in all media (ambient air, soils, plants, animals) strongly correlate with concentrations of nickel and copper, decreasing exponentially with an increase of the distance from the smelter [14, 22].

Ways of determining of plants' reaction to the action of factors of technogenic stress. Naturalists have always been intrigued by the ability of life to sustain conditions inhospitable to humans. Both scientific and popular literature contains numerous descriptions of biota living "on the edge" – in deserts, on barren soil of polar islands, under Antarctic ice, in deep waters, and in many other more or less unusual conditions, including industrial zones.

Plant-plant interactions, which are mostly competitive in favourable habitats, tend to become positive in stressful environments [5, 6, 8]. In industrial barrens, where competition among plants is low due to decreased density, the role of facilitation increases.

The sites of biological significance within severely degraded environments may not be as rare as is commonly thought, and assumption that physically or chemically hostile environments are incapable of attaining biological diversity is far from being true [13]. Industrial barrens are rather heterogeneous, with a range of different substrate types that favour different species. Therefore, in spite of the general loss of biodiversity, these habitats can develop a great richness of unusual and interesting plants, including regionally rare and endangered species, and the overall site diversity can be high even when each patch is relatively poor. Furthermore, several plant species of low competitive ability benefit from fragmentation of the continuous 'carpet' of vegetation. Invertebrates in industrial barrens may escape from strong enemy pressure, and this 'enemy-free space' phenomenon may explain high abundance of some species that are usually depressed in less disturbed habitats. Industrial pollution often causes dramatic perturbations in natural communities, leading to dynamic changes in plant populations. However, while changes in abundance and productivity of vascular plants have been reasonably well documented, little is known about the age structure of plant populations affected by aerial pollution. Shortage of information on the demography of plant populations persisting in extreme environments of industrial barrens [10, 22] hampers prediction of long-term consequences of pollution impact on terrestrial biota at both local and regional scales. Quite frequently, conclusions on the contamination level (in terms of the excess over the background value or critical load), spatial pattern or extent of pollution are based on the samples collected during one growth season, or samples are compared between two study years in order to reveal changes in the contamination [12].The results of long-term monitoring demonstrated pronounced spatial and temporal variation in concentrations of Ni and Cu in foliage of plants near the large point polluter. These data suggest that oneyear sampling, frequently used in ecological and environmental studies, can easily produce misleading results on both the levels of pollution load and spatial distribution of pollutants. Scientists investigate the general pattern of changes in species richness and diversity of vascular plants due to environmental contamination and associated habitat changes imposed by point polluters, and identify the sources of variation in the response of plant communities to industrial pollution [3, 6, 10, 17, 22]. Extant plants in industrial barrens facilitate deterioration of soil quality in their own rootinhabited areas: plant foliage traps contaminants, which then enter the soil (with either rainfall or plant litter) immediately under a plant.

Vegetation or habitat types are ecological phases, which can assume multiple states, and transformations from one type of phase to another are ecological phase transitions. If an ecological phase maintains its condition of normality in the linked processes and functions that constitute ecosystems then is believed healthy. An adaptive cycle, such as in model, has been proposed as a fundamental unit for understanding complex systems and their dynamics. Such model alternates between long periods of aggregation and transformation of resources and shorter periods that create opportunities for innovation.

An important function of indicators is to evaluate the functional compliance of ecosystems. In the context of an eco-systematic environment evaluation and for monitoring tasks the necessity results to characterize all eco-systemic fundamental functions by means of corresponding indicator sets: according to a classification by [5, 13, 19] this includes aside from: 1) production functions (that is producing or making abiotic and biotic resources available); 2) regulatory functions (that is the ability for self purification, stabilization and shielding against external influences); 3) the medium function or carrying capacity of ecosystems (that is their ability to provide locations for human utilization and to absorb resulting impacts) and also 4) its information functions. The information function of an ecosystem in a wider sense refers to the indicator principle, such as a function; in the narrower sense it refers to the structure of the environment and its function for regulating the satisfaction of certain needs.

Indication trends: asymmetry of plants texture, structural transformations, abnormalities, functional criteria [1, 4, 6, 9, 14, 19, 21, 23]**.** One possible application of the special approach can be demonstrated by the impacts of streets on the visual landscape. This example makes it evident that indicators for landscape diversity are only able to illustrate changes of individual elements but not of the character of landscapes themselves. This fact makes it necessary to additionally integrate aspects aside from quantitative ones when evaluating the visual landscape. Furthermore, it is necessary to empirically verify aspects that are significant for the perception of landscapes in order to make them more accessible than has been thus far for evaluations in the sense of indicators.

The methodology is based on exposure, registration and comparative analysis of asymmetry of different species of living organisms using definite indices [23]. The indicative quality of bioindicators, ranging from organelles, organs or single organisms to complex ecosystems, depends on inherent ecophysiological properties, population dynamics, and stress reactions with regard to physical and chemical changes in site conditions. The primary task of bioindicators is the general determination of physiological effects in the sense of strain reactions rather than the direct measurement of environmental concentrations of stressors. Thus, in early recognition perspective the lack of specificity has the advantage of a broad-based caveat, inducive to subsequent systematic search for quantitative causal inter-relationships.

A further advantage of biomonitoring is its comparatively low cost on the one hand and the integrative recording character on the other. Contrary to these positive aspects of bioindicator use there is, however, an essential deficiency resulting from the highly variable susceptibility of the test species exposed to stressors, which leads to difficulties in comparing specific effect data.

Active and passive biomonitoring approaches on the basis of single-species reactions yield spatially valid data only on condition the underlying sampling networks are implemented in compliance with geostatistical requirements or the corresponding test methodologies of variogram analysis and kriging procedures, respectively. Analogously, also the selection of complex bioindicators such as biocenoses or ecosystems must be based on rigid criteria of spatial and temporal representativeness. After a short introduction on approaches using either structural or functional indicators, we develop a methodological framework for the analysis and management of landscapes, using landscape ecological principles related to a holistic approach. In a next step, we disaggregate some of the internal processes in landscapes in order to delineate groups of indicators in its spatiotemporal context.

Strategies of species' survival under conditions of industrial pollution, ways of realization of vital positions of species of plants and signs of functional adaptation in the anthropogenically transformed environment [2, 7, 8, 18, 19]**.** All these habitats exist for millennia, and living beings had sufficient time to evolve biochemical, morphological and behavioural adaptations allowing to live and even flourish in these "extreme environments". More astonishing is the diversity of life persisting in industrial barrens – extreme habitats that appeared as a byproduct of human activities only about a century ago. Unfortunately, industrial barrens are studied much less than other "extreme habitats": the scientists were only called to evaluate the damage or develop rehabilitation measures. Importantly, information on several industrial barrens is reported only in publications describing reclamation measures. Even the researchers exploring pollution effects on plant communities tend to select the most polluted sites outside industrial barrens, because these habitats seem not comparable with less disturbed sites [5, 6, 10].

The state of the regional and phytocoenological species pool and the relationship between autochthonous and allochthonous species may help to describe the importance and potential risks of biological invasions. Life strategy types reflect the interactions between species trade-offs and environmental constraints. The species preferences for different hemerobic steps may be used as indicators of human impacts especially in agricultural and urban landscapes and ecological indication values for different site qualities.

Biodiversity in its different aspects can only be successfully sustained, if the multitude of biological interactions with the human way of life in and subsiding on ecosystems are considered. A regional application of these principles is necessary for sustainable landscape planning.

According to any parameter reflecting reproductive biology or relationships between a plant and environment, the species form continuum that is reduced to the discrete types because of pragmatic reasons. Continuum of species strategy (behavior) reflects their relationships to the level of resource supply, biotic factors and disturbances. The last index is basic for analysis of disturbed habitats on the territory of Donbass.

Different species adapts to the same environmental factor using different sets of physiological and structural modes. The greater number of such modes, the more successfully species can get over environment resistance. When monitoring landscape changes, the visual landscape should also be considered. This pertains to the information function of ecosystems and landscapes that refers to environmental structure and its function for satisfying needs.

The program is ambitious. Essential elements are: to consider temporal and spatial interactions, to involve an adapted management of all ecosystems, an integrative monitoring of changes in ecosystem structures and functions, the interdisciplinary research with a broad perspective and a close cooperation with stakeholders and decision makers, cooperative decision-making including scientists, landscape planners, politicians and the local and regional population, to include integrative ecological perspectives in the spatial and temporal planning procedures, the attempt to carry out appropriate decentralized decision-making and, last not least, to implement all regions with various population densities into a sustainable ecosystem management.

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***Сафонов А. І.* Нові діагностичні критерії комплексної фітоіндикації для апробації в Донбасі.** – Обгрунтовано практичні можливості принципово важливих блоків інтегрування напрямків промислової індикаційної ботаніки. Потенціалізовано показники структурної трансформації рослин, їх флуктуаційної асиметрії в умовах техногенних та природних екотопів. Враховано стратегії виживання рослин у несприятливих умовах зростання.

Ключові слова: фітоіндикація, діагностика стану довкілля, Донбас.

***Сафонов А. И.* Новые диагностические критерии комплексной фитоиндикации для апробации в Донбассе.** – Обоснованы практические возможности принципиально важных блоков интегрирования направлений промышленной индикационной ботаники. Потенциализированы показатели структурной трансформации растений, их флуктуационной асимметрии в условиях техногенных и природных экотопов. Учтены стратегий выживания растений в неблагоприятных условиях произрастания.

Ключевые слова: фитоиндикация, диагностика состояния среды, Донбасс.