Sustainable development – state and prospects
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Sustainable development of a compound landscape complex: approval of the compartmental concept

Introduction

Sustainable development of ecosystems is primarily the conservation and rational use of natural resources [1, 2]. The environmental factor now recognized as one of the most important conditions of life not only of production systems of various purposes, but of society as a whole. Therefore, the environmental component should be considered as one of the decisive factors in addressing sustainable development and an acceptable level of economic security, both for individual entities and for individual regions and the country. This problem can generally be characterized by the diversity of forms of environmental impact, the composition and intensity of impacts on the environment, the nature of social, economic, physiological and other consequences. To quantify these effects using a large number of indicators calculated both in natural and in financial form [3, 4]. Each indicator shows some signs of global ecological impact on the environment and recipients: the intensity and emissions of certain ingredients by different sources into the atmosphere and water, the levels of morbidity that may be caused by the impact on individuals from certain pollutants, socio-economic consequences of demographic content, economic consequences for individual sources of pollution, etc. That is, most of the used indicators only partially characterize the relevant impacts and are not suitable for a comprehensive assessment of solutions aimed at radically improving the ecological state of the environment, the practical implementation of which occurs under many constraints, including resource constraints.

In the most general form, solving of environmental rationing to achieve the goals of sustainable development comes to the analyze relationships and dependencies in the system of "anthropogenic load – a biota condition – ecosystem quality". However, the diversity of existing approaches and concepts in this field is determined by the targeted use of ecosystems and the interpretation of the concepts of "environmental norm" or "undesirable changes" and transformed through the choice of methods for determining boundary environmental loads and maximum permissible environmental changes, methods of measuring anthropogenic load, methods for describing the status of biota etc.

Analysis of the literature

Contemporary ideas about the role of compound landscape complexes (CLCs) are related to the ideas of V.V. Dokuchaev regarding the harmonious ratio in field-protected plantations of arable land, forests, meadows, reservoirs and the teachings of GM. Vysotsky's "Forest Pertinence" is the spatial impact of forests on the environment. Theoretical background, practical and analytical material presented in articles of the D.M. Vysotskyi, V.O. Bodrov, B.I. Logginov, Yu.P. Bialovich, V.I. Koptev, V.P. Kucheryavyi, M.I. Dolgilevich, O.I. Pilipenko, A.P. Stadnyk, G.B. Gladun, V.Yu. Yukhnovskyi and other researchers make it possible to outline a rather comprehensive scientific picture of the spatial-functional role of compound landscape complexes in the context of sustainable development.

Topicality

The CLC quality management system for sustainable development is a comprehensive mechanism regulated on the one hand by universal regulatory documents and, on the other, by a professional regulatory framework that takes into account the industry specificity of the quality management system (QMS). The combination of these two components allows to identify the main principles of QMS CLC:

– a systematic approach that is seen in the consideration of all elements of the CLC as interconnected and interacting to achieve a single management goal; its characteristic feature is the optimization of the functioning of the system as a whole, not of individual elements;
– the principle of total cost, namely the accounting of the totality of the costs of managing the traffic flows and related information, financial and other flows of the entire logistics chain;
– the principle of global optimization. While optimizing the structure or administration in the CLC, it is necessary to agree on the local goals of the functioning of the system elements to achieve the global optimum;
– the principle of coordination and integration is the achievement of coherent, integrated participation of all CLC units in energy flow management in the implementation of the objective function;
– the principle of total quality management of CLC – ensuring the reliability of operation and high quality of work of each element of CLC to ensure the overall quality;
– the principle of sustainability and adaptability. The CLC must function invariably with allowable deviation of parameters and factors of anthropogenic loading. With significant fluctuations in the stochastic environmental factors, the CLC must adapt to new conditions, changing the operation, optimization parameters and criteria.

Research results

As an environmental regulation of CLC we understand the process of developing regulatory support and regulations for anthropogenic factors, regarding their impact on the compartment, compliance with which guarantees the quality of CLC functioning (reliability, protective efficiency and sustainability). In general, the problem is to set the following load values, which do not cause deviations in the normal functioning of the compartment for an indefinitely long period of time (ensuring reliability and stability), and allow the compartment to perform its protective function.

The central methodological problem of CLC environmental regulation is the issue of compartment norm and criteria of normality. The proposed approach determines that the norm is a measure of the quality of the compartment's functioning. That is, the norm is a limited area of state of the compartment subsystems, which satisfies the existing in the normative documents the notion of high quality CLC. This quality criteria should be explicitly formulated (sustainability criteria).

The axiological understanding of a norm determines its relativity: the norm is defined by a specific CLC and a time interval. However, this does not mean that the formulation of normality criteria are arbitrary. Ecologists can be the only adequate entities to create quality criteria, since they alone have the knowledge about the functioning of ecosystems and their sustainability as a whole. Also, experts must consider the economic, social and aesthetic needs of indigenous peoples.

The system of value criteria includes parameters that provide:

- direct implementation of socio-economic functions (e.g. primary and secondary products of a certain structure and size);
- reliability of the compartment as a whole (without which they cannot perform their functions);
- the necessary contribution of a particular compartment to the functioning of the CLC (up to the biosphere as a whole), without which the functioning of local ecosystems is impossible – the sustainability of the compartment.

In the first stage, the background state of the studied CLC is taken as the reference point (for compartments whose source areas are not significantly overlapped).

The characteristic spatial scale in this variant is local. This implies that the main object in the development of standards – compartment (compartment is an elementary functional element of rationing. It is characterized by the minimum volume and current composition of the substance). This is due to two factors. First, the size of the compartment is significantly smaller than the entire area CLC (ie, it can serve as a point of space). The existing method of selection of compartments in accordance with large plant communities is chosen insofar as it corresponds to the scale of space and time in which a human lives. [5, 6]

Some compartment subsystems are not included in the local rationing system, the reasons for this are:

- local subsystems may go beyond the specific compartments, and in some cases overlap zone the emissions source or other anthropogenic factors;

– ecosystem parameters may remain unchanged when transforming subsystem compartments and species changes.

Therefore, the impact on the subsystems (especially industrial, rare and endangered species) should be regulated by regional and global regulation.

The whole set of parameters that can be described by the CLC is divided into two subsets: main and correlative. The main parameters that characterize sustainability and ensure the reliable functioning of compartments and the contribution to the functioning of the CLC in general. Correlative parameters an associated with the first subset, but are not directly interpreted in the value scales – reliability and protective efficiency.

Boundary loads are found by allocating the critical curve points of the dose → effect constructed for all major and correlative variables that naturally change with the gradient of contamination. At a critical point means the beginning of the rapid change of setting. To build dose dependence, passive experiments are required – field research of real CLC compartment experiencing different doses of anthropogenic impact on the real source of emissions. The interpretation of the results is based on the principle of spatio-temporal analogies: the spatial gradient is considered a reflection of the successive change in the compartment.

The maximum permissible environmental load (MPEL) is the minimum of the limit loads on a set of parameters. The set of main parameters defines the current (operational) standard, correlative – the introductory (perspective) standard. The most stringent target standards can be obtained only through regional and global regulation. The MPEL standard is interpreted as the necessary multiplicity of emission reductions of a given source to such a level that the compartments, their subsystems and tiers will not differ from the background values throughout the CLC near this source. Therefore, reaching the standards can be achieved if emissions are reduced on all components. That is, the cumulative load from the emission source is normalized, but not the individual ingredients of its emissions. The standard obtained only means that at the load level found important parameters for compartments of a particular type of CLC in this region for the duration of a particular type of emission source will not go beyond the critical level. [7] Extrapolation of the results beyond the outlined area is illegal. Norm in the form of emission reductions multiple more realistic than the absolute values of the concentrations of the individual toxicants.

Obtained standards can be expressed in absolute and relative form (Fig. 1).

Possible options for presentation are different forms of the same standard, which can be derived from one another. Besides, for each standard there are two time forms: current (operational) – for existing industries and trial (perspective) – for the projected. Therefore, the most informative form of the primary standards is the required multiplicity of emission reductions.

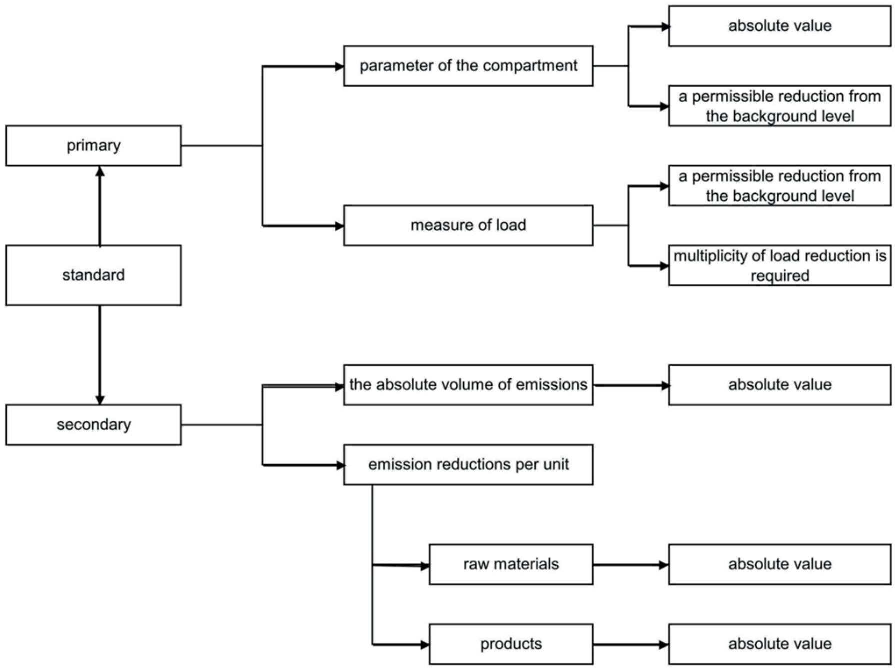

Fig. 1. Forms of presentation of environmental standards

The absolute values of the compartments parameters of the layers and subsystems are unsuitable for direct use because of the difficulty of measuring them and controlling for considerable natural variability.

The sequence of procedures for establishing environmental standards. In the implementation of the procedure of normalization of CLC, according to the compartmental approach are the following stages (Fig. 2):

– selection of test areas that meet specific requirements and may be analogous to other compartments within geobotanical areas, CLCs, or physical and geographical areas;
– measuring the extent of loading at each test area;
– formation of the list of the main and correlative parameters of the compartment to be registered. Registration of main and correlative parameters at each test area;
– construction dependencies of dose → effect for all registered parameters that regularly change with load gradient: the selection of approximating equations of logistic curve. Finding the critical points of logistic curves for all parameters. Choosing the smallest abscissa of these points for a subset of the main and correlative parameters. Determination of the primary environmental standards;
– comparison of found MPEL with hygienic MPCs for the major air, soil and water ingredients of emissions. If the MPC is less rigid than the MPEL, they are not accepted; if the MPC is more rigid than the MPEL, further constructions are based on them (the corresponding load measure is calculated on the basis of them);
– analysis of the technological cycle of production. Definition of absolute and specific emission indicators. Calculation of secondary environmental standards for

important absolute and specific production indicators in which the normal state of the compartment and its subsystems is observed at the factory walls.

Investigated CLC is the aggregate of areas – compartments that are under the action of a load gradient from the maximum to the minimum level. The background load (that is, the load outside local sources, or the load from regional and global emissions) is taken as the minimum level.

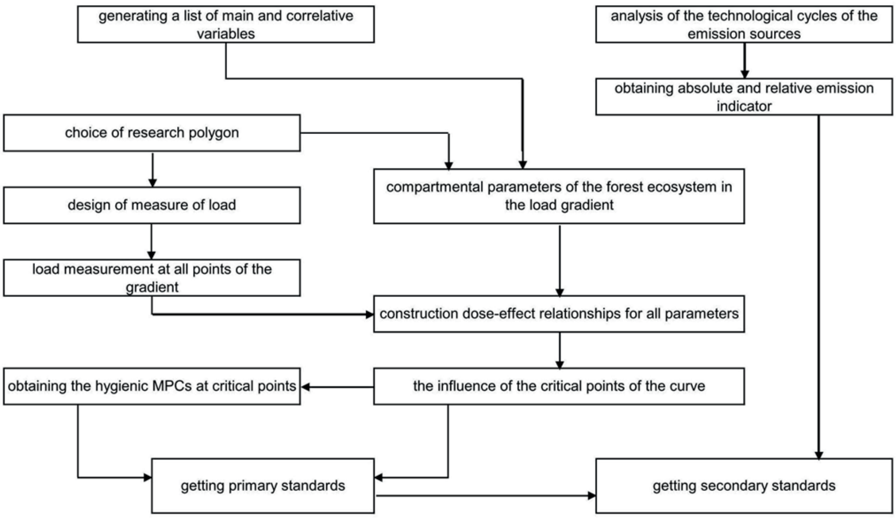

Fig. 2. The sequence of the procedure of environmental regulation

The compartment selected for the study must meet the following criteria:

– the source of emissions of pollutants, sediments, and radionuclides has been active for a long time (for a time comparable to the life time of the species of ecosystem engineer; for forest compartments, it is about 50 years). In this case, the transformation of the compartment must reach a stationary level;
– CLC's test areas must represent the same genetically type of compartments or subsystems of compartments located in the same terrain elements (i.e., they must be biogeocenoses of the same type before the emission source begins);
– the compartment should "go out" to the regional background and not "lean" to the area of another source of emissions;
– the structure of the emissions and their magnitude should change little over the lifetime of the source;
– detailed information on the structure and absolute magnitudes of emissions is required.

CLC compartments can be located in different directions from the source of emissions (even with symmetrical wind rose); it is important that their aggregate form a fairly divisible load gradient. The number of test areas should be at least 25-30. This number is necessary for a correct approximation the depending dose → effect.

The results obtained in these compartments serve as the norms for projected productions, the background environment of which does not allow for proper research. In other words, standards cannot be obtained from any source of emissions (but, of course, they can be applied to any one). Obviously, the compartment should serve as an adequate analogue of CLC.

Load measure it is an indicator with which the values of the biota parameters at each point of the gradient must be compared. Accordingly, the measure of anthropogenic impact should be:

– easily measurable at any point in space;
– an integral indicator (index) of the impact of all toxic agents from this source emissions (hence, these should not be the concentrations of individual pollutants, but relative indicators);
– compared to specific and absolute emission indicators;
– environmentally significant (i.e. related to the toxic effects).

These criteria make it possible to conclude, that the load can be any aggregate index, based on the content of pollutants, sediments, and radionuclides in the compartment subsystem tiers (for example, the average excess of the background level by content of elements).

For the purpose of normalization, it is necessary to clearly divide all parameters of the CLC compartment into two unequal groups – main and correlative. The criteria for assigning a parameter to the main are:

– implementation of protective functions;
– ensuring reliability;
– the impact of each compartments subsystem and tier on the functioning of the CLC.

The parameter will be the main, if it meets at least one (or more) criteria. Correlative parameters should be outstripping indicators of change in the main. The procedure of separation of parameters into main and correlative is carried out experimentally. Each of the CLC compartments can be described by an infinite number of parameters or indicators, supplemented by state index values. At the stage of determining the range of indicators, should not use the averaging procedure and no a priori restrictions on the number of indicators should be imposed; they can be used in parallel, and competitiveness and a certain amount of redundancy can guarantee the reliability of conclusions.

However, since there is always a need to limit the set of variables, so preference should be given to parameters that meet the following criteria:

– integrity – such indicators are more stable and are the resultant values of many multidirectional processes;
– nonspecific response of the value of the indicator to the influential action;
– the ability to generate a response in space and time (plane estimates, not point; permanent, not momentary);
– low costs measurement, possibility of non-destructive registration (visual or remote);
– reliability of the results (minimum variance under the same measurement conditions, insensibility to the factors causing interference);

– small characteristic time parameter changes (It should be substantially less time pollution source actions, which is being investigated).

Logistic function can be used as an analytical form of response dose → effect for CLC compartments. At critical points should be understood as areas where qualitative jumps of function occur, that is, a small increment of the argument corresponds to a disproportionately large increment of function. Critical points can be identified by derivative analysis. For the logistic curve, the most important information load has three critical points – upper, middle and lower. The sections to the upper and after the lower points are the area of stable parameter values (slow changes). The area between the critical points is an area of instability (quick change). The midpoint is the measure of the load which corresponds to a 50% change in parameter. The greatest important point is the upper critical point – after its passage, the fastest and, therefore, unacceptable, parameter change begins. Its abscissa can be adopted as a critical load.

Discussion of results

To obtain the primary standard of maximum permissible environmental load, it is necessary to:

– identify all the major and correlative parameters that regularly change with the pollution gradient;
– for each such parameter, find the approximation equation of the logistic curve and its upper critical point;
– in each group select the minimum value of the abscissa of the critical points.

The value for the subset of the main parameters is adopted as the current standard, for the subset of the correlative – as a trial. Secondary environmental standards are the absolute and specific emission values under which all areas near a source outside the alienated region are in a good condition. Strictly speaking, for accurate calculation of secondary standards requires a sufficiently detailed formalized model that relates the technological parameters of production, the volume and structure of emissions, on the one hand, and the total distribution of the content of pollutants, sediments and radionuclides in the compartments layers and subsystems for the entire life of the enterprise for the entire CLC near the source. Then, knowing the value of the limit loads, it is possible to solve the inverse problem on this model to determine the emission volumes that will correspond to the limit loads.

In the first approximation (assuming that the situation is stationary in emissions and there is a linear relationship between the flow of pollutants, sediments, radionuclides and their deposition), the secondary standards can be obtained on the basis of a simple proportion: existing emission values correspond to the maximum found and required sustainability and needs find an amount of emissions that is consistent with the obtained values of protective efficiency and reliability. In consequence:

$$\text{Secondary\_standard} = \frac{\text{Reliability}}{\text{Protective efficiency}} \qquad (1)$$

This does not consider the necessity for additional load reduction or remediation measures required, which is needed for returning of the already degraded CLC compartments tiers and subsystems to the initial state. Another limitation is that the emission indicator must be achieved for each ingredient separately and not on average for all, as the standards are developed for a specific emission structure, with a certain synergism of hazardous factors.

Conclusions

1. In implementation of the procedure of normalization of compound landscape complex, according to the compartmental approach, a sequence of environmental normalization procedure is proposed, which clearly defines the criteria to be met by the compartment.

2. Based on the processed material, it is concluded that for the purposes of normalization, it is necessary to clearly divide all parameters of the description of the compartment into two unequal groups – the main and the correlative, where parameters admission criteria to the main are: implementation of protective functions; ensuring reliability; ensuring the contribution of each compartment with its subsystems to the functioning of the of the whole CLC (the stability of the CLC, due to the risk of loss of the compartment).

3. As an analytical form of the representation of the dependence dose → effect for the compound landscape complexes, you can use the logistic function.

4. The theoretical substantiation of creation of the system of normative indices of anthropogenic loading for a compound landscape complex is determined by the content and accumulation of heavy metals, trace elements and radionuclides in the soil→plant system, as a component of the compartments quality control system.

5. Evaluation of the developed standards for the content of heavy metals, trace elements and radionuclides in soils and other components of the trophic chains for the existence of a shortage, excess of chemical elements it is proposed to carry out according to the list of their controlled indicators (prediction and determination of trends in changes of norms on the basis of methods of mathematical statistics, analysis of dynamic lines and using of index method; the degree of scientific validity and progressiveness (determined by systematic sampling monitoring of scientific validity of standards); comparability with background indicators, existing norms and standards, actual data of European standards, world analogues; retrospective, perspective and complexity of the main features that characterize the system of norms, rules and regulations (separation the most essential features of a particular process); unity of principles of development and unity of efficiency criteria of use; the interconnection of the individual elements of the system; graduation of the main and accessory indicators).

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