СУЧАСНІ ГЕОГРАФІЧНІ ТА ЕКОЛОГІЧНІ ДОСЛІДЖЕННЯ ДОВКІЛЛЯ

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METHODOLOGICAL PRINCIPLES OF THE CONSTRUCTION GEOGRAPHY ON THE STUDY OF THE STATE AND PROTECTION OF NATURAL LANDSCAPES

Purpose. The paper is devoted to some aspects that influence the formation of landscapes. Among the main objectives of the study: to consider the anthropogenic load as one of the factors influencing the development and change of landscapes; to give an analysis of the scientific works of scientists who have considered issues of landscape science in general, as well as anthropogenic landscape science; to consider the importance of research results that can be used in projects for the conservation and sustainable use of natural resources. **Results**. The landscape, being a multifunctional formation, is suitable for performing a different type of activity, but the functions it performs should correspond to its natural properties and resource potential. One of the basic principles of the protection of natural landscapes is the preservation of their structure and nature of functioning in conditions of intensive environmental management, and as a result of anthropogenic pollution. **Conclusions.** Conducting environmental management in any territory requires an objective and comprehensive environmental assessment of the state of the environment. Integrated assessment of the state of the environment and the geological environment in particular (the natural-geological environment) is the most complex geo-ecological task located in the cognitive methodological and methodological chain: system approach → system analysis → integrated assessment. Since there is no single integrated indicator of the ecological state in nature, a number of bioindication, spatial and dynamic indicators serve as criteria for assessing the ecological state of natural environments and ecosystems, and the integrated assessment is based on a certain number of the most representative indicators.

Key words: landscape, anthropogenic landscape, constructive geography, geo-ecology, aquatic complexes

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МЕТОДОЛОГІЧНІ ПРИНЦИПИ КОНСТРУКТИВНОЇ ГЕОГРАФІЇ ПРИ ДОСЛІДЖЕННІ СТАНУ ТА ЗАХИСТУ ПРИРОДНИХ ЛАНДШАФТІВ

Мета. Охоплення деяких аспектів, що впливають на формування ландшафтів. Серед основних завдань дослідження: розглянути антропогенне навантаження як один з факторів, що впливає на розвиток і зміну ландшафтів; провести аналіз наукових праць учених, які розглядали питання ландшафтної науки в цілому, а також антропогенної ландшафтної науки; розглянути важливість результатів досліджень, які можуть бути використані в проектах із збереження та сталого використання природних ресурсів. **Результати.** Ландшафт, будучи багатофункціональним утворенням, підходить для виконання різних видів діяльності, але функції, які він виконує, повинні відповідати його природним властивостям і ресурсному потенціалу. Одним з основних принципів охорони природних ландшафтів є збереження їх структури та характеру функціонування в умовах інтенсивного природокористування та внаслідок антропогенного забруднення. **Висновки.** Проведення екологічного менеджменту на будь-якій території вимагає об'єктивної та всебічної екологічної оцінки стану навколишнього середовища. Інтегральна оцінка стану навколишнього середовища та геологічного середовища зокрема (природно-геологічне середовище) є найбільш складним геоекологічним завданням, що знаходиться в когнітивному методологічному та методо-

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логічному ланцюзі: системний підхід → системний аналіз → інтегральна оцінка. Оскільки не існує єдиного інтегрального показника екологічного стану в природі, ряд біоіндикаційних, просторових і динамічних показників слугують критеріями оцінки екологічного стану природних середовищ і екосистем, а інтегральна оцінка базується на певній кількості найбільш репрезентативні показники.

Ключові слова: ландшафт, антропогенний ландшафт, конструктивна географія, геоекологія, водні комплекси

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МЕТОДОЛОГИЧЕСКИЕ ПРИНЦИПЫ КОНСТРУКТИВНОЙ ГЕОГРАФИИ ПО ИЗУЧЕНИЮ СОСТОЯНИЯ И ОХРАНЫ ПРИРОДНЫХ ЛАНДШАФТОВ

Цель. Освещение некоторых аспектов, влияющих на формирование ландшафтов. Среди основных задач исследования: рассмотреть антропогенную нагрузку как один из факторов, влияющих на развитие и изменение ландшафтов; дать анализ научных работ ученых, которые рассматривали вопросы ландшафтной науки в целом, а также антропогенной ландшафтной науки; рассмотреть важность результатов исследований, которые могут быть использованы в проектах по сохранению и устойчивому использованию природных ресурсов. **Результаты.** Ландшафт, будучи многофункциональным образованием, подходит для выполнения другого вида деятельности, но функции, которые он выполняет, должны соответствовать его природным свойствам и ресурсному потенциалу. Одним из основных принципов охраны природных ландшафтов является сохранение их структуры и характера функционирования в условиях интенсивного природопользования и в результате антропогенного загрязнения. **Выводы.** Проведение природопользования на любой территории требует объективной и комплексной экологической оценки состояния окружающей среды. Интегральная оценка состояния окружающей среды и геологической среды в частности (природно-геологической среды) является наиболее сложной геоэкологической задачей, находящейся в когнитивно-методологической и методологической цепочке: системный подход → системный анализ → интегральная оценка. Поскольку не существует единого интегрального показателя экологического состояния в природе, ряд биоиндикационных, пространственных и динамических индикаторов служат критериями для оценки экологического состояния природных сред и экосистем, а интегральная оценка основана на определенном числе наиболее репрезентативных показателей.

Ключевые слова: ландшафт, антропогенный ландшафт, конструктивная география, геоэкология, водные комплексы

Introduction

Ideas about the landscape have been repeatedly changed, transformed and supplemented. According to V.M. Pashchenko [1], it is precisely “the geoecological nature of constructive and geographic workings that greatly increased the importance of landscape knowledge and landscape-based approach to them”. With the development of science, in-depth study of natural processes and their interrelations with human activity, the concept of landscape was revealed, expanded, encompassing not only the natural, but also the economic, cultural, social sphere. In most cases, the landscape is regarded as a natural formation. In the works of N. A. Solntsev [2] we can find the following definition: “A geographic landscape should be called such a genetically homogeneous territory in which there is a regular and typical repetition of the same interrelated combinations: geological structure, landforms, surface and groundwater, microclimates, soil differences, phytocenosis and zoocenosis”. Along with the natural understanding of the landscape (N.A. Solntsev), there is an understanding of the anthropogenic landscape (F. N. Milkov, G. I. Denisik) and the cultural landscape (Y. G. Saushkin, A. G. Isachenko, V. A. Nikolaev). According to F. N. Milkov [3], “by the anthropogenic landscape is meant such complexes in which any of the landscape components, including vegetation, has undergone a fundamental change under the influence of a person over the entire area, or over a larger area”. According to N. F. Reimers [4]: “the landscape is cultural - purposefully created anthropogenic landscape, possessing expedient structure and functional properties for human society”. According to Y. G. Saushkin [5] – “a cultural landscape is a landscape that has acquired new, qualitatively different, features in comparison with the former natural state due to the direct application of the labor of human society”. At the initial stage, the integrity of the natural and economic components in the interpretation of anthropogenic landscapes, rather, was declared. Technogenic systems, like human himself, were most often viewed as external to the natural complex. At the same time, in a number of works, landscape begins to be understood as the most complex territorial system consisting of natural, economic, and social components [6–8]. So “landscape” is identified with the concept of “natural technology” or “geotechnical system” [9]. In the development of the term “geotechnical system”, the concepts “natural-economic system” [6] and “natural-economic territorial system ” [8] are proposed. Here, the consideration of the structure of natural-technical geosystems with regard to management, including the management of elements of environmental management, comes to the fore. A special model of the natural-economic territorial system, where the economic and natural subsystems form an integral unity, and the anthropogenic factor is an internal element of the development of the system, suggested by G. I. Schwebs [8]. The understanding of the landscape as an integrated system, including the natural, anthropogenically transformed, industrial and social subsystems, proposed by V.A. Nikolaev [10]. He formulates the concept of “natural anthropogenic landscape”. All of the above-mentioned definitions have a common basis, and differently interpret the influence of social aspects on the landscape, reflecting the degree of perfection of the landscape created by human. [11].

The purpose of this article is to highlight some aspects that influence the formation of landscapes. Among the main objectives of the study: to consider the anthropogenic load as one of the factors influencing the development and change of landscapes; to give an analysis of the works of scientists who have considered issues of landscape science in general, as well as anthropogenic landscape science; to consider the importance of research results that can be used in projects for the conservation and sustainable use of natural resources.

Results and discussions

The formation of technogenic landscapes can go in two ways: at the expense of natural (biogenic) landscapes, as well as the formation of new ones at the expense of previously existing technogenic landscapes. Technogenic landscapes, formed in the first way, are most often in undeveloped and poorly developed areas, and landscapes, formed in the second way - in regions with long-standing anthropogenic activities. If the end result of the anthropogenic transformation of the natural environment almost always leads to the formation of human-made landscapes, then its initial stages are very diverse. On the one hand, this diversity is explained by different geographic (more precisely, landscape-geochemical) peculiarities of the territories under consideration, and on the other, by the diversity of anthropogenic activities. If geographic factors for certain territories in most cases are practically unchanged, then anthropogenic activity changes quite quickly and the rate of change increases all the time [11].

In the work [12], considering the natural configuration of the landscape, M. D. Grodzinsky identified 5 types of structure: genetic-morphological, positional-dynamic, paragenetic, basin and biocentric-network.

The basis of the allocation of territorial units of the genetic and morphological configuration of the landscape is the association of territorially adjacent geotopes in larger units on the principle of their common origin, time of origin and patterns of development. The position-dynamic configuration of the landscape assumes the same intensity of processes caused by planetary material flows. Therefore G. I. Schwebs [13] called them landscapes, groups of adjacent geotopes, which have a common location relative to the change in the intensity of the material plane flows. Under the paragenetic configuration of the landscape refers to the horizontal connections between adjacent geotopes of common origin [14]. In accordance with this provision, the paragenetic landscape is a territorial structure composed of genetically close geotopes, which are closely interconnected by horizontal flows, and therefore form a dynamic integrity.

The biocentric-network configuration of the landscape is an example of spotted territorial structures. The connections between the structures of the landscape, forming its biocentric-network configuration, are related to the territorial features of behavior, migration, resettlement and other relationships among populations. In such a configuration of the landscape, biocentres play a decisive role, the main significance of which is the conservation of biological diversity.

In today's conditions of widespread anthropogenic pollution of the natural environment, studies of the consequences of its harmful effects on natural landscapes are of great importance. According to the interpretation given in the Dictionary of Landscape Protection, edited by Preobrazhensky [15], geographic systems in which natural and anthropogenic elements interact in the course of nature use are objects of environmental protection.

One of the main principles of the protection of natural landscapes is to preserve their structure and character of functioning, therefore, in the conditions of intensive nature management and as a result of anthropogenic pollution, the constructive-geographical methodology of the combination of approaches - landscape approach (type, structure, character of functioning, state of the geocosystem) and ecological approach (interconnections between living organisms and their habitat) [6].

Under such conditions, it becomes clear that the study of complex systems in the existing paradigm will not lead to breakthrough results, but risks, with time, to discredit the very meaning of complex research. In order to achieve real action in favor of the ecological components of the systems under study, a change in the research paradigm is needed, moving from the paradigm of the contrast between anthropogenic systems and natural systems within the framework of the ecological-economic system model to a coordinated, managed development paradigm in the presence of certain management constraints. One of the first thoughts about the necessity of the study of ecological-economic systems was expressed by V. N. Sukachev and supported by V. B. Sochava. The transition to a management paradigm will make it possible to specify the answers to questions posed by a person (end-user) to the socio-economic system from the position of multicriteria management on the chosen criteria of optimality.

Based on the foregoing, at the present stage of the study of complex systems, as the main object of research, one should choose a single (unity from the position of the general control circuit) system in which the priority of the natural subsystem is given, generally referred to as the landscapes, which are influenced by human activity on the transformation of the eco-economic system. An important characteristic of the ecological-economic system is that it belongs to the category of dynamic systems. Its subsystems interact continuously and are changed. In order for the system to function properly, it should be in a state of dynamic equilibrium, in which the energy, information and material exchange between society, production and the natural environment is organically "inserted into the natural cycle of substances and natural energy flows, resulting in a total balance of substances and energy is preserved" [16]. Any system under the influence of external and internal factors can acquire a different state: equilibrium (stable, stable), local equilibrium or disturbance of equilibrium (unstable). Interest in the state of the equilibrium of the system, because only in this state undergoing radical changes in the system, and even insignificant manifestations of influence on this system, may create conditions for a fundamentally new state of the system or a new trajectory of its evolution. Such a state of engineering ecology is called the state of bifurcation, or the state of dynamic equilibrium. Such a dynamic equilibrium represented the established ecological system or system of elemental natural landscape. According to V. I. Vernadsky, this is an absolute (in a natural state) landscape, which has the properties of a complete central symmetry relative to the location of the centers of the geosphere [17-19]. Under the influence of anthropogenic and human-made factors anthropogenic landscape is formed. There are changes in the potential composition of the Vernadsky's geospheres, there is an asymmetry regarding the location of centers of the geosphere, which causes a disturbance of the equilibrium of the natural-technical or ecological-economic system. Components of any landscape (soils, water, air) constantly interact with each other and seek to achieve a state in which the flow of substances and energies would be equal to the natural part, that is, the ecosystem naturally goes to a state of equilibrium. Since the landscape as a macrosystem consists of microsystems that have direct and reverse bonds, the change of one component leads to a change of another. The ability of the ecological-economic system to self-regulation and the achievement of dynamic equilibrium is defined as a dynamic homeostasis of the ecological-economic system. Of particular importance is the problem of equilibrium between macrosystems that are part of the geosphere: between ecological and ecological-economic systems, between ecological and economic and socio-economic ones. Due to the low level of environmental knowledge, wrong decisions are made in the process of nature management, which leads to the degradation of ecological and economic systems [20]. In this way, each component of the landscape develops according to its laws, but none of them (soils, vegetation, wildlife, etc.) can function in isolation, without affecting the influence of other components. The interconnection and integrity of the components of the landscape existed and will always exist. The study and forecasting of anthropogenic landscape changes allows us to solve the problems of inefficient nature management and to implement measures for the protection of the natural environment. Economic-and-geographical tasks are solved together with the ecological and economic ones: e.g. the location of productive forces, the location of industrial objects, agriculture and recreation, population, transport, etc. The degree of transformation of natural landscapes as a result of the implementation of specific socio-economic projects is determined by the scale of the region, population, natural resource potential, placement of productive forces, energy base, socio-economic conditions, period of anthropogenic impact [21].

At the present stage of development of society, the geoecologization of environmental management is becoming increasingly important. One of the most important components of this process is the assessment of the quality of the human living environment with the aim of optimally multifunctional use of geographic space in accordance with its natural resource potential, functional ability to satisfy public requests while maintaining the ecological stability of regional and local natural-anthropogenic geosystems.

The development of geoecology has led to the formation of a new direction of ecological and geographical researches, which has received the name “geoecological assessment”. The formation of this direction is connected with the works of V. S. Preobrazhensky [29], A.M. Green, N. N. Klyuev, L. I. Mukhina [23], A. G. Isachenko [27], B. I. Kochurova [28], A. G. Emelyanov [24, 25], and other authors. They considered a number of methodological, theoretical and methodological issues of evaluation, and showed the ways of practical use of ecological-geographical research. N. N. Klyuev, L. I. Mukhina, A. M. Green [23] understand the geoecological assessment as “complex interdisciplinary studies of geosystems aimed at creating scientific foundations for solving the problems of improving the ecological situation and rationalizing environmental management”. The authors highlight the complex nature of the assessment, the territorial location of the objects of study, the constructive nature of the research. Geoecological assessment should be considered as a complex of researched aimed at identifying anthropogenic changes in natural and natural-anthropogenic systems and their components, as well as the consequences of these changes affecting the ecological state of the environment, life and activities of the population [26]. It is based on a landscape-ecological approach to the objects of study, which includes consideration of the integrity and spatial-temporal structure of geosystems and ecosystems, spatial heterogeneity of the natural environment, consideration of the objects studied as human habitats. Particular importance is gained by the identification of causal relations between the socio-economic and natural conditions of changes in territories and waters, as well as the dependencies between specific types of environmental management and its consequences for human life and activity. The goal of geo-environmental assessment is to obtain reliable information that is necessary to prevent, minimize or eliminate adverse environmental impacts of people's economic activities, maintain the given socio-economic functions of the territory and optimal living conditions for the population. The objects of assessment are geo-ecosystems − complex formations that simultaneously combine the properties of geosystems and ecosystems. Geo-ecosystems are considered as separate territories and water areas within which a relatively homogeneous ecological situation is formed as a result of the interaction of economic, natural and social components. The presence of interconnections, the constant exchange of matter, energy and information between these components makes it possible to investigate them as integrated, relatively stable formations. Geo-ecosystems include natural-territorial complexes with inherent biocenosis and territorial-industrial complexes with their socio-economic objects and problems. The interaction between them forms the living environment and human socio-economic activity.

Geo-ecosystems consist of the following subsystems: a) the natural environment, slightly modified by human; b) nature, substantially modified by human activities; c) anthropogenic and technogenic component; d) population and social environment. If there are adjustable geo-ecosystems, one more component can be distinguished − the control unit. Natural-anthropogenic systems can be considered as geo-ecosystems, if the leading task of studying them is to identify or change the conditions of human life support. Therefore, the most important properties of geo-ecosystems are anthropo-(socio)centricity, territoriality, the presence of interrelations between human activity and the environment, components and elements of nature, hierarchy.

The ecological state of geo-ecosystems is advisable to consider as a set of their most important landscape-ecological indicators in a certain more or less long period of time. It is necessary to distinguish between physical-geographical (landscape), ecological (geo-ecological), sanitary and hygienic, medico-demographic indicators of the state of territorial and aquatic systems.

The solution of environmental problems is connected with the development of issues of geo-ecological monitoring, forecasting of anthropogenic changes in the environment, management of the ecological state of natural and anthropogenic geosystems.

Landscape management is the activity of organizing a rational interaction between the economy, technique, human activity and landscapes on the regulation of the functioning of landscapes in the course of their social and economic functions [30-32]. The management includes the selection of landscape-performing functions, one of which is the ecological (mediating and medium-reproducing) function. The ecological function of water landscapes is to support the main ecological properties of aquatic space, which determine the living conditions and economic activity of the population. The ecological function is aimed at ensuring the needs of society in the natural environment. In the process of environmental management it is necessary to take into account and use the processes of self-organization, functioning, dynamics and development of landscapes. Self-regulation of the ecological state is expressed primarily in self-cleaning, natural environment. Self-cleaning of aquatic landscapes manifests itself in their ability to process (dissolve, absorb, decompose, etc.) or remove pollutants beyond their borders. Self-cleaning depends on the speed, nature of chemical transformations of substances, which is determined by the amount of energy entering the landscape and geochemical conditions. An important role in this process is played by the activity of living organisms and the removal of matter beyond the boundaries of the landscape, the rate of dispersal of contaminants. Aquatic complexes have the greatest ability to self-clearning with high intensity of the matter circulation and the predominance of scattering streams. This process is less intense in accumulative aquatic systems [33-35].

Aquatic landscapes are complex systems that are closely interrelated with the catchment landscape. As a result, the ecological state of aquatic landscapes is capable of characterizing not only the processes prevailing in the water body itself, but also the resultant influence of all the processes in the “catchment - water body” system. Therefore, ecological studies of aquatic landscapes are of great scientific and applied importance, and the methodological basis of research is of particular importance, since it largely determines the nature and reliability of the results obtained. The ecological state of aquatic landscapes is determined by a set of indicators characterizing water quality, chemical composition of bottom sediments, the state of aquatic ecosystems, etc. In order to give such a comprehensive assessment, it is necessary to consider all these indicators holistically in their interrelation and interdependence.

Surface water bodies are the lowest (aquatic) level in the elementary geochemical landscape and are most vulnerable to chemical pollution. The quality of surface waters makes it possible to judge the overall level of chemical exposure on the part of subsoil users. However, the dynamics of the aquatic environment determines a high degree of variability in the content of pollutants in it. In this regard, the monitoring includes bottom sediments, which, being a conservative system, are capable of accumulating and storing information about the state and changes in geochemical, dynamic, microclimatic environmental conditions, including anthropogenic effects on the aquatic environment. The features of substance migration in the landscape are largely determined by the properties of the depositing media − soil cover and vegetation. The soil is formed as a result of the interaction of such components of the landscape as rocks, atmospheric air, natural waters and biota. During the monitoring, soil contamination was assessed by two horizons: organogenic and mineral.

Geosystems of regional and local levels in their morphological structure, in addition to eluvial and superaquatic complexes, include aquatic complexes of rivers, lakes, estuaries, ponds, reservoirs, canals, etc. The need to distinguish aquatic geosystems was noted by N.A. Solntsev, A.G. Isachenko, N.N. Nazarov, O.A. Tikhomirov and other researchers.

F.N. Milkov [36] identifies semiaquatic landscapes as part of the landscape sphere, which include rivers, lakes, coastal complexes. A variety of physiographic conditions, landscape structure of the territory, economic use determines the features of the formation, structure and functioning of aquatic geosystems. Aquatic complex is characterized by the composition of components, morphological features, spatial structure and functional organization. The system of relations between the elements provides the processes of exchange and transformation of matter and energy. Aquatic complexes used by man, transformed or artificial ones, are formed as a result of the interaction of natural factors and various activities of the population [37]. The water landscape is an interconnected system of aquatic complexes, similar in their morphology and flowing physical and geographical processes, characterized by certain hydrothermal conditions and combinations of bottom sediments (flooded soils), vegetation and water masses. Lake, river, and transitional lacustrine landscapes can be attributed to the aquatic type. Lakes and rivers are fundamentally different in their morphology and morphometry. In rivers, the main physiographic processes, the development of hydrobiocomplexes are associated with the activity of flowing waters. The processes of formation of water complexes in lakes occur under conditions of slow water exchange. This type of landscape is affected by high-altitude and natural zonality. In this case, it is possible to distinguish the classes of aquatic landscapes - plain, zonal or mountain ones [38]. Elementary unit of the water landscape is aquafacies. It stands out on the element of the underwater relief and includes one hydrobiocenosis that forms on certain bottom sediments and the water mass associated with them. Tracts are a complex of homogeneous facies formed in similar conditions and isolated morphological-morphometric elements or due to the heterogeneity of bottom sediments, flooded soils, vegetation, water masses, and also as a result of human activity [38]. The diversity of anthropogenic changes in water bodies is associated with various forms of human exposure and use of aquatic complexes. A number of researchers distinguish natural and human-made groups of inland freshwater landscapes. According to O.A. Tikhomirov, the separation of altered water landscapes is possible according to the criterion of the degree of their technogenic change into natural, natural-anthropogenic and anthropogenic (man-made) aquatic complexes [39]. It should be noted that this division is somewhat arbitrary, since theoretically all water bodies are indirectly influenced by human. At the same time, many technical facilities are built using natural materials, and in the case of non-systematic regulation they begin to evolve according to the natural type. Aquatic complexes, which practically did not experience human impact, and have retained their structure and functions, are natural. Natural water landscapes function under the influence of natural factors and experience a relatively weak, mainly indirect human impact, which does not lead to qualitative changes in the natural components. Aquatic complexes, transformed under the influence of human activity, belong to the natural-anthropogenic. Such landscapes are formed as a result of the interaction of natural conditions and various activities of the population. They have a significant impact on the environment, which leads to environmental and geographical situations of varying degrees of tension. The quality of the natural components used by human in their economic activities changes. Some aquatic landscapes function mainly due to the natural component. Other complexes are formed under the influence of technical regulatory activities. An example would be natural reservoirs geosystems. The geotechnical system consists of two subsystems (natural and technical ones) and a control unit. The management of a system is reduced to regulating the flow of matter, energy and information in order to maintain a high degree of balance between the direct and reverse links between its components and the fulfillment by it of social and economic functions set by society [40]. The formation of anthropogenic geosystems is influenced by man-made factors, the impact of which led to a complete or almost complete violation of not only the "secondary", but also the "primary" components of nature (geological structure and topography), as well as the replacement of natural components with structures made of artificial, and natural materials. Over the decades of the existence of reservoirs, some of the natural components have been destroyed, the other has been greatly changed, and in some cases new components have appeared. The reservoirs are a complex natural-anthropogenic system consisting of aquatic complexes closely related to each other. Over time, the development of reservoirs is increasingly subject to natural laws. The predominant landscape-forming processes lead to the formation of erosion, abrasion-accumulative, alloy-accumulative and other aquatic complexes in reservoirs [39].

Water masses of river aquatic complexes of the natural-anthropogenic type are characterized by higher values of the content of the main ions (hydrocarbonates, calcium, magnesium, potassium, chlorine, sulfates, sodium, phosphates), as well as metal ions - copper, zinc, manganese and iron; reduced oxygen content and increased turbidity compared with natural-type river aquacomplexes. This situation can be explained by the lower flowage of aquatic complexes of reservoirs, significantly greater depths (compared to reocomplexes), as well as the influence of polluted sewage from the territories of settlements and industrial zones [41]. All these reasons create conditions for sedimentation of the soils of reservoirs, accumulation of heavy metal salts in silts and, as a result, the development of secondary water pollution of these aquacomplexes. Both in the natural and in the natural-anthropogenic landscape, the content of biogenic elements is closely related to the hydrological conditions and has a seasonal character. In the littoral regions, the compounds of nitrogen and phosphorus in water are somewhat larger than the pelagic. The composition of the main mass of water (riverbed of pelagic zone) depends on the natural flow from the catchment. In the littoral zone, surface and groundwater runoff determine slightly higher concentrations of nutrients, especially during the growing season. Littoral aquacomplexes are characterized by better water quality indicators compared to profound ones. The water quality of the river aquatic complexes of the reservoir type is inferior to the water quality of the river geosystems of a natural type in a number of indicators [42].

The final link in the cycle of anthropogenic elements in the landscape is bottom sediments of water bodies. Over the past decades, the discharge of pollutants with wastewater leads to their accumulation in water and bottom sediments. Consequently, the accumulation of toxic compounds in water bodies increases the environmental hazard for aquatic organisms and humans. This actual problem has already been reflected in a number of publications [43–46]. Most researchers consider a lake or a reservoir as a single complex acting as a storage facility for heavy metals. At the same time, reservoirs are complex heterogeneous systems, including aquatic complexes, which differ in position in the water area and physiographic conditions. Based on a number of landscape-forming features, we proposed a classification of aquatic complexes of reservoirs (according to the characteristics of morphology, morphometry, hydrodynamic activity, nature of aquatic vegetation and bottom sediments) [46]. Consideration of the processes of accumulation of technogenic elements in the reservoir, taking into account the differentiation of the reservoir into separate geosystems, is one of the methodological approaches that allow not only to assess the role of aquatic complexes as accumulators of heavy metals, but also to predict the nature of their accumulation in bottom sediments. Such a forecast can be used in the development of environmental management systems, as well as zoning of reservoirs for environmental purposes.

Conclusions

The landscape, being a multifunctional formation, is suitable for performing a different type of activity, but the functions it performs should correspond to its natural properties and resource potential. In the natural landscape, which has not yet been affected by the influence of modern culture, the main are large spaces. The development of human territory causes the fragmentation of the landscape into parts. There are new factors affecting the landscape: the inclusion of elements of agricultural areas, reservoirs, roads and railways, industrial and other structures. These factors greatly change the natural landscape. Conducting environmental management in any territory requires an objective and comprehensive environmental assessment of the state of the environment. Integral assessment of the state of the environment and the geological environment in particular (the natural-geological environment) is the most complex geo-ecological task located in the cognitive methodological and methodological chain: system approach → system analysis → integrated assessment. Its complexity lies in the poorly developed scientific conceptual base of geo-ecology and the still insufficient practical experience in various natural-territorial, geological-technological and landscape-geochemical conditions. Since there is no single integral indicator of the ecological state in nature, a number of bioindication, spatial and dynamic indicators serve as criteria for assessing the ecological state of natural environments and ecosystems, and the integral assessment is based on a certain number of the most representative indicators.

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