Theoretical and methodological foundations of sustainable development of Geosystems

O M Mandryk1, L M Arkhypova2, A V Pukish3, A Zelmanovych1 and Kh Yakovlyuk4

1Ivano-Frankivsk National Technical University of Oil and Gas, Institute of Environmental Engineering, Department of Ecology, Karpatyska str., 15, 76018, Ivano-Frankivsk, Ukraine
2Ivano-Frankivsk National Technical University of Oil and Gas, Institute of Architecture, Construction and Tourism, Department of Tourism, Karpatyska str., 15, 76018, Ivano-Frankivsk, Ukraine
3Research and Development Institute PJSC “Ukrafla” North Boulevard., 2, 76019, Ivano-Frankivsk, Ukraine
4Ivan Franko National University of Lviv, Faculty of Foreign Languages, Department of English Philology, Universytetska str., 1, 79000, Lviv, Ukraine

E-mail: konsevich@ukr.net

Abstract. The theoretical and methodological foundations of sustainable development of Geosystems were further evolved. It was grounded the new scientific direction "constructive Hydroecology" - the science that studies the Hydrosphere from the standpoint of natural and technogenic safety based on geosystematical approach. A structural separation for constructive Hydroecology based on objective, subjective, and application characteristics was set. The main object of study of the new scientific field is the hydroecological environment under which the part of Hydrosphere should be understood as a part of the multicomponent dynamic system that is influenced by engineering and economical human activities and, in turn, determines to some extent this activity.

1. Introduction
Since the time of the formation of all existing hydrosphere sciences (Hydrology, Hydrochemistry, Hydrobiology, etc.) the principle of systemic approach was set into their theoretical foundation. The doctrine of multifactor formation of quantitative and qualitative composition of water of Hydrosphere is formulated in the works of famous scientists [1-13], who carried out the idea of the unity of physical, chemical and biological processes that occur in all natural waters and about their systematic conditioning by a complex natural and anthropogenic factor. O.M. Adamenko proposed a new constructive trend in the development of ecological science and environmental protection - "constructive Ecology" as the basis of environmental safety [1]. According to the author, constructive Ecology - is the part of the "Great Ecology" by M.F. Reimers, that not only diagnoses the state of the environment and forecast its evolution, but also offers specific ways of its optimization and improvement. It also constructs such natural-technogenic geosystems, that will ensure sustainable balanced harmonious development of Human - Nature - Technosphere. Constructive Ecology - the science and environmental protection sector, which justifies the creation of sustainable natural-technogenic geosystems structures which are the part of the Earth's biosphere and their development should not degrade under the influence of technogenic pressures [2], [3].

We should note that in modern geosciences and practice the term "Geocology" is widely used, which was introduced to the science by the German geographer (K. Troll, 1970). However, scientist geographers and geologists who use this term at present time, often invest in its content not exactly the same concept [4], [5]. In particular, authors [6], [7] define the term Geocology as interdisciplinary science of environmental
problems of geospheres. According to the famous socioecologists [7], [9], Geoecology is a subdivision of Socioecology and Geography, which studies the spatial variability of the geographical environment for the purpose of sociologically optimal territorial organization of the interaction between society and nature. The authors agree with the broad interpretation of the term Geoecology as a complex science that studies the environmental positions of all covers (areas) of the Earth. The object of the study of the Geoecology is geocoeosystems.

2. Presentation of the fundamental material

According to the wording of most environmental scientists, Hydroecology is a new direction in Earth sciences, which studies the hydrosphere as one of the abiotic components of the ecosystems of high level organization [2], [3], [10], [11]. Thus, Hydrosphere is treated and investigated as a multicomponent dynamic system that consists of basin systems and affects the existence and development of biota and the human community.

Please note that all living things supposedly are removed beyond the scope of the system that is studied. The latter is experienced the influence and itself affects living substance, and the only investigation is the interaction of the Hydrosphere and the living beings (always considering the human factor). However, many biologists against such extended interpretation of Ecology and leave it in the theory formation provided by Haeckel.

For any mature science the differentiation and integration of scientific fields are inherent. The appearance of a new object - namely anthropogenically altered water bodies (including artificial water bodies), the existence of such powerful factor as technogenic impact, allows you to believe that there are grounds for isolation of new scientific direction for objective, applicative and even subjective criteria. This direction can be called Constructive Hydroecology (Figure 1).

The object of study of this direction is hydroecological environment and its components – hydroecosystems that are under the constant influence of human activities - natural technogenic hydroecosystems (NTHES). They also include objects similar to natural, that appeared in result of economic activity. The subject of scientific direction is natural technogenic (environmental) safety of NTHES, balanced water use based on sustainable development.

The authors proposed the definition of "constructive Hydroecology" as a science that studies hydroecological environment from the standpoint of natural and technogenic safety and balanced sustainable water use.

The formation of constructive Hydroecology connected both with the development of methodology of different scientific direction in Ecology, Hydrology, Hydrochemistry, Hydroecology, Geology, and the need to ensure natural technogenic safety, balanced sustainable water use, prevention and prediction of adverse risks, which had precedents as a result of efforts to use raw materials, energy, food, recreation, and other resources of the natural ecosystems of the Earth’s water shell. At the same time natural hydroecosystems fall under the influence of the technogenic systems (hydraulic, hydropower, transportation, etc.).

The main object of study of new scientific field that is seen in the work is hydroecological environment under which it should be understood terrestrial or marine part of the Hydrosphere - multicomponent-dynamic system that is influenced by engineering and economic human activities and, in turn, to some extent determines this activity.

We consider it necessary to research the object of structural Hydroecology of the hydroecological environment with the help of biosphere-ecological concept and the concept of ecosystem-structural approach (see Figure 1). Biosphere-ecological concept and ecosystem-structural approach involves consideration of the biosphere as a global ecosystem rank [5], [6], [7]. That part of the biosphere, where operate modern living organisms, including humans as a species and the humanity as a social structure is defined in the term of "ecosphere" and relevant concept. Such approach allows us to consider the atmosphere, hydrosphere and lithosphere as ecological subsystems of ecosphere.

At the same time the living organisms, or the living matter in the aggregate [6], play the role of the major structural elements of the ecosphere that define the formation of the characteristics of three mentioned areas, subsystems and their relationships.

The need to change the ecological paradigm is emphasized by many outstanding ecologists [7], [8]. The basis of the new paradigm, with no doubt must be the systematic approach that is based on known general
scientific position, which goes back to Plato about the irreducibility of properties of the whole to a sum of the properties of its parts. This principle, according to renowned world-class environmentalists, "should serve as the first ecologists working commandment".

**Figure 1.** The object-subject structure of the constructive Hydroecology

Some sciences can be distinguished either the object of study (Physics, Chemistry, Biology, Geology, etc) or by unitary methodological approach (Cybernetics, Information theory, etc). Nowadays we distinguish Systemology as a special science whose objects of study are complex systems, and which has a specific means of their study [9]. The central concept of Systemology is the concept of system. There are more than thousands of its definitions, in the broadest sense the system can be understood as a set of the world's real or imaginary objects that were isolated from the rest in any possible way. During the evolution in time the aggregate is deemed as one system if between its elements at different points of time you can conduct unique correspondence. It is also emphasized that integral properties of the system are the result of the interaction of
its parts, and that the relationship between elements of the system must reflect the essential properties of elements and be stronger than the relationship with the elements that are not included in it.

Especially significant the systematic approach to Ecology. So, "the major paradigm of Ecology should be voted as the concept of Ecosystem" [9], here follows and recognition of the need for a systematic approach.

At the early stages of the research of hydroecological environment arise the questions of its structure and size, of hierarchy levels of its territorial dimension and of methodical approaches to solve these procedures.

The analysis of existing approaches to local hydrological and hydro-chemical structures showed that all of them are based only on two basic principles: the zonal (geographically) and the basin (hydrological). The law of geographical zoning, that was introduced by V.V. Dokuchaev in 1898, is also apparent in the territorial structure of hydrological and hydrochemical information fields [12].

Landscape-genetic approach, that takes into account the principle of geographical zoning of the chemical composition of surface waters, was successfully applied for the allocation of elementary hydrochemical structures, such as "hydro-chemical fields" [12]. At the same time, we should take into account that geographical zoning is seen in the spatial change only of those chemicals, the concentrations of which are formed mainly by natural factors. In the spatial distribution of concentrations of substances that are of mixed and anthropogenic origin we not observe any signs of geographical zoning.

Therefore, in researches the application of issues of sustainable water use and environmental safety of hydroecosystem only the scheme of physical-geographic division into districts for the classification of hydroecological environment and its components – hydroecosystem, for which are typical poly-components with increasing in the last decade the predominance of mixed (natural-anthropogenic) and anthropogenic origin substances, is seen to be methodologically groundless.

The basin approach as a method to study integral-functional geosystems, is best suited, according to the authors, to explore hydroecological environment and, within it, NTHES. The methodological base of using the basin approach in organization of sustainable water use is based on the idea that river basin is complicated hierarchically constructed natural-technogenic system, within which the unidirectional flow of natural substances, energy, information facilitates the structuring of natural-technogenic components, establishing strong ties and interaction between them. The systematic relationship of natural and technogenic components of the basin, the exactness and simplicity of allocation of its limits, the possibility to predict the change of the state of natural components and complexes of basin in time and space, form the basis of wide application of basin approach.

The authors proposed structural division in constructive Hydroecology within its objective, subjective, and application features (see Figure 1). In particular, within the objective attributes we distinguish constructive Hydroecology of sea and constructive Hydroecology of land, which can be divided into constructive Hydroecology of rivers, lakes (reservoirs), wetlands, groundwater, glaciers. By subjective characteristics (individual sides of objects) we can identify constructive Hydrogecophysics, constructive Hydroecochemistry, constructive Hydroecobiology, constructive Hydroecogeology. In turn, in these areas we distinguish more narrow and specialized ones.

Due to the applied features we can highlight: constructive Hydroecology of the production sector (industry, agriculture, construction) and constructive Hydroecology of the non-production sphere.

Among the priorities of constructive Hydroecology are:
1. The development of methodology of natural-technogenic (environmental) safety and sustainable balanced water use of Hydroecosystem [10-12];
2. The development of topological classification of NTHES for different regions;
3. The development of the classification of various anthropogenic pressures on the hydroecological environment (the study of natural and with anthropogenic impact modified processes - their direction, intensity, interaction with other processes, the impact on the dynamic stability and changes in NTHES, the creation of complex models of NTHES etc.);
4. The substantiation of quantitative and qualitative indicators of Hydroecosystem potential and maximum permissible anthropogenic pressures on different types of Hydroecosystem [11], [12];
5. The finding of spatial and temporal regularities of the change of Hydroecosystem potential and mapping of different NTHES types and different anthropogenic pressures on them;
6. The prediction about the changes of NTHES under the influence of various anthropogenic pressures;
7. The development of the recommendations on the conservation the dynamic equilibrium and optimization of NTHES [13].

3. Conclusions
Constructive Hydroecology is an interdisciplinary science that uses achievements and combines the scientific disciplines: Hydrology, Hydrochemistry, Hydrobiology, Hydrogeology, Oceanography, Meteorology and Climatology, general Ecology and others using modern geoinformation technology.

Consequently, constructive Hydroecology - is part of a constructive Geoecology that not only diagnoses the condition of hydroecological environment and forecasts its evolution, but also offers specific models of sustainable water management and environmental safety of hydroecosystems, constructs such NTHES that would ensure "sustainable and harmonious balanced development, the focus of which is a person who is entitled to a healthy and productive life in harmony with nature" (Rio 20+, 2012).

References
[1] Adamenko O M 2007 Our future home - Ecoeurope. The novel of life, science and love in 4 volumes, V4, P 428, Symphony forte, Ivano-Frankivsk, Ukraine
[2] Rud’ko G I and Adamenko O M 2009 Earthlogy: resource and ecology safety of the Earth, P512, Academpres, Kiev, Ukraine
[3] Rud’ko G I and Adamenko O M 2008 Constructive geoecology: scientific foundations and practical implementation, P 320, Maklaut, Kiev, Ukraine
[4] Rosenberg G S and Smelyanskiy I E 1997 Environmental pendulum (paradigm shift in modern Ecology), Journal general biol. 58(4) 5-19
[5] Reimers N F 1990 Nature usage, P 634, Nauka, Moscow, USSR
[6] Isakov Y A, Kazanskaya N S and Tishkov A A 1986 Zonal laws of dynamics of ecosystems, P 150, Nauka, Moscow, USSR
[7] Gilyarov A M 1998 Ecology in search of a universal paradigm, Nature 3 73-82
[8] Vernadsky V 1944 A few words about the Noosphere, Successes of modern Biology 18(2) 113-120
[9] Fleishman B S, Fedorov V D and Gilmanov T G 1980 Basics of systemology P 464, Radio and Communications, Moscow State University, USSR
[10] Korchemlyuk M and Arkhypova L 2016 Environmental audit of Ukrainian basin ecosystem of the Prut river, Scientific bulletin of National Mining University 155(5) 98-106
[11] Arkhypova L M and Permerovska S V 2015 Forecasting water bodies hydrological parameters using singular spectrum analysis Scientific bulletin of National Mining University. Scientific and technical journal 146(2) 45-50
[12] Adamenko Y O, Arkhypova L M and Mandryk O M 2016 Territorial standard quality hidroekosystem protected areas, Hydrobiological Journal 52(6) 51-59
[13] Mandryk O M, Arkhypova L M, Pobigun O V and Maniuk O R 2016 Renewable energy sources for sustainable tourism in the Carpathian region, IOP Conf. Ser.: Mater. Sci. Eng. 144 012007