Остроумов Сергей Андреевич – д.б.н., профессор, в.н.с., Московский государственный университет им. М.В. Ломоносова, г. Москва
Ostroumov Sergey A. – Dr. Biol. Sc., professor, leading researcher, M.V. Lomonosov State University, Moscow

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TOWARD CONCEPTUAL CHANGES IN ECOLOGY AND BIOSPHERIC SCIENCES. HI-ECOLOGICAL TECHNOLOGIES AND SCIENTIFIC BASIS FOR ALLEVIATION OF ENVIRONMENTAL PROBLEMS

The scientific progress in several areas of modern science made less visible some important advances in ecology and environmental science, hydrobiology, ecological biogeochemistry, ecotoxicology. Therefore it is worth revisiting some fundamental concepts. Several fundamental notions of ecology are undergoing significant changes. The author presented some elements of innovation on the following topics: information network in the biosphere; self-maintenance mechanisms and stability in ecosystem and the biosphere; entropy flows; negative entropy outside of organisms; the biosphere and biomatrix of the biosphere; a new system of criteria for ecological hazard identification; environmental hazards of new types; better understanding of how ecosystems maintain water quality; new concept of exometabolism, and integral metabolism; indirect way of biotic conditioning of the environment; practical applications and 'hi-ecological technologies' in ecosystems.

Key words: **ecology, biospheric science, hydrobiology, water quality, biosphere, pollution, ecosystems, environmental safety, hazards, biochemical ecology.**

Introduction

The scientific achievements in several areas of modern science made less visible some important advances in ecology and environmental science [1–12], hydrobiology [9,13–22], ecological biogeochemistry [23, 24], ecotoxicology [10–22, 25, 26]. Some these contributions to ecology and adjacent areas of science are briefly considered below.

Revisiting some fundamental concepts

Several fundamental notions of ecology are undergoing significant changes. E.g., among the fundamental concepts of ecology is the concept of ecological optimum associated with many ecological factors. According to that concept each or almost each of ecological factors reach some optimum (say, optimal temperature etc.), at which organisms of the given species feel most comfortable and demonstrate maximum productivity. The research done by Professor A.S. Konstantinov at the Moscow University (see his presentation at the scientific session, "Aquatic Ecosystems, Organisms, Innovations", Moscow, 2005) demonstrated that this concept is no longer correct. He proposed and substantiated a new concept of ecological optimum that is different from the currently accepted one.

Information network in the biosphere

We see now that the biological communities are not only the trophic webs but also networks of information flows. The information channels are based on several types of communication: physical (optical, acoustical, possibly electromagnetic) and chemical (chemical signals). The details of the chemical communication were analyzed in our publications e.g.: www.springerlink.com/index/E58651U631313465.pdf.

New concepts of ecological chemoregulators and ecological chemomediators were introduced in [2].

Self-maintenance mechanisms and stability in ecosystem and biosphere

The relative stability of ecological systems and the biosphere as whole is a surprising fact. The stability of the thermal conditions, the stability of the biotic communities, and the stability of the chemical composition of water are important things that cannot be taken for granted. There are some complex ecological mechanisms behind those facts of stability. One of those mechanisms is the ecological mechanism for water self-purification in freshwater bodies and streams, as well as in marine systems. It was described in other my publications [15–22].

Entropy flows; negative entropy outside of organisms

The Nobel Prize Awardee Erwin Schrodinger (1887–1961) made a statement that organisms feed on negative entropy (book "What Is Life?", first edition, 1944; one of the most recent – Cambridge: Cambridge University Press, 2002 [27]). His idea was that organisms produce entropy, which is equal to their eating negative entropy. However, our analysis showed that in aquatic ecosystems, as a result of activities of organisms, the water outside of organisms is far away from passive equilibrium in terms of concentrations of organic and inorganic chemicals. In other terms, there is a flow of negative entropy from organisms to the external water. It is a paradoxical addition to the picture that was described by E. Schrodinger.

The biosphere and biomatrix of the biosphere

One of previous concepts of the biosphere was that it is the part of space where organisms live; another concept was that the biosphere is the sum of organisms. Now we see the biosphere in a different way. We see it as what we called biomatrix, which is densely packed with matter, ecologically important natural chemicals which carry signals from one organism to another one and physical fields. All three components are in part either components of living matter or are of biogenic origin. This new vision is different from the traditional one, and the difference was analyzed in the publication [4].

A new system of criteria for ecological hazard identification

A new system of criteria for considering chemicals or other man-made factors as serious hazards to the biosphere is emerging. It was formulated in the publications [5].

Environmental hazards of new types

In a series of new experiments, type types of environmental hazards were identified [28–31]. Inter alia, synecological summation of anthropogenic effect was identified as a new hazard [28, 29].

Hazards of uncoupling of benthal-pelagial coupling in aquatic ecosystems were identified in experiments with filter-feeders [30].

Hazards to natural mechanisms of water self-purification in freshwater and marine ecosystems were found [13–22]. These hazards could be considered as hazards to natural mechanisms of ecological repair of water quality [31].

These new facts also lead to better seeing hazards from relatively low (sublethal) concentrations of chemicals that pollute aquatic environment [13,17].

Better understanding of how ecosystems maintain water quality

The new experiments led to understanding of how various groups of organisms in biological community of aquatic ecosystem function together toward maintaining water quality. This led to formulation of theory of biotic (or ecological, or hydrobiological) self-purification of water in both freshwater and marine ecosystems [19–22]. The fundamental conclusion of this theory is that biodiversity in aquatic ecosystems is a prerequisite to long-term water quality in these ecosystems.

New concept of exometabolism and integral metabolism

The development of the abovementioned theory of ecosystem-dependent biotic self-purification of water led to introduction of some new concepts, namely *exometabolism* in ecosystem and *integral metabolism* [32]. *Exometabolism* is the extra-organismal, extracellular metabolism of chemicals, especially xenobiotics and pollutants (but not only them) in aquatic media of aquatic ecosystems. *Integral metabolism* is the summation of both intracellular metabolism (classical biochemical metabolism) and exometabolism of chemical molecules. The final fate of chemicals which enter ecosystems (including aquatic ecosystems) depends on integral metabolism.

Indirect way of biotic conditioning of the environment

Now it is a well-documented fact that the biota conditions the environment including the aquatic environment and atmosphere. In addition to that, our experiments and analysis led to a discovery of an additional indirect way of conditioning the environment. This way of conditioning involves various types of biogenic material including, inter alia, excreted organic matter, biogenic detritus, mortmass and some other types of biogenic material. This material immobilizes toxic chemical elements. By doing so it contributes to detoxification of the environment. In more detail, our experiments (with participation of colleagues of various institutions) and the analysis were described in [33–38].

Practical applications

There are several interrelated ways of practical usage of new ecological knowledge. We may consider three examples.

Example 1: phytoremediation. More detail see in my publications, e.g.: www.springerlink.com/index/ML1062K7271L318N.pdf;http://www.researchgate.net/file.FileLoader.html?key=8fd8998627b86102db72c9b237c25054

Example 2: preventing global change. It was shown that the global change is prevented or mitigated by a number of ecological or biogeochemical processes. Those processes and the biota which is the driving force for the processes should be better studied and protected.

Example 3: preventing new potential forms of terrorism (bioterrorism, ecoterrorism). Usually the term 'bioterrorism' is interpreted as something to do with harmful microorganisms and other infectious agents, including those that are genetically constructed. They are dangerous, but the prophylaxis of bioterrorism must cover a broader range of potential threats. In our ecological analysis, we have found some threats that we designated as 'the ecological hazard of the first type' and 'the ecological hazard of the second type'. Those threats are to be better studied and we are looking for sponsorship in studying them and the ways to counteract the threats. We already discovered important biotic mechanisms that serve as a beneficial remedy to prevent the threat of the ecological hazard of the second type.

Concluding remark

The common denominator of many of the ecological mechanisms mentioned above is that they meet the criteria that we formulated in some of our recent publications as the criteria for a hi-tech device in the field of technology.

As a result we could consider some ecological mechanisms (involved in information transfer, in self-purification etc.) as ecological (ecosystem) analogy of high technology. We suggest to use the term 'hi-ecological technologies' that we can found in natural ecosystems; we may create them in artificial ecosystems. The systems for phytoremediation are a good example. Further solutions to environmental problems (alleviation of some issues of anthropogenic impact, including chemical pollution and some other issues) could involve using some ideas of those hi-ecological technologies [32, 39, 40].

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