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Problems of Ecology

The authors discuss the most important fallacies in modern climatology and ecology and priorities in solving nature-protective problems.

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A Strategy for the Survival of Humanity Is on the Agenda

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Modern civilization is the result of three hundred years of modernization of the world community based on the progress of science and technology. The ideology of modernism has formed the concept of the biosphere as only a source of resources for the improvement of human life, which has led to unprecedented destruction of natural ecosystems and a rapid decrease in biodiversity. Only in the last quarter of the 20th century, due to serious global changes taking place at a high rate, was the question of the limits of destruction and the role of natural ecosystems and, hence, life in the biosphere posed. Comprehensive empirical data, obtained by biologists, geographers, and geologists, at the end of the 20th century in Russia, have proven that natural ecosystems form and control the environment, and that the permissible level of their destruction has already passed the point of no return. Any subsequent total injurious impact would lead to the ultimate loss of stability in the environment and life on the whole; hence, the problem of the survival of civilization and of human beings as a species would arise.

The population of the planet has no clear idea why it is necessary to preserve undisturbed ecosystems. The reason for this ignorance largely concerns the ruling elites, whose strategic thinking does not extend beyond short-term and, even more seldom, long-term political programs. As far as corporate industrial and financial structures that considerably affect the elaboration of political strategies are concerned, the situation is much worse, since their main principle is gaining a profit in the shortest possible time. Therefore, individual countries and the world as a whole have no serious political strategies for preserving nature, which leads to indifference among people to this problem. Fallacies and the erroneous order of ecological priorities also promote this.

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Biotic regulation of the environment. Life is based on the biochemical reactions of the conversion of inorganic substances to organic substances and vice versa. The intensity of biochemical flows of synthesis and decomposition is such that, in the absence of a relationship between them, the environment can change to a state unfit for life in only a few dozen years. To natural biochemical reactions, humans added synthesis and decomposition of various products of civilization. In the absence of a relationship between these flows, the environment can become unfit for use over one century owing to the accumulation of pollutants.

The environment in the preindustrial epoch is believed to have remained suitable for life owing to the equilibrium of synthesis and decomposition of organic substances, which researchers consider the closedness of the biochemical cycle. Therefore, it is suggested that, in connection with the needs of the increasing population of the planet, any rearrangement of the biosphere is permissible on a single condition—the liquidation of industrial pollutions, i.e., the transition to waste-free technologies, which solves all the ecological problems [1]. This is the first and main fallacy.

If the cycles of substances generated by biota and civilization were completely closed, the environment would be in a state equal to the absence of life. In this case, change proceeds due to the physical mixing with the interior of the earth, i.e., thanks to the difference between outward flows of substances from the interior of the earth to the environment and their deposition in sedimentary rocks. The flows of substances to the environment from the cosmos are 4–5 orders of magnitude smaller than flows from the interior of the earth, and they can be ignored. The outflow of matter from the interior of the earth and its deposition in sedimentary rocks takes place as a result of various physical processes. A pure flow of arriving substances, equal to the difference between outflows of substances and their deposition, has the same order of magnitude as each flow separately. The intensity of the physical fluxes of the outflow and the deposition and of their difference is four orders of magnitude weaker than the biochemical

flows of synthesis and decomposition. Therefore, in the complete closedness of the biochemical and civilizational cycles of matter, the environment would change by four orders of magnitude slower than at a complete openness of biochemical cycles. However, even in this case, the environment could completely change and become unsuitable for life approximately over 100 000 years, i.e., for a period 4–5 orders of magnitude smaller than the period of existence of life on the planet. It follows that life is impossible without the directed openness of biochemical cycles, preventing environmental change in a direction unsuitable for life.

Actually, the complete closedness of biochemical cycles, i.e., the cessation of the impact of life on the environment, is physically impossible. Mathematically complete closedness would suggest a precise equality of all meaningful figures in the values of synthesis and decomposition. These are biochemical processes with the involvement of various organisms of the biota. These processes cannot coincide at any moments of time. Their correlated relationship emerges not as a result of the closedness of cycles of substances but is determined by the threshold of biota sensitivity: if changes in the environmental characteristics do not exceed the sensitivity threshold, the biota does not react to them. The response starts when the relative changes exceed the sensitivity threshold. Changes can occur both due to the functioning of the biota itself and due to the abiotic process of physical mixing of the environment with the interior of the Earth. Compensation of the environmental disturbances induced by the biota also inevitably compensates changes arising as a result of biotic physical processes. Environmental changes occurring due to anthropogenic impact are compensated similarly. Note that ignoring the directed physical environmental changes after averaging over accidental fluctuations determined by the biota, the flows of synthesis and decomposition coincide with the relative accuracy of the order of magnitude of biota sensitivity, which is perceived as the closedness of biogeochemical cycles. The sensitivity of biota is a fundamental characteristic of a biosphere having a magnitude not less than 10^{-4} [2]. The mechanism of formation and support of an environment suitable for life within the limits determined by the sensitivity of the biota was called biotic regulation [2].

The impossibility of the existence of life without biotic regulation also follows from the physical instability of the modern climate of the earth, which contains a liquid hydrosphere [3]. The greenhouse effect, which maintains average global near-earth temperature above the water freezing point is mainly determined by water vapors and cloudiness. According to physical laws, vapors and cloudiness are in equilibrium with the liquid hydrosphere of the ocean and the land. The equilibrium depends on the near-earth temperature. With its increase by every 10°C, the concentration of vapors in the atmosphere increases twofold, which leads to a respective increase in the greenhouse effect and a subsequent rise in temperature. Therefore, the existing equilibrial climate state is unstable with respect to a transition either to a state of complete evaporation or to glaciation of the hydrosphere. A stable maintenance of the average global temperature within 10–20°C over the last billion years can be explained only by biotic control of the global water cycle.

It follows from the aforementioned that the presence of life on the earth is possible provided the biota maintains all the environmental characteristics formed by the biota itself. An essential condition for such maintenance is the preservation of an undisturbed biota on a global scale.

Principles of life functioning. The biota in the process of evolution has accumulated a large pool of genetic information, distributed as a complete cover on the earth, and formed information processing flows inaccessible at any development of civilization. The biosphere contains about 10^{30} cells of organisms, each of which processes approximately 10^8 bit/s, i.e., as many as does the modern personal computer. It is easy to assess that the information flow of the earth's biota exceeds the information flows of modern civilization by 20 orders of magnitude. This gap will never be overcome [2]. The idea that biotic environmental control can be replaced by technological control is the second widespread fallacy.

The complexity of life is the main property that provides for the biotic regulation of the environment. The activity of live organisms in the composition of natural communities essential for regulation is programmed in the genetic information of biological species. Any change or liquidation (by way of artificial selection, genetic engineering, or the introduction of alien species into a community) of this information deteriorates or completely disturbs the biotic regulation. Hope that better changes would occur in an environment that degraded as a result of human activity due to the replacement of natural aboriginal communities by artificial (for instance, turning "desert into a blossoming orchard") is a particular manifestation of the aforementioned second fallacy. Undisturbed natural communities have the maximum possible potential of biotic control over the environment.

The orderliness of closed systems can only decrease, passing into a state of complete chaos. The orderliness of open systems is capable of increasing due to the absorption of external energy fluxes. Yet such an increase of any nonlinear physical systems has a limit depending on the absorbed external flux. Such a process is called physical self-organization. Estimates show that the orderliness of the existing life (the density of information reserve in a unit of volume) surpasses the orderliness of any physical system in any external fluxes by 24 orders of magnitude [4]. Therefore, the self-origin of modern life is impossible. The stability of life of any level from monocellular and multicellular organisms to social structures and ecological communi-

ties is based on a principle that physical systems lack. This principle involves the formation of populations of homogeneous self-reproducing systems and the inclusion of competitive interaction and stabilizing selection within a population. This stabilizing selection based on intraspecific competition rather than evolution is the main property or law of life and its essential distinction from physical self-organizing systems. Evolution is nothing more than an optional consequence of stabilizing selection. Hope to explain the observed complexity of life and development by the physical self-organization of nonlinear physical systems is the third widespread fallacy.

The ecological principles of biotic environmental regulation. Biotic regulation is possible if community species retain genetic information as to what is optimal for the life environment and how disturbances in its normal state should be compensated. This means that species cannot adapt their genetic program and adapt to arbitrary environmental changes. The inability to adapt is explained by the stability of the morphological and genetic characteristics of a species over the period of its existence observed from paleodata that has an order of several million years. This is proved by the absence of transitional forms between all existing species [2, 5]. If species could genetically adapt to environmental changes, they would not be able to stop these changes and there would be no biotic regulation. Without it, as was stated above, there would be no life. The idea that biota can adapt to any environmental changes is the fourth fallacy.

The consequence of this delusion was widespread concern with the low intraspecific genetic diversity, since it is assumed that a high diversity increases the ability of a species to adapt to the changing conditions. In fact, a low diversity of a population indicates the closeness of individuals to the normal type and a small proportion of defective individuals with partially erased genetic information. Low intrapopulational diversity characterizes the information program of a species providing both efficient participation in environmental control and the possibility of existence in various external conditions.

An environment, created and supported by biota, cannot restrict the biotic regulation, production, and decomposition of organic material. The limitation by various biogens and the effect of the Liebig law arise only under disturbed conditions, in particular, in transferring the aboriginal species of one community into an alien community that is unnatural for them. The limitation of functioning arises also during cultivating decomposition changes in the genetic program of plant varieties and animal breeds used in agriculture. The unjustified distribution of limitation principles to the undisturbed biota of land and oceans often leads to insoluble contradictions [5] and is the fifth fallacy.

Ecological communities contain a program of recovery after external disturbances. In an undisturbed state, a community is capable of maintaining a certain distribution of the numbers of individuals by species and an optimum environmental state with maximum efficiency, i.e., with the fastest rate of compensation of any deviations from the norm. After the cessation of an external disturbance, the distribution of species in a community considerably changes. Those species that return the environment to the normal state as rapidly as possible become dominant. Other species that more efficiently function at the subsequent stage of recovery (succession) perform their functions until the undisturbed community and its environment are restored. Since "repair" species are replaced by other species, it means that they change the environment in a direction unfavorable for them. Therefore, during the recovery, the biotic control is weakened or lacking altogether. The replacement of some repair species by other species takes place only upon the recovery of a disturbed community and is often erroneously interpreted as an intraspecific competitive interaction.

In a mature forest, trees are in complex relations with the activity of other organisms. The increase of foliage is limited by defoliation; the increase of wood and roots, by fungal and bacterial activities. Such a forest where all organic components of a tree are used for the life of other organisms is a healthy body of a community. In the period of succession, the evolvement is directed at the most rapid recovery of a natural mature forest capable of controlling the environment with maximum efficiency. At this time, trees grow at the maximum rate and have sterile pulp not participating in metabolic processes (called *commercial* timber); i.e., the forest recovers itself and is incapable of controlling the environment. The maintenance of forest ecosystems in a state of continuous succession by cutting down commercial timber every 40–50 years is equivalent to maintaining a patient in a state of incessant recovery. The idea of the permissibility of cutting down *overmature* and *rotting* undisturbed forests (and analogous recipes for "sanitary" interference into other ecosystems) is the sixth fallacy.

Mathematical models in climatology and ecology. The aforementioned six kinds of fallacies existing in modern climatology and ecology could arise only in these sciences. The cause is the absence of the possibility of rapid empirical verification of basic postulates. Various computer models process numerous but isolated and often erroneously interpreted empirical data. Their main aim is to select the parameters of assumed correlations so that they include all the empirical points. With the emergence of new data, supplementary parameters are added to the model; therefore, the information stored in them does not differ from the information stored in the tabular data presentation. Many models disturb the laws of energy and matter conservation, as well as the second law of thermodynamics, which the authors themselves often acknowledge as a common phenomenon [6]. Such models offer various and often contradictory predictions.

Natural science operates with measurable magnitudes and considers and forecasts their values with a certain accuracy (error). As science progresses, the accuracy of forecasts increases. It should be emphasized that no natural science can tolerate a "pluralism of opinions." The latter means the presence of chaos and the absence of information [7]. Proceeding from the definition of science, there is only one correct answer to every question within the achieved accuracy. A wide use of mathematical simulation in climatology and ecology to obtain fundamental conclusions and predictions is the seventh fallacy.

The aforementioned delusions could not have arisen in sciences directly connected with experiments and direct application to technology. When there are fallacies, technology stops functioning. (In part, such fallacies have begun to appear in physics, chemistry, and some sections of biology with the belief that computer simulation can replace direct measurements, which has an immediate effect, for instance, increases the number of disasters.)

The stated fallacies are actual delusions rather than alternative views of the problems under consideration. This conclusion is based on the use of well-established laws of energy and matter conservation and the second law of thermodynamics, as well as other laws and facts.

Priorities in solving ecological problems. The preservation of the mechanism of biotic regulation in the needed range is a priority task of the 21st century. This requires the maintenance of global-sized areas covered by undisturbed communities of biota. The great productivity of modern undisturbed biota makes it possible to liquidate considerable environmental fluctuations within periods of approximately ten years [2]. There are also large rare fluctuations related to changes in solar activity and poorly studied processes in the interior of the earth leading, for instance, to the alternation of glacial and interglacial periods. The reversibility of unfavorable processes indicates that biotic regulation functions in any period. The biota stops these changes; however, it is incapable of completely preventing their origin. Even in the most catastrophic periods of glaciation, areas covered by undisturbed biota decreased less than twofold. The time of recovery of the environment after common fluctuations increased from ten to twenty years; i.e., it did not change by an order of magnitude. This was possible only because areas covered with glaciers and devoid of biota did not contribute to biochemical cycles and were not involved in biotic control.

Quite a different situation arises now, when more than 60% of land is developed and covered with a strongly disturbed biota [8]. It has the former or higher productivity but is incapable of controlling the environment. With the subsequent nature development and decrease of undisturbed areas, the biotic potential of control can be completely lost. There will begin not a global warming or cooling by several degrees with the respective change of climatic zones but a rapid and irreversible transition of the planet to a state unfit for life. Therefore, the main ecological task is to determine the critical ratio of the area of developed territories and those occupied by undisturbed biota. The analysis of the carbon cycle has indicated that the cessation of the increase of CO_2 concentrations in the atmosphere can be approximately attained at the existing size of the planet's population by reducing two times the area of the exploited forests [2]. However, the basis for the biotic regulation of the near-earth temperature is the aquatic regime of the planet rather than the atmospheric CO_2 [3]. The observed increase of CO_2 concentrations does not change the climate stability provided the areas covered by undisturbed biota are preserved.

Limitations on the change of aquatic conditions are much more rigid. The world map shows that numerous rivers and their tributaries indent large areas of the continents covered with forests. Such are the areas of Amazonia, Equatorial Africa, Siberia, and Canada. Large areas of the Sahara, Australia, and Central Asia are devoid of rivers, although the physical transfer of oceanic moisture to these areas cannot considerably differ from the transfer to woodlands. Forests on continents are oceans on land that control moisture content and aquatic conditions. Land became inhabitable and can remain inhabited by life due to the formation of the forest cover. Western Europe, which destroyed its forests several hundred years ago, has not turned into a desert only thanks to its unique geographic position. The destruction of natural forests in Amazonia, Equatorial Africa, Siberia, and Canada would turn these areas into deserts. The inversion or even an insignificant change of the current of Siberian rivers is out of the question. The rapid development of the biosphere and a reduction of areas with undisturbed biota undermine the potential for biotic regulation and decrease the environmental stability, which manifests itself in the increasing number of regional catastrophic fluctuations (floods, droughts, and changes in the duration of abnormally hot or cold periods).

Humanity could repeatedly exceed the permissible numbers due to the use of oil and natural gas. Their resources will be depleted in the nearest decades. The still considerable coal deposits will not be able to compensate for oil and gas, since the efficiency of coal is less than that of oil or gas.

Nuclear energy has never been used by natural biota; therefore, the biota is incapable of utilizing the wastes of nuclear fuel. The total proportion of civilization's nuclear energy does not exceed several percent. The resources of the safest nuclear energy obtained by fission of enriched uranium are insignificant, and they are depleted at the same rate as the resources of liquid and gas fuel. There has been no progress in mastering control over the considerably greater resources of nuclear fusion energy.

Nature has no alternative energy sources capable of replacing the capacity of fossil fuel in the current vol-

umes. The capacity of so-called renewable energy (water, wind, geothermal, and tidal) sources comprises less than one-tenth of the present consumption of fossil fuel. The energy of rivers, the use of which involves the disturbance of large areas covered by natural communities, is the greatest among the listed inexhaustible and renewable capacities. Other types of inexhaustible and renewable energy are smaller by an order of magnitude [2].

The possibility of using hydrogen fuel is currently the subject of wide speculation. At combustion, hydrogen combines with air oxygen, and water is formed. The reaction results in a great release of energy equal to the energy of atoms binding the water molecule. Hydrogen is undoubtedly an ecologically pure energy carrier, which can be used in industry, transport, and the municipal economy. However, free or weakly bound hydrogen resources do not exist in nature; therefore, any technology to produce free hydrogen from water, due to the limited capacities of converters, would consume much more energy than it would produce after combustion. Hopes for the discovery of "catalysts," decreasing energy expenditures, are like hopes for inventing perpetual engines.

When analyzing possible scenarios of the future and elaborating long-term strategies of development, one should consider the following postulates.

• After the depletion of the resources of liquid and gaseous fossil fuels and the transition to coal, the energy capacity of civilization will inevitably decrease, at least by an order of magnitude. This would lead to a decrease in the anthropogenic share of consumption of the biospheric production from the current 10% to possibly 1%. This would be sufficient for stopping global changes at the expense of a partial recovery of the potential of environmental biotic regulation. Achieving the needed maximum rate of regulation at the expense of the subsequent decrease of the anthropogenic share of consumption could extend to several centuries without the risk of losing environmental stability. The present capacity of civilization is sufficient for complete destruction of the undisturbed biota over the entire planet. A sudden recognition by humanity of the inevitable end of civilization, maintained by the energy of fossil fuel, will cause attempts to preserve the number of conflicting groups of people (countries, nationalities) by any means, including the application of nuclear weapons. In this situation, the global biota could be completely destroyed, and biotic regulation could be irreversibly lost.

• The most dangerous situation would arise from the discovery (as stated, unlikely) of the possibility of using thermonuclear energy, unlimited in its resources. In this case, the euphoria of permissiveness in considering the biosphere as a resource of civilization, the continuation of economic growth, and the preservation of the existing number of the planet's population would inevitably result in the liquidation of the undisturbed biota with all the effluent consequences.

• A decrease of the global anthropogenic share of consumption of biospheric production cannot proceed at the expense of decreasing the share of consumption of each human being by an order of magnitude, since human consumption is mainly determined by the specific biological features of the human organism. Hence, the main problem of the present time is reduction of the population. If humanity realizes the necessity of this step, it will manage to prepare for the rapidly coming changes and preserve civilization and life on the planet. Family planning and a decline in birth rate by transitioning to one-child families are the only ways of reducing the population. Depopulation is some countries no longer causes anxiety regarding the loss of competitiveness; on the contrary, many countries fear population growth and the resultant loss of competitiveness.

Population growth in a number of countries leads the *immigrant colonization* of countries where the population is decreasing. This global process may lead to far-reaching consequences, when nearly every five years a new nuclear empire would appear. Such developments would only accelerate the destruction of civilization.

REFERENCES

1. W. Leontief, *The Future of World Economy* (Oxford Univ. Press, New York, 1977).
2. V. G. Gorshkov, *Physical and Biological Foundations of Life Stability* (VINITI, Moscow, 1995) [in Russian].
3. A. M. Makar'eva and V. G. Gorshkov, "Greenhouse Effect and the Problem of Stability of the Average Global Temperature of the Earth Surface," Dokl. Akad. Nauk **376** (6) (2001).
4. V. G. Gorshkov and A. M. Makar'eva, "On the Possibility of Physical Self-Organization of Biological and Ecological Systems," Dokl. Akad. Nauk **378** (4) (2001) [Dokl. Biol. Sci. **378**, 258–261 (2001)].
5. A. M. Makarieva, V. G. Gorshkov, B. Mackey, and V. V. Gorshkov, "How Valid Are the Biological and Ecological Principles Underpinning Global Change Science," Energy Environ., No. 13 (2002).
6. S. A. L. M. Kooijman, *Dynamic Energy and Mass Budgets in Biological Systems* (Cambridge Univ. Press, Cambridge, 2000).
7. L. Brillouin, *Science and Information Theory* (Academic, New York, 1956).
8. *World Resources 1988–1989* (Basic Books, New York, 1988).